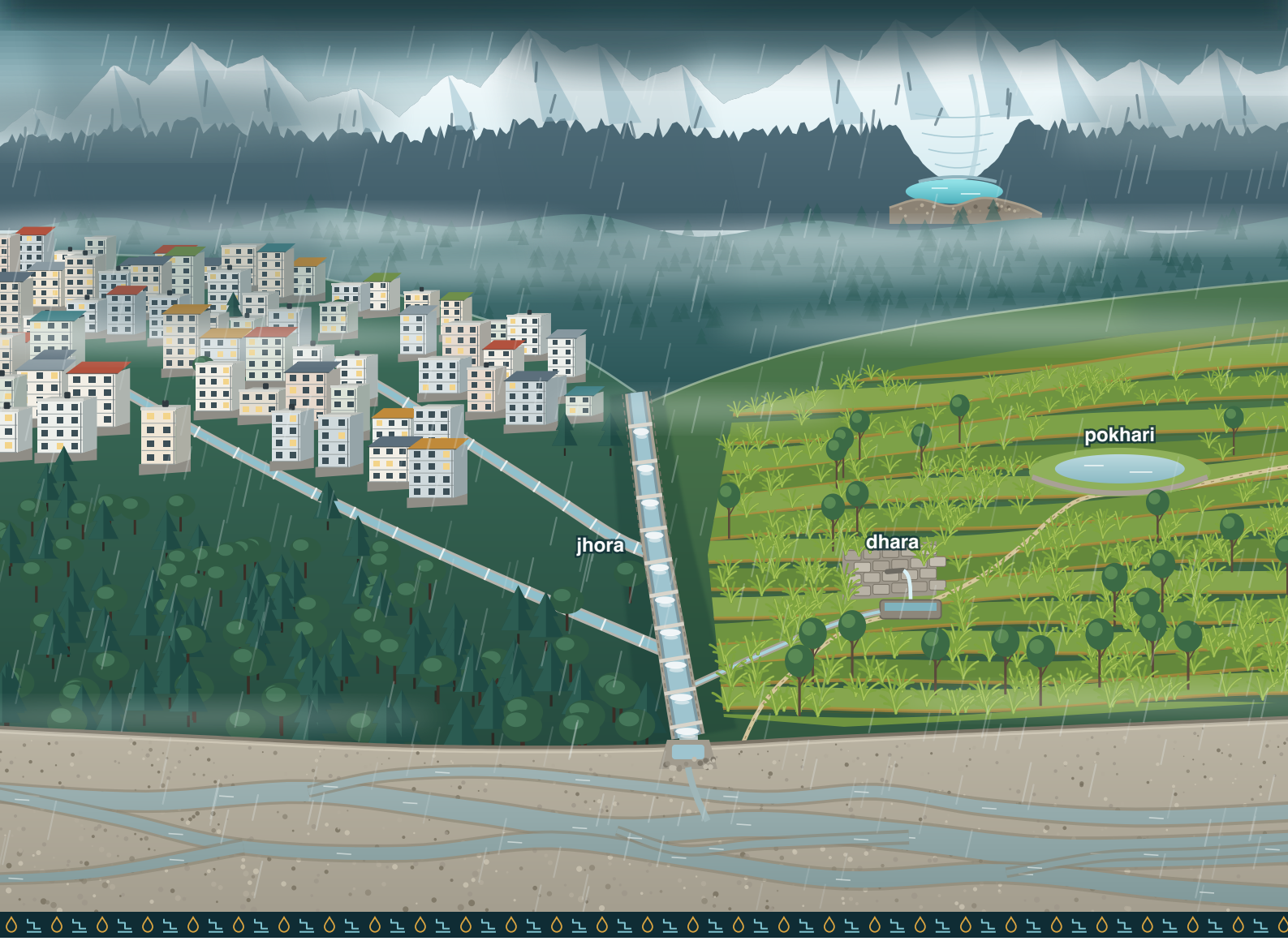
SIKKIM

# Stormwater Design Manual

Standards for the planning, design, construction, operation and maintenance of stormwater systems




Preserve | Retain | Detain | Convey | Maintain

**Draft v1.0**

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Prepared by

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## About this draft

**Status.** This is Draft v1.0 of the *Sikkim Stormwater Design Manual*. It was prepared by Neer as a proposed stormwater design standard for Sikkim. It is published in English; a Nepali edition is to follow.

**Not adopted.** This Manual has not been adopted, notified or endorsed by the Government of Sikkim, by its Governor, its Council of Ministers or its Legislative Assembly, or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Urban Development Department (UDD), formerly the Urban Development and Housing Department (UD&HD), by the Gangtok Municipal Corporation (GMC), the Namchi Municipal Council or any Nagar Panchayat (Rangpo, Singtam, Mangan, Gyalshing, Nayabazar-Jorethang, Soreng or Pakyong), by Gangtok Smart City Development Ltd (GSCDL), or by any District Collector. Nor has it been adopted, notified or endorsed by the Sikkim Commission on Glacial Hazards, the High-Level Steering Committee or the Multi-disciplinary Task Force constituted by the Home Department, the River Rejuvenation Committee of the Forest and Environment Department, the State-level Monitoring Committee, or the Sikkim Town and Country Planning Board, which is not yet constituted. Where it names a body, such as the Water Resources Department (WRD), formerly the Irrigation and Flood Control Department, the Public Health Engineering Department (PHED), the Rural Management and Development Department (RMDD) or its Dhara Vikas programme, the Land Revenue and Disaster Management Department (LR&DMD), the Sikkim State Disaster Management Authority (SSDMA) or a District Disaster Management Authority, the Mines and Geology Department, the Science and Technology Department, the Forest and Environment Department, the Sikkim State Pollution Control Board (SSPCB), the State Wetland Authority, the Roads and Bridges Department or the Public Works Department (PWD), the Energy and Power Department or the Home Department; NHPC Ltd (NHPC) or any other hydropower operator; the National Highways and Infrastructure Development Corporation Ltd (NHIDCL), the Border Roads Organisation (BRO) or IRCON International Ltd (IRCON); the High Court of Sikkim, the National Green Tribunal (NGT) or the Supreme Court; or a body of the Union or an external or research body, such as the Central Water Commission (CWC), the India Meteorological Department (IMD), the Central Ground Water Board (CGWB), the Central Pollution Control Board (CPCB), the National Disaster Management Authority (NDMA), the National Dam Safety Authority (NDSA), the Ministry of Environment, Forest and Climate Change (MoEF&CC), the Comptroller and Auditor General of India (CAG), the National Institute of Hydrology (NIH), the Asian Development Bank (ADB) or the International Centre for Integrated Mountain Development (ICIMOD), it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role. Citing a body's document does not make this Manual that body's document.

**No legal force.** Until a competent authority adopts it, with or without changes, this Manual has no legal force. Until then, the Sikkim Building Construction Regulations, 1991 as amended (the SBCR 1991), the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 as amended (the 1985 Act), the stability zones notified by the Mines and Geology Department in 2021, the Sikkim Municipalities Act, 2007 as amended, the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 as amended (the 1988 Act), the monsoon notices that stop earth excavation, any development plan made once the Sikkim Town and Country Planning Act, 2024 commences, orders of courts and tribunals, and approval conditions in force continue to apply.

**Where this Manual can apply.** The SBCR 1991 apply "to all the notified areas in Sikkim" (regulation 1(2)), to State, Central, semi-government and private builders alike, except Defence, and the 1985 Act requires prior permission for any construction in a notified area (section 7(1)). Inside Gangtok, building plans have been approved since 2017 by GMC's Town Planning Cell, still under the SBCR 1991. The Municipalities Act also provides a building permit system of its own (sections 266–287) and a power to make rules on "infrastructure in relation to building activity" (section 287), but no drainage rules have been made under it, as far as was found, and the Town and Country Planning Act, 2024 has not commenced. So in this Manual, setbacks and corridors are **conditions of**

**building permission in the notified areas and the municipal areas, and guidance elsewhere**. The competent authority for the area is: in Gangtok, GMC; in another notified area, UDD or the urban local body that approves plans there (how approval is divided between them outside Gangtok was not found [TBC]); for the bank of a scheduled river, the Forest Department; and for a public work, the department or agency that executes it. Outside every notified and municipal area the SBCR 1991 give no building permission at all, so there the Manual reaches public works and any body that adopts it, and is guidance for everyone else. Land for a public drain or corridor that is not State or municipal land is secured by agreement with its owner or by donation, or reserved in a development plan once the 2024 Act commences; this Manual does not assume that land can be taken. A competent authority could take the Manual up in several ways: the State Government could amend the SBCR 1991 under section 7(2) of the 1985 Act, at regulations 6, 13(iii), 21, 25(iv) and 35; the Mines and Geology Department could cite its standards for jhora training and catchment drains in the conditions for reviewing a stability zone; a Municipality could make rules or regulations under the Municipalities Act, or the State could notify the limits of jhoras under its section 173; development plans could carry its drainage and flood-control content once the 2024 Act commences; SSDMA could refer to it in district disaster management plans; and the departments could apply it to their public works. None has done so.

**The October 2023 flood.** On the night of 3–4 October 2023 the South Lhonak glacial lake, in the far north of the State, drained into the Teesta; on that all sources agree, and this Manual calls the event the South Lhonak lake outburst and Teesta flood of 3–4 October 2023. Sattar et al. (2025) date the collapse of a frozen moraine into the lake to 22:12 IST on 3 October, from seismic records; the flood reached Chungthang at about 00:30 IST, where "The 60 m high dam" of Teesta-III "was destroyed", and Rangpo, about 135 km downstream, was "severely impacted by the debris, burying buildings and automobiles". The river bed "has risen by an average of 7-8 meters", in the words of a project prefeasibility report annexed to the State's affidavit to the NGT of 28 February 2026. Whether it was a glacial lake outburst flood (GLOF) or a cloudburst is disputed. The State's affidavit of 5 April 2024 attributed the flood "primarily to a cloudburst"; a committee constituted by NDSA found in June 2024, in a report not published, that "all scientific data and satellite images from that period points to GLOF and not a cloudburst", as reported; and Sattar et al. found a moraine collapse under modest rain, 29–39 mm over the lake from 28 September to 5 October in the ERA5 reanalysis. This Manual takes no side. The toll is also given two ways: 55 dead and 74 missing, with over 7,025 displaced, in SSDMA's multi-stakeholder survey as cited by Sattar et al.; and 79 dead and 44 missing in the post-disaster needs assessment (PDNA) of SSDMA with NDMA, annexed to the State's affidavit of 28 February 2026. Press figures differ again. Whatever its trigger, the flood was not a rainfall flood that a drain can be sized for: at the lake the water "peaked at $4.85 \times 10^4$ m³ $s^{-1}$", with $1.03 \times 10^4$ m³ $s^{-1}$ of sediment besides (Sattar et al.). So this Manual screens the GLOF corridors and the Teesta valley floor separately from rainfall design: there, siting, setbacks and floor levels govern (Chapters 2, 5 and 7).

**Names.** Some places, rivers, gauges and instruments have more than one name or spelling in statutes, sources and on IMD and CWC stations:

- the **Teesta** is the **Tista** in CWC's flood estimation report and in IMD's tables; the **Rangit** is also the **Rangeet** (as in the Schedule of the 1988 Act) and the **Great Rangit**. The **Rani Khola** of Gangtok is also written Ranikhola, Ranichu and Rani chu; the Schedule of the 1988 Act does not name it under any of these, and this Manual reads the scheduled "Rongni chu" (no. 14) as probably the same river, a reading still to be confirmed [TBC]. The **Rongni Chu** is also the Rongni Chhu, and the **Roro Chu** is written "Ro-Ro Chu" in the State's reports. **Darjeeling** is printed **DARJILING** on CWC's plates.;
- **Gyalshing** is also **Geyzing**; **Chaten**, near Lachen, is also **Chhaten**; **Khecheopalri** lake is also **Khachoedpalri**; and **Nayabazar-Jorethang**, the name of the Nagar Panchayat, is written Jorethang/Nayabazar in the State's reports. Some glacial lakes carry *Pokhari* in their names, such as Bhalay Pokhari and Doodh Pokhari: they keep their names, and they are glacial lakes, not pokharis of the storage clauses (below);
- Sikkim has had **six districts** since 2021, named as IMD's Meteorological Centre Gangtok names them in its reports, as summarised: **Gangtok**, **Mangan** (formerly North Sikkim), **Namchi** (formerly South Sikkim), **Gyalshing** (formerly West Sikkim), **Pakyong** and **Soreng**. Older sources, such as CGWB's district reports, use the four earlier districts, and a clause that names a district must be checked against the current list;

- CWC's flood estimation report for **subzone 2(a), North Brahmaputra** (NB/18/1991) covers the whole State, but its maps of design rainfall draw no contour north of Gangtok. This subzone is not the two rainfall zones (SK-Z1 and SK-Z2) and four hydrologic sub-areas (SK-A, SK-B, SK-B1 and SK-C) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7, nor the six stability zones of the Mines and Geology Department;
- the hydropower projects are named as their operators and the State name them: **Teesta-III** at Chungthang, **Teesta-V** with its dam at Dikchu, **Teesta-VI**, and the **Teesta Low Dam** projects III and IV (**TLDP-III** and **TLDP-IV**); Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III are the names of projects, not only of places. Sattar et al. (2025) print "Teesta Low Dam VI", which this Manual reads as probably Low Dam IV [TBC], and does not use;
- CWC's levels for its sites on the Teesta and its tributaries were read only as SANDRP transcribed them, or in snippets of CWC's bulletins, and no source read states their datum [TBC]. The sources conflict at Melli, where the peak of October 2023 is 225.5 m in SANDRP's text and 228.0 m in a CWC bulletin of 2024. This Manual names the gauge, the date and the source with every level; and
- in this Manual **"the monsoon" and "the monsoon season" mean the wet season of 1 April to 31 October**: the pre-monsoon storms of April and May and the south-west monsoon. That is not IMD's usage, and IMD's normal dates of onset and withdrawal for Sikkim were not found [TBC]; the Manual's season begins on 1 April because Gangtok's wet season does, and because the largest 24-hour falls on record at Gangtok and at Singhik both fell in May (Chapter 2).

This Manual uses the first form and keeps the others where a title, a source or a station uses them. Some names of bodies and laws need a word of explanation:

- the **Sikkim Building Construction Regulations, 1991** (the **SBCR 1991**) are the State's building rules. This Manual cites them as the Sikkim Building Construction Regulations, 1991 (UD&HD Notification No. 29(202)UD&HD/90/295, 19 March 1991, made under section 7(2) of the 1985 Act), as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001, 16 October 2001), and writes "regulation 25(iv) of the SBCR 1991" or "SBCR 1991, reg. 25(iv)" for a provision. The copy read is hosted by a third party, Sikkim Manipal University. A Sikkim Building Construction (Amendment) Regulation, 2022, reportedly published on 12 April 2023, was not read, and may change what this Manual says of the regulations [TBC]. They apply only in notified areas, whose current list was not found [TBC]; they set a building's height by the stability zone of its site (regulation 17(i)), and regulation 39, added in 2001, lets the Government relax any provision. No instrument called the Gangtok Building Bye-laws was found, and this Manual cites none. **MBBL 2016**, in Chapters 1 and 10, is the national Model Building Bye-Laws of 2016, not the State's rules;
- the **stability zones** are those of the Mines and Geology Department's Notification No. 17/DMG/20-21 of 19 March 2021 (Sikkim Government Gazette Extraordinary No. 86, 6 April 2021), read as an annexure to the State's counter-affidavit in NGT case OA 5/2022. Zones 1 to 6 allow 5½, 4½, 3½, 2½ and 1½ storeys and "No construction", and they are graded partly by the state of the jhoras: zone 1 "Training of jhoras/drains have been completed and done properly (with safe distance)", zone 3 "Jhora training is required/annual maintenance of drain is necessary" and zone 4 "Untrained jhora/ erosional potential jhora". The copy of the 2001 amendment read gives zone 2 "1 ½" storeys, against the 4½ of the 2021 notification; this Manual cites the 2021 notification for the zones and notes the conflict;
- the **1985 Act** (Act 11 of 1985, amended in 2000, 2001, 2007 and 2022) requires permission for any construction in a notified area and lets the Government make building regulations (section 7) and demolish illegal works (section 8). Its preamble records that allotments made without consulting the PWD had caused "encroachment of septic, water supply tanks … within the notified green belt and effecting and likely to cause land slides during monsoons";
- the **Sikkim Municipalities Act, 2007** (Act 5 of 2007, amended six times to 2026) makes a jhora a drain (section 2(24)) and defines it as "any natural watercourse, whether on a public land or on a private land" (section 163(b)); "the Municipality shall protect any jhora, whether on a public land or on a private land, within the municipal area" (section 172(2)); and rain water is to be "connected with the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (section 193(b)). Under it, GMC is the Gangtok Municipal

Corporation, whose wards rose from 19 to 21 by an ordinance of 2026. The sources do not agree on how many urban local bodies the State has: the State told the NGT on 19 December 2025 that there are seven, and UDD's notification No. 06/UDD/2026 of 23 April 2026 lists nine, the Gangtok Municipal Corporation, the Namchi Municipal Council and the Rangpo, Singtam, Mangan, Gyalshing, Nayabazar-Jorethang, Soreng and Pakyong Nagar Panchayats. UDD's web page lists seven and calls Namchi a "Municipal Corporation". This Manual uses the names of the 2026 notification and says "seven or nine, as the sources differ";

- the **1988 Act** (Act 6 of 1988, amended by Act 8 of 2000) defines the "river bank" of each of the 103 rivers in its Schedule as "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (section 29(1)), under the Forest Department's control "as if it were a forest" since 2000 (section 29(9)). The words "whichever is less" make it a maximum, not a minimum, as this Manual reads them. It is the only line along water in the State's law that was found;
- the **Sikkim Town and Country Planning Act, 2024** (Act 10 of 2024, amended by Act 24 of 2025) was enacted in 2024 and amended in 2025, but has not commenced: it comes into force on a date the State Government notifies, and no such notification, rules, Board or development authority was found. When it commences it repeals the planning Acts of 1998 and 2007, whose status until then this Manual leaves open [TBC]; its development plans are to carry "proposals for flood control, land stability and sloped linked controls";
- **UDD**, formerly UD&HD (renamed in about 2020), is "the nodal department which undertakes planning and development in the notified areas", administers the SBCR 1991, issues the monsoon notices and is the executing agency of the ADB-assisted **Sikkim Integrated Urban Development Project** (SIUDP), which covers about 60 km of roads "with … stormwater drains" in seven towns. **GSCDL** is the company for Gangtok's Smart City Mission;
- **WRD**, formerly Irrigation and Flood Control, does river and jhora works, and is named in this Manual as the State groundwater agency, although no State network of observation wells was found; the only network found is CGWB's. **PHED**, written "Water Security and PHED" at times, is "the concern department for sewage management in the State". **RMDD** manages sewage in rural and peri-urban areas and runs the **Dhara Vikas** programme of spring-shed development. The **Mines and Geology Department** prepares the stability maps. The **Forest and Environment Department** holds the scheduled river banks and the slip reserves under the 1988 Act, and its **River Rejuvenation Committee** was "notified as the Nodal Agency for all water bodies" in 2021. The **Science and Technology Department** is the nodal department for GLOF studies and mitigation (Notification No. 10/Home/2025, 7 February 2025), and the Home Department constituted the **Sikkim Commission on Glacial Hazards** (No. 73/Home/2024) and the **High-Level Steering Committee** and **Multi-disciplinary Task Force** (No. 72/Home/2024), both on 11 September 2024. **LR&DMD** keeps the land records and, with **SSDMA**, the disaster function; the District Disaster Management Authorities are written in full. **SSPCB** grants consents to sewage treatment plants. The **Roads and Bridges Department**, written "PWD" in many sources, keeps the State's roads and their drains, and **NHIDCL** and **BRO** the national highways; **IRCON** builds the Sevoke–Rangpo railway. **NHPC** operates Teesta-V, and other companies operate the other hydropower projects;
- the **High Court of Sikkim** and the **NGT** have shaped the State's drainage, river and glacial-lake work. The High Court's suo motu case *In re Climate Justice in State of Sikkim* (WP(PIL) 11/2026) is known only from press reports, and its orders were not read [TBC]. Before the NGT the State has filed affidavits on the breach of Teesta-III (OA 171/2023), on its rivers (OA 673/2018), on sewage and solid waste (OA 606/2018) and on building height in Gangtok (OA 5/2022 and OA 38/2022). This Manual cites court and tribunal orders with their status; and
- where a shared clause names a revenue subdivision, this Manual uses the **sub-division**. Where it says "revenue village", Sikkim's land records use **revenue blocks**, as this Manual reads them [TBC]. A district is headed by a **District Collector**, the "chief executive and chief administrative and revenue officer" of the district, who "also deals with disaster management during natural calamities"; this Manual writes District Collector, the title the State's affidavits use, not Deputy Commissioner.

Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2 and 3; this Manual does not use it for any municipal body;
- GMC is the Gangtok Municipal Corporation. In other editions of this series and in some sources the same letters stand for other bodies; in this Manual they mean only this one, and each chapter writes the full name at its first use;
- "SBCR 1991" is the Sikkim Building Construction Regulations, 1991, as amended, and "MBBL 2016" the national Model Building Bye-Laws 2016. Neither is the building rule of any other State;
- HFL is the highest flood level recorded at a gauge, and DL and WL the danger and warning levels that CWC sets at its sites. None is a design level, and every HFL recorded before October 2023 on the Teesta must be checked against the raised bed. In the 1988 Act "high flood level mark" is the line that bounds a river bank;
- FRL and MWL are the full reservoir level and the maximum water level of a hydropower reservoir; no operator's levels or release rules were found [TBC];
- PPR is a project prefeasibility report and PDNA a post-disaster needs assessment, as the State's affidavit of 2026 uses them; and
- "District Disaster Management Authority" is always written in full.

The sense is clear from the context.

**Languages.** This Manual is published in English; a Nepali edition is to follow. The Sikkim Official Languages Act, 1977 (Act 5 of 1977), as amended, makes "the Nepali, the Bhutia, the Lepcha and the Limbu languages" the languages "to be used for all official purposes of the State" (the amendment of 1981); Newari, Rai, Gurung, Mangar, Sherpa and Tamang were added in 1995, as reported, Sunuwar later, by an amendment not seen, and Bhujel by Act 16 of 2022, in force on a date to be notified. Where a shared clause calls for the State's language, this Manual names **Nepali**, the first language the Act names, the language of the edition to follow and the language of the local words it uses; the Nepali script is Devanagari, and the data fields whose names end in NE, such as NAME_NE in Annex 7A, hold a name in Devanagari. As set by this Manual, **signs and flood-depth markers are in Nepali and English; where the local body's own public notices also use another official language of the State, such as Bhutia, Lepcha or Limbu, the sign carries that language too**, because a sign must be readable by the people it warns.

Some local words are used in the text, and are explained again where they first appear in each chapter. Their meanings are taken from R. L. Turner's *A Comparative and Etymological Dictionary of the Nepali Language* (1931), with his page numbers; his headwords sometimes use older spellings, and this Manual writes the modern form:

- a **pokhari** (पोखरी; pond, lake or tank) is this Manual's word for a natural or built body of standing water. Turner spells it पोखरि and gives "Lake, pool, tank" (p. 391), which covers natural lakes and built ponds alike. This Manual uses it because it is the plain Nepali word for the whole class, because it is in current use in Sikkim in the names of lakes, and because it passes directly into the Nepali edition; *tāl* (ताल, p. 281) also means musical time and a palm, and *talāu* (तलाउ, "Tank, pool, lake", p. 275) is less used. In the shared clauses a "tank" is water impounded by a bund with a surplus weir, which Sikkim hardly has, so the tank clauses apply in this Manual to pokharis, to the hydropower reservoirs and to any other impounded water. Engineered storage is a **detention pond**, and a glacial lake keeps its own name and is a hazard source, never storage, even where its name contains "Pokhari";
- a **jhora** (झोरा; plural jhoras) is a natural watercourse or ravine stream, the word the Municipalities Act and the 1988 Act use. Turner marks it as a Darjeeling word for "Ravine" (p. 237). A ridge town's drains fall to its jhoras, and the jhoras to a khola or a river;
- a **khola** (खोला) is a river or large stream, as in the Rani Khola and the Maney Khola. Turner's headword is खोलो *kholo*, "Small river, valley" (p. 130). The words "khola-kholsas" appear only inside the quotation of section 193 of the Municipalities Act; Turner gives *kholso* as "Stream, ravine" (p. 131);

- a **dhara** (धारा) is a spring or a spring spout, often with a small stone basin, and the name of RMDD's Dhara Vikas programme. Turner's headword is धारो *dhāro*, "Spring of water" (p. 328); and
- a **kulo** (कुलो) is an irrigation channel. Turner gives "Any channel for water, drain, ditch, irrigation-channel; small stream, watercourse" (p. 101).

A built channel is a **drain** in this Manual, not a *nāli* (नाली, p. 341). The Bhutia and Tibetan *chu* (river) and *chho* or *tso* (lake) appear only inside proper names, such as Lachen Chu and Shako Chho, and are not glossed, because no dictionary was consulted for them; no Lepcha word is used, for the same reason; and *pahiro* (landslide) and *bāḍhi* (flood) were not found in Turner by headword, and are not used [TBC].

**Use with care.** Clauses and values may change after review. Designers remain responsible for their designs and for checking the data they use. Neer accepts no liability for decisions made on the basis of this draft.

**Disclosure.** Neer publishes the India Flood Atlas, a national map of modelled 1% AEP flood depth. Clause 6.11.3 names it as one example of a regional map that an Approving Authority may adopt for floor levels. The Manual does not require the Atlas; any map adopted under Clause 7.3.4 may be used.

**Comments.** Comments and corrections are welcome at info@neer.ai.

# Preface

Sikkim's towns flood, slide and fail for three reasons. Gangtok's own rain gauge shows the first: its largest day, 310.3 mm on 30 May 1975, lies near the top of the band that CWC's map gives for a 100-year day there, and north of the capital the map gives no value at all. The ridge towns show the second, in every monsoon: water put into their slopes moves the ground, and the State's own building rule already grades a site by the state of the jhora beside it. And the valley towns show the third: on the night of 3–4 October 2023 a glacial lake drained into the Teesta, and the river that receives every jhora of the State now runs metres higher on its own debris.

1. **Rainfall that the national products barely cover.** The whole State lies in CWC's subzone 2(a), North Brahmaputra, whose report (NB/18/1991) names "Gangtok the capital of Sikkim" first among the subzone's towns. Its ratios of short to 24-hour rain come from recording gauges in the subzone, none identified in Sikkim, and its maps draw no contour north of Gangtok, so that Mangan, Chungthang, Lachen and Lachung read only by implication, at about 200–240 mm for the 50-year day, as this Manual reads the plate. The State's records exceed the maps. At Gangtok the 100-year band on Plate 10 is about 240–320 mm, and the gauge recorded 310.3 mm in a day; in the north, Singhik recorded 504.2 mm on 12 May 1981 and Dikchu 400.8 mm on 25 August 1969, 1.7 to 2.5 times the plate's implied value by this Manual's arithmetic, both printed in the report's own Table 7. The steepness is local too: on 25 September 2005 Gangtok recorded 141.0 mm and Tadong, 4–5 km away, 212.5 mm. IMD's national set of rainfall intensity curves (Das et al., 2022) has no panel for any Sikkim station; the gridded rainfall of NIH-DHAARA gives Gangtok a 50-year day of 195 mm and Lachung 121 mm, lower than the records, not higher; and no hourly rainfall from any Sikkim gauge was found.
2. **Ridge towns on phyllite and colluvium, where water put into the slope moves the ground.** Gangtok stands on "Precambrian rocks which contain foliated schists and phyllites", as summarised from a study of its slopes, and the ridge towns on thin hill soils, colluvium and the cut and fill of their own terraces. In June 1997, a month in which Gangtok's gauge recorded 1,281.3 mm, the town's largest month on record, landslides killed 38 people, as one source reports. GSCDL told the NGT that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora". The State's rules already link building to drainage: the stability zones of 2021 are graded partly by whether the jhora beside a site is trained, and a site's zone can be reviewed only after the "Training of untrained Jhora" and the "Proper channelization of surface runoff by providing catchment drains … to natural waterways/Jhora". But the rules say nothing of what training or a catchment drain is, and the SBCR 1991 send every building's sewage to a septic tank and soak pit within the site (regulations 6, 13(iii) and 25(i)), on a wet slope as on a dry one.
3. **Valley towns on a river whose bed a glacial-lake outburst raised by metres.** The flood of October 2023 destroyed the Teesta-III dam at Chungthang, buried parts of Rangpo, damaged the sewage treatment plants at Singtam, Rangpo and Melli, and left the Teesta's bed "risen by an average of 7-8 meters", with National Highway 10 "prone to submergence and subsidence"; NHPC estimates the rise at about 7.44 m at TLDP-IV and 7.29 m at TLDP-III. At Toong Naga 155 households were "mandated for relocation". Every outfall set from the old bed may now be buried, every highest flood level recorded before 2023 is suspect, and the sources disagree on the level the river reached at Melli. The State has 320 glacial lakes in the count of the project prefeasibility report (other inventories give 232 or 266), of which NDMA counts 40 as high-risk and 16 as very high-risk, and hydropower reservoirs and their release reaches line the trunk from Chungthang to Melli.

Over all three lie four more conditions. **The only building rule is a storey-based one of 1991**: it sets no setback from a jhora or a river, requires no rainwater harvesting and sets no design storm, runoff coefficient or detention; its drainage clauses carry no numbers. The only statutory rainwater harvesting is section 186 of the Municipalities Act, for buildings owned or occupied by the State Government and its bodies, and no manner has been specified under it, as far as was found. **Drains carry sewage into the jhoras.** In September 2025 the State estimated the towns' sewage at 29.51 MLD and the flow actually treated at Gangtok's plants at 15.22 MLD; the sewerage of Namchi and of Jorethang "has remained stalled since the year 2013 and 2015 respectively"; at Soreng, effluent from septic tanks discharges "into the open surface drains", as an ADB report found; and the NGT recorded on 4 July 2024 that "treated sewage is entering in

to river/ rivulets/ jhoras and this is not permissible under the Water Act", while the State replied that "No sewage is disposed off in the rivers or fast flowing water bodies". **No line protects a jhora**: the 1988 Act's river bank reaches only the 103 scheduled rivers and is a maximum, the SBCR 1991 set no line from water, the Municipalities Act's power to notify the limits of a jhora (section 173) has not been used, as far as was found, and no setback along the Teesta was found after 2023. And **no drain has a design standard**: no State, municipal or departmental document fixes a design storm, a return period or a runoff coefficient for any town's drains.

Behind all of this lie the State's springs, jhoras, pokharis, glacial lakes and reservoirs. Springs, not wells, supply most of the State: RMDD's Dhara Vikas, begun in 2008 (2010 in one source), mapped 704 springs for rejuvenation, as reported, while an RMDD presentation of 2018 counts "more than 2000 springs mapped on GIS platform", as reported; the two counts conflict. Groundwater lies "largely in disconnected localized pockets and in deeper fracture zones", as CGWB is quoted, and no State network of observation wells was found. Khecheopalri lake became Sikkim's first Ramsar site in February 2025, as reported; its area is given in figures that conflict, and this Manual cites none. No wetland has been notified under the Wetlands Rules, as far as was found, and no statute protects a spring or a pokhari.

Design for Sikkim therefore has to cover a wet season that starts in April. At Gangtok IMD's normals (1981–2010) give 296.9 mm in April, on 15.2 rainy days, and 496.4 mm in May, before 609.8, 626.3, 565.9 and 438.7 mm from June to September and 173.4 mm in October, out of 3,490.4 mm in the year; March to May bring 26% of the year, by this Manual's sum. Thunder peaks in April and May, and Gangtok's and Singhik's largest days both fell in May. The State itself stops earth excavation each monsoon by notice, from 6 May in 2019 and from 1 June in 2020. This Manual's monsoon season is 1 April to 31 October, so that drains and jhoras are cleared before the April storms. Large falls come outside it too, as on 11 November 1995 (96.0 mm) and 27 March 2008 (72.0 mm) at Gangtok, so design statistics use the annual maxima of every month. Above about 2,500 m there is seasonal snow, and Gangtok itself has recorded −2.2 °C in January.

National guidance sizes public drains but does not control the runoff that new building adds. This Manual makes stormwater a **condition of development approval** wherever a building permission is granted. Every development above a modest size must:

- hold frequent rainfall on site, in tanks for use, and in the ground only where the ground can safely take it;
- release the large storms no faster than the undeveloped land did, or slower where catchments already flood; and
- show that its outfall still works when the receiving jhora, khola, river, pokhari or reservoir is high, when a dam upstream is releasing, or when a drain or culvert is choked with debris, silt and garbage.

The Manual also sets how public drains, hill roads and their drains and culverts, jhoras and their training, kholas, rivers, pokharis, the hydropower reservoirs, springs and their recharge areas, outfalls and basin-wide master plans are designed, and how drains in steep catchments are protected against debris, sediment and garbage, so that private sites and public works aim at the same standard.

The Manual draws on leading stormwater standards from India and abroad. Each is adapted to Sikkim's wet season of April to October and its pre-monsoon storms; to the ridge towns, Gangtok, Pakyong, Namchi, Ravangla, Gyalshing and Soreng, built on phyllite, schist and colluvium whose slopes slide, and graded into stability zones by their jhoras; to the valley-floor towns of the Teesta, the Rangit and the Rongni Chu, Singtam, Rangpo, Melli, Majitar and Jorethang, on river terraces and a bed raised by the flood of 2023; to the middle Teesta valley of Dikchu, Mangan, Singhik and Chungthang, where the State's largest days were recorded and no CWC contour is drawn; to the high valleys of Lachen and Lachung, with their snow, glaciers and glacial lakes; to the hydropower reservoirs and their release reaches; and to springs that supply the towns and villages.

1. **National base.** The CPHEEO *Manual on Storm Water Drainage Systems* (2019). This Manual builds on it and sets higher standards where it allows a State to do so. IRC road-drainage codes, including IRC:SP:42-2014 on hill roads, and the NDMA urban flood guidelines are also used. The drainage chapter of the IRC's hill road manual, IRC:SP:48, was not read for this Manual.

2. **Overall structure.** Kansas City Metro APWA Section 5600 (Version 2025.01), the most recent comprehensive regional standard. It supplies the preserve, retain, detain, convey and maintain sequence and the required retention volume.
3. **Design rainfall.** The CWC *Flood Estimation Report* for subzone 2(a), North Brahmaputra (NB/18/1991), as the interim source, with the report's own ratios of short to 24-hour rain in every part of the State. Where the plates draw contours, in the southern hills and valleys, the plate governs, with no departure below it, and Gangtok's record of 310.3 mm raises the design day within 25 km of the gauge on the same side of the Teesta. In the middle Teesta valley, where no contour is drawn, the design day is not less than a floor set from the Singhik record until a station there is analysed; in the high valleys it is not less than the plate's values at Gangtok, and every large structure has a site study. The design day is checked against the largest reliable days recorded within 25 km, but only within the same domain and never across the Teesta or the Rangit valley floor. NIH-DHAARA gives only the shape of the growth and duration curves and is reported beside the design value; IMD's national curves (Das et al., 2022) are not used, since they have no Sikkim panel. Glacial lake outbursts and the Teesta valley floor are screened separately: no drain is sized for them.
4. **Monsoon practice.** The PUB Singapore *Code of Practice on Surface Water Drainage* (7th ed., 2025), for the fixed-coefficient route for small sites and drainage reserves. Malaysia's MSMA 2 (2012), for monsoon design storms and simplified on-site detention.
5. **Runoff reduction and treatment.** The Georgia Stormwater Management Manual (2016), for runoff reduction and downstream analysis. CIRIA C753 *The SuDS Manual* (2015), for the treatment train. The Mile High Flood District criteria manual, for outlet and storage design.
6. **Local rules.** The SBCR 1991 and their amendments of 2000 and 2001; the 1985 Act; the stability zones of 2021; the Sikkim Municipalities Act, 2007 and its amendments; the 1988 Act; the Sikkim Town and Country Planning Act, 2024, not yet commenced; the monsoon notices of 2019 and 2020; the State's affidavits to the NGT of 2022, 2025 and 2026, with the PDNA of 2023 and the project prefeasibility report on the Lhonak valley annexed to them; and the High Court's judgments on the Dikchu release (2021) and the flood of 2023. This Manual follows them or, where disclosed, makes them stricter. The amendment of the SBCR 1991 of 2022, the notification that transferred building-plan approval in Gangtok to GMC, the list of notified areas, the orders of the High Court in its climate-justice case of 2026 and the report of the committee constituted by NDSA were not read. Every rule cited must be checked against the current text.

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## Why this Manual is needed

**India has no uniform stormwater design standard.** The CPHEEO *Manual on Storm Water Drainage Systems* (2019) is the country's first manual dedicated to storm water drainage, but it is advisory. The Ministry of Housing and Urban Affairs lists it among advisory guidelines and treats urban flooding as a matter for State Governments and urban local bodies. None of the national rules or State building rules reviewed for this Manual makes runoff control a condition of building approval, and neither does the Model Building Bye-Laws 2016.

**The national documents leave key values open, or give different answers.**

- **Return periods.** CPHEEO recommends 5 years for drains in Class I cities and 2 years elsewhere, and lets a State committee adopt higher values. A 2023 CPHEEO presentation shows a different table. IRC:SP:50-2013 suggests 1–2 years for urban road drains; IRC:SP:42-2014 suggests 5–25 years for road drains and 10–50 years for culverts, by class of road and size of culvert. An engineer designing a drain in Sikkim can cite 1, 2, 5, 10 or 25 years, depending on the code chosen.
- **Detention.** CPHEEO describes limiting peak outflow to pre-development rates as general practice. It uses no "shall" and names no storm frequencies.
- **Climate.** The NDMA Urban Flooding Guidelines (2010) call for detention and retention facilities and for rainfall curves adjusted for climate change, but give no sizing rule or return period. No factor for Sikkim was found: the trends are mixed, with most indices of extreme rainfall falling over 1950–2018 and the number of days of 10 mm

or more rising (Dubey et al., 2022, as summarised), while the monsoon rain over the South Lhonak catchment has risen by 8.6 mm a decade in ERA5 (Sattar et al., 2025), and the glacial lakes are growing. The State Action Plan on Climate Change was not read [TBC].

- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. The CWC report for subzone 2(a) (1991) covers the whole State, but draws no contour north of Gangtok, and the records at Singhik and Dikchu are about twice the value the plate implies there; its ratio of the 1-hour to the 24-hour rain, 0.260, was built on recording gauges outside the State, and is the only published set. IMD's 2022 national set of rainfall intensity curves has no panel for Gangtok, Tadong or any other Sikkim station. The one study that offers rainfall intensity curves for a Gangtok catchment (Wangsu et al., 2022) derives them from daily rain and reports a "peak intensity" of 259.785 mm/h for July, which is not a usable design value.

**Sikkim has no drainage design standard of its own.** Research for this Manual found no standard, IDF relationship or circular of UDD, GMC or any other local body, GSCDL, WRD, PHED, RMDD or the Roads and Bridges Department that fixes a return period, a runoff coefficient or a design rainfall for town storm drains. No IDF relationship with published constants was found for any station in the State. Gangtok's City Development Plan of 2006 proposed works for "Drainage and Landslip Protection", but "Projects under Drainage, Landslip Protection, Traffic, Street Lighting, Tourism and Environment were not taken up", as the CAG found in 2016. GSCDL has tendered drainage and jhora-training works in Gangtok, as reported, and the SIUDP is building stormwater drains on about 60 km of roads in seven towns, but no design storm was seen for either. These are projects, not a State standard. This Manual is offered as a technical companion to the SBCR 1991, the stability zones of 2021, the Municipalities Act's duties on jhoras, drains and outfalls, the 1988 Act's river banks and slip reserves, the monsoon notices, and the development plans of the 2024 Act once it commences: it supplies the design storm, detention, slope, water-level and buffer values that they leave open. It has not been adopted by UDD, GMC, any other local body or any other body. In particular:

- **The building rule asks for drains, but sizes nothing, and asks for no rainwater harvesting.** The SBCR 1991 require roof gutters and down pipes "of such design and capacity that the water will neither spill out of them nor leak through them", connected to "the storm water plinth protection drain" (regulation 21); a "Pucca storm water/plinth protection drain … leading to the road side drain or to adjoining permanent drains or jhora" (regulation 25(iv)); and no occupation certificate "if the drain has not been provided to main outlet/jhora" (regulation 13(iii)). None of these gives a capacity, and no rule requires on-site detention, limits peak runoff or sets a design storm. The only rainwater rule for roofs is that a quarter of each roof be sloped "with rain water gutter" (regulation 6); the only statutory rainwater harvesting is section 186 of the Municipalities Act, for buildings of the State Government and its bodies;
- **The slope rules grade sites, but say nothing of infiltration.** The stability zones set a building's height by the ground, its slope and its jhora, and regulation 35 forbids allotment in "any sinking area, landslide prone or in areas having scars of old landslides or in slope exceeding or around 70 (Seventy) degree". No rule restricts soak pits, recharge pits or infiltration trenches on slopes, on colluvium or above a cut or retaining wall, and regulation 25 sends sewage to a septic tank and soak pit within every site;
- **There are no setbacks from jhoras, springs or pokharis.** The SBCR 1991 set setbacks only from roads and plot lines (regulation 18). The 1988 Act's river bank of "sixty metres … or area within high flood level mark, whichever is less" reaches only the scheduled rivers and is a maximum, and after 2023 the flood mark itself has moved. Zone 1 asks for jhoras trained "with safe distance", without a distance; the Municipalities Act makes the Municipality protect every jhora in its area, without a width; and no setback along the Teesta was found after the flood of 2023;
- **There is no floodplain law.** No floodplain zoning Act or notified flood line was found. A project prefeasibility report annexed to the State's affidavit of 2026 proposes "High-risk Zoning" of the floodplains below glacial lakes, and the 2024 Act's development plans are to carry "proposals for flood control, land stability and sloped linked controls", but neither is in force. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7); where a line that a development plan, a notification or a court draws is wider and binds, it governs; and

- **No document sets the river or reservoir level for which an outfall is designed.** CWC's levels for its sites on the Teesta, the Rongni Chu and the Rangit were read only in transcriptions, on no stated datum; the October 2023 peak at Melli is 225.5 m in one and 228.0 m in another, and Rangpo has no CWC level that was found. The levels recorded before 2023 sit on a bed that has since risen by metres. No operator's reservoir levels or release rules were found, although the High Court directed in 2021, after a release from the Dikchu project, that "the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines". Highest flood levels are records, not design levels.

**So each agency and each local body interprets the central manual its own way.** GMC and the other urban local bodies, UDD, GSCDL, WRD, PHED, RMDD, the Roads and Bridges Department, NHIDCL and BRO, the Forest Department, the hydropower operators, their consultants and funding agencies fill the gaps differently. No notification divides the drains between them. Jhoras on public land other than forest land within a municipal area vest in the Municipality, and it must protect every jhora in its area, public or private (section 172); drains vest "in the Municipality, or the concerned Department, or organization, of the State Government, or the agency, as the case may be" (section 189(1)); the banks of the scheduled rivers are the Forest Department's; the road drains are the road owner's; PHED runs the sewers; and jhoras outside the municipal areas, or on forest land, have no named owner at all. In Gangtok a jhora may take a road's drainage and a ward's sullage, be trained by one agency and cleared by GMC's waste contractor, and end in a scheduled river under the Forest Department. And a reviewer has no common basis against which to check a design.

**What this Manual does about it.** It turns those open choices into one State standard:

- one source and method for design rainfall across the State, in two rainfall zones and four hydrologic sub-areas, with a checked station analysis to govern where one exists; the 2(a) plates where they draw contours, with the report's ratios everywhere; Gangtok's record as a floor within 25 km of the gauge east of the Teesta; a floor from the Singhik record in the middle Teesta valley, and the plate's values at Gangtok carried north into the high valleys, until stations there are analysed; a check of the design day against the largest reliable days recorded nearby that never crosses a ridge or the Teesta or Rangit valley floor; and a separate screening of every site for glacial lake outbursts, the Teesta valley floor, landslide ground and hydropower releases (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites, with rainwater storage credited only through its use (Chapter 4);
- a required tailwater check for outfalls: in the ridge towns, a free outfall to a jhora with energy dissipation and a check of the jhora downstream; on the valley floors, the higher of CWC's highest recorded level and the surveyed flood mark of October 2023, with outfall inverts above the surveyed post-2023 bed; and in reservoir and release reaches, release scenarios from the operator's levels (Chapter 5);
- a standard for what a "trained" jhora is, with the capacity, freeboard, drop structures, toe protection, debris basins and maintenance access that the stability zones' "proper" training leaves undefined (Chapter 6);
- a design flood line, and corridors and setbacks along jhoras, kholas and rivers and around pokharis and springs, proposed by this Manual where no line binds, with a corridor at least 15 m from the top of bank, or from the crest of an incised bank, on every natural channel draining 8 ha or more; the 1988 Act's river bank wherever it is wider; a condition of building permission in the notified and municipal areas, and guidance elsewhere; corridor land that is not State or municipal land secured by agreement or donation, never taken; and every drainage asset sited above the flood and aggradation level of October 2023 and outside a mapped GLOF path (Chapter 7);
- no deliberate infiltration on slopes steeper than 10°, on colluvium, fill or slide debris, in stability zones 3 to 6 without a geotechnical certificate and in zones 4 to 6 at all, or above a cut slope or retaining wall; none on the valley floors below the 1% AEP flood level, on the bed raised in 2023 or where the water table rises within 2 m of the ground; roof runoff to storage for use, with its overflow to lined, stepped drains and trained jhoras; no storm outfall within 15 m of a dhara, and the recharge areas of springs kept free of paving and road runoff; and the interception of dry-weather flow before every outfall to a jhora that feeds a dhara, a pokhari or an intake, and to the Rani Khola, the Roro Chu, the Rongni Chu and the Teesta within a town (Chapters 4 and 8);
- debris racks and basins, allowances for sediment, garbage and blockage, energy dissipation in steep drains, and hill-road drainage that never discharges onto an unprotected slope (Chapters 6 and 9), with drains, jhora channels, inlets, racks and culverts cleared and certified ready by 31 March, cleared again by 30 April before the

May storms, and again by 15 November after the season, standby kept from 1 April to 31 October, and, above about 2,500 m, the dates moved for snow and inlets kept clear of snow and ice in winter (Chapter 10); and
- basin-wide master plans, so that the agencies that share a basin plan together, from the ridge towns' jhoras to the Teesta (Chapter 11).

It uses the route the CPHEEO manual itself provides: a State may adopt standards higher than the national values (CPHEEO 2019, Table 4.1, Note 2). The State in the SBCR 1991, a Municipality in its rules, the Mines and Geology Department in its stability zones, or a development plan once the 2024 Act commences can still adopt a stricter standard (Chapter 1).

*Sources: CPHEEO (2019) Part A §4.4–4.5 and Table 4.1; CPHEEO presentation to CSE (August 2023); IRC:SP:50-2013 §6; IRC:SP:42-2014 cl. 7.1.4 and 8.5.1; NDMA (2010) Urban Flooding Guidelines, para 6.6.2; MoHUA Model Building Bye-Laws (2016); Sikkim Building Construction Regulations, 1991 (UD&HD Notification No. 29(202)UD&HD/90/295, 19 March 1991), as amended in 2000 and 2001 (No. GOS/UD&HD/6(294)2001, 16 October 2001), regs. 1, 3, 4–6, 13, 17, 18, 21, 22, 25, 33–35 and 39 and Form III (copy hosted by Sikkim Manipal University); Mines and Geology Department Notification No. 17/DMG/20-21 (19 March 2021); Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 (Act 11 of 1985), as amended to Act 24 of 2022; Sikkim Municipalities Act, 2007 (Act 5 of 2007), ss. 2, 163, 172, 173, 186, 187, 189, 193, 266–287, as amended to 2026, and the Sikkim Municipalities (Amendment) Ordinance, 2026; UDD Notification No. 06/UDD/2026 (23 April 2026); Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Act 6 of 1988), ss. 2, 29, 30 and 32 and the Schedule, as amended by Act 8 of 2000; Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024) and (Amendment) Act, 2025 (Act 24 of 2025); Sikkim Official Languages Act, 1977 (Act 5 of 1977), as amended; UD&HD Notice No. 613/GOS/JCTP/UD&HD (1 May 2019) and UDD Notice No. T(1689)/997 (26 May 2020); NGT, OA 5/2022 (EZ), counter-affidavits of the State and of GMC (2022), and OA 38/2022 (EZ), reply of GSCDL; NGT, OA 171/2023 (EZ), affidavit of the State of Sikkim of 28 February 2026, with the Home Department's notifications of 2024, the project prefeasibility report on GLOF risk mitigation in the Lhonak valley and the PDNA of the floods of 2023; NGT, EA 35/2023 in OA 673/2018, affidavit of the State of 19 December 2025 with the monthly progress report of September 2025, and the State's compliance report; NGT, OA 606/2018, six-monthly report of the State; High Court of Sikkim, WP(PIL) 4/2017 (1 March 2021) and WP(PIL) 3/2023 (7 December 2023); CAG, Report No. 3 of 2016 (Economic Sector, Sikkim), Chapter II; ADB, Sikkim Integrated Urban Development Project (57230-001), due-diligence report on Soreng sewerage (December 2024); CWC, Flood Estimation Report for North Brahmaputra subzone 2(a), No. NB/18/1991, Table 7 and Plates 8–10, read by eye; IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012), Gangtok and Tadong; IMD, climatological normals of Gangtok, 1981–2010; Das et al. (2022), MAUSAM 73(4); Wangsu et al. (2022), as summarised; Dubey et al. (2022), as summarised; Sattar et al. (2025), Science; NIH-DHAARA (queried 14 November 2026); R. L. Turner, A Comparative and Etymological Dictionary of the Nepali Language (1931); CWC levels as transcribed by SANDRP; reports of the floods and landslides of 1968, 1997, 2023, 2024 and 2025, of the State's springs, wetlands and glacial lakes, of the High Court's climate-justice case and of the amendment of the SBCR 1991 of 2022 (press and secondary sources).*

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# How to use this Manual

**Clauses and commentary.** Numbered clauses (for example 4.5.2) are the requirements of this Manual and use "shall". Paragraphs headed **Commentary** explain the reason for a clause and cite its precedent. They are guidance, not requirements. Where a value has no direct precedent elsewhere, the commentary says so and explains why this Manual sets it.

**Return periods.** Storms are described both by annual exceedance probability (AEP) and by return period. For example, "1% AEP (100-yr)" means a storm with a 1-in-100 chance of being equalled or exceeded in any year.

**Illustrative values.** Worked examples and figures marked "Illustrative — not design values" show method and scale only. Design values come from the sources set in Chapter 2.

**Annexes and forms.** Each chapter lists the annexes and forms it relies on. They follow the chapters, grouped by chapter, and hold the forms to submit, worked examples, templates, model text and standard drawings. Annexes that need data not yet collected are marked *To be prepared*. They say what they will contain, and the clause that depends on them states the rule that applies in the meantime.

**Figures.** All figures are original drawings prepared for this Manual. Where a figure follows a published concept, its caption credits the source.

**Where to start.**

| If you are… | Read first |
|---|---|
| A developer or architect | Chapter 1 (does it apply?), Chapter 4 (what to provide), Chapter 10 (what to submit) |
| A design engineer | Chapters 2–6, then 8 and 9 |
| A local body or approving authority | Chapters 1, 10 and 11 |
| A planner or waterbody manager | Chapters 7 and 11 |

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# Abbreviations

| Abbreviation | Meaning |
|---|---|
| ABC Waters | Active, Beautiful, Clean Waters (PUB Singapore's design guidelines) |
| ADB | Asian Development Bank |
| AEP | Annual exceedance probability |

| Abbreviation | Meaning |
|---|---|
| AIDR | Australian Institute for Disaster Resilience |
| AMC | Antecedent moisture condition |
| AMRUT | Atal Mission for Rejuvenation and Urban Transformation |
| ANSI / HI | American National Standards Institute / Hydraulic Institute (pump standards) |
| APWA | American Public Works Association |
| ARF | Areal reduction factor |
| ARI | Average recurrence interval |
| ASABE | American Society of Agricultural and Biological Engineers |
| ASCE | American Society of Civil Engineers |
| ASTM | ASTM International (standards) |
| AWS | Automatic weather station |
| BMP | Best management practice |
| BOD | Biochemical oxygen demand |
| BRE | Building Research Establishment (UK) |
| BRO | Border Roads Organisation |
| BSMP | Basin Stormwater Master Plan |
| CAG | Comptroller and Auditor General of India |
| CCTV | Closed-circuit television (pipe inspection) |
| CDP | City Development Plan (Gangtok, 2006) |
| CGP | Construction General Permit (US EPA) |
| CGWB | Central Ground Water Board |
| CIP | Capital improvement programme (of a BSMP) |
| CIRIA | Construction Industry Research and Information Association (UK) |
| CN | Curve number (SCS/NRCS method) |
| COD | Chemical oxygen demand |
| CPCB | Central Pollution Control Board |
| CPHEEO | Central Public Health and Environmental Engineering Organisation |
| CRZ | Coastal Regulation Zone (coastal term; not applicable in Sikkim) |
| CSE | Centre for Science and Environment |
| CSV, GeoTIFF, JSON, PDF | File formats for data, rasters and documents |
| CWC | Central Water Commission |
| DCIA | Directly connected impervious area |
| DEM | Digital elevation model |
| DGWL | Design groundwater level |

| Abbreviation | Meaning |
|---|---|
| DID | Department of Irrigation and Drainage, Malaysia |
| DL / WL | Danger level / warning level (CWC) |
| DMG | Department of Mines and Geology (its stability-zone notification, No. 17/DMG/20-21) |
| DPR | Detailed project report |
| DST | Department of Science and Technology (as the Lhonak valley PPR names its author) |
| DWF | Dry-weather flow |
| EA | Execution Application (NGT) |
| EN | European Standard (Norme Européenne) |
| EPA | Environmental Protection Agency (United States) |
| EPD | Environmental Protection Division (Georgia, United States) |
| EPSG | EPSG geodetic parameter registry (codes for coordinate systems) |
| ERA5 | The fifth-generation global atmospheric reanalysis of the European Centre for Medium-Range Weather Forecasts |
| ESC | Erosion and sediment control |
| EV1 | Extreme value type I (Gumbel) distribution |
| EZ / PB | Eastern Zone Bench / Principal Bench (of the NGT) |
| F&ED | Forest and Environment Department (in order numbers) |
| FER | Flood Estimation Report (CWC) |
| FHWA | Federal Highway Administration (United States) |
| FRL / MWL | Full reservoir level / maximum water level |
| FRP | Fibre-reinforced plastic |
| FTL | Full tank level |
| GIS | Geographic information system |
| GLOF | Glacial lake outburst flood |
| GMC | Gangtok Municipal Corporation |
| GOS | Government of Sikkim (in notification and order numbers) |
| GPT | Gross pollutant trap |
| GSCDL | Gangtok Smart City Development Ltd |
| GSI | Geological Survey of India |
| GSMM | Georgia Stormwater Management Manual |
| HAT / MHWS / MHWN / CD | Highest astronomical tide / mean high water springs / mean high water neaps / chart datum (coastal terms; not applicable in Sikkim) |
| HDPE | High-density polyethylene |
| HDS | Hydraulic Design Series (FHWA) |

| Abbreviation | Meaning |
|---|---|
| HEC | Hydrologic Engineering Center (US Army Corps of Engineers): HEC-HMS, HEC-RAS; also FHWA's Hydraulic Engineering Circulars (HEC-14, HEC-22) |
| HFL | High flood level (the highest level recorded at a gauge) |
| HGL | Hydraulic grade line |
| HSG | Hydrologic soil group |
| HY-8 | FHWA's culvert hydraulic analysis program |
| ICIMOD | International Centre for Integrated Mountain Development |
| ICLEI | ICLEI – Local Governments for Sustainability |
| IDF | Intensity–duration–frequency |
| IISc | Indian Institute of Science |
| IIT | Indian Institute of Technology |
| IMD | India Meteorological Department |
| IMDAA | Indian Monsoon Data Assimilation and Analysis (a regional reanalysis) |
| INCOIS | Indian National Centre for Ocean Information Services |
| India-WRIS | India Water Resources Information System |
| IRC | Indian Roads Congress |
| IRCON | IRCON International Ltd |
| IS | Indian Standard (Bureau of Indian Standards) |
| ISO | International Organization for Standardization |
| ISRO | Indian Space Research Organisation |
| IST | Indian Standard Time |
| JNNURM | Jawaharlal Nehru National Urban Renewal Mission |
| KC | Kansas City (Kansas City Metro APWA Section 5600) |
| LID | Low impact development |
| LiDAR | Light detection and ranging (laser survey) |
| LoS | Level of service |
| LR&DMD | Land Revenue and Disaster Management Department |
| MARC | Mid-America Regional Council (Kansas City) |
| MBBL 2016 | Model Building Bye-Laws 2016 (MoHUA; not the State's rule) |
| MHFD | Mile High Flood District (Denver) |
| MLD | Million litres a day |
| MoEF&CC | Ministry of Environment, Forest and Climate Change |
| MoHUA | Ministry of Housing and Urban Affairs |
| MSL | Mean sea level |
| MSMA | Urban Stormwater Management Manual for Malaysia |

| Abbreviation | Meaning |
|---|---|
| MW | Megawatt |
| NBSS&LUP | National Bureau of Soil Survey and Land Use Planning |
| NCCR | National Centre for Coastal Research |
| NDMA | National Disaster Management Authority |
| NDSA | National Dam Safety Authority |
| NEH | National Engineering Handbook (USDA NRCS) |
| NGT | National Green Tribunal |
| NH | National highway |
| NHIDCL | National Highways and Infrastructure Development Corporation Ltd |
| NHO | National Hydrographic Office |
| NHPC | NHPC Ltd (operator of Teesta-V and the Teesta Low Dam projects) |
| NIH | National Institute of Hydrology, Roorkee (NIH-DHAARA is its online design-rainfall platform) |
| NIO | National Institute of Oceanography |
| NIT | National Institute of Technology |
| NOC | No-objection certificate |
| NPDES | National Pollutant Discharge Elimination System (United States) |
| NRCS | Natural Resources Conservation Service (USDA; formerly SCS) |
| NRSC | National Remote Sensing Centre |
| NSE | Nash–Sutcliffe efficiency |
| NWIA | National Wetland Inventory and Assessment (ISRO) |
| O&M | Operation and maintenance |
| OA | Original Application (NGT) |
| OGC | Open Geospatial Consortium |
| OSD | On-site detention |
| PDNA | Post-disaster needs assessment (the floods of 2023) |
| PHED | Public Health Engineering Department |
| PIL | Public interest litigation |
| POC | Point of comparison (where runoff leaves a site) |
| PPR | Project prefeasibility report (the Lhonak valley GLOF report annexed to the State's affidavit of 2026) |
| PRS | PRS Legislative Research (source of the copies of Acts read) |
| PSD | Permissible site discharge |
| PUB | PUB, Singapore's national water agency |
| PWD | Public Works Department (in Sikkim, the Roads and Bridges Department) |
| RCC | Reinforced cement concrete |

| Abbreviation | Meaning |
|---|---|
| RMDD | Rural Management and Development Department |
| RMSE | Root-mean-square error |
| RRV | Required retention volume |
| RWH | Rainwater harvesting |
| SANDRP | South Asia Network on Dams, Rivers and People |
| SBCR 1991 | The Sikkim Building Construction Regulations, 1991, as amended |
| SCS | Soil Conservation Service (USDA; now NRCS) |
| SH | State highway |
| SI | International System of Units |
| SIUDP | Sikkim Integrated Urban Development Project (ADB) |
| SK-Z1, SK-Z2; SK-A, SK-B, SK-B1, SK-C | The rainfall zones and hydrologic sub-areas of this Manual (Annex 2A) |
| SLA | Sea-level allowance (coastal term; not applicable in Sikkim) |
| SRRG | Self-recording rain gauge |
| SSDMA | Sikkim State Disaster Management Authority |
| SSPCB | Sikkim State Pollution Control Board |
| SSR | Site storage requirement |
| STP | Sewage treatment plant |
| SuDS | Sustainable drainage systems |
| SUH | Synthetic unit hydrograph (CWC) |
| SWMM | Storm Water Management Model (US EPA) |
| TBC | To be confirmed: a fact or value not yet found in a source |
| TBL | Top bund level |
| TCPO | Town and Country Planning Organisation (MoHUA) |
| TLDP | Teesta Low Dam Project (TLDP-III, TLDP-IV) |
| TR-55 | Technical Release 55 (USDA SCS/NRCS) |
| TSS | Total suspended solids |
| UD&HD | Urban Development and Housing Department (now UDD) |
| UDD | Urban Development Department |
| UDFCD | Urban Drainage and Flood Control District (Denver; now MHFD) |
| UH | Unit hydrograph |
| UK / US | United Kingdom / United States |
| ULB | Urban local body (in Sikkim, a Municipal Corporation, Municipal Council or Nagar Panchayat) |
| URDPFI | Urban and Regional Development Plans Formulation and Implementation Guidelines (MoHUA, 2015) |
| USACE | US Army Corps of Engineers |

| Abbreviation | Meaning |
|---|---|
| USDA | United States Department of Agriculture |
| UT | Union Territory |
| UTM | Universal Transverse Mercator |
| VR | Value rating (of a BMP treating the WQv) |
| WGS 84 | World Geodetic System 1984 |
| WMO | World Meteorological Organization |
| WPCF | Water Pollution Control Federation (now the Water Environment Federation) |
| WQv | Water quality volume |
| WRD | Water Resources Department |
| WSUD | Water-sensitive urban design |

CHAPTER 1

# Policy, Applicability and Adoption

## 1.1 Purpose and objectives

1.1.1 This Manual sets the minimum standards for the planning, design, construction, operation and maintenance of stormwater systems in Sikkim. It applies to private development and to public works, as set out in Clause 1.5.

1.1.2 The Manual has the following objectives:

- (a) to make stormwater management a **condition of development approval**, so that new development and redevelopment do not increase flood peaks or runoff volumes downstream;
- (b) to retain frequent rainfall on site, so that groundwater recharge is sustained and pollutant loads are reduced;
- (c) to size storage for the long-duration storms of the monsoon season, which in Sikkim begin with the pre-monsoon storms of April and May, when Gangtok recorded its highest day, 310.3 mm on 30 May 1975 (IMD), and Singhik 504.2 mm on 12 May 1981 (CWC, 2(a)), run through the south-west monsoon, when Gangtok received 1,281.3 mm in June 1997 (IMD), and end with the storms of October, falling for days on thin soils over rock and colluvium that the stability zones already record as wet, and filling the hydropower reservoirs on the Teesta and the Rangit, as well as for short-duration intensities;
- (d) to design outfalls for the jhoras (झोरा; natural watercourses or ravine streams), kholas (खोला; rivers or large streams), rivers and reservoirs into which the towns drain: the steep jhoras of the ridge towns, among them those of Gangtok to the Rani Khola and the Roro Chu, which rise within the hour and carry slide debris and garbage to free outfalls with no river tailwater; the Teesta, the Rangit and the Rongni Chu at the valley-floor towns of Rangpo, Singtam, Melli, Majitar and Jorethang, on a bed that the flood of October 2023 raised by metres; and the reservoirs and release reaches of the hydropower projects on the Teesta and the Rangit, held and released by their operators, while the glacial-lake outburst flood (GLOF) corridors are screened apart from rainfall design (Clause 2.3.6(i)), including the case where the outfall is closed;
- (e) to protect tanks (pokharis), marshes, rivers, supply channels and surplus courses as part of the drainage system;
- (f) to give every element of the drainage network a safe overland path for the 1% AEP (100-yr) storm;
- (g) to make design inputs, approvals and facility records public, so that designs can be checked and repeated; and
- (h) to make sure that facilities, once built, are maintained and remain effective.

1.1.3 This Manual does not replace the rainwater harvesting (RWH) mandate, the building regulations made by the Government under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 for the notified areas of the State (the Sikkim Building Construction Regulations, 1991), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> Commentary. Sikkim's floods come from three sources, often together, and its worst was not a rainfall flood. The first is the slide and debris of the ridge towns, where rain on thin soils over phyllite, schist and colluvium moves the slopes and the jhoras carry the debris down. In June 1997 landslides in Gangtok were reported to have killed 38 people (a single source, as reported; no official account found [TBC]), in a month in which Gangtok received 1,281.3 mm, its highest monthly total on record, with 223.8 mm on 9 June (IMD, *Extremes*). On 12–13 June 2024 rain and landslides in Mangan district killed 6 people in the first reports and 9 in a later one, stranded 1,200–2,000

tourists at Lachung and brought down the Sangkalang bridge, after about 250 mm had fallen over the State in 1–13 June, "54% above the normal 162 mm" (as reported; the tolls conflict, and no SSDMA toll or IMD station rainfall was found [TBC]); and at about 19:00 on 1 June 2025 a landslide struck the army camp at Chaten, near Lachen, after three days of rain in north Sikkim, with 3 dead and 6 missing (as reported). The 18 September 2011 earthquake (Mw 6.9) was reported to have killed 92 people by 23 September and between 97 and 116 in later totals (as reported; conflict); the landslides it set off were not researched for this Manual [TBC]. The second is the river flood of the valley floors. On 2–5 October 1968 four days of rain over the Darjeeling and Sikkim hills set off hundreds of landslides, washed away the Anderson Bridge at Teesta Bazar on 4 October and killed about 1,000 people in the region; a figure of "1,000 mm of rainfall in 52 hours" was attributed to a scientist in the press (all as reported; no Sikkim toll and no official account found), while IMD recorded 419.2 mm at Kalimpong on 5 October (IMD). In 2017 a release from the Dikchu hydropower project without warning was reported, and the High Court of Sikkim closed the public-interest litigation that followed with the direction "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" (WP(PIL) 4/2017, judgment of 01.03.2021). In July 2025 the Teesta submerged NH-10 (as reported). The third is the glacial-lake outburst flood (GLOF). On the night of 3–4 October 2023 the South Lhonak lake drained into the Teesta after a moraine collapse at 22:12 IST, and the flood destroyed the 60 m dam of Teesta-III at Chungthang, damaged about 25,900 buildings and 31 major bridges and buried parts of Rangpo, about 135 km downstream, under debris (Sattar et al., 2025); the river bed "has risen by an average of 7-8 meters" (Lhonak valley PPR, annexed to the State's affidavit before the NGT, 28.02.2026). Its cause is disputed: the State's affidavit of 05.04.2024 attributed the flood "primarily to a cloudburst", a committee constituted by NDSA reported in June 2024 that "all scientific data and satellite images from that period points to GLOF and not a cloudburst" (as reported), and Sattar et al. (2025) found a moraine collapse with modest rain over the lake; this Manual takes no side and calls it the South Lhonak lake outburst and Teesta flood of 3–4 October 2023. Its toll is stated in two ways: 55 dead, 74 missing and over 7,025 displaced (SSDMA multi-stakeholder survey, as cited by Sattar et al., 2025), and 79 dead, 44 missing, 26 grievously injured, 5,665 evacuated and 7,025 in 30 relief camps, with 2,004 houses damaged and damage and loss of ₹1,480.07 crore (PDNA summary, SSDMA with NDMA, annexed to the State's affidavit before the NGT, 28.02.2026); press figures differ again (as reported). The PPR also lists an outburst of the Sangmya Meghu lake in August 2024. In September 2026 the High Court took up a suo motu public-interest litigation, *In re Climate Justice in State of Sikkim* (WP(PIL) 11/2026), in which the State is reported to have been asked to examine "land-use regulation, spatial planning, slope management, and drainage in ecologically and geologically fragile areas", and a later order urged early-warning systems for the 40 high-risk glacial lakes (as reported; the orders were not read [TBC]). No town in the State has a drainage design standard, and the 1991 regulations that govern building have no design storm, so this Manual sets the design rainfall for drains and screens the GLOF corridors and the Teesta valley floor apart, by siting rather than by drain size (Clause 2.3.6(i)).

In Sikkim neither the SBCR 1991 nor any other rule found requires rainwater harvesting of a private building: the regulations ask only that at least a quarter of each roof be sloped "with rain water gutter" (reg. 6), and the only statutory rainwater harvesting is in buildings owned or occupied by the State Government, its statutory bodies and the companies and institutions it owns or controls (Sikkim Municipalities Act, 2007, s.186).

No national instrument requires on-site detention. CPHEEO (2019) is advisory and describes peak control only as typical practice. NDMA (2010) says detention and retention "will" be included but gives no sizing rule. MBBL 2016 and the Sikkim Building Construction Regulations, 1991 mandate RWH only. Objective (a) is therefore the main new step this Manual takes.

## 1.2 Stormwater management hierarchy

1.2.1 Every development to which Chapter 4 applies shall consider stormwater measures in the following order. A designer shall not use a lower measure in place of a higher one that is practicable on the site.

1. **Preserve** — keep or restore natural drainage features, tanks, wetlands, permeable soils, trees and overland flow paths (Chapter 7).
2. **Retain** — hold the runoff from the retention depth of Annex 2E on site, by infiltration, reuse or evapotranspiration (Chapters 4 and 8).
3. **Detain** — store larger storms temporarily and release them at or below the rates in Chapter 4, checked against downstream and tailwater conditions (Chapters 4 and 5).
4. **Convey** — carry the remaining flow safely in the minor system, and the 1% AEP flow in the major system (Chapters 6 and 9).

1.2.2 **Maintenance** underlies all four measures. A measure that cannot be maintained by its owner under Chapter 10 shall not be credited.

1.2.3 Credits from higher measures reduce the requirements of lower ones. Preserved areas and retained volume reduce detention storage as set out in Chapter 4.

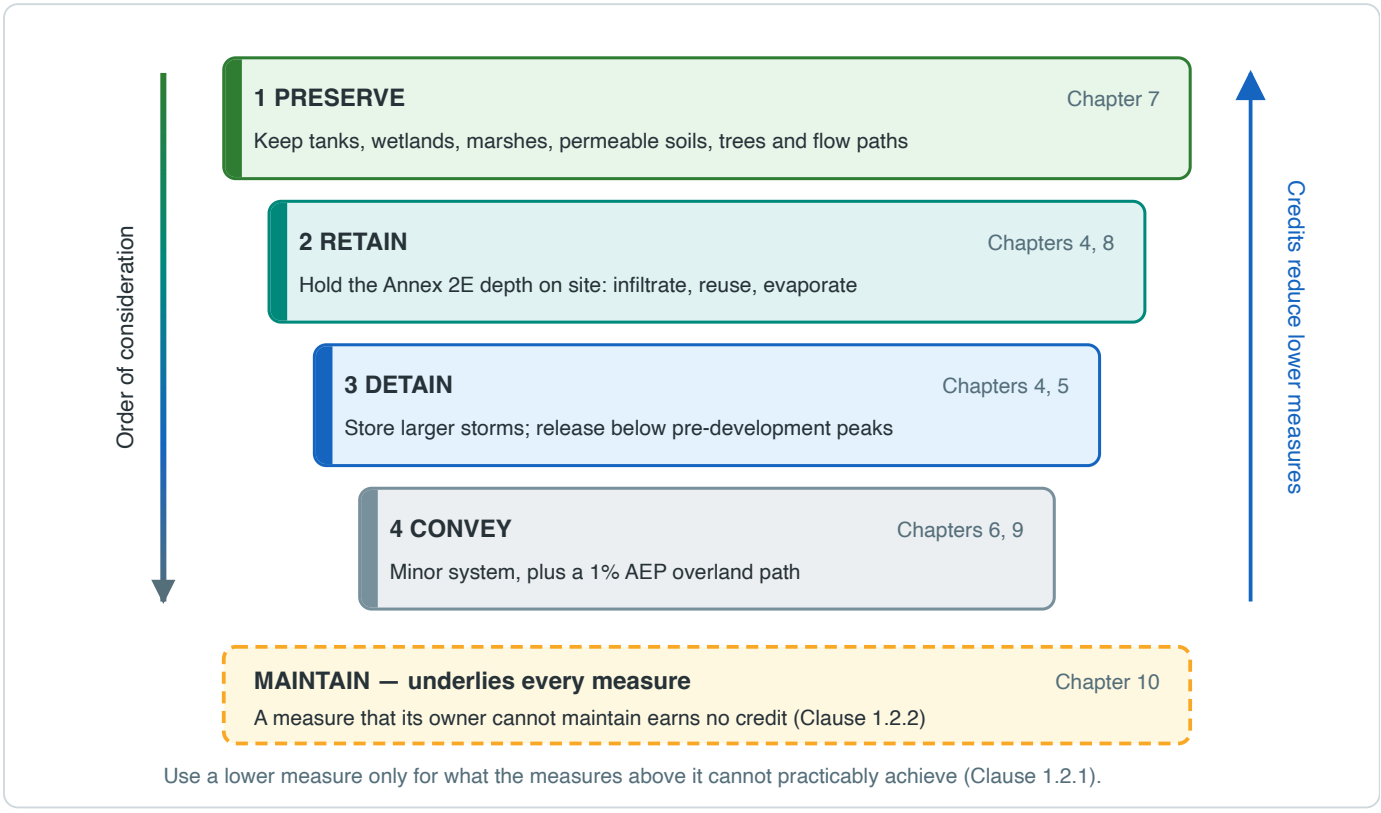


*Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).*

**Commentary.** The order follows the "layers" of Kansas City Metro APWA Section 5600, Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet, 2025). The same logic is behind Georgia's runoff-reduction standard and CSE's "attenuate and infiltrate first" principle (CSE, 2023). For Sikkim, the top two layers have a particular meaning. Much of the State's natural storage and supply lies in its springs. A dhara (धारा; a spring or spring spout; Turner's headword is धारो, "Spring of water", Turner, 1931, p. 328) is the main water source of rural Sikkim, where "about 80%" of households are reported to depend on springs and "half of the perennial springs

have already dried up or have become seasonal" (as reported). The Rural Management and Development Department (RMDD) has run the Dhara Vikas springshed programme since 2008 (2010 in one source; as reported, conflict), and its spring counts differ by date and source: 704 springs mapped for rejuvenation (as reported) and "more than 2000 springs mapped on GIS platform" (RMDD presentation of 2018, as reported). The storage lies too in the jhoras and kholas of the ridges; in the State's pokharis (पोखरी; ponds, lakes or tanks; Turner's पोखरि, "Lake, pool, tank", p. 391), among them Khecheopalri (Khachoedpalri), reported to have become the State's first Ramsar site in February 2025 (as reported; its area is given in several conflicting figures, none of which is used here); in the flat benches of the ridges and the gravel terraces of the Teesta and Rangit valley floors; and, high in the north, in 320 glacial lakes (State affidavit before the NGT, 2026). A glacial lake keeps its own name, even where the name contains "Pokhari", as Bhalay Pokhari and Doodh Pokhari do: it is a hazard source under Clause 2.3.6(i) and Chapter 7, never storage, and no storage credit or tank clause of this Manual applies to it. The law protects little of this. The Sikkim Municipalities Act, 2007 makes a jhora "any natural watercourse, whether on a public land or on a private land" (s.163(b)), vests jhoras on public land other than forest land in the municipality (s.172(1)) and requires that "the Municipality shall protect any jhora, whether on a public land or on a private land, within the municipal area" (s.172(2)); the State may "specify the limits of any jhora, watercourse or channel within a municipal area" by notification (s.173), but no such notification was found. The Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 keeps a river bank of "sixty metres on either side of such river or area within high flood level mark, whichever is less" for the 103 rivers of its Schedule (s.29(1)), under the Forest Department (s.29(9)), and the River Rejuvenation Committee is "the Nodal Agency for all water bodies" (Order No. 205/GOS/F&ED/SECY of 21.01.2021). No statute or rule found protects springs or pokharis with a buffer, no floodplain zoning law was found, and no wetland of the State was found notified under rule 4 of the Wetlands (Conservation and Management) Rules, 2017. On the slopes the second layer, retain, is limited by the ground: water put into a slope near a jhora can move it, and GSCDL told the NGT that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (GSCDL reply, NGT OA 38/2022), which is why Clause 4.11 allows infiltration only on tested ground and keeps it out of stability zones 3 to 6.

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## 1.3 Legal basis and status

1.3.1 **Notification.** This Manual shall be given statutory effect by the Government of Sikkim through:

- (a) an amendment to the Sikkim Building Construction Regulations, 1991 that makes compliance with this Manual a condition of planning permission, building permit, layout approval and completion certificate, for development to which Clause 1.5 applies; and
- (b) bye-laws or standing orders of each urban local body (ULB), adopting the Manual for works executed or approved by that ULB, including the ULB's own drains and roads.

1.3.2 **Higher State standards.** The design return periods and performance criteria of this Manual exceed the national advisory minimums of the CPHEEO Manual on Storm Water Drainage Systems (2019). The State shall constitute, by notification, a high-powered committee (the **State Stormwater Technical Committee**, Clause 1.9) to adopt these higher standards. This is the route that CPHEEO (2019) provides for higher return periods.

1.3.3 **Precedence.** Within its scope, this Manual governs where it is stricter than CPHEEO (2019), IRC:SP:42-2014, IRC:SP:50-2013 or any departmental standard. Where a statute or statutory rule sets a stricter requirement (for example a waterbody setback), the statute governs.

1.3.4 **Design-practice standard for public works.** Departments and ULBs that procure drainage, road or waterbody works shall require compliance with this Manual in detailed project reports (DPRs) and contracts, from the dates in Clause 1.11.

Commentary. In Sikkim the building rules are the Sikkim Building Construction Regulations, 1991 (SBCR 1991): UD&HD Notification No. 29(202)UD&HD/90/295 of 19 March 1991, made under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 (Act 11 of 1985), as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001 of 16 October 2001). The copy read for this Manual is one hosted by a third party, Sikkim Manipal University; the 2001 amendment was also read as a true copy annexed to the State's counter-affidavit before the NGT. A Sikkim Building Construction (Amendment) Regulation, 2022 was reportedly published on 12 April 2023 (as reported); its text was not read, and it may change what follows [TBC]. The regulations "shall extend to all the notified areas in Sikkim" (reg. 1(2)) and apply to State, Central, semi-government and private builders, Defence excepted; the 1985 Act requires permission for any construction in a notified area (s.7(1)), lets the Government make building regulations (s.7(2)) and demolish illegal works (s.8), and, since its amendment by Act 24 of 2022, punishes an offence with "such fine as may be notified from time to time", triable by the District Magistrate. Rural land outside the notified areas has no building permission under the regulations (NEER reading; the list of notified areas was not found [TBC]). Applications go to "the Secretary, UD&HD" (reg. 4); since 2017 building-plan approval inside Gangtok has been with the Town Planning Cell of the Gangtok Municipal Corporation (GMC), still under the 1991 regulations (GMC affidavit before the NGT; the transfer notification's number was not seen [TBC]). No "Gangtok Building Bye-laws" were found. The Sikkim Municipalities Act, 2007 has its own building-permit system, under which "No person shall undertake any building activity without obtaining" a permit (s.271), with rules that may cover "infrastructure in relation to building activity" (s.287); no rules under it were found, and whether GMC applies it beside the 1991 regulations is not clear (NEER reading). The Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024, amended by Act 24 of 2025) would provide development plans with "proposals for water supply, drainage, sewage and solid waste disposal" and "proposals for flood control, land stability and sloped linked controls", but it comes into force only on a date to be notified (s.1(3)), and no commencement notification, rules, Board or development authority was found: it is enacted, not in force.

The regulations already tie a site's drainage to its approval, without numbers. The blue-print plan shows "drainage including connection to main outlet and the slopes of the roof" and the "sanitary/plumbing layout … drainage system … sewerage disposal system/septic tank and soak pit" (reg. 6); gutters and down pipes are "of such design and capacity that the water will neither spill out of them nor leak through them" and go to "the storm water plinth protection drain" (reg. 21); a "Pucca storm water/plinth protection drain" leads "to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)); and "No occupation certificate shall be issued … if the drain has not been provided to main outlet/jhora" (reg. 13(iii)). Height is set by the six stability zones of the Mines and Geology Department (reg. 17(i), as substituted in 2001), whose parameters of 2021 grade each zone partly by its jhoras: zone 1 "Training of jhoras/drains have been completed and done properly (with safe distance)", zone 3 "Jhora training is required/annual maintenance of drain is necessary", zone 4 "Untrained jhora/ erosional potential jhora" (Notification No. 17/DMG/20-21 of 19.03.2021). The 2001 copy of the regulations gives zone 2 "1 ½" storeys and the 2021 notification 4½; this Manual cites the 2021 notification. The regulations set no storm-water volume, peak flow, detention, runoff coefficient, design storm or setback from a jhora or river, and **they do not mandate rainwater harvesting**: they ask only that at least 25 per cent of each roof be sloped "with rain water gutter" (reg. 6). The only statutory rainwater harvesting in the State is for buildings owned or occupied by the State Government and its bodies (Sikkim Municipalities Act, 2007, s.186), "in such manner as may be specified", and no manner has been specified, as far as found. Nor do the regulations, as read, set up a register of professionals: the Municipalities Act registers "Architects, Structural Engineers and Construction Engineers on Record" (ss.266–287), and where this Manual speaks of a person registered under the SBCR 1991, or of SBCR 1991 registration (Form 10A), that register or the Authority's recognition is meant (Clause 1.4) [TBC]. The Government may relax any provision (reg. 39, 2001), and has relaxed heights for a hospital (11 storeys), the State Secretariat (8 storeys) and a GSCDL car park (4 + 7 storeys, "subject to confirmation of a Geotechnical investigation and Report") (State and GMC affidavits before the NGT, 2022).

Clause 1.3.1 sets out how the Manual could be given effect; none of these steps has been taken. The State Government could amend the SBCR 1991 under section 7(2) of the 1985 Act, at regs. 6, 13(iii), 21, 25(iv) and 35, to make compliance with this Manual a condition of permission and of the occupation certificate (Clause 1.3.1(a);

the model text is Annex 1D). The Mines and Geology Department could cite the Manual's jhora-training and catchment-drain standards in the conditions for reviewing a site's zone, which already ask for "Training of untrained Jhora" and "Proper channelization of surface runoff by providing catchment drains" to "natural waterways/Jhora". In place of the bye-laws of Clause 1.3.1(b), a municipality could act under the Municipalities Act: the State Government could notify jhora limits (s.173), the State Government or the Municipality could specify the manner of rainwater harvesting (s.186), and rules could be made on "infrastructure in relation to building activity" (s.287). Once the 2024 Act commences, development plans could carry the Manual's flood-sensitive catchments, corridors and regional facility sites. SSDMA could refer to it in district disaster management plans, and the departments could apply it to their own works (Clause 1.3.4). Where land is needed for a corridor or a regional facility, it is secured by agreement or donation, or reserved in a development plan once the 2024 Act commences; this Manual never takes or acquires land. MoHUA told Parliament in July 2026 that urban flooding "falls under the purview of the State Governments and the ULBs" and listed the CPHEEO manual among "advisory guidelines" (Lok Sabha AU1847). The State therefore needs no central approval to adopt higher standards. CPHEEO's Note 2 to Table 4.1 (§4.4.1.4) allows "a high powered committee constituted by State/UT Government through a notification" to adopt higher return periods. Clause 1.3.2 uses that route so that higher standards are on record for centrally funded schemes.

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## 1.4 Definitions

1.4.1 The following terms apply throughout this Manual. Chapter-specific terms are defined in each chapter (for example Clause 2.2).

| Term | Meaning in this Manual |
|---|---|
| Approving Authority (the Authority) | The body that grants planning permission, building permit or layout approval for a development, or that sanctions a public work: the competent authority for the area: in Gangtok, the Gangtok Municipal Corporation (GMC), which has approved building plans in its area under the Sikkim Building Construction Regulations, 1991 since 2017 (GMC affidavit before the NGT) and owns and protects its drains and jhoras under sections 172 and 187 of the Sikkim Municipalities Act, 2007; in another notified area, the Urban Development Department (UDD) or the urban local body that approves plans there (how approval is split between UDD and the urban local bodies outside Gangtok was not found [TBC]); for the bank of a river scheduled under the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, the Forest Department; for a public work, the department or agency that executes it (the Roads and Bridges Department / PWD, NHIDCL, BRO, WRD, PHED, RMDD, UDD or GSCDL); and on land outside every notified and municipal area, where the regulations give no building permission, none: there this Manual is guidance, except for public works and for any body that adopts it (NEER reading), or a department for its own works. |
| Applicant | The owner, developer or department that seeks approval, and its successors in title. |
| Development | Any building, layout, sub-division, road, paving or land-use change that requires approval under the Sikkim Building Construction Regulations, 1991 or that is executed as a public work. |
| Redevelopment | Development on a site where impervious cover already exists. |
| Land disturbance | Clearing, grading, excavation, filling or paving of land, measured in plan area over the whole of a common plan of development (Clause 1.5.5). |
| Impervious area | Roofs, paving, compacted gravel, decks and other surfaces that prevent infiltration. Permeable paving designed to Chapter 8 is counted as pervious only for the area it treats. |
| New or replaced impervious area | Impervious area created, or removed and rebuilt down to the subgrade, by the development. Resurfacing that leaves the base in place is not "replaced". |
| Retention | Permanent removal of runoff from the drainage system on site, by infiltration, reuse or evapotranspiration (Chapter 4). |
| Detention | Temporary storage of runoff with a controlled outlet, emptied after the storm (Chapter 4). |

| Term | Meaning in this Manual |
|---|---|
| Rainwater harvesting (RWH) | Collection of rainfall for supply or recharge under the RWH mandate. RWH storage is not detention unless Chapter 4 allows it. |
| Minor system | Drains, pipes and inlets designed for the minor-system AEP of Chapter 6. |
| Major system | The overland and floodway path that carries the 1% AEP (100-yr) flow (Chapter 6). |
| Pre-development condition | Greenfield: open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted (Chapter 3). |
| Flood-sensitive catchment | The catchments of Gangtok's jhoras to the Rani Khola and the Roro Chu; the Teesta valley floor in the corridor of the flood of October 2023, at Chungthang, Dikchu, Singtam, Rangpo and Melli, with Toong Naga; the Rangit at Jorethang and Majitar; the Rongni Chu at Ranipool and Singtam; Mangan town and the slopes of the North Sikkim road; Lachen and Chaten, and every catchment below a high-risk glacial lake; the hydropower reservoirs and release reaches (Teesta-III once restored, Teesta-V, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III); the NH-10 corridor along the Teesta; Namchi; and Soreng, and any catchment the Authority notifies (Chapter 4; Annex 1B). |
| Waterbody | A river, stream, canal, tank (pokhari), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7). |
| Regional facility | A detention, retention or tank storage facility serving more than one development, built or restored under a basin plan (Chapter 4). |
| Tier A / Tier B authority | An Approving Authority classed under Clause 1.6. |
| Policy supplement | The set of adoptable alternative clauses in Clause 1.7 and Annex 1C. |
| Drainage report | The preliminary or final report required by Chapter 10. |
| Registered professional | A person registered under the Sikkim Building Construction Regulations, 1991 to prepare and sign the relevant plans, with any further qualification required by Clause 10.6. |
| Compliance calculator | The State-issued tool for computing and reporting compliance (Clause 10.5). |
| Maintenance declaration | The registered undertaking by an owner to maintain a stormwater facility (Clause 10.10). |
| Variance | Approval to depart from a numeric requirement, with equivalent performance shown (Clause 1.10). |
| Waiver | Approval that a requirement does not apply to a site, on the grounds in Clause 1.10. |
| Notified | Published by the Government or the State Stormwater Technical Committee in the Sikkim Government Gazette. |
| Competent authority for the area | The body that grants permission for the site, or executes the work, under the instrument that applies there: in Gangtok, the Gangtok Municipal Corporation (GMC), which has approved building plans under the SBCR 1991 since 2017 and owns and protects its drains and jhoras (Sikkim Municipalities Act, 2007, ss.172 and 187); in another notified area, the Urban Development Department (UDD) or the urban local body that approves plans there [TBC: the split outside Gangtok was not found]; the Forest Department for the bank of a scheduled river under the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988; and the executing department or agency for a public work (the Roads and Bridges Department / PWD, NHIDCL, BRO, WRD, PHED, RMDD, UDD or GSCDL). On land outside every notified and municipal area the SBCR 1991 give no building permission, and this Manual is guidance there, except for public works and for any body that adopts it (NEER reading). Where this Manual says "the Authority", the competent authority for the area is meant. |
| Notified area | An area notified by the Government to which the SBCR 1991 extend (reg. 1(2): "They shall extend to all the notified areas in Sikkim"), and in which no construction may begin without permission (Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985, s.7(1)). The list of notified areas was not found for this Manual [TBC]. |

| Term | Meaning in this Manual |
|---|---|
| Jhora | Jhora (झोरा): a natural watercourse or ravine stream. In law, "any natural watercourse, whether on a public land or on a private land" (Sikkim Municipalities Act, 2007, s.163(b)), and a "drain" includes "a jhora or water-course of natural drainage line" (s.2(24)); "river" includes any "jhora" (1988 Act, s.2(m)). Turner gives झोरा "Ravine", marked as Darjeeling usage (Turner, 1931, p. 237). A jhora draining 8 ha or more is a natural channel under Chapter 7. |
| Trained jhora | A jhora whose channel, as built and maintained, meets the jhora-training standard of Clause 6.3.6(m): it carries the 1% AEP flow with bulking and the Manual's freeboard, with toe and bed protection, drop structures with energy dissipation, a debris basin or rack above every culvert and a maintenance access, without loss of the jhora's 1% AEP capacity (set by this Manual). It gives a number to the "Training of jhoras/drains … done properly (with safe distance)" of stability zone 1 (Mines and Geology Department, 2021); it is not a finding of that Department. |
| Stability zone | One of the six site-stability zones of the Mines and Geology Department, on which the SBCR 1991 set the height of a building (reg. 17(i), as substituted in 2001): zones 1 to 6, from 5½ storeys to "No construction", with the parameters of Notification No. 17/DMG/20-21 of 19.03.2021, which grade each zone partly by the state of its jhoras, its slope and its ground water ("Dry/nil" in zone 1 to "Flowing" in zones 5 and 6). The 2001 copy of the regulations reads "1 ½" storeys for zone 2 and the 2021 notification 4½; this Manual cites the 2021 notification. |
| GLOF corridor | The path of a glacial-lake outburst flood (GLOF): the Teesta from the South Lhonak lake through Chungthang, Mangan, Dikchu, Singtam, Rangpo and Melli to the State border, the Lachen Chu and the Lachung Chu, and every stream below a glacial lake listed as high-risk by NDMA, the Science and Technology Department or the Sikkim Commission on Glacial Hazards, as shown on a GLOF hazard or evacuation map where one exists [TBC]. A GLOF corridor is screened for siting under Clause 2.3.6(i); no drain is sized for a GLOF. |
| Registration (in Sikkim) | The SBCR 1991, as read for this Manual, set up no register of professionals. Where this Manual refers to a person registered under them, or to SBCR 1991 registration, it means a professional registered under Chapter XXXII of the Sikkim Municipalities Act, 2007, which registers "Architects, Structural Engineers and Construction Engineers on Record" (ss.266–287), or a professional the Authority recognises for the purpose until a register exists (set by this Manual) [TBC]. |

> Commentary. "Replaced" impervious area is defined to the subgrade so that redevelopment of a fully paved site is captured, while routine resurfacing is not. This follows the approach of the APWA 5600 (2025.01) redevelopment triggers (MARC Supplement, 2025).

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## 1.5 Applicability

1.5.1 **Who is covered.** This Manual applies to:

- (a) all development requiring planning permission, building permit or layout approval under the Sikkim Building Construction Regulations, 1991;
- (b) all drainage, road, bridge, culvert, waterbody and flood-mitigation works executed by a ULB, a State department, a board, or a State undertaking; and
- (c) works executed by Central agencies or their contractors within Sikkim, to the extent that the Authority's approval or no-objection is required.

1.5.2 **Retention and detention threshold.** Chapters 4 and 5 (retention, detention, downstream and tailwater analysis) apply to any development that, over the common plan of development, involves:

- (a) land disturbance of **0.1 ha or more**; **or**
- (b) new or replaced impervious area of **500 m² or more**.

1.5.3 **RWH.** The existing RWH mandate continues to apply under section 186 of the Sikkim Municipalities Act, 2007 to "every building owned or occupied by the State Government or a statutory body or a company or an institution owned or controlled by the State Government", "in such manner as may be specified by the State Government or the Municipality

from time to time" (no manner has been specified, as far as found), and to no other building (the SBCR 1991 require no rainwater harvesting, only that at least 25 per cent of a roof be sloped "with rain water gutter", reg. 6), as now. This Manual does not change it.

1.5.4 **Provisions that apply at every size.** The following apply to all development under Clause 1.5.1, whatever its size, unless exempted by Clause 1.5.8:

- (a) no sewage connection to a storm drain (Chapter 8);
- (b) lowest habitable floor and openings at or above the 1% AEP level plus 0.5 m, where a 1% AEP level is mapped or determinable (Chapter 6);
- (c) waterbody setbacks and the no-fill zone (Chapter 7); and
- (d) no obstruction of a natural drainage path or major-system flow path (Chapter 6).

1.5.5 **Common plan of development.** The thresholds of Clause 1.5.2 apply to the total area of a development, including all phases, plots and sub-divisions under one layout approval or one ownership at the date of application. A development shall not be divided to avoid the thresholds.

1.5.6 **Redevelopment.** For redevelopment, the thresholds apply to new plus replaced impervious area. Retention and detention apply to the whole of the new and replaced impervious area, and the pre-development condition is greenfield (Clause 1.4). Where greenfield control cannot be achieved on a constrained redevelopment site, the relief route of Clause 4.5.6 applies: a minimum on-site cut of 50% from existing peaks, with the shortfall paid as fee-in-lieu into basin storage.

1.5.7 **Linear public works.** For roads, widening and other linear works, the impervious area threshold applies to the added impervious area within each drainage catchment crossed. Retention and detention shall be provided within the right of way, or in a regional facility under Chapter 4, where the right of way cannot hold them.

1.5.8 **Exemptions.** The following are exempt from Chapters 4 and 5:

- (a) a single dwelling on its own plot, where the thresholds of Clause 1.5.2 are not met; and
- (b) linear road resurfacing that adds no impervious area.

Exempt development remains subject to the RWH mandate and to Clause 1.5.4.

1.5.9 **Applicability determination.** The Applicant shall record the applicability decision on **Form 1-1** (Applicability Determination) with the first submittal under Chapter 10. The Authority may confirm or correct it at the pre-application stage.

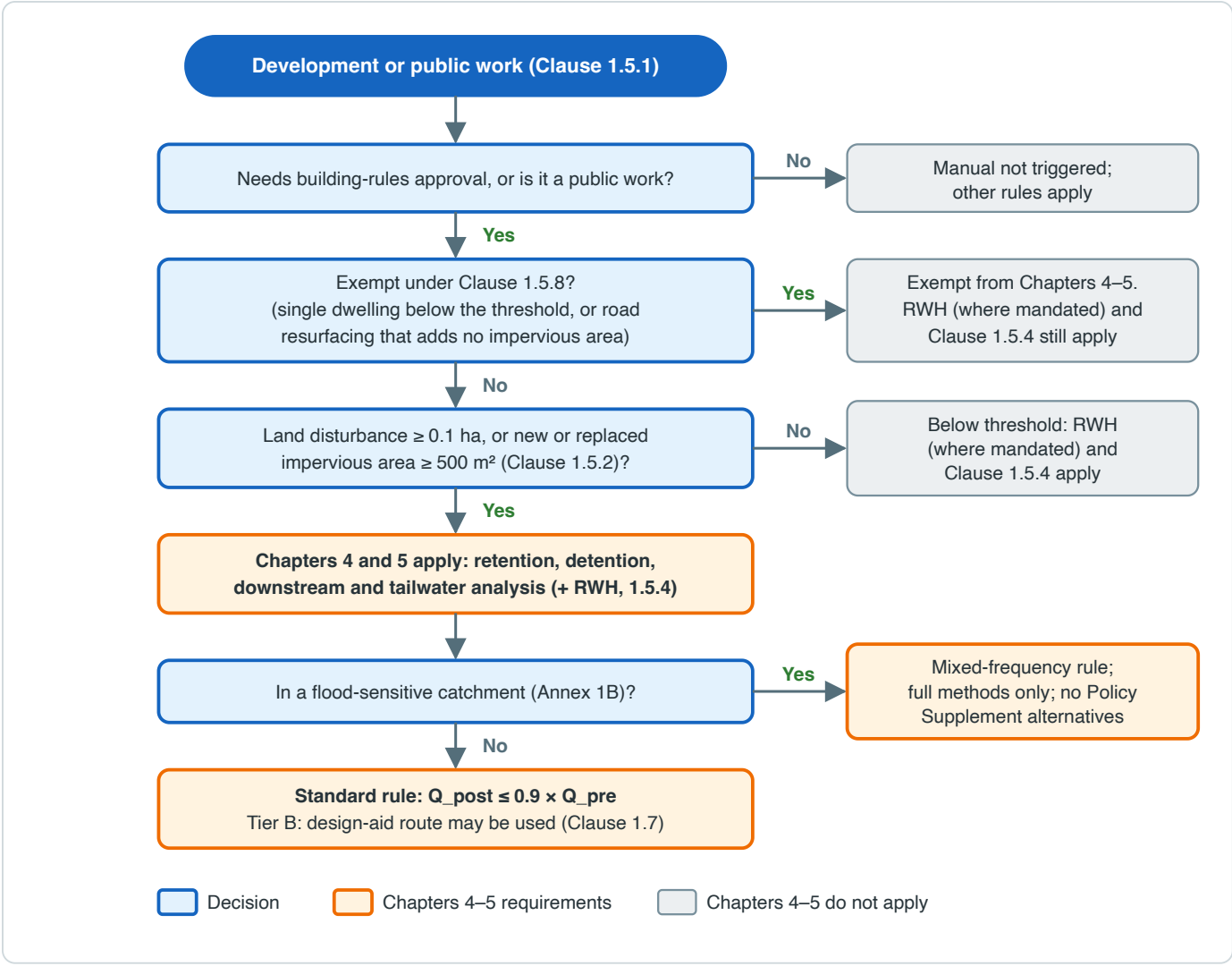


*Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.*

**Commentary.** The thresholds have no single direct precedent; they are set by this Manual. Precedents span a wide range:

- Singapore controls peak runoff from developments of 0.2 ha or more (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5).
- Malaysia's 2008 DID checklist used on-site detention for sites up to 0.1 ha and community ponds above that.
- The APWA 5600 (2025.01) Policy Supplement offers alternative triggers of ¼ acre (about 0.1 ha) disturbed, or 1 acre (about 0.4 ha) with 10,000 sq ft (about 930 m²) impervious, and warns agencies not to exceed a 1-acre trigger.
- MBBL 2016 makes recharge mandatory for buildings over 500 m².

The 0.1 ha / 500 m² trigger sits at the strict end of these, because typical Sikkim plots are small and the cumulative effect of many small plots is what fills Gangtok's drains. For small buildings in Sikkim, the SBCR 1991 already ask every site to drain: roof gutters and down pipes go to "the storm water plinth protection drain" (reg. 21), the plinth drain leads "to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)), and no occupation certificate is issued until the drain reaches "main outlet/jhora" (reg. 13(iii)). None of this sets a size, a volume or a release rate, so none of it limits what leaves the plot in a design storm, and a lined drain that sends every roof's water straight to a jhora sends it sooner and with more energy down a slope that the stability zones may already record as wet. The regulations also put sewage into the ground on every site without a sewer, in a septic tank and soak pit (regs. 6, 13(iii) and 25(i)), which on a wet slope puts water where the hill rule of Clause

> 4.11 keeps it out; this Manual does not override the regulation, puts no storm water into a soak pit, and recommends that no new soak pit be placed in stability zones 3 to 6 and that one on a slope of more than 10° be sited by a geotechnical engineer, downslope of buildings and cuts (set by this Manual), referring sewage to Clause 8.9. Clause 1.5.4(b) applies to every building whatever its size for these reasons. Outside the notified areas, where the regulations do not reach (reg. 1(2)), no building rule found reaches a small building, and this Manual is guidance only: a household, a village body or a public agency could use the small-site method of Chapter 4 and the hill rule of Clause 4.11 as guidance. A small building on a slope is where a soakaway can do most harm, and an Authority may make the hill rule of Clause 4.11 a condition of every permission in its area, whatever the size of the site (a recommendation of this Manual, not a requirement of Clause 1.5.4).
>
> Clause 1.5.4(b) has no direct precedent; this Manual sets it because floor levels are the cheapest protection a building can have, and it would be perverse to protect only large developments. Where no 1% AEP level is mapped, Chapter 6 gives the method for small sites.

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## 1.6 Tiered adoption

1.6.1 **Tier A authorities.** The following are Tier A:

- (a) the Gangtok Municipal Corporation (GMC), for its whole area; and
- (b) once a development plan under the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced) is published for a planning area, every approving authority within that planning area, whichever has jurisdiction over a site (no such plan has been published).

1.6.2 **Tier B authorities.** All other Municipal Councils, Nagar Panchayats and other approving authorities under the regulations are Tier B.

1.6.3 **What differs between tiers.** All criteria of this Manual apply in both tiers. The tiers differ only in method and review:

**Table 1.1 — Differences between Tier A and Tier B authorities**

| Item | Tier A | Tier B |
|---|---|---|
| Performance criteria (Chapters 2–9) | Apply in full | Apply in full |
| Hydrologic method for storage | Hydrograph method (Chapter 3) | Hydrograph method, or the design-aid route of Clause 1.7 where eligible |
| Compliance calculator (Clause 10.5) | Required as a summary | Required; may be the sole calculation on the design-aid route |
| Policy supplement alternatives (Clause 1.7) | Only with State Stormwater Technical Committee concurrence | May be adopted by council resolution |
| Technical review | By the Authority | By the Authority, with UDD regional support or an empanelled reviewer (Clause 10.7) |
| Flood-sensitive catchment rule | Applies | Applies |

1.6.4 **Moving between tiers.** A Tier B authority may opt into Tier A by council resolution. The Government may notify a Tier B authority as Tier A when it becomes a Corporation, joins the area of the Gangtok Municipal Corporation or, once a development plan is published under the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced), the planning area of that plan (none has been published), or is found by a post-event review (Clause 10.16) to need the full methods.

1.6.5 **Flood-sensitive catchments override tier.** In a flood-sensitive catchment, whatever the tier, the alternatives of Clause 1.7 are available only as Table 1.2 allows: S-1 (the design-aid route) for sites of 0.5 ha or less (Clause 4.14.1), and S-5 fee-in-lieu where a basin plan has been notified (Clause 1.10.3(d)). S-2, S-3 and S-4 are not available.

> **Commentary.** Gangtok Municipal Corporation, with no drain inventory or drain design standard found, building-plan approval in its area under the SBCR 1991 since 2017 (GMC affidavit before the NGT), the State's only sewer network, whose plants treated 15.22 MLD in September 2025 against 18.33 MLD of sewage estimated for its area (State affidavit before the NGT, 19.12.2025), and the clearing of its jhoras let to its waste agency (GMC, 2024), and a small Nagar Panchayat with one assistant engineer cannot be asked to review the same hydrograph models. The Kansas City solution was to keep one regional standard and publish adoptable alternatives for the most contested criteria, so that smaller agencies can "opt down" without leaving the standard (MARC Supplement, Nov 2025). The tiers here keep the performance criteria the same in both tiers and vary only the method, so that a building in a Tier B town is protected to the same level as one in Gangtok.

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## 1.7 Policy supplement: adoptable alternatives

1.7.1 The Government shall publish, with this Manual, a **Policy Supplement** (Annex 1C) of alternative clauses. An Approving Authority may adopt one or more alternatives under the conditions in Clause 1.7.3.

1.7.2 The alternatives are:

**Table 1.2 — Policy supplement: adoptable alternatives S-1 to S-5**

| No. | Main-text requirement | Adoptable alternative | Eligibility |
|---|---|---|---|
| S-1 | Storage sized by hydrograph method (Chapter 3) | **Design-aid route:** retention and detention volumes taken from the unit-storage tables (m³ per ha, by rainfall zone, soil group and impervious fraction) in Annex 4 and the compliance calculator | Sites ≤ 2 ha outside flood-sensitive catchments; ≤ 0.5 ha within them (as Clause 4.14.1) |
| S-2 | Release rate Q_post(T) ≤ 0.9 × Q_pre(T), computed for the site | **Permissible site discharge (PSD):** a tabulated unit-area release rate (m³/s/ha) by zone and AEP, derived from the 0.9 × Q_pre rule | Any site outside flood-sensitive catchments |
| S-3 | Waterbody setback extended to the mapped 1% AEP flood extent plus margin (Chapter 7) | **Fixed-width setback table** by waterbody class, where no 1% AEP extent is mapped. Never less than the Zone 1 minimum of Clause 7.4.7 | Waterbodies with no mapped 1% AEP extent |
| S-4 | Downstream analysis by hydraulic model (Chapter 5) | **Screening checklist** of downstream capacity and known flooding, with a model only where the screen fails | Sites < 1 ha, outside flood-sensitive catchments, not discharging to a tidal outfall |
| S-5 | On-site detention | **Fee-in-lieu** toward a regional facility or restored tank storage in a master-planned basin (Chapter 4) | Where a basin plan has been notified |

1.7.3 **Conditions on adoption.**

- (a) An alternative shall not lower any criterion below the values of this Manual. S-1 and S-2 are simplified methods for meeting the same criterion. They are not lower criteria.
- (b) A Tier B authority adopts an alternative by council resolution, sent to the State Stormwater Technical Committee within 30 days. A Tier A authority needs the Committee's concurrence before adoption.
- (c) The adopted alternatives shall be published on the Authority's website and in the register of Clause 10.17.
- (d) Retention (Annex 2E depth) cannot be replaced by any alternative, except where fee-in-lieu under S-5 funds equivalent retention in the same basin.

- (e) The tables for S-1, S-2 and S-3 shall be issued by the State Stormwater Technical Committee, and reviewed with Chapter 2 (Clause 2.14).

> **Commentary.** The supplement follows the model of the APWA 5600 (2025.01) Policy Supplement, which gives alternatives for the four most contested criteria (applicability, Rational Method limits, stream setback trigger, and Zone 2 setback width). Two of those map onto S-3 and onto the applicability threshold of Clause 1.5.2. Alternative S-3 copies the APWA answer to the same problem: the 1% AEP extent is not mapped for small drainage areas, so a fixed-width table is offered. S-2 follows the Kansas City 2011 shift from "match existing" to fixed unit-area release rates. Local agencies preferred a set rate because existing conditions were hard to determine consistently (MARC Evolution deck). It also reflects the Sydney Water permissible site discharge (PSD) method. The 2 ha / 0.5 ha limits for S-1 (matching Clause 4.14.1) and the 1 ha limit for S-4 have no direct precedent; they are set by this Manual.

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## 1.8 Relationship with other instruments

1.8.1 This Manual shall be applied together with the instruments below. Where they overlap, Clause 1.3.3 governs.

**Table 1.3 — Relationship with other instruments**

| Instrument | Relationship |
|---|---|
| the Sikkim Building Construction Regulations, 1991 (SBCR 1991; UD&HD Notification No. 29(202)UD&HD/90/295 of 19 March 1991, made under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985), as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001 of 16 October 2001); a further amendment of 2022, reportedly published on 12 April 2023, not read (as reported) [TBC] | Continue where they apply: in the notified areas (reg. 1(2)), with the Urban Development Department (UDD), and since 2017 the Gangtok Municipal Corporation in Gangtok, as the approving body. They require a site plan with the "position of sewer line, water main pipe line" (reg. 5(f)); a blue-print plan with "drainage including connection to main outlet and the slopes of the roof" and the septic tank and soak pit (reg. 6); roof gutters and down pipes to "the storm water plinth protection drain" (reg. 21); no spoil in "drains, gullies and jhoras", on a fine of ₹500 at least (reg. 22); a "Pucca storm water/plinth protection drain" to "the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)); no occupation certificate "if the drain has not been provided to main outlet/jhora" (reg. 13(iii)); and no allotment or regularisation in "any sinking area, landslide prone or in areas having scars of old landslides or in slope exceeding or around 70 (Seventy) degree" (reg. 35). They set no storm-water volume, peak flow, detention, runoff coefficient, design storm, rainwater-harvesting rule or setback from a jhora or river. The design criteria of Chapters 2–6, the hill, valley-floor and recharge rules of Clause 4.11 and the corridors of Chapter 7, whose Zone 1 is at least 15 m, are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the SBCR 1991 or a statute is stricter, it governs (Clause 1.3.3). |
| Site stability zones: Mines and Geology Department Notification No. 17/DMG/20-21 of 19.03.2021 (Sikkim Government Gazette Extraordinary No. 86, 06.04.2021), "In continuation with" the zones of the 2001 amendment (SBCR 1991, reg. 17(i)) | Continue. Zones 1 to 6 set building height from 5½ storeys to "No construction"; the 2001 copy of the regulations reads "1 ½" storeys for zone 2 and the 2021 notification 4½ (a conflict; this Manual cites the 2021 text). The zones are graded partly by jhora training (zone 1 "done properly (with safe distance)"; zone 3 "Jhora training is required"; zone 4 "Untrained jhora/ erosional potential jhora"), slope (zone 1 "<15°" to zones 5 and 6 ">45°") and ground water ("Dry/nil" to "Flowing"), and a site's zone may be reviewed after "Proper channelization of surface runoff by providing catchment drains … and connect it to natural waterways/Jhora". The zones are site classes for building height, not infiltration rules; this Manual uses them as such in Clause 4.11, forbids deliberate infiltration in zones 4 to 6 and requires a geotechnical certificate for it in zone 3, and gives numbers to "training" and "catchment drains" (Clause 6.3.6(m)). |

| Instrument | Relationship |
|---|---|
| Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 (Act 11 of 1985), as amended in 2000, 2001, 2007 and by Act 24 of 2022 | Continue. Prior permission for any construction in a notified area (s.7(1)); power to make building regulations (s.7(2)) and to demolish illegal works (s.8); penalty "such fine as may be notified from time to time", offences "triable by the District Magistrate" (2022). Its preamble records allotments that caused "encroachment of septic, water supply tanks … within the notified green belt and effecting and likely to cause land slides during monsoons". The route by which the regulations could be amended to give effect to this Manual (Clause 1.3.1(a)). |
| Sikkim Municipalities Act, 2007 (Act 5 of 2007), as amended up to Act 3 of 2026 and by Ordinance 5 of 2026 | Continue. A "drain" includes "a jhora or water-course of natural drainage line" (s.2(24)), and a jhora is "any natural watercourse, whether on a public land or on a private land" (s.163(b)); jhoras on public land other than forest land in a municipal area vest in the Municipality (s.172(1)), which "shall protect any jhora, whether on a public land or on a private land" (s.172(2)); the State may "specify the limits of any jhora, watercourse or channel within a municipal area" by notification (s.173; none found); rainwater harvesting is required in buildings owned or occupied by the State Government and its bodies, in a manner to be specified (s.186; none specified, as far as found); the Municipality provides "a safe and sufficient outfall … in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187), and drains vest in "the Municipality, or the concerned Department, or organization, of the State Government, or the agency, as the case may be" (s.189(1)); sewage and rain water go in separate drains, the rain water to "the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (s.193(b)); and Chapter XXXII sets up a building-permit system (ss.266–287) under which no drainage rules have been made. This Manual supplies the hydraulic meaning of "protect" and of a "safe and sufficient outfall" (Chapters 5–7). |
| Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Act 6 of 1988), as amended by Act 8 of 2000 | Continue. For the 103 rivers of its Schedule, from the Teesta and the Rangeet to the Khani Khola at Melli, the river bank is "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (s.29(1)), under the Forest Department "as if it were a forest" (s.29(9)); its unauthorised occupation is an offence (s.30), and a river bank may be closed by notification (s.32). "Whichever is less" makes the line a maximum, not a minimum (NEER reading), and "river" includes "any stream, channel, jhora" (s.2(m)) though the 60 m applies only to the Schedule. Slip reserves (s.29(2)) are a hook for slope works. Where the statutory bank is wider than this Manual's Zone 1 it binds as well; where the flood mark lies nearer the channel, the Manual's corridor is stricter (Chapter 7). After October 2023 the high flood level itself has moved. |
| Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024; Gazette Extraordinary No. 317, 15.06.2024), amended by Act 24 of 2025 (Gazette Extraordinary No. 13, 17.01.2026) | Enacted, not yet commenced: it comes into force on a date to be notified (s.1(3)), and no commencement notification, rules, Board or development authority was found. Once in force, its development plans would carry "proposals for water supply, drainage, sewage and solid waste disposal" and "proposals for flood control, land stability and sloped linked controls"; this Manual offers them its flood-sensitive catchments, corridors, 1% AEP extents and facility sites. It repeals the planning Acts of 1998 and 2007 (s.124); their status until it commences is not settled (NEER reading: a repeal takes effect when the repealing Act commences) [TBC]. |
| Monsoon notices of UD&HD and UDD: Notice No. 613/GOS/JCTP/UD&HD of 01.05.2019 (no earth excavation from 6 May to 30 September 2019) and Notice No. T(1689)/997 of 26.05.2020 (1 June to 30 September 2020); a ban from 1 May 2024, extended by 15 days (as reported) | Continue, as annual notices, not regulations. They stop "construction involving earth excavation works" and the issue of Construction Orders for the monsoon, and seize material "lying on the road setback or over drains". Drainage earthworks under this Manual are therefore finished before the ban, by the deadline of Chapter 10, and the notices are the hook for construction-phase sediment control (Chapter 8). |
| Official languages: Sikkim Official Languages Act, 1977 (Act 5 of 1977), as amended | Continue. "The Nepali, the Bhutia, the Lepcha and the Limbu languages" are the languages "for all official purposes of the State" (as amended in 1981), with other languages added later, the last being Bhujel (Act 16 of 2022). This Manual is published in English; a Nepali edition is to follow. Signs and depth markers are in Nepali and English, and in another official language of the State where the local body's own notices use it (front matter). |

| Instrument | Relationship |
|---|---|
| Floodplains, waterbodies, springs and private rainwater harvesting: no State law found; the Wetlands (Conservation and Management) Rules, 2017 | No floodplain zoning law, notified flood line, waterbody or spring protection law, or rainwater-harvesting rule for private buildings was found, and no wetland of the State was found notified under rule 4 of the 2017 Rules. The River Rejuvenation Committee is "the Nodal Agency for all water bodies" (Order No. 205/GOS/F&ED/SECY of 21.01.2021). No setback along the Teesta was found after October 2023; the "High-risk Zoning" of floodplains below glacial lakes in the State's Lhonak valley PPR is a proposal, not a rule. The corridors, spring rule and glacial-lake siting rule of Chapter 7 are this Manual's proposals. |
| Courts and tribunals: High Court of Sikkim, WP(PIL) 4/2017 (judgment of 01.03.2021), WP(PIL) 3/2023 (judgment of 07.12.2023), WP(PIL) 1/2024 (judgment of 15.05.2025) and the suo motu WP(PIL) 11/2026, *In re Climate Justice in State of Sikkim* (as reported); the NGT, OA 171/2023 (EZ), OA 5/2022 and 38/2022 (EZ), OA 673/2018 and OA 606/2018 | Directions to the parties, not rules of this Manual. The High Court directed "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" and that authorities "undertake periodic inspection and review" (WP(PIL) 4/2017); in WP(PIL) 11/2026 the State is reported to have been asked to examine "land-use regulation, spatial planning, slope management, and drainage in ecologically and geologically fragile areas" (as reported; orders not read [TBC]). The NGT has recorded that "treated sewage is entering in to river/ rivulets/ jhoras and this is not permissible under the Water Act" (OA 606/2018, order of 04.07.2024, as quoted by the State), which the State answered with "No sewage is disposed off in the rivers or fast flowing water bodies"; both are stated in Chapter 8. A design under this Manual also meets any order that applies to its site. |
| Disaster Management Act, 2005; SSDMA, the District Disaster Management Authorities and the District Collectors; the Science and Technology Department as nodal department for GLOF (Notification No. 10/Home/2025 of 07.02.2025); the Sikkim Commission on Glacial Hazards (No. 73/Home/2024 of 11.09.2024) | Continue. GLOF corridors, landslide ground and release reaches are screened under Clause 2.3.6(i) from their maps and inventories where they exist [TBC]; this Manual sets no setback for the cascade and sites its own drainage assets above the October 2023 flood and aggradation level (Chapter 7). No urban-flood standard operating procedure of SSDMA was found [TBC]. |
| Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; the Sikkim State Pollution Control Board (SSPCB) | Continue. Consents for sewage treatment plants and other discharges; Chapter 8 deals with sewage in storm drains and jhoras. |
| Terms of the Sikkim Integrated Urban Development Project (ADB 57230-001) and of GSCDL's drainage and jhora-training works | Apply to those works as their contracts say. No design storm, return period or runoff coefficient was seen in them; where a project's terms govern, the designer states on the submittal which governs (this Manual does not override a contract). |
| IRC:SP:42-2014, IRC:SP:48 (Hill Road Manual) and the practice of the Roads and Bridges Department / PWD, NHIDCL and BRO on hill-road drainage | Apply to road drainage where they do not conflict with Chapter 6; no road drain discharges onto an unprotected slope (Clause 6.3.6(k)). |
| CPHEEO Manual on Storm Water Drainage Systems (2019) | Engineering reference. This Manual sets higher return periods under Clause 1.3.2. |
| NDMA Guidelines on Management of Urban Flooding (2010) and MoHUA SOP (2017) | This Manual puts into effect the NDMA directives on catchment-based design, detention and retention, waterbody protection and climate-adjusted IDF. |
| NDMA Urban Flood Risk Management Programme (UFRMP) and AMRUT 2.0 | Works funded under these programmes shall comply with this Manual. The development controls of Chapters 4–5 protect the capacity those works create. |
| IRC:SP:42-2014 and IRC:SP:50-2013 | Apply to road drainage only where they do not conflict with Chapter 6. |
| MBBL 2016, Chapter 9 | Model for RWH and for the inspection regime in Chapter 10. |

**Commentary.** RWH in Sikkim is framed as a water supply and recharge measure. It works well for that purpose. It cannot, however, be relied on for flood control in the monsoon, because RWH sumps are usually full or the ground saturated by the time a June to September monsoon storm, such as those of 9 June 1997 at Gangtok and 25

September 2005 at Tadong, arrives after weeks of rain. The Manual therefore keeps harvest volume and attenuation volume apart, while letting recharge count as retention where it truly removes water from the system.

Sikkim is building drains and training jhoras, but without a design basis. The Gangtok City Development Plan of 2006 proposed works of ₹2,217 crore, among them "Drainage and Landslip Protection", but "Projects under Drainage, Landslip Protection, Traffic, Street Lighting, Tourism and Environment were not taken up" (CAG, Report No. 3 of 2016, para 2.3.9.2). Gangtok Smart City Development Ltd (GSCDL) has tendered "Construction of drainage and jhora training works" in Gangtok, of about ₹13.41 crore (as reported); the ADB's Sikkim Integrated Urban Development Project includes "Improving about 60 km roads in seven towns with junction improvements, improved pavement and stormwater drains", with infrastructure master plans for four towns other than Gangtok (ADB, 57230-001); and GMC has begun to refurbish the back drainage of MG Marg (as reported). None of the documents found states a design storm or a return period, and no development-control condition stops new plots in the same catchments from using up the capacity such works create. Linking Chapters 4–5 to approvals closes that gap.

The State's law holds some of the tools. The SBCR 1991 require a drain to "main outlet/jhora" before occupation (reg. 13(iii)) and ban spoil in jhoras (reg. 22); the stability zones of 2021 already make a site's buildability depend on whether its jhora is trained and its surface water carried off by catchment drains; the Sikkim Municipalities Act, 2007 makes the municipality protect every jhora in its area (s.172(2)), route rain water to jhoras or storm drains apart from sewage (s.193) and provide outfalls that do not cause "nuisance … by flooding … any area surrounding the outfall" (s.187); and the river bank of the 1988 Act keeps the scheduled rivers' edges under the Forest Department. None of them says how large a drain or a trained jhora must be, how much a site may release, or how far a building must stand from a jhora. This Manual supplies those numbers: the design rainfall of Chapter 2, the on-site controls of Chapter 4, the outfall rules of Chapter 5, the jhora-training standard of Clause 6.3.6(m) and the corridors of Chapter 7. It also adds a step that no Sikkim document takes: storage first. Every litre sent faster down a jhora arrives sooner, with more energy and more debris, on a slope that the 2021 zones already treat as unstable where the jhora is "untrained" or "erosional", and the jhoras end in a Teesta whose bed rose by metres in 2023 and whose valley-floor towns receive everything the ridge towns send.

Rainwater harvesting in Sikkim is a matter of supply, not flood control. The only statutory requirement is for buildings owned or occupied by the State Government and its bodies (Sikkim Municipalities Act, 2007, s.186), in a manner not yet specified as far as found, and a reply in the Rajya Sabha in 2019 listed Sikkim as "NA asked to take up rain water harvesting structure for Government buildings" (as quoted). Where this Manual credits harvested water, it does so as storage and reuse only (Clause 4.4.3), never as detention, because the tanks are full when the season's largest storms arrive.

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## 1.9 Roles and responsibilities

1.9.1 The responsibilities below apply under this Manual. They do not change any agency's statutory powers.

**Table 1.4 — Roles and responsibilities under this Manual**

| Agency | Role under this Manual |
|---|---|
| Urban Development Department (UDD; formerly the Urban Development and Housing Department, UD&HD) | "The nodal department which undertakes planning and development in the notified areas" (State counter-affidavit before the NGT, 2022); issued the SBCR 1991, approves plans in notified areas outside Gangtok with the urban local bodies [TBC], issues the monsoon excavation notices and is the executing agency of the ADB's Sikkim Integrated Urban Development Project (ADB). Could propose the amendment of Clause 1.3.1(a) under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985, design its drainage works to this Manual and give regional support to Tier B authorities (Table 1.1), if the Manual were adopted; once the Sikkim Town and Country Planning Act, 2024 commences, could carry its corridors and facility sites into development plans. |
| State Stormwater Technical Committee (Clause 1.3.2) | Would set the higher standards of Clause 1.3.2, issue Annexes, tables and the compliance calculator, concur with Tier A alternatives, decide variances referred to it and review the Manual (Clause 1.12). |
| Gangtok Municipal Corporation (GMC) | "A statutory body established under the Sikkim Municipalities Act, 2007"; has approved building plans in Gangtok under the SBCR 1991 since 2017 (GMC affidavit before the NGT); holds its drains and the jhoras on public non-forest land in its area and must protect every jhora there (ss.172, 189); lets the "Clearing of Jhoras" to its waste agency (GMC, 2024). Would be Tier A (Clause 1.6.1), review drainage reports, keep the drain and jhora register of Table 1.5 and publish its decisions, if the Manual were adopted. |
| The other urban local bodies: the Namchi Municipal Council and the Nagar Panchayats of Rangpo, Singtam, Mangan, Gyalshing, Nayabazar-Jorethang, Soreng and Pakyong (UDD Notification No. 06/UDD/2026; seven or nine bodies, as the sources differ) | Hold and protect the drains and jhoras of their areas under the Municipalities Act (ss.172, 187, 189, 193). Would be Tier B authorities (Clause 1.6.2) and keep drain and jhora registers, if the Manual were adopted; could act under the Act as Clause 1.3.1 describes. |
| Mines and Geology Department | Prepares the stability map on which building height rests (reg. 17) and notified the zone parameters of 2021, with their jhora and drainage conditions; advised against "any form of physical intervention on the moraine dam" at Shako Chho (State affidavit before the NGT, 2026). Could cite the jhora-training and catchment-drain standards of this Manual in its zone-review conditions. |
| Water Resources Department (WRD; formerly Irrigation and Flood Control) | Builds river and jhora works; nodal authority for the monitoring of NGT OA 673/2018 (Office Order No. 135A/CS/SKM/2022 of 09.12.2022) and monitors river water quality with CWC and SSPCB. Would supply river levels and flood marks for Chapter 5, train jhoras to Clause 6.3.6(m) and concur in works in or on a river. |
| Forest and Environment Department and its River Rejuvenation Committee | Hold the river banks of the 103 scheduled rivers "as if it were a forest" and the slip reserves (1988 Act, s.29); the River Rejuvenation Committee is "the Nodal Agency for all water bodies" (Order No. 205/GOS/F&ED/SECY of 21.01.2021). Would be the competent authority for works on a scheduled river's bank and keep the waterbody records of Chapter 7. |
| Public Health Engineering Department (PHED) | "The concern department for sewage management in the State" (State report before the NGT); runs Gangtok's sewers and treatment plants. Would receive the records of sewage found in storm drains and jhoras under Chapter 8. |
| Rural Management and Development Department (RMDD) | Supervises rural and peri-urban sewage (State report before the NGT) and runs the Dhara Vikas springshed programme (as reported). Would supply spring locations and recharge areas for the spring rule of Chapter 7, and train rural jhoras to this Manual. |
| Roads and Bridges Department / PWD, NHIDCL and BRO | Build and maintain the roads, their side drains and culverts, which in the hill towns are much of the minor drainage system; NH-10 runs along the Teesta. Would apply Chapter 6 to road drainage and never discharge onto an unprotected slope. |
| Gangtok Smart City Development Ltd (GSCDL) | Builds works in Gangtok under the Smart Cities Mission, among them drainage and jhora training (as reported). Would design them to this Manual, if it were adopted. |

| Agency | Role under this Manual |
|---|---|
| SSDMA, the Land Revenue and Disaster Management Department (LR&DMD), the District Collectors and the District Disaster Management Authorities | Prepare for and respond to floods, landslides and GLOFs and report their tolls; ran the GLOF participatory risk assessments of May 2024 and the State mock exercise of 17.11.2025; the PDNA of 2023 was SSDMA's, with NDMA (State affidavit before the NGT, 2026). Would supply the event records, maps and inventories used in the screening of Clause 2.3.6(i) and lead post-event reviews with the Authority (Clause 10.16). |
| Science and Technology Department; the Sikkim Commission on Glacial Hazards; the High-Level Steering Committee and Multi-disciplinary Task Force (Home Department Notifications No. 72/Home/2024 and 73/Home/2024 of 11.09.2024) | The Science and Technology Department is the nodal department for GLOF studies and mitigation (Notification No. 10/Home/2025 of 07.02.2025). Would supply the glacial-lake lists and GLOF hazard maps used in the screening of Clause 2.3.6(i). |
| Sikkim State Pollution Control Board (SSPCB) | Grants consents for sewage treatment plants and other discharges. Would receive the records of Chapter 8. |
| NHPC and the other hydropower operators (Teesta-III once restored, Teesta-V, Teesta-VI, the Teesta Low Dam projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu, Rangit-III) | Operate the dams and their gates. Operators, not approving authorities: would supply reservoir levels, release records and release rules, which were not found [TBC], for Chapter 5 and the screening of Clause 2.3.6(i). |
| Central Water Commission (CWC), a body of the Union | Publishes the Flood Estimation Report for subzone 2(a) used in Chapters 2 and 3 and runs the level sites on the Teesta, the Rangit and the Rongni Chu. Would supply stage records and site sheets for Chapter 5. |
| IMD (Meteorological Centre Gangtok), and road and rail owners | IMD's stations at Gangtok (42299) and Tadong (22209) and the district network of its Gangtok centre supply the rainfall records of Chapter 2; Gangtok is the first data request of Clause 2.3.6(a). Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7). |

**Commentary.** Stormwater in Sikkim is split, first, by land. In the notified areas the SBCR 1991 apply, with UDD and, in Gangtok, the Gangtok Municipal Corporation (GMC) as approving bodies; in the municipal areas the Sikkim Municipalities Act, 2007 makes the urban local body the owner of the public drains and of the jhoras on public land other than forest land, and the protector of every jhora, public or private (s.172); the banks of the 103 scheduled rivers are Forest Department land (1988 Act, s.29(9)); and outside the notified and municipal areas no building rule found applies and no body is named as the owner of a jhora, on forest land or off it (NEER reading). How many urban local bodies there are is itself stated two ways: the State told the NGT on 19.12.2025 that "there are seven Urban Local Bodies (ULBs) in the State", while UDD's Notification No. 06/UDD/2026 of 23.04.2026 lists nine, the Gangtok Municipal Corporation, the Namchi Municipal Council and seven Nagar Panchayats, and UDD's web page lists seven and calls Namchi a "Municipal Corporation"; this Manual uses the 2026 notification's names. The split is then repeated among the bodies that drain the land: UDD, GSCDL and the ADB project build drains; the Roads and Bridges Department / PWD, NHIDCL and BRO build the road drains that are much of the minor system in the hill towns; WRD trains rivers and jhoras; PHED runs the sewers, and septic tanks serve the rest; RMDD works on springs and rural sewage; and the hydropower operators set the river below their dams. No notification divides the drains of any Sikkim town among their owners (NEER reading). Until the State issues such a rule [TBC], this Manual assigns the drainage elements as in Table 1.5, as Chapter 6 does for the drains themselves, and requires each town to keep a **drain and jhora register** giving every reach its owner under this split, its land status (municipal, Forest Department, private or road reserve) and its outfall (set by this Manual). The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers, and on private land it is put into effect by agreement or donation, not by acquisition.

**Table 1.5 — Working assignment of drainage elements under this Manual**

| Element | Assigned to |
|---|---|
| Municipal drains, and jhoras on public land other than forest land within a municipal area | The urban local body (Sikkim Municipalities Act, 2007, ss.172(1) and 189(1)); in Gangtok, GMC |
| Every jhora in a municipal area, public or private, for its protection | The urban local body (s.172(2)) |
| River banks of the 103 scheduled rivers | The Forest Department (1988 Act, s.29(9)) |
| Road drains | The road owner: the Roads and Bridges Department / PWD for State roads; NHIDCL or BRO for national highways (by inference) |
| Jhora training | The executing agency: GSCDL for Smart City works (as reported); WRD for river and jhora works; RMDD in rural areas |
| Sewers and sewage treatment plants; rural and peri-urban sewage | PHED; RMDD |
| Hydropower reservoirs and their gates | The operator (data, not approval) |
| Springs | No statutory owner (RMDD's Dhara Vikas works on them, as reported) |
| Jhoras outside municipal limits or on forest land | No named owner |

This Manual names departments and authorities as the statutes, orders and records name them. A manual that names one owner for each task does not fix institutions by itself, but it removes ambiguity about who signs what.

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## 1.10 Variances and waivers

1.10.1 **Variance.** The Authority may grant a variance from a numeric requirement where the Applicant shows, through a report certified under Clause 10.6, that:

- (a) compliance is impracticable because of site conditions such as a high groundwater table, contaminated soil, rock, or a site area too small for the required facility; and
- (b) the proposed alternative gives equal or better performance at the downstream point of Chapter 5, or the shortfall is made up by fee-in-lieu or off-site works in the same catchment.

1.10.2 **Waiver.** The Authority may waive Chapter 4 detention requirements (not retention) where a hydraulic analysis certified under Clause 10.6 shows that the site discharges directly to the sea, or to a tidal reach with no flood-prone property downstream, and that undetained flow does not worsen the outfall-closed condition of Chapter 5. Sikkim has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to the Teesta, the Rangit or the Rongni Chu at a valley-floor town, to a hydropower reservoir or its release reach, or to any river in flood, is in the outfall-closed condition of Chapter 5 whenever the receiving water is high, and detention is not waived for it; nor is it waived for a site because it drains to a steep jhora, which carries every litre sent to it sooner, with more energy and more debris, to the slopes and the valley-floor towns below.

1.10.3 **No variance or waiver.** No variance or waiver shall be granted for:

- (a) a sewage connection to a storm drain;
- (b) the lowest habitable floor level of Chapter 6;
- (c) any reduction of a waterbody setback below the Zone 1 minimum of Clause 7.4.7, or any fill or construction in the no-fill zone of Chapter 7; or
- (d) the retention requirement in a flood-sensitive catchment, except by fee-in-lieu under Clause 1.7.

1.10.4 **Procedure.**

- (a) The request shall be made on **Form 1-2** (Variance / Waiver Request) with the preliminary drainage report.

- (b) A Tier B authority shall refer any variance on a site of 1 ha or more to the State Stormwater Technical Committee.
- (c) A decision shall state its reasons and any conditions, and shall be entered in the public register of Clause 10.17.
- (d) A variance runs with the approval. It lapses if the approval lapses.

> Commentary. The 2006 APWA 5600 included a waivers section (5601.6), and Georgia allows waivers where downstream analysis shows a peak control is unnecessary. The waiver of Clause 1.10.2 is narrow: on a tidal coast, undetained flow can help by passing through before the tide closes the outfall, but only an analysis can show that. This Manual requires every decision to be published because publication deters case-by-case erosion of the standard; in Sikkim no statute or regulation sets any line along a jhora, the one statutory river line found, the river bank of "sixty metres on either side of such river or area within high flood level mark, whichever is less" (Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, s.29(1)), is a maximum that shrinks to the flood mark on an incised reach, the State's power to "specify the limits of any jhora" in a municipal area (Sikkim Municipalities Act, 2007, s.173) has not been used as far as found, and the stability-zone notification of 2021 asks only that jhoras be trained "with safe distance", undefined (Mines and Geology Department, 2021).

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## 1.11 Transition provisions

1.11.1 **Effective date.** This Manual takes effect for new applications **6 months** after notification (the effective date).

1.11.2 **Applications in process.** An application filed complete before the effective date may be decided under the rules in force when it was filed, if a decision is issued within 12 months of the effective date. Otherwise, this Manual applies.

1.11.3 **Phased start for Tier B.** In Tier B authorities, Chapters 4 and 5 apply from **24 months** after notification, except in flood-sensitive catchments, where they apply from the effective date.

1.11.4 **Public works.** DPRs sanctioned before the effective date may proceed as sanctioned. Any DPR revised or re-tendered after the effective date shall comply. Departments shall report non-compliant works in progress to the State Stormwater Technical Committee within 12 months.

1.11.5 **Before the annexes are issued.** Until an annex referred to in this Manual is issued, the Applicant shall use the method stated in the clause, with values agreed with the Authority and recorded in the drainage report.

> Commentary. The 6-month lead time matches the lead time for NIH-DHAARA updates in Clause 2.14.2. Singapore gave a similar interval for its 2025 detention addendum (issued 16 Apr 2025, applied from 1 Oct 2025). The 12- and 24-month periods are set by this Manual to let Tier B authorities train staff and to let the State issue the design-aid tables (Clause 1.7).

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## 1.12 Review and amendment

1.12.1 The State Stormwater Technical Committee shall review this Manual every **10 years**, and after any event that exceeds the 1% AEP design depth as set out in Clause 2.14.1.

1.12.2 Amendments shall be notified in the Gazette, published with a change log, and take effect 6 months after notification unless the notification states otherwise.

1.12.3 Any person may propose an amendment to the Committee. Proposals and the Committee's decisions shall be published.

## References (chapter)


- Government of Sikkim, Urban Development and Housing Department. Sikkim Building Construction Regulations, 1991, Notification No. 29(202)UD&HD/90/295 of 19 March 1991, as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 (copy hosted by a third party, Sikkim Manipal University). https://smu.edu.in/img/content/dam/manipal/smu/IQAC/SDG/documents/BUILDING%20STANDARDS.pdf
- Government of Sikkim, UD&HD. Sikkim Building Construction (Amendment) Regulations, 2001, No. GOS/UD&HD/6(294)2001 of 16 October 2001 (read in the copy above and as Annexure R/1 to the State's counter-affidavit in NGT OA 5/2022 (EZ)).
- Sikkim Building Construction (Amendment) Regulation, 2022, reportedly published on 12 April 2023 (as summarised by TeamLease; text not read [TBC]). https://teamleaseregtech.com/updates/article/22995/sikkim-building-construction-amendment-regulation-2022/
- Government of Sikkim. Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 (Act 11 of 1985), with Amendment Acts 16 of 2000, 8 of 2001, 6 of 2007 and 24 of 2022. https://prsindia.org/files/bills_acts/acts_states/sikkim/1985/1985SK11.pdf
- Government of Sikkim, Department of Mines and Geology. Notification No. 17/DMG/20-21 of 19.03.2021, site stability zonation parameters (Sikkim Government Gazette Extraordinary No. 86, 06.04.2021), read as Annexure R/2 to the State's counter-affidavit in NGT OA 5/2022 (EZ).
- Government of Sikkim. Sikkim Municipalities Act, 2007 (Act 5 of 2007), with amendments up to Act 3 of 2026. https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf ; Sikkim Municipalities (Amendment) Ordinance, 2026 (Ordinance 5 of 2026), Gazette Extraordinary No. 95, 20.03.2026. https://sikkim.gov.in/uploads//Notifications/Gazette_Num_95_74_20260502.pdf
- Government of Sikkim, Urban Development Department. Notification No. 06/UDD/2026 of 23.04.2026 (the nine urban local bodies). https://sikkim.gov.in/uploads//Notifications/Gazette_Num_158_74_20260502.pdf ; "Urban scenario" web page. https://www.sikkim.gov.in/departments/urban-dev-housing-department/urban-scenario
- Government of Sikkim. Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Act 6 of 1988), as amended by Act 8 of 2000. https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf
- Government of Sikkim. Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024; Gazette Extraordinary No. 317, 15.06.2024), and (Amendment) Act, 2025 (Act 24 of 2025; Gazette Extraordinary No. 13, 17.01.2026); not yet commenced. https://prsindia.org/files/bills_acts/acts_states/sikkim/2024/Act10of2024SK.pdf
- Government of Sikkim. Sikkim Official Languages Act, 1977 (Act 5 of 1977), as amended, with the (Amendment) Act, 2022 (Act 16 of 2022). https://prsindia.org/files/bills_acts/acts_states/sikkim/1977/1977SK5.pdf
- UD&HD Notice No. 613/GOS/JCTP/UD&HD of 01.05.2019 and UDD Notice No. T(1689)/997 of 26.05.2020 (monsoon excavation bans), Annexure R/5 to the State's counter-affidavit in NGT OA 5/2022 (EZ); the 2024 extension (as reported).
- National Green Tribunal (EZ). OA 5/2022, *Dr. Bina Basnett v. State of Sikkim & Ors.*: counter-affidavits of the State (Respondents 1, 4, 7 and 9, 25.02.2022) and of GMC (Respondent 10); OA 38/2022, reply of GSCDL. https://www.greentribunal.gov.in/
- National Green Tribunal (EZ). OA 171/2023, additional affidavit of the State of Sikkim of 28.02.2026, with Home Department Notifications No. 72/Home/2024 and 73/Home/2024, Notification No. 10/Home/2025, the PPR "GLOF Risk Mitigation in Lhonak Valley, Sikkim" and the PDNA summary. https://www.greentribunal.gov.in/
- National Green Tribunal (PB). OA 673/2018, EA 35/2023: affidavit of the State of Sikkim of 19.12.2025, with the monthly progress report of September 2025, and the State's compliance report; OA 606/2018, six-monthly report of the State after the order of 04.07.2024. https://www.greentribunal.gov.in/
- High Court of Sikkim. WP(PIL) 4/2017, *In re: Release of water from Dikchu Hydelpower Project*, judgment of 01.03.2021; WP(PIL) 3/2023, *Mani Kumar Subba v. State of Sikkim*, judgment of 07.12.2023; WP(PIL) 1/2024, judgment of 15.05.2025. https://hcs.gov.in/
- High Court of Sikkim. WP(PIL) 11/2026, *In re Climate Justice in State of Sikkim* (as reported, LiveLaw, 17.09.2026 and November 2026; orders not read [TBC]).
- Comptroller and Auditor General of India. Report No. 3 of 2016 (Economic Sector, Government of Sikkim), Chapter II, Performance Audit of JNNURM. https://www.cag.gov.in/

- Turner, R.L. (1931). *A Comparative and Etymological Dictionary of the Nepali Language* (pp. 237, 328, 391), via the Digital South Asia Library. https://dsal.uchicago.edu/dictionaries/turner/
- MoHUA / CPHEEO (2019). Manual on Storm Water Drainage Systems, Part A, §4.4.1.4 (Table 4.1 and notes).
- Kakkar, R. (CPHEEO) (2023). Understanding Urban Stormwater Management. CSE, Aug 2023.
- National Disaster Management Authority (2010). National Guidelines on Management of Urban Flooding.
- MoHUA (2016). Model Building Bye-Laws, Chapter 9.
- Lok Sabha Unstarred Question 1847, 30 Jul 2026 (MoHUA). https://sansad.in/getFile/lsapps/loksabhaquestions/annex/188/AU1847_x29brZ.pdf
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*. doi:10.1126/science.ads2659 (accepted manuscript).
- Sikkim State Disaster Management Authority with NDMA. Post Disaster Needs Assessment, Teesta flood of October 2023 (summary, field assessment 7–11 December 2023), Annexure R-6 to the State's affidavit in NGT OA 171/2023 (EZ), 28.02.2026.
- India Meteorological Department. Extremes of Temperature and Rainfall for Indian Stations (up to 2012): Gangtok (42299) and Tadong (22209). https://imdpune.gov.in/library/public/EXTREMES%20OF%20TEMPERATURE%20and%20RAINFALL%20upto%202012.pdf
- Press and secondary reports of the floods and landslides of October 1968, June 1997, September 2011, 2017 (Dikchu), October 2023 (the cause and the toll), June 2024 (Mangan), May–June 2025 (Chaten) and July 2025 (NH-10), and of the NDSA committee of 2024 (ThePrint, 01.10.2024) (secondary sources).
- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01.
- Mid-America Regional Council (2025). APWA 5600 Manual Factsheet; APWA Stormwater Standards Supplement (7 Nov 2025). https://www.marc.org/document/apwa-stormwater-standards-supplement
- Mid-America Regional Council. The Evolution of Regional Stormwater Design Standards (presentation). https://www.marc2.org/Assets/Environment/WQEC/The_Evolution_of_Regional_Strormwater_Design_Standards.pdf
- Kansas City Metro Chapter APWA (2006). Section 5600, §5601.6 Waivers.
- PUB Singapore (2018, with Addendum No. 3 of 16 Apr 2025). Code of Practice on Surface Water Drainage, 7th ed.
- Department of Irrigation and Drainage Malaysia (2008). Submission Checklist for Stormwater Management.
- Centre for Science and Environment (2023). Urban Stormwater Management (presentation).
- Asian Development Bank. Sikkim Integrated Urban Development Project (57230-001): Resettlement and Indigenous Peoples due-diligence report, Soreng sewerage (draft, December 2024, prepared by UDD). https://www.adb.org/sites/default/files/project-documents/57230/57230-001-sddr-en.pdf
- Gangtok City Development Plan (2006), as cited by CAG (Report No. 3 of 2016, para 2.3.9.2).
- Urban Development Department. Request for Proposal for a GIS-based Master Plan for the Namchi Planning Area (as listed on the Department's page); Sikkim Strategic Plan (2008) ("Long-Term Strategies: 2040"; as reported, not read [TBC]).
- Gangtok Smart City Development Ltd. Tenders for "Construction of drainage and jhora training works" (as reported; documents not read [TBC]).


## Annexes and forms

| Annex / Form | Content |
|---|---|
| 1A | List of Tier A authorities, with the boundary of the Gangtok Municipal Corporation and, once a development plan is published under the Sikkim Town and Country Planning Act, 2024 (not yet commenced), the boundary of its planning area |
| 1B | Maps of flood-sensitive catchments |
| 1C | Policy Supplement: text of alternatives S-1 to S-5 and model council resolution |

| Annex / Form | Content |
|---|---|
| 1D | Model SBCR 1991 amendment and model ULB bye-law |
| Form 1-1 | Applicability Determination |
| Form 1-2 | Variance / Waiver Request |

CHAPTER 2

# Design Rainfall and Design Storms

## 2.1 Purpose and scope

2.1.1 This chapter sets the rainfall inputs for every hydrologic calculation in this Manual: drain and inlet sizing (Chapter 6), retention and detention sizing (Chapter 4), downstream and tailwater analysis (Chapter 5), and waterbody and tank works (Chapter 7).

2.1.2 It specifies:

- (a) the approved sources of design rainfall depth and intensity;
- (b) how depths are converted between durations, between point and area, and from present to future climate;
- (c) how design storms (hyetographs) are constructed; and
- (d) the storms that must be applied to pre- and post-development conditions.

2.1.3 This chapter applies throughout Sikkim. Where the Gangtok Municipal Corporation, another urban local body or UDD in a notified area has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Sikkim trace to the rainfall input, not the hydraulics. Sikkim shows how. No design storm, return period or runoff coefficient was found for the drains or the trained jhoras (झोरा; natural watercourses or ravine streams) of any town in the State: the drainage works of the Gangtok City Development Plan of 2006 "were not taken up" (CAG), and the drainage and jhora-training works of GSCDL and the stormwater drains of the ADB's project in seven towns state no design storm that was seen (as reported; ADB). The published sources that seem to fill the gap do not. The CWC report for subzone 2(a) covers the whole State, but its plates draw no contour north of Gangtok, and they lie below the State's own records: Gangtok recorded 310.3 mm on 30 May 1975 (IMD), above its 50-year plate value, and Singhik 504.2 mm on 12 May 1981, about twice what the plate implies there (CWC, 2(a)). NIH-DHAARA is lower still, 195 mm at Gangtok and 121–183 mm in the north at 50 years. IMD Das et al. (2022) has no Sikkim panel. The only Gangtok IDF in print was built by disaggregating daily rainfall and gives a July "peak intensity" of 259.785 mm/h (Wangsu et al., 2022, abstract), and a national fallback quoted in Parliament, "12 to 20 mm/hr" (as quoted), is far below any of these (Clause 2.3.6). Fixing one transparent source and method for the whole state is the main purpose of this chapter.

## 2.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Annual exceedance probability (AEP) | Probability that a given rainfall depth is equalled or exceeded in any one year. A 1% AEP storm is the "100-year" storm. Both forms are used here: T-year = 1/AEP. |
| IDF / DDF | Intensity–duration–frequency and depth–duration–frequency relationships for a location. |

| Term | Meaning in this Manual |
|---|---|
| Point rainfall | Rainfall at a single location, as measured by a rain gauge. |
| Design storm | A hyetograph (rainfall depth versus time) of stated AEP, duration and temporal pattern. |
| Critical duration | The storm duration that produces the largest peak flow, water level or storage requirement for the element being designed. |
| Areal reduction factor (ARF) | Ratio of catchment-average rainfall to point rainfall for the same AEP and duration. |
| Monsoon season (as used in this Manual) | 1 April to 31 October. In this Manual "the monsoon" and "the monsoon season" mean this wet season, which takes in the pre-monsoon storms of April and May as well as the south-west monsoon; it is the Manual's season, not IMD's, and IMD's south-west monsoon does not begin in April. IMD's normal dates of onset and withdrawal of the south-west monsoon in Sikkim were not found for this Manual [TBC], and none is given here. The season begins on 1 April for four reasons. Gangtok's wet season starts in April: its normals are 126.4 mm in March, 296.9 mm in April on 15.2 rainy days, with 10.7 thunder days, 496.4 mm in May on 20.1 rainy days, 609.8 mm in June, 626.3 mm in July, 565.9 mm in August, 438.7 mm in September and 173.4 mm in October, of an annual 3,490.4 mm on 161 rainy days (IMD, Gangtok, 1981–2010), so that March to May bring about 26% of the year (NEER sum); its highest April total is 687.8 mm (1974) and its highest May total 951.7 mm (1996) (IMD, *Extremes*). The largest 24-hour falls are pre-monsoon: Gangtok's record, 310.3 mm, fell on 30 May 1975 (IMD, *Extremes*, 1958–2012), and Singhik's, 504.2 mm, on 12 May 1981 (CWC, 2(a), Table 7); Gangtok's other large days fall in early June (223.8 mm, 9 June 1997) and at the turn of September and October (201.0 mm, 3 October 1996), and Tadong's on 25 September 2005 (212.5 mm) (IMD, *Extremes*). The State already treats May onwards as the season for earthworks: its notices ban "construction involving earth excavation" each monsoon (6 May–30 September 2019; 1 June–30 September 2020), the ban of 2024 ran from 1 May and was extended by 15 days (as reported), and the State told the NGT that the monsoon "starts around the month of May or June and continues till September" (State counter-affidavit, 2022). And the CWC report for the subzone says that "The south-west monsoon and cyclonic storm causes the rainfall in the subzone from May to October" (CWC, 2(a), p. 29). Drainage work must therefore be finished before May at the latest, and the April storms argue for the deadline of 31 March (Chapter 10), the date that NDMA (2010) sets for pre-monsoon desilting and that the other North-East editions of this series use. High North Sikkim (sub-area SK-C) has seasonal snow, and Gangtok has occasional snow (its lowest temperature, −2.2 °C, was recorded in January 1956; IMD); no snow-day statistics were collected [TBC], and Chapter 10 keeps a snow regime for the works above about 2,500 m. The antecedent moisture rule of Clause 2.11.4 and the standby period of Chapter 10 refer to this season. |
| Storms outside the season | Large falls come before and after the season. Gangtok's highest days outside it are 72.0 mm in March (27 March 2008), 96.0 mm in November (11 November 1995) and 63.3 mm in January (6 January 1958), and Tadong's 87.7 mm in March (21 March 2004) (IMD, *Extremes*). Within the season, the storms of October have been among the worst: the storm of 2–5 October 1968 over the Darjeeling and Sikkim hills (as reported; Kalimpong 419.2 mm on 5 October, IMD), Gangtok's 201.0 mm of 3 October 1996 and the outburst flood of 3–4 October 2023. Design statistics use annual maxima from all months, no works deadline or operating rule shall assume that heavy rain is confined to June–September, and the works calendar of Chapter 10 keeps a mid-season clearance by 30 April, standby to 31 October and a post-season clearance by 15 November for this reason. |
| Climate factor (CF) | Multiplier applied to present-day design depths to represent the design-life climate. |
| Approved source | A rainfall source listed in Clause 2.3. |

## 2.3 Approved sources of design rainfall

2.3.1 **Primary source.** Design rainfall depths and intensities shall be taken from the National Institute of Hydrology, Roorkee **NIH-DHAARA** platform (Design Hydrology and Advanced Rainfall Analysis, nihdhaara.in). Use its IDF / frequency tools for the site's coordinates, for each duration and AEP required by Clause 2.4. In Sikkim this clause is suspended until Annex 2A is published: Clause 2.3.6 sets the interim source, and NIH-DHAARA enters it only as Clause 2.3.6(d), (e), (f) and (m) say, as a shape and for comparison, never as a depth.

2.3.2 **Station IDF.** A station-specific IDF relationship may be used in place of 2.3.1 only if all of the following hold:

- (a) it is derived from at least 30 years of recording-gauge (hourly or finer) data;
- (b) it has been published or approved by IMD, the State Hydrology Authority or the approving authority; and
- (c) the gauge is within 10 km of the site, with no major change of terrain or coastal exposure in between.

Where a station IDF is used, the design value shall be the **greater** of the station value and the NIH-DHAARA value.

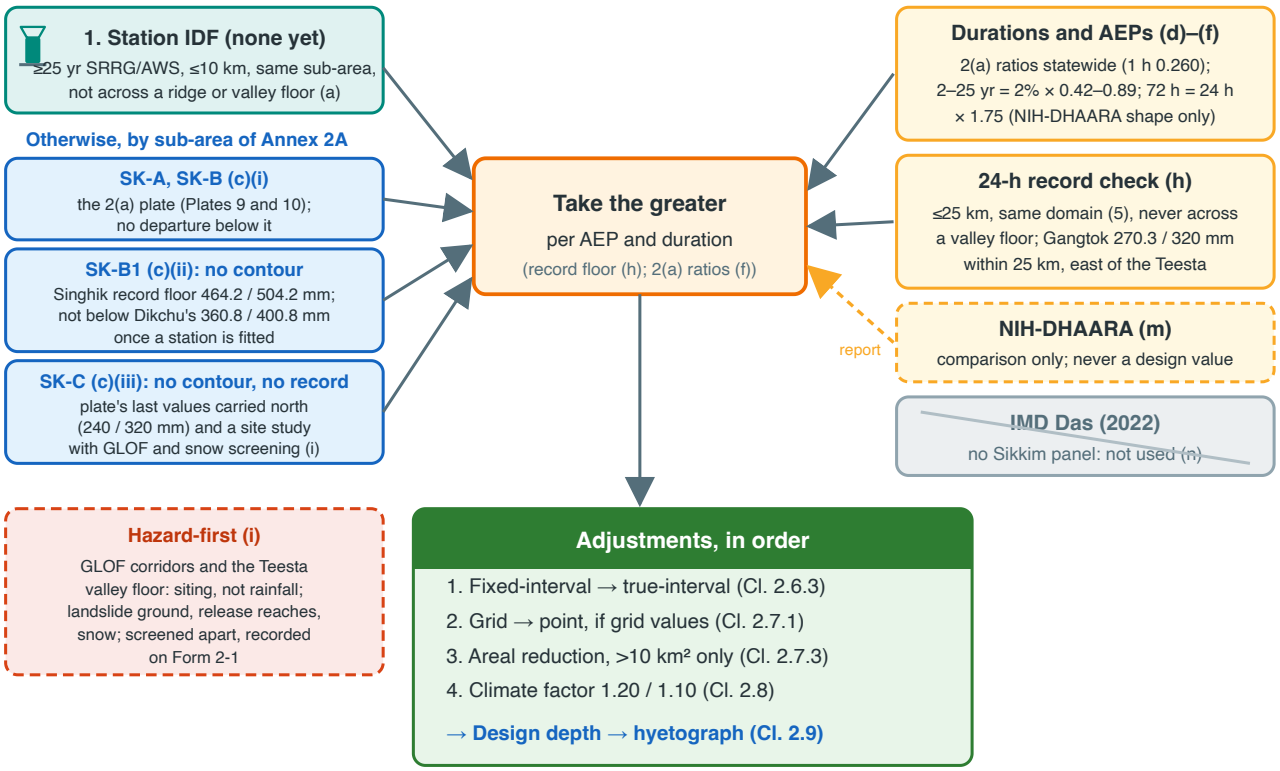
2.3.3 **Cross-checks (mandatory, not alternatives).** The designer shall report, but need not adopt, the following values for comparison:

- (a) the IMD isopluvial / IDF values of Das et al. (2022), *MAUSAM* 73(4), for durations of 1–24 h;
- (b) for catchments of 25–5,000 km², the 24-hour point rainfall from the CWC Flood Estimation Report for subzone 2(a) (North Brahmaputra), which covers the whole State but whose isopluvial plates draw no contour north of Gangtok, so that in sub-areas SK-B1 and SK-C no CWC point rainfall exists for the cross-check of Clause 2.3.3(b) and the depths of Clause 2.3.6(c)(ii) and (c)(iii) apply instead; its unit hydrograph is not applied to a catchment with permanent snow, a glacier or a mapped glacial lake, or to the Teesta trunk, which need a site-specific study (Clause 2.3.6(i); Annex 3E), as applicable.

Where the design value is lower than the CWC subzone 2(a) (North Brahmaputra) plate (in sub-areas SK-A and SK-B; north of the plates' last contour, in sub-areas SK-B1 and SK-C, the plate gives no value and the depths of Clause 2.3.6(c)(ii) and (c)(iii) apply instead) value for the same AEP, the CWC value shall be adopted as a floor.

2.3.4 **Not permitted.** None of the following shall be used as a design rainfall source:

- (a) generalised all-India IDF formulae (for example Kothyari & Garde, 1992);
- (b) rainfall values that cite no source, including vendor or web-calculator tables;
- (c) single-event maxima; or
- (d) design intensities carried forward from a previous project without a stated AEP.




Sikkim (Cl. 2.3.6): no station IDF yet; 2(a) plates in SK-A and SK-B; record floors in SK-B1; plate's last values in SK-C; zone- and ridge-bounded record check; GLOF corridors and the Teesta valley floor screened apart from rainfall design.

*Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.*

2.3.5 **Version control.** Every submittal shall record the source, its version or access date, the coordinates queried, and the values extracted (Clause 2.13).

2.3.6 **Interim source in Sikkim.** Until Annex 2A is published and confirms NIH-DHAARA, or an approved station IDF, for a zone, Clause 2.3.1 does not apply in Sikkim, and design rainfall shall be taken as follows:

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station and in the same sub-area of Annex 2A, for the durations and AEPs it covers, in place of (f), and subject to (c)(ii), (g) and (h); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e) and (h). A record is checked when its annual totals and annual maxima have been compared with the IMD normals and station extremes for the station, and every year that disagrees has been explained or removed. An IDF derived from daily data by the one-third rule (Clause 2.6.4) or by any other fixed ratio is not a station IDF. In Sikkim Clause 2.3.2(a) is read with 25 years in place of 30, as in the mountain editions of this series, and the gauge shall not be separated from the site by a ridge or by the valley floor of the Teesta or the Rangit (set by this Manual, because the State's rain changes over a few kilometres: on 25 September 2005 Tadong recorded 212.5 mm and Gangtok 141.0 mm, about 4–5 km apart and about 300 m apart in height (IMD, *Extremes*; distance and height a NEER reading)). No IDF has yet been published in Annex 2B, and no published design criterion, IDF with constants or recording-gauge ratio was found for any station or town in the State. The only Gangtok "IDF" found, for the Ranikhola watershed (Wangsu, Isaac and Tirkey, 2022), was built by disaggregating daily rainfall and reports a July "peak intensity" of 259.785 mm/h (as given in its abstract); it is not a station IDF and is not used: it is cited only to show that no gauge-based IDF exists for Gangtok. The first data requests of this Manual are, by station: (1) **Gangtok (IMD 42299)**, the Meteorological Office at 27°20' N, 88°38' E and 1,765 m (IMD), its daily annual maxima for 1958–2026 and its recording-gauge and automatic weather station maxima for 15 minutes to 72 hours; (2) **Tadong (IMD 22209)**, its series of 1978–2007 and after; (3) **Singhik and Dikchu**, the two Sikkim ordinary rain gauges of the CWC 2(a) report, their record lengths and the series behind 504.2 mm and 400.8 mm (c)(ii); then the gauges at Mangan and Chungthang and the hydro-meteorological gauges of the hydropower projects (Teesta-V, Dikchu, Chuzachen); (4) the hourly series of the **Lachen automatic weather station**, used by Sattar et al. (2025), and the India-WRIS stations, among them Lachen; (5) the district network of the Meteorological Centre Gangtok (Namchi, Gyalshing, Pakyong airport, Soreng), whose types and record lengths are to be confirmed; and (6) IMD's extremes for 2013–2026 at Gangtok and Tadong [TBC].

- (b) **Reports, zones and sub-areas.** One CWC report covers the whole State: the **Flood Estimation Report for North Brahmaputra Subzone 2(a)**, Design Office Report No. NB/18/1991, placed before the Flood Estimation Planning and Co-ordination Committee at its 49th meeting on 24–25 October 1990 (CWC, 2(a)). Its text names "Gangtok the capital of Sikkim" first among the subzone's important towns (p. 28), says that the subzone covers "mainly parts of Assam, and small portion of Sikkim, Arunachal Pradesh and West Bengal" (p. 8), and lists the "Tista" among its rivers with a catchment of 10,616.74 km² (p. 29); its plates are "Isopluvials supplied by I.M.D." (title block). There is no separate report for the Teesta or for Sikkim, and no other subzone lies over the State (NEER reading). The 2(a) plates (Plates 8–10) draw Sikkim, the Tista and a dot for Gangtok, but **north of Gangtok they draw no contour**: Mangan, Chungthang, Lachen and Lachung lie east of a single curve along the north-western edge, labelled 180, 200 and 240 mm on Plates 8, 9 and 10, and read "180–200", "200–240" and ">240" mm only by implication (CWC, 2(a), Plates 8–10; NEER reading). Where the core refers to the CWC report north of that contour, in sub-areas SK-B1 and SK-C, the substitutes are (set by this Manual): for the 24-hour depths, (c)(ii) and (c)(iii); for areal reduction (Clause 2.7.3) and for rural rivers of 25–2,500 km², the ARF curves and unit hydrograph of the 2(a) report, the only published method, with the cautions of Chapter 3; and for the cross-check of Clause 2.3.3(b), none, because no CWC value exists there. The rainfall zone and sub-area of the site are those of Annex 2A: zone **SK-Z1 Southern hills and valleys**, with sub-areas **SK-A Lower valleys (Rangpo–Singtam–Melli–Jorethang)** and **SK-B Ridge towns (Gangtok–Pakyong–Namchi–Gyalshing)**; and zone **SK-Z2 North Sikkim**, with sub-areas **SK-B1 Middle Teesta valley (Dikchu–Mangan–Singhik–Chungthang)** and **SK-C High valleys (Lachen–Lachung–Thangu)**. Both zones lie in subzone 2(a); SK-Z1 is contoured on the plates and SK-Z2 is not. They fix the

source of (c), the bounds of the check of (h) and the screening of (i). A catchment that crosses the line between two zones or two sub-areas of Annex 2A takes, at every duration, the higher value of the two (set by this Manual). The town lists of Annex 2A are a guide; their boundaries follow the ridges, the altitude bands of about 1,000 m and 2,500 m and the plates' last contour, and are to be confirmed [TBC].

- (c) **24-hour depth, 2% and 1% AEP (50- and 100-yr).** By sub-area (all set by this Manual):
    - (i) **SK-A and SK-B: the 2(a) plates.** The 24-hour point value at the site read from the 50- and 100-year isopluvial plates of the 2(a) report (Plates 9 and 10), whatever the catchment area. Where the site lies between two contours, the higher contour value is used; where it lies inside a closed contour with no higher contour within it, the value is that contour plus one contour interval; where it lies on a contour, the higher of the two contours either side is used; and where the Plate 10 reading does not exceed the Plate 9 reading, the 1% AEP depth is the 2% AEP depth plus one contour interval, 40 mm. A site is on a contour when the line passes within about 1 km of it, about the placing error of town markers on these plates. The last two rules are those of another North-East hill edition of this series, set here because the plates were drawn by hand from few Sikkim gauges (two Sikkim stations appear in the report's Table 7; its 82 State ordinary rain gauges in four States are not listed one by one (CWC, 2(a), p. 40)), and because the gradient is steep, about 80–120 mm in 25 km at 50 years from Gangtok south to Melli (NEER reading). The contours over Sikkim are, on Plate 9, 200 mm (the north-western curve), 240 mm (south of Gangtok), 280, 320 and 360 mm (through Darjiling) and 400–480 mm towards the Duars front; on Plate 10, 240 mm (the north-western curve), 320 mm south of Gangtok, with no 280 mm line drawn, and 360, 400, 440 and 480 mm. Plates are read by the coordinates of the site, not by the town labels, and each reading is recorded on Form 2-1 with the contours on either side. For orientation only, read by eye to about one contour (low confidence; NEER reading of the plates, with town markers placed from the printed Gangtok and Darjiling dots), the readings at 2% / 1% AEP are: **Gangtok, with Tadong and Ranipool, 240 / 320 mm**, well north of the 240 mm and 320 mm lines; **Pakyong 240 / 320 mm**, about 2–4 km north of them; **Singtam 280 / 360 mm**, on the 240 mm and 320 mm lines; **Rangpo 280 / 360 mm**; **Ravangla 280 / 320 mm**, on the 240 mm line of Plate 9 and just north of the 320 mm line of Plate 10; **Gyalshing 280 / 360 mm**; **Namchi 320 / 400 mm**; **Jorethang 360 / 400 mm**; and **Melli 360 / 440 mm**, on the 320 mm and 400 mm lines. Soreng, near the west frame of the plates, was not read; until it is, it takes the higher of the Gyalshing and Namchi readings, 320 / 400 mm [TBC]. The Plate 10 reading exceeds the Plate 9 reading at every town read, so the last rule binds nowhere at present. Where the Gumbel estimate of (d) for the station of the site is higher for the same AEP, it governs; the 24-hour depth is then checked under (h).
        - **The plate governs wherever it draws contours; no departure below it is made.** In the south NIH-DHAARA agrees with the plates: its 50-year 24-hour depths are 284 mm in the Namchi and Jorethang cell and 282 mm at Rangpo, against plate readings of 280–360 mm (m). At Gangtok it lies below them, at 195 mm, and the station's own record, 310.3 mm (h), lies above the 50-year plate value.
    - (ii) **SK-B1: no contour, so the north's own records set the floor.** In sub-area SK-B1 the 24-hour depth shall be **not less than 464.2 mm at 2% AEP and 504.2 mm at 1% AEP**: the highest daily fall at Singhik, 504.2 mm on 12 May 1981 (CWC, 2(a), Table 7, checked on the page image), and that fall less one contour interval of the plates, 40 mm. When a station fit under (a) and (d) of at least 25 years of an IMD, CWC or India-WRIS gauge in SK-B1 is made, the fit governs, **but not below 360.8 mm at 2% AEP and 400.8 mm at 1% AEP**, the highest daily fall at Dikchu, 400.8 mm on 25 August 1969 (CWC, 2(a), Table 7), less one interval and as recorded, until Annex 2A is published. The reasons are these. The plate gives no value in SK-B1, and the 200–240 mm it implies at 50 years is about half the Singhik record, which the Dikchu record exceeds by 1.7 to 2 times (NEER arithmetic). NIH-DHAARA is lower still, 183 mm at 50 years in the Mangan cell and 154 mm in the Chungthang cell, and its reanalysis grid cannot resolve the orographic cells on the valley sides (m). Two independent gauges in the same valley recorded 400.8 mm and 504.2 mm, and Gangtok, about 20–25 km to the south (NEER distance), recorded 310.3 mm in 55 years of IMD record (h). An adjoining North-East hill edition set its plateau capital's floor in the same way, from the highest fall printed in a CWC report annex, where its plate could not be used. Both Table 7 values fail the record-check tests of (h), because their record lengths are not confirmed by an IMD table, so they enter here as a stated floor

and not through (h). **The floor is probably high as a 1% AEP depth: 504.2 mm is a single-day maximum at one ordinary gauge of unknown record length, and the series of Singhik, Dikchu, Mangan and Chungthang are the first data request of (a).** The plate's implied values and the NIH-DHAARA value of the site's cell are recorded on Form 2-1 beside the design depth.

    - (iii) **SK-C: no contour and no record, so the plate's last values are carried north.** In sub-area SK-C the 24-hour depth shall be **not less than 240 mm at 2% AEP and 320 mm at 1% AEP**, the Plate 9 and Plate 10 readings at Gangtok, the northernmost town that the plates contour. NIH-DHAARA's 50-year cells, 138 mm at Lachen, 121 mm at Lachung and 154 mm at Chungthang, and the plate's implied 200–240 mm are not used: no gauge checks them, and in SK-B1, the one area where the plate and NIH-DHAARA can be set against records at altitude, both lie far below the records. **The Singhik and Dikchu floors of (c)(ii) do not reach SK-C**, which is a different domain of (h), higher and behind the ridges above Chungthang, with no record of its own. Every cross-drainage structure and outfall in SK-C with a catchment of more than 1 km² has the site-specific study of (i).

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr).** The depth is the Gumbel (EV1) estimate from the annual maximum daily rainfall series, of all months, of the IMD station agreed with the Authority, with 30 or more years of daily record, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3. The station is Gangtok (42299), for sites within 25 km of it in SK-B east of the Teesta; no IMD daily series long enough was found for any other part of the State, and Gangtok's has not been obtained [TBC]. Until it is (set by this Manual), in every sub-area the 50%, 20%, 10% and 4% AEP depths are the 2% AEP depth of (c), after the check of (h), multiplied by **0.42, 0.61, 0.73 and 0.89**, and the 4% AEP depth is not less than the 25-year plate value (Plate 8) read as in (c)(i) where the plate draws one. The factors are the upper envelope, rounded up to 0.01, of the growth curves of the twelve NIH-DHAARA cells queried in the State for this Manual (the 24-hour depth at each AEP divided by the 50-year depth: 0.392–0.419, 0.587–0.605, 0.716–0.729 and 0.879–0.884; the cells agree within 0.03) (NIH-DHAARA, queried 14 Nov 2026; NEER arithmetic): they take the platform's shape, not its values, and they are the factors of another North-East hill edition of this series. At Gangtok, on 270.3 mm after (h), they give about 114, 165, 197 and 241 mm; Gangtok lies north of the 200 mm line of Plate 8, so the plate check does not bind. The Plate 8 readings are about 200 mm at Gangtok, 240 mm at Pakyong, Singtam, Rangpo, Ravangla (on the 200 mm line) and Gyalshing, 280 mm at Namchi and Soreng, and 320 mm at Jorethang and Melli (NEER reading), and the factor gives more at every one. In SK-B1, on the floor of 464.2 mm, the factors give about 195, 283, 339 and 413 mm: these follow the floor and are as uncertain as it is. In SK-C, on 240 mm, they give about 101, 146, 175 and 214 mm. A day of record excluded under (h) is left out of a station series, and the fit with it is reported beside the fit without it on Form 2-1.

- (e) **48- and 72-hour depths.** The Gumbel estimate from the annual maximum 2-day and 3-day rainfall series of the same IMD station, with the fixed-interval factors of Clause 2.6.3, once obtained [TBC], and not less than the 24-hour depth for the same AEP as checked under (h). Until then (set by this Manual), in every sub-area the 72-hour depth is the 24-hour depth after the check of (h) multiplied by **1.75**, and the 48-hour depth is interpolated between the 24- and 72-hour depths on logarithmic axes. The factor is the upper envelope, rounded up to 0.05, of the 50-year 72-hour to 24-hour ratios of the twelve NIH-DHAARA cells: Pakyong 1.736, Rangpo 1.721, Lachen 1.721, Mangan 1.702, Singtam 1.698, Gangtok 1.684, Namchi 1.662, Soreng 1.662, Ravangla 1.643, Chungthang 1.629, Gyalshing 1.617 and Lachung 1.609; their 48-hour to 24-hour ratios are 1.337–1.426 (NIH-DHAARA, queried 14 Nov 2026; NEER arithmetic). The multi-day volume matters in Sikkim because its slopes, jhoras and reservoirs respond to weeks of rain: Gangtok's wettest months on record are June 1997, with 1,281.3 mm, and May 1996, with 951.7 mm (IMD, *Extremes*); about 250 mm fell over the State in 1–13 June 2024 (as reported); and the storm of 2–5 October 1968 is reported to have brought "1,000 mm of rainfall in 52 hours" over the Darjeeling and Sikkim hills, a figure attributed to a scientist in the press and not a gauge value (as reported; unverified).

- (f) **Durations of 1 to 24 hours.** The 24-hour depth of (c) or (d), after the check of (h), multiplied at every AEP, in every sub-area, by the ratios of the CWC report for subzone 2(a), North Brahmaputra: **0.260 at 1 hour, 0.37 at 2 hours, 0.457 at 3 hours, 0.615 at 6 hours, 0.720 at 9 hours, 0.805 at 12 hours, 0.875 at 15 hours and 0.930 at 18 hours** (set by this Manual). The report derived them by frequency analysis of the hourly data of 12 self-recording rain gauges of IMD in the subzone and printed them for the 50-year depth (CWC, NB/18/1991, §3.1.2, p. 24); its

Fig. 10 gives the 2-hour value, which logarithmic interpolation between 1 and 3 hours reproduces. None of the 12 gauges was identified in Sikkim (NEER reading). The set is used in every sub-area for three reasons. It is the only published ratio set for the subzone. It is the set that the West Bengal edition uses in the Darjeeling–Kalimpong hills across the Rangit and the Teesta, and the set that an adjoining North-East hill edition uses on its plateau, so that one storm reads alike on both sides of a border. And it lies above every Sikkim NIH-DHAARA cell at every duration: the cells' maxima are 0.190 at 1 hour and 0.310 at 2 hours (Pakyong), about 0.40 at 3 hours and about 0.58 at 6 hours (interpolated on logarithmic axes), 0.709 at 9 hours, 0.778 at 12 hours, about 0.84 at 15 hours and 0.898 at 18 hours (NIH-DHAARA; NEER arithmetic), so the series' envelope rule returns the 2(a) set itself. The NIH-DHAARA ratios, 0.13–0.19 at 1 hour, are not used: no Sikkim recording gauge exists to decide between them and the 2(a) set; the reanalysis grid, of about 0.12°, cannot resolve convective pre-monsoon bursts; and Gangtok's thunder days peak in April and May, 10.7 and 8.7 days a month (IMD, 1981–2010), the months in which its record and Singhik's fell. On Gangtok's 270.3 mm and 320 mm the set gives about 70 mm and 83 mm in 1 hour at 2% and 1% AEP, against 32 mm and 36 mm in NIH-DHAARA's Gangtok cell; on the floors of SK-B1 it gives about 121 mm and 131 mm. These are probably high, the conservative margin that the North-East hill editions accepted while no gauge exists, and they are why the Lachen automatic weather station and the Singhik series are priorities of (a). Between the tabulated durations the ratio is interpolated on logarithmic axes. No recording-gauge or automatic weather station ratio for any Sikkim station was found [TBC].

- (g) **Short storms.** No absolute floor in millimetres is set for any sub-area of the State, as in the other North-East hill editions of this series, because no Sikkim recording-gauge maximum exists to base one on: no sub-daily record for any Sikkim station was found, and the hourly values of the Lachen automatic weather station were not tabulated in the work that used them (Sattar et al., 2025). Where a station fit later replaces (f), its 1-hour ratio for every AEP shall be not less than 0.26 until Annex 2B is published (set by this Manual). The depths of (f) are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to plate or table products, which are already 24-hour sliding values, and the climate factor of Clause 2.8 is applied to them.

- (h) **24-hour record check, bounded by domain.** The 1% AEP (100-yr) 24-hour depth of (c) or (d) shall be not less than the highest qualifying 24-hour rainfall recorded at any station within 25 km of the site, **in the same domain and not separated from the site by the valley floor of the Teesta or the Rangit**, where that record is higher; the record is used as printed, without the fixed-interval factor, and is treated as a 1% AEP depth; and the 2% AEP (50-yr) 24-hour depth is then not less than the record less one contour interval of the plates, 40 mm (all set by this Manual, in the form of the Assam edition). The domains are five: SK-A; SK-B east of the Teesta (Gangtok, Tadong, Ranipool, Pakyong); SK-B west of the Teesta (Namchi, Ravangla, Gyalshing, Pelling, Soreng); SK-B1; and SK-C. A record never crosses the Teesta or the Rangit between two ridges and never passes from one sub-area to another. A record qualifies only when it is printed by IMD (in *Extremes of Temperature and Rainfall for Indian Stations*, a climatological summary, a monthly or seasonal climate summary, a later IMD table or an IMD press release that names the gauge and the day); the number of years of data at its gauge is confirmed by an IMD table as at least 20; it was made in 1901 or later; it falls in a month in which a fall of that size is plausible for the station; the location of its gauge is known; and it is not contradicted by another IMD table for the same gauge. A value printed only in a CWC report annex, such as Table 7 of the 2(a) report, is a flag that does not qualify until IMD confirms the gauge's record length, as in the Assam edition and the other North-East hill editions (set by this Manual). The outcomes at present are:

    - **Gangtok (42299), 310.3 mm on 30 May 1975** (IMD, *Extremes*, rainfall data 1958–2012), qualifies: it is the station's highest day in IMD's monthly and seasonal tables for the station, and May is a plausible month. **It sets the 2% AEP 24-hour depth at not less than 270.3 mm, and the 1% AEP depth at not less than 310.3 mm, within 25 km of the gauge in SK-B east of the Teesta**: Gangtok with Tadong and Ranipool, and Pakyong, about 11 km away (NEER distance from approximate town positions). The plate's 320 mm already exceeds 310.3 mm, so **the Gangtok values are 270.3 mm at 2% AEP and 320 mm at 1% AEP**. The record does not reach Ravangla, about 25 km away across the Teesta, Singtam or Rangpo, which lie in SK-A and whose plate values are higher in any case, or Dikchu and Mangan, in SK-B1.

- **Tadong (22209), 212.5 mm on 25 September 2005** (IMD, *Extremes*, data 1978–2007), qualifies, lies below the plate and raises nothing. On the same day Gangtok, about 4–5 km away and about 300 m higher, recorded 141.0 mm (IMD, *Extremes*): evidence of the steep local gradients that the 25 km radius cannot see.
- **Singhik, 504.2 mm on 12 May 1981, and Dikchu, 400.8 mm on 25 August 1969** (CWC, 2(a), Table 7), do not qualify: their gauges' record lengths are not confirmed by an IMD table [TBC]. They set the floors of (c)(ii) instead.
- **Outside every Sikkim domain**, recorded on Form 2-1 as flags only: Kalimpong, 419.2 mm on 5 October 1968 (IMD, data 1921–2006), and Darjeeling, 492.8 mm on 25 September 1899, before 1901 (IMD, *Extremes*), and the Darjeeling-district values of the 2(a) report's Table 7, Mongpoo 546.1 mm, Kurseong 501.7 mm and Darjeeling 454.1 mm, all in June 1950 (CWC, 2(a), Table 7). They lie in the hill zone of the West Bengal edition, across the Teesta and the Rangit, and that edition governs them; Kalimpong is flagged on Form 2-1 for Melli, Rangpo and Jorethang.

Until Annex 2A is published, the designer lists on Form 2-1 every record within 25 km of the site, with its domain and the tests it passes or fails. The check stops at 24 hours. It raises the 24-hour depth and, through (d) and (e), the more frequent AEPs and the 48- and 72-hour depths; it raises the 1- to 18-hour depths only through the ratio products of (f), because the records are daily totals and no hourly record of any of them exists.

- (i) **Hazard-first sites.** No drain is sized for a glacial-lake outburst flood (GLOF), a landslide or a debris flow, so siting, setbacks and floor levels govern on the ground below, which is screened separately from rainfall design. No design is complete without a screening, recorded in the drainage report and on Form 2-1, that identifies the following and states whether the site lies on their path (set by this Manual):

  - **GLOF corridors**: the Teesta from the South Lhonak lake through Chungthang, Mangan, Dikchu, Singtam, Rangpo and Melli to the State border; the Lachen Chu and the Lachung Chu; and every stream below a glacial lake that NDMA, the Science and Technology Department (the nodal department for GLOF studies and mitigation, Notification No. 10/Home/2025 of 07.02.2025) or the Sikkim Commission on Glacial Hazards lists as high-risk. NDMA has identified 40 high-risk glacial lakes in Sikkim, 16 of them very high risk (13 in Mangan district and 3 in Gyalshing district; 12 in the Lachen Chu watershed), and the State reports that "Shako Chho has habitations and Army establishments just 15 km downstream" (State affidavit before the NGT, 28.02.2026). The GLOF evacuation maps of SSDMA and the District Disaster Management Authorities, prepared with the participatory risk assessments of May 2024, are used where they exist [TBC];
  - **the Teesta valley floor**: land at or below the level of the flood and aggradation of October 2023. The State reports that the river bed "has risen by an average of 7-8 meters", with NHPC's estimates of about 7.44 m at the Teesta Low Dam IV project, 7.29 m at Teesta Low Dam III, 6.00 m at Teesta-V and 2.00 m at Teesta-VI; that 155 households at Toong Naga were "mandated for relocation"; and that NH-10 along the Teesta "has become prone to submergence and subsidence" (Lhonak valley PPR, annexed to the State's affidavit before the NGT, 28.02.2026);
  - **landslide and sinking ground**: stability zones 4 to 6 of the Mines and Geology Department (2021); land that is sinking, landslide-prone or "having scars of old landslides" (SBCR 1991, reg. 35); the Daling Group, "especially the Gorubathan Formation", reported to be more prone to landslides than the Higher Himalayan gneisses and schists (as reported; CGWB names both the Daling Group and the Gorubathan Formation as dominant in South Sikkim, an internal conflict [U]); and debris-flow fans and jhora gullies, such as those of Mangan district in June 2024 and of Chaten near Lachen on 1 June 2025 (as reported);
  - **hydropower release reaches**, below Teesta-III (under restoration), Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, the Dikchu project, Rongnichu, Jorethang, Tashiding and Rangit-III, whose release rules and full and maximum water levels were not found [TBC]; and
  - **snow and rain-on-snow** in SK-C and in any SK-B1 catchment with permanent snow or a glacier.

In SK-C every drain is designed with the depths of (c)(iii). **Every cross-drainage structure and outfall with a catchment of more than 1 km² in SK-C, every catchment in any sub-area with permanent snow, a glacier or a mapped glacial lake, and every work on the Teesta trunk** has a site-specific hydrology study, agreed with the Authority and recorded on Form 2-1, with GLOF, landslide-lake and debris-flow screening; no CWC unit hydrograph applies to such a catchment (set by this Manual, the rule of the mountain editions of this series for their high Himalaya). The reason is the cascade of 3–4 October 2023. The South Lhonak lake drained after a moraine collapse; its outflow "peaked at $4.85 \times 10^4$ m³ s⁻¹" of water, with "$1.03 \times 10^4$ m³ s⁻¹" of sediment, "equivalent to a return period exceeding 200 years"; at Chungthang the "discharge peaked at 5340 m³ s⁻¹ … within ~6 minutes", with a depth of 9 m and a velocity of 9 m/s; about $270 \times 10^6$ m³ of material was eroded; and Rangpo, about 135 km downstream, was "severely impacted by the debris, burying buildings and automobiles". Water alone, the outburst equalled "a 1–100 year meteorological flood at Chungthang", but the sediment made the total far higher, and outburst peaks exceeded meteorological floods for about 50 km below the lake (Sattar et al., 2025). **The 1% AEP rainfall flood is therefore not the design flood for the Teesta trunk, and no rainfall-based setback or level protects against such a cascade.** Its cause is disputed, and its toll is stated in two ways (Clause 1.1, Commentary).

- (j) **Cloudbursts.** IMD calls a fall of 100 mm or more in one hour over a small area a cloudburst (as quoted; no IMD primary document was found for this Manual [TBC]). No measured cloudburst rate exists for Sikkim, and no hourly value for any Sikkim gauge was found. The State's affidavit of 05.04.2024 attributed the October 2023 flood "primarily to a cloudburst" (State affidavit before the NGT), while ERA5 reanalysis "shows 29–39 mm of rainfall" over the lake from 28 September to 5 October, with about 5 mm and 14 mm on 3 and 4 October, and no cloudburst near the lake (Sattar et al., 2025): both are stated, and this Manual takes no side. No design rule is drawn from the term. The 1% AEP 1-hour depth of (f) on the floor of SK-B1, about 131 mm, exceeds the threshold; Gangtok's, about 83 mm, does not. What a burst brings to a steep catchment that a design storm does not represent is boulders, slide debris and garbage in its first minutes; there the capacity of inlets, debris racks and culverts to stay open governs more than the conveyance of the drain, and Chapters 6 and 9 size them for it.

- (k) **Durations below 1 hour.** No sub-hourly frequency analysis for any station in the State was found in research for this Manual. Until Annex 2B gives one, the ratio of the depth for a duration below 1 hour to the 1-hour design depth is agreed with the Authority, from a published recording-gauge analysis whose source is stated, and recorded on Form 2-1 [TBC]; the average intensity for a duration below 1 hour shall be not less than the 1-hour design intensity for the same AEP (set by this Manual). The time distribution of storms in the 2(a) report was not extracted for this Manual [TBC].

- (l) **Order of depths.** For the same AEP, no depth shall be less than the depth for a shorter duration.

- (m) **NIH-DHAARA.** NIH-DHAARA was queried at thirteen points in the State for the research for this Manual and at twelve of them for every duration it serves, on 14 November 2026 (IMDAA dataset). In Sikkim it is **never a design value, a floor or a check**: its growth shape is used in (d), its 72-hour to 24-hour shape in (e) and its duration-ratio shape in (f), and in every sub-area its present-day values at the site are reported on Form 2-1 beside the interim values, for comparison only. In the south it agrees with the plates (Namchi and Jorethang 284 mm, Rangpo 282 mm at 50 years); at Gangtok it gives 195 mm at 50 years and 218 mm at 100 years, 70% of the station record; and in the north it gives 121–183 mm at 50 years (Lachung 121 mm, Lachen 138 mm, Chungthang 154 mm, Mangan 183 mm) against records of 400.8–504.2 mm (NIH-DHAARA, queried 14 Nov 2026; NEER arithmetic). Its projected depths are not used under Clause 2.8.4.

- (n) **IMD Das et al. (2022).** The paper prints IDF curves for 27 cities and none for Gangtok, Tadong or Darjeeling (*MAUSAM* 73(4), pp. 895–896); its range for the North-East region, 4–160 cm, is set by the wettest stations of the region. It is not cited for any Sikkim value, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available.

- (o) **Earlier design values.** No design storm, return period, IDF or runoff coefficient was found for the drains of any town in the State. GSCDL's "Construction of drainage and jhora training works" (about ₹13.41 crore, as reported) and the stormwater drains on about 60 km of roads in seven towns under the ADB's Sikkim Integrated Urban

Development Project (ADB, 57230-001) state no design storm that was seen; the drainage and landslip works of the Gangtok City Development Plan of 2006 "were not taken up" (CAG, 2016). A reply in the Lok Sabha that "rainfall intensity is usually taken in the range of 12 to 20 mm/hr" where records are lacking (as quoted) is a national fallback far below every Sikkim value in this clause and is not used. Road drains follow IRC:SP:42-2014 and IRC:SP:48 (Chapter 6). A designer who uses any other value reports it on Form 2-1; the AEPs of Table 2.1 and the depths of this clause apply.

- (p) **Other clauses.** Where Clauses 2.3.2, 2.6.1, 2.7.1 and 2.13, Annexes 2A to 2C and Form 2-1 refer to the NIH-DHAARA value, the value under this clause is meant.

Commentary. NIH-DHAARA is a national, publicly accessible product from a Government of India institution, and it can be queried at any point in the State. That makes it a reproducible default that an approving authority can check. NIH-DHAARA's sub-daily values are derived from hourly records, not disaggregated from daily totals. That makes it the only public source suitable for sizing drains, which depend on short-duration intensity. Its values should still be checked against the long IMD daily record at 24 hours and longer (Annex 2A). In Sikkim the platform has not yet been shown to meet that purpose. It was queried at thirteen points of the State for this Manual. In the south its cells agree with the CWC plates: Namchi, Jorethang and Rangpo give 282–284 mm at 50 years in 24 hours, against plate readings of 280–360 mm. Northwards it falls away from every gauge that exists: Gangtok's cell gives 195 mm at 50 years, while IMD's Gangtok gauge recorded 310.3 mm on 30 May 1975, and the Mangan and Chungthang cells give 183 mm and 154 mm, while the Singhik and Dikchu gauges of the CWC 2(a) report recorded 504.2 mm and 400.8 mm in a day (IMD, *Extremes*; CWC, 2(a), Table 7; NIH-DHAARA, queried 14 Nov 2026). Its 1-hour ratios, 0.13–0.19, are half the CWC value, and no Sikkim recording gauge exists to say which is right. A source that fails a check in part of the State cannot be adopted for any of it, so Clause 2.3.6 uses the CWC report, the IMD station records and the north's own gauge maxima until Annex 2A has been done, and uses NIH-DHAARA only for the shape of its growth, duration and multi-day curves and for comparison on Form 2-1. IMD Das et al. (2022) is not cited, because it has no panel for any Sikkim station. Sikkim is the series' last North-East edition, and three things set its interim source apart. First, one CWC report covers the whole State, but its plates stop at Gangtok: the 2(a) report of 1991 names Gangtok first among its towns, yet draws no contour north of it, so that SK-B1 and SK-C, the middle and upper Teesta, have no CWC value at all. Clause 2.3.6(c)(i) therefore lets the plate govern wherever it draws contours, with no departure below it, and takes the plate's last values north into SK-C, where nothing else exists. Second, the State's own records exceed the plates. Gangtok's 310.3 mm lies above its 50-year plate value and close to its 100-year one, and Singhik's 504.2 mm and Dikchu's 400.8 mm, in the valley where the plate implies 200–240 mm, are about twice it; both fell in May or the monsoon, in the valley that the outburst flood of 2023 later followed. Clause 2.3.6(h) applies Gangtok's record within its own domain, east of the Teesta, and Clause 2.3.6(c)(ii) sets SK-B1's floor from the Singhik and Dikchu maxima, which fail the record-check tests but are the only values the valley has; the floor is probably high, and the Singhik series is the first data request. Third, the State's reference flood was not a rainfall flood. On 3–4 October 2023 the South Lhonak lake drained into the Teesta, after a moraine collapse, while the rain over the lake was modest (Sattar et al., 2025); the cause is disputed (Clause 1.1, Commentary), and under either account Clause 2.3.6(i) screens the GLOF corridors and the Teesta valley floor apart from rainfall design, and sends every structure there to siting and setback rules and to a site study, not to a larger design storm. The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the SK-B1 and SK-C floors, the sub-area of each town, the ratio set, the bounded record check, the hazard-first screening and durations below 1 hour are set by this Manual. Several points are unresolved. The plate values were read by eye, to about one contour, from town markers placed on page images, and Soreng was not read [TBC]. The record lengths of the Singhik and Dikchu gauges are not known [TBC]. No sub-daily record for any Sikkim gauge was found, so the 1-hour ratio of 0.26 is unchecked in the State [TBC]. No storm-drain DPR for any town of the State with its design rainfall analysis was found for this Manual [TBC].

## 2.4 Design return periods (summary)

2.4.1 Design AEPs are set in the chapters for each element. They are summarised here so that the correct rainfall is extracted at the start of design.

**Table 2.1 — Design return periods (summary)**

| Element | Design AEP (return period) | Check event | Chapter |
|---|---|---|---|
| Minor drains: Gangtok, Namchi, Jorethang and Rangpo core and high-density areas | 10% (10-yr) | 1% (100-yr) overland path | 6 |
| Minor drains: other Class I urban areas | 20% (5-yr) | 1% overland path | 6 |
| Minor drains: other areas | 50% (2-yr) | 1% overland path | 6 |
| Arterial roads and crossings | 2–4% (25–50-yr) | next higher AEP | 6 |
| Collector / local roads | 4% / 10% (25 / 10-yr) | 2% / 4% (50 / 25-yr), plus the 1% overland path | 6 |
| Major (overland) system | 1% (100-yr) | — | 6 |
| Retention volume | Percentile daily rainfall (Clause 2.10) | — | 4 |
| Detention: standard catchments | 50%, 10%, 1% (2, 10, 100-yr) | 1% emergency spillway | 4 |
| Detention: flood-sensitive catchments | Mixed-frequency rule, Clause 2.11 | 1% | 4 |
| Building floor levels | 1% + 0.5 m freeboard | — | 6 |
| Detention emergency spillway | 1% with outlet blocked | 0.2% (500-yr) where high hazard | 4 |

> **Commentary.** These values exceed the CPHEEO (2019) national advisory minimums of 5-yr (Class I cities) and 2-yr (other areas). CPHEEO allows a State to set higher values. The values are set in Chapters 4 and 6, and the table is reproduced here for convenience.

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## 2.5 Design durations

2.5.1 **Conveyance elements** (pipes, open drains, inlets, culverts) shall be designed with the intensity for a duration equal to the time of concentration (Tc) of the contributing area (Chapter 3). The minimum duration is **10 minutes**.

2.5.2 **Storage elements** (detention, retention, tanks, pumped sumps) shall be checked for every duration in the set {1, 2, 3, 6, 12, 24, 48, 72 h}. The largest required storage or water level governs. The 24-, 48- and 72-hour storms are **mandatory** checks at every site, whatever the critical-duration result.

2.5.3 **Tidally influenced outfalls.** For storage draining to a tidally influenced outfall (Chapter 5), the 48- and 72-hour storms shall also be run with the tailwater boundary of Clause 2.12.

> **Commentary.** Sikkim's damaging floods have come when days of rain fill the soils, the jhoras and the reservoirs. In June 1997 Gangtok received 1,281.3 mm, its highest month on record, with 223.8 mm on 9 June (IMD, *Extremes*), and landslides in the town were reported to have killed 38 people (as reported); in May 1996 it received 951.7 mm (IMD, *Extremes*). About 250 mm fell over the State in 1–13 June 2024, against a normal of 162 mm,

before the slides of 12–13 June in Mangan district (as reported), and three days of rain in north Sikkim preceded the Chaten landslide of 1 June 2025 (as reported). The storm of 2–5 October 1968 lasted four days over the Darjeeling and Sikkim hills, with "1,000 mm of rainfall in 52 hours" reported but not measured at any gauge found (as reported). The jhoras of the ridge towns rise within an hour of a burst, but the slides and debris that block their culverts, the saturated slopes that the stability zones record as wet, and the river and reservoir levels that hold the valley-floor outfalls up are set by the whole wet spell, not its peak hour. A rule based only on critical duration, applied to a small site, picks a 1–2 hour storm and misses this failure mode. That is why the long-duration checks are mandatory.

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## 2.6 Sub-daily rainfall

2.6.1 Where NIH-DHAARA or an approved station IDF provides values directly for the required duration, those values shall be used.

2.6.2 Where only daily (24-hour) depths are available for a duration below 24 hours, the sub-daily depth shall be derived using the **ratio set of Annex 2B**. These are duration-to-24-hour ratios calibrated to Sikkim recording gauges. They shall not be lower than the ratios of the CWC Flood Estimation Report for subzone 2(a) (North Brahmaputra), which covers the whole State; that report derived them from recording gauges in the subzone, none of which was identified in Sikkim. The lower duration ratios of the NIH-DHAARA cells for Sikkim are not used, and IMD Das et al. (2022) prints no panel for any Sikkim station.

2.6.3 **Fixed-interval adjustment.** Depths from fixed observation windows (for example 08:30–08:30 IST daily data, or clock-hour data) shall be converted to sliding-window ("true interval") depths:

- 1.13 for a single fixed observation interval;
- 1.04 for 2 intervals;
- 1.02 for 3–4 intervals.

This adjustment does not apply where the approved source already gives true-interval values.

2.6.4 The empirical relationship P(t) = P(24)·(t/24)^(1/3) shall not be used for design unless Annex 2B confirms it for the zone concerned.

> Commentary. The one-third power rule is common in Indian project reports, but no primary IMD source for it was found during research for this Manual. It applies one fixed curve shape everywhere: P(1h)/P(24h) = 0.35, P(3h) = 0.50, P(6h) = 0.63 and P(12h) = 0.79. It cannot represent the difference between a short convective burst and a long monsoon soak, and it tends to understate short-duration depths in convective coastal storms. Annex 2B shall tabulate the NIH-DHAARA ratios P(t)/P(24h) against these values by zone. That comparison shows whether the rule is acceptable anywhere in the State and corrects older daily-based analyses. The fixed-interval factors are the standard WMO (Hershfield) values. The IMD 2022 study applies similar clock-hour to any-hour corrections.

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## 2.7 Point, grid and areal rainfall

2.7.1 Design depths are point values. Where an approved source provides grid-average values (for example 0.25° cells), they shall be converted to point values with the grid-to-point factors in Annex 2C before use.

2.7.2 For catchments **≤ 10 km²**, ARF = 1.0.

2.7.3 For catchments **> 10 km²**, apply ARF as follows:

- for 25–5,000 km² in subzone 2(a) (North Brahmaputra): use the ARF curves of the applicable CWC Flood Estimation Report;
- for 10–25 km²: interpolate linearly between ARF = 1.0 at 10 km² and the CWC value at 25 km².

2.7.4 An ARF shall never be applied to storage design for a single development site.

> **Commentary.** Gridded and district-average return levels are much lower than point values. For example, NIH-DHAARA's cell over Gangtok gives 195 mm at 50 years in 24 hours and 218 mm at 100 years, against the 310.3 mm that IMD's Gangtok gauge recorded on 30 May 1975, and its Mangan cell gives 183 mm, against the 504.2 mm and 400.8 mm recorded at Singhik and Dikchu in the same valley (NIH-DHAARA, queried 14 Nov 2026; IMD, *Extremes*; CWC, 2(a), Table 7). On 25 September 2005 Tadong recorded 212.5 mm and Gangtok, about 4–5 km away, 141.0 mm (IMD, *Extremes*): no grid cell of 0.12° or more can hold both. Neither error can be corrected without the factors of Annex 2C. Using grid values as point values without correction would make site-level design unsafe.

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## 2.8 Climate factor

2.8.1 Until a statewide future-climate rainfall product is adopted, present-day design depths shall be multiplied by the following interim climate factors:

**Table 2.2 — Interim climate factors**

| Duration | Climate factor (CF) |
|---|---|
| ≤ 6 h | **1.20** |
| > 6 h to 72 h | **1.10** |

2.8.2 The CF applies to all elements with a design life of more than 25 years. For temporary works (design life ≤ 5 years), CF = 1.0.

2.8.3 The climate factor does not apply to the retention depth (Clause 2.10) or to the water quality volume depth (Chapter 8). Those depths are percentile or frequent-event statistics of everyday rainfall, not AEP design values.

2.8.4 Where NIH-DHAARA, or a product adopted on review under Clause 2.14, provides projected future-climate depths, those depths shall replace the interim factors.

> **Commentary.** CPHEEO (2019) considers a fixed climate factor "not feasible" nationally and recommends trend testing instead. That leaves designers without a usable number. The 1.20 short-duration factor matches the UK value cited by CPHEEO itself. No design uplift factor has been adopted in Sikkim, and none was found in any document read for this Manual. The observed record is mixed: a study of IMD gridded rainfall for 1950–2018 found most extreme-precipitation indices over the State falling, the number of days of 10 mm or more rising, and changes in the one- to five-day maxima mainly in the west and north (Dubey et al., 2022, as summarised). ERA5 reanalysis shows the June–September precipitation over the South Lhonak catchment rising by 8.6 mm a decade, with glacier mass balance negative (Sattar et al., 2025), and the South Lhonak lake grew from about 17 ha in 1977 to 167.4 ha on 28 September 2023 (as reported). The Sikkim State Action Plan on Climate Change and NIH-DHAARA's climate grids for the State were not read for this Manual [TBC]. The case for an uplift rests on the size of the State's recorded extremes and on the cascade risk of its glacial lakes, not on trend statistics. The factors of

Table 2.2, 1.20 up to 6 hours and 1.10 for longer durations, are therefore interim values, not Sikkim estimates; as in the mountain editions of this series they are applied after the record check of Clause 2.3.6(h), including to Gangtok's record where it governs. NIH-DHAARA's projected depths are not used (Clause 2.3.6(m)).

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## 2.9 Temporal patterns (design hyetographs)

2.9.1 **Storms up to 24 hours.** Use the nested **alternating-block** method:

- construct the storm from the same IDF relationship (after the climate factor), at time steps no longer than Tc/3 and no longer than 15 minutes;
- place the peak block at **50%** of the storm duration.

2.9.2 **48- and 72-hour storms (monsoon pattern).** Construct as follows:

- (a) The total storm depth equals the design depth for the full duration (48 or 72 h).
- (b) The **final 24 hours** contain the 24-hour design depth for the same AEP, distributed by the alternating-block method of 2.9.1.
- (c) The remaining depth (total minus the 24-hour depth) is spread uniformly over the preceding 24 or 48 hours.

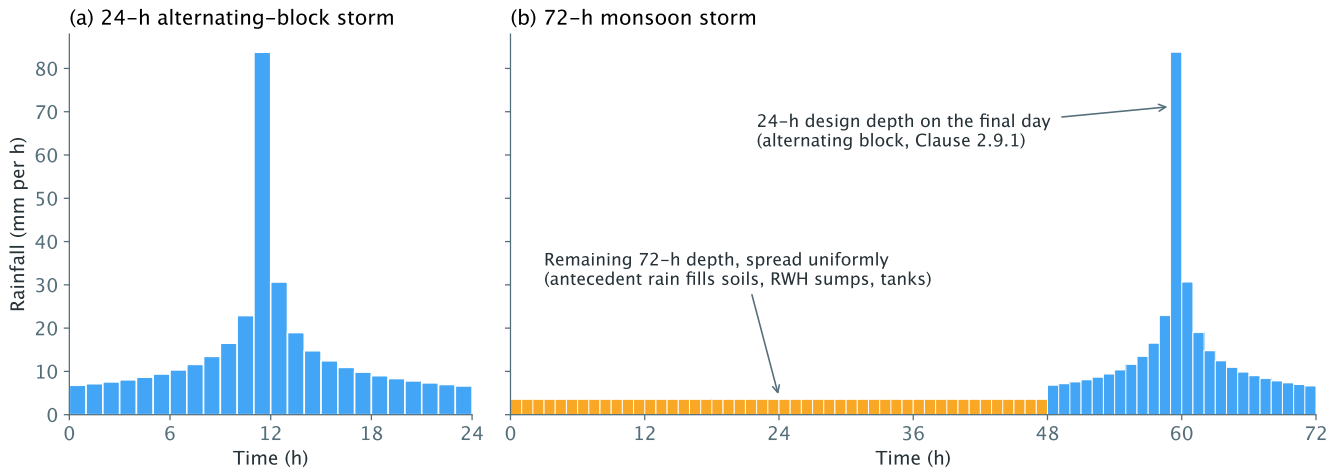


*Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.*

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Sikkim storms may be used instead of 2.9.1 and 2.9.2 only after they are published in Annex 2D. SCS Type I, IA, II and III distributions shall not be used.

2.9.4 **Large catchments.** For catchments of 25–5,000 km², the CWC Flood Estimation Report time-distribution curves may be used, and a sensitivity run with 2.9.1 shall be reported.

**Commentary.** The alternating-block storm embeds every shorter-duration design intensity in one hyetograph. That makes it conservative and consistent across durations. The 72-hour pattern puts the most intense day last. This reproduces the monsoon sequence of Sikkim: by the time the largest falls arrive, in May and from June to October after the storms of April, the thin soils and colluvium of the ridges and the fill behind their cuts are saturated, the

springs and seepage zones are flowing, and the hydropower reservoirs on the Teesta and the Rangit are full or releasing. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Sikkim records.

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## 2.10 Retention rainfall depth

2.10.1 The **retention design depth** is the 24-hour rainfall depth not exceeded on **90%** of days with rain (≥ 2.5 mm) in the long-term record, read from the zone value in Annex 2E.

2.10.2 The site must retain on site the runoff from this depth (Chapter 4). Retention earns a detention credit equal to the reduction in required detention storage found by routing with the retention in place (Clause 4.4.6). The credit is not the retained volume subtracted one-for-one.

> Commentary. This follows the Kansas City Metro APWA 5600 (2025.01) Required Retention Volume concept and Georgia's 1.0-inch runoff reduction standard. Both are based on percentile storms. A percentile depth is a statistic of everyday rainfall, not an AEP value, so it is computed from the daily record rather than from the frequency curves.

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## 2.11 Design storms for pre- and post-development comparison

2.11.1 **Same storm for both scenarios.** Pre- and post-development runs shall use the same design storms:

- same AEP, duration, temporal pattern and climate factor;
- same antecedent moisture condition (Clause 2.11.4).

The two runs differ only in land surface parameters and Tc.

2.11.2 **Standard catchments.** For each of the 50%, 10% and 1% AEP storms and each duration in Clause 2.5.2:

> $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$

2.11.3 **Flood-sensitive catchments** (as listed in Chapter 4: the catchments of Gangtok's jhoras to the Rani Khola and the Roro Chu, of the Teesta valley floor in the October 2023 corridor, of the Rangit at Jorethang and Majitar, of the Rongni Chu at Ranipool and Singtam, of Mangan town and the North Sikkim road, of Lachen, Chaten and every catchment below a high-risk glacial lake, of the hydropower reservoirs and release reaches, of the NH-10 corridor, of Namchi and of Soreng, and any catchment notified by the authority). The **mixed-frequency rule** applies:

> $Q_{post}$(1% AEP, 100-yr) ≤ $Q_{pre}$(10% AEP, 10-yr), and $Q_{post}$(50% AEP, 2-yr) ≤ $Q_{pre}$(50% AEP, 2-yr),

The post-development peak is checked for each duration in Clause 2.5.2. The caps are taken at the **pre-development critical duration**. The 10-yr cap is the largest pre-development 10-yr peak over all durations, and the 2-yr cap is the largest pre-development 2-yr peak over all durations. Each cap applies to every post-development duration.

2.11.4 **Antecedent moisture.** Use **AMC III** (wet conditions) for every design storm, whatever its duration, from 1 May to 30 September at a site in any sub-area of Annex 2A (SK-A, SK-B, SK-B1 or SK-C). Use AMC III for every design storm from 1 April to 31 October on valley-floor land below the 1% AEP flood level of the Teesta, the Rangit, the Rongni Chu or another river, on the river bed and terraces raised by the flood of October 2023, wherever the seasonal high water table is within 2 m of the ground, and in stability zones 3 to 6 of the Mines and Geology Department's notification of 2021, whose ground it records as "Wet", "Dripping" or "Flowing". Use AMC III for every design storm at any time of year in a catchment that drains to a hydropower reservoir or its backwater (among them Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Jorethang, Tashiding, Rangit-III and Rongnichu), to a reach below a dam into which the dam releases water, or to a river reach whose CWC gauge stands above its warning level. At any other site or time, use AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm. Use AMC II (average conditions) for every other storm. AMC I is not used for design.

2.11.5 **Pre-development condition.** Pre-development is defined in Chapter 3: greenfield, open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted as pre-development.

> **Commentary.** Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that monsoon extremes arrive after weeks of rain. In Sikkim the season, the ground and the receiving waters together decide how wet a catchment is. On the ridges thin soils lie over phyllite, schist and gneiss, and on steep ground water emerges "as seepages and springs wherever the land surface intersects local ground water body" (CGWB, as quoted); the stability zones of 2021 record the ground of zones 3 to 6 as "Wet", "Dripping" or "Flowing" (Mines and Geology Department, 2021). Gangtok has 20.1 to 27.0 rainy days a month from May to September (IMD, Gangtok, 1981–2010), and its 24-hour record (310.3 mm, 30 May 1975) and Singhik's (504.2 mm, 12 May 1981) both fell in May (IMD; CWC, 2(a)). The hydropower reservoirs on the Teesta and the Rangit hold water all year. This Manual therefore uses AMC III for every design storm from 1 May to 30 September in every sub-area; from 1 April to 31 October on valley-floor land below the 1% AEP flood level, on the river bed and terraces raised by the flood of October 2023, wherever the seasonal high water table is within 2 m of ground, and in stability zones 3 to 6, because April already brings 296.9 mm on 15.2 rainy days at Gangtok (IMD) and that ground is wet from the first storms; at any time of year in a catchment that drains to a hydropower reservoir, its backwater, a release reach or a river reach above its CWC warning level; and otherwise after a 5-day total of more than 53 mm, the NRCS growing-season threshold for AMC III; AMC II otherwise (Clause 2.11.4). The West Bengal edition uses AMC III from June to September in its hill zone across the Rangit; Sikkim's window starts in May because the State's largest 24-hour falls are pre-monsoon. AMC I is not used, because no part of the State is dry enough during the season to justify it. These are interim choices set by this Manual; no study in the State has yet validated AMC classes against observed runoff.
>
> **Illustrative scale of the mixed-frequency rule.** The values below are not design values. They assume a 2 ha site in a hillside colony in Gangtok draining to a jhora with 24-h depths of 200 mm (10-yr) and 350 mm (100-yr), SCS-CN runoff with Ia = 0.2S, and CN 70 pre-development and CN 92 post-development:

**Table 2.3 — Illustrative scale of the mixed-frequency rule (not design values)**

| Case | Runoff depth | Runoff volume (2 ha) |
|---|---|---|
| Pre-development, 10-yr 24 h | 111 mm | 2,210 m³ |
| Post-development, 100-yr 24 h | 325 mm | 6,500 m³ |

The post-development 100-yr storm generates about three times the runoff volume of the pre-development 10-yr storm. A peak-rate cap at the pre-development 10-yr level means most of the difference must be stored and released slowly, so storage of the order of 0.2 m³ per m² of site may be needed. For this reason the rule applies only in flood-sensitive

catchments (Clause 2.11.3); elsewhere the 0.9 × Q_pre rule of Clause 2.11.2 applies.

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## 2.12 Joint occurrence with tailwater

2.12.1 For outfalls under tidal or river backwater influence, the design rainfall of this chapter shall be combined with the tailwater conditions of Chapter 5 as follows. The more severe case governs.

- (a) Design rainfall (AEP as required) with a mean high water springs (MHWS) tailwater plus the sea-level allowance.
- (b) A 10% AEP (10-yr) 48-hour storm with the 1% AEP still-water level (tide plus surge) plus the sea-level allowance.

Sikkim has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the jhora, khola, river, pokhari or reservoir into which a town drains. Most outfalls of the ridge towns, among them Gangtok, Pakyong, Namchi, Ravangla and Gyalshing, fall freely to a steep jhora, with no river tailwater; there the design case is a free outfall, with energy dissipation and a check of the receiving jhora to the next confluence (Clause 5.8.5(a)). At the valley-floor towns the receiving water is a river on a bed that the flood of October 2023 raised by metres. For an outfall under river or reservoir backwater, the site storm is combined with the receiving-water level under Clause 5.8.4, which pairs a design event on one side with a 10-yr event on the other in the same way as case (b), and the river and reservoir levels are those of Clause 5.8.2. CWC levels on the State's rivers are known only as transcribed by SANDRP or seen in snippets, and their datum is not stated [TBC]. On the Teesta at Khanitar the old highest level, 297.7 m (18.09.1974), was exceeded by 298.4 m at 09:00 on 4 October 2023 (as reported). At Melli the old highest level is given as 225.25 m and the peak of 4 October 2023 as 225.5 m in SANDRP's text and as 228.0 m in a CWC bulletin of 2024 seen in a snippet, with a warning level of 226.0 m and a danger level of 227.0 m; the two peaks conflict, and so does SANDRP's statement that the new level is "2.75 meter higher than the old HFL" (as reported) [U]; where a check level is needed at Melli the higher, 228.0 m, is used (Chapter 5). The Rongni Chu at Singtam has a danger level of 355.09 m and a highest level of 356.09 m, undated, and the Rangit at Majitar a highest level of 279.29 m (17.10.1985) (as reported); no CWC level was found for Rangpo [TBC], and the gauges upstream of Teesta-V stopped reporting between 22:00 and 23:00 on 3 October 2023 (as reported). Every level set before October 2023 needs a post-2023 survey, because the bed has risen by metres along the trunk, and an outfall invert set from a pre-2023 bed may now be buried; Chapter 5 takes the higher of the recorded level and the surveyed October 2023 flood mark (Clause 5.8.5(b)). The hydropower reservoirs have operator levels that were not found: no full or maximum water level or release rule was found for Teesta-V, Teesta-VI, the Teesta Low Dam projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu or Rangit-III [TBC], and Teesta-III at Chungthang is under restoration (State affidavit before the NGT, 28.02.2026); until the operator gives them in writing, an outfall in a reservoir reach is treated as having an unknown tailwater and is sited above the October 2023 flood mark (Clause 5.8.5(c)). The GLOF corridors are screened apart under Clause 2.3.6(i): no rainfall tailwater governs there. Below Melli the Teesta and the lower Rangit form or cross the border with West Bengal, and the West Bengal edition governs those reaches. In the ridge towns the jhoras rise within the hour while the storm is still falling, and on the valley floors the river may be high from rain upstream, from a release or from an outburst while the local storm is light, so storage and outfalls are checked for the outfall-closed condition with the local storm falling before, during or after the river's peak. No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC], and Chapter 5 sets the interim rule.

> Commentary. Sikkim has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the level of the rivers and reservoirs that receive the town drains. The coincidence works both ways. In a monsoon spell the rivers rise with the slopes: in June 2024, after about 250 mm over the State in thirteen days, landslides in Mangan district brought down the Sangkalang bridge while the rivers ran high (as reported), and in July 2025 the Teesta submerged NH-10 (as reported). But the Teesta's highest recorded flood came with little rain: on the night of 3–4 October 2023 the South Lhonak lake outburst raised the river to new highest levels at Khanitar and Melli (as reported) while ERA5 shows about 5 mm and 14 mm over the lake on 3 and 4 October (Sattar et al., 2025). A release from a dam does the same: the Dikchu release of 2017 came without warning (as reported). These levels

> give no warning of a local storm, and a local storm gives none of them. The river levels quoted for the State are transcriptions of CWC data or snippets, not readings of a CWC bulletin, and they conflict at Melli, which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Sikkim, which has no coast, the counterpart of surge is the stage of the Teesta, the Rangit and the Rongni Chu and of the hydropower reservoirs that receive the town drains, raised by the same monsoon spells that bring the heaviest rain to the towns: in 1–13 June 2024 about 250 mm fell over the State, against a normal of 162 mm, while rivers rose and slides cut the roads of Mangan district (as reported); the outburst flood of October 2023, which raised the Teesta with little rain, is screened apart under Clause 2.3.6(i)), they cannot be treated as independent. Case (b) is a simple joint-probability surrogate until a statistical joint analysis is adopted.

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## 2.13 Submittal requirements

Every hydrologic submittal shall include a **Design Rainfall Sheet** (Form 2-1) stating:

1. the site coordinates and zone;
2. the source (Clause 2.3), version or access date, and a screenshot or export of the values extracted;
3. a depth table for each AEP and duration used, before and after the fixed-interval factor, grid-to-point factor, ARF and climate factor;
4. the cross-check values of Clause 2.3.3 and the floor check;
5. the hyetographs used, as a table and a plot, for each design storm; and
6. the AMC and pre-development definition adopted.

Figure 2.3 shows the steps of this chapter in the order in which the sheet records them.

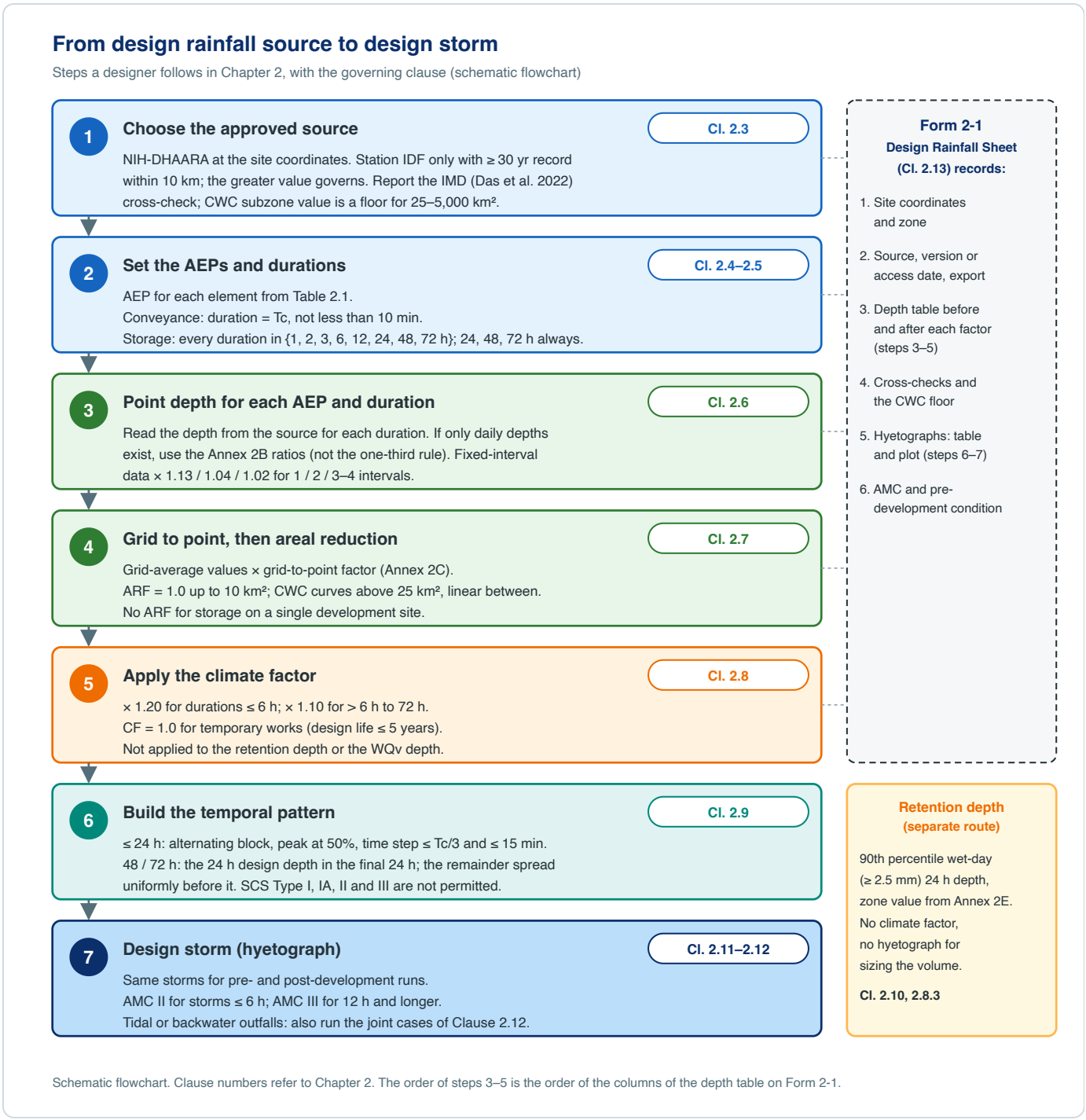


*Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the retention depth. Schematic. Original drawing for this Manual.*

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## 2.14 Review and update

2.14.1 The approving authority shall review this chapter **every 10 years**. It shall also review it within 2 years of any event in which recorded rainfall exceeds the 1% AEP 24-hour or 72-hour design depth at two or more approved gauges in the State.

2.14.2 Updates to NIH-DHAARA take effect for new submittals 6 months after release, unless the authority notifies otherwise.

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## References (chapter)


- National Institute of Hydrology, Roorkee. NIH-DHAARA: Design Hydrology and Advanced Rainfall Analysis. http://www.nihdhaara.in/
- Das, S.K. et al. (2022). Isopluvial analysis and intensity–duration–frequency curves for different cities in India. *MAUSAM* 73(4), 887–898. https://metnet.imd.gov.in/docs/mausamdocs/173412_F.pdf
- Central Water Commission (1991). Flood Estimation Report for North Brahmaputra Subzone 2(a), Design Office Report No. NB/18/1991, placed before the Flood Estimation Planning and Co-ordination Committee at its 49th meeting, 24–25 October 1990 (p. 8 and p. 28, coverage and towns; p. 29, the river table and rainfall; p. 40, the rain-gauge network; §3.1.2, p. 24, and Fig. 10, the short-duration ratios; Table 7, the highest daily falls, with the Singhik and Dikchu rows; Plates 8, 9 and 10, the 25-, 50- and 100-year maps, "Isopluvials supplied by I.M.D.", read by eye from page images). https://cwc.gov.in/regional-flood-estimation-report
- MoHUA / CPHEEO (2019). Manual on Storm Water Drainage Systems, Part A.
- India Meteorological Department. Extremes of Temperature and Rainfall for Indian Stations (up to 2012): Gangtok (42299) and Tadong (22209), monthly and seasonal tables (p. M190); Kalimpong and Darjeeling (flags only). https://imdpune.gov.in/library/public/EXTREMES%20OF%20TEMPERATURE%20and%20RAINFALL%20upto%202012.pdf
- India Meteorological Department, Meteorological Centre Gangtok. Mean monthly meteorological parameters of Gangtok, 1981–2010. https://mausam.imd.gov.in/gangtok/mcdata/climatology_gangtok.pdf
- National Institute of Hydrology. NIH-DHAARA, IMDAA dataset, queried at thirteen points in Sikkim (1 and 24 hours) and at twelve of them for 1–72 hours, 14 November 2026 (tool output).
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*. doi:10.1126/science.ads2659 (accepted manuscript).
- Wangsu, M., Isaac, R.K. and Tirkey, N. (2022). Development of rainfall-intensity-duration-frequency (IDF) curves for Ranikhola watershed, Gangtok, India. *Journal of Soil and Water Conservation* (abstract only; cited to show that it is not a station IDF).
- Dubey et al. (2022). Variability of precipitation extremes and drought intensity over the Sikkim State, India, during 1950–2018 (as summarised; full text not read).
- National Green Tribunal (EZ). OA 171/2023: affidavits of the State of Sikkim of 05.04.2024 and 28.02.2026, with the PPR "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (DST) and the PDNA summary. https://www.greentribunal.gov.in/
- Lok Sabha reply on design rainfall intensity where records are lacking ("12 to 20 mm/hr"; as quoted, not used).
- SANDRP transcriptions of CWC levels on the Teesta, the Rangit and the Rongni Chu, October 2023 (secondary source). https://sandrp.in/
- Chow, V.T., Maidment, D.R. & Mays, L.W. (1988). *Applied Hydrology*. McGraw-Hill (alternating-block method, §14.4).
- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01.
- Mile High Flood District (Denver). Urban Storm Drainage Criteria Manual (90% release rationale).
- Department of Irrigation and Drainage Malaysia (2008, 2012). Urban Stormwater Management Manual (MSMA).


## Annexes

| Annex | Content |
|---|---|
| 2A | NIH-DHAARA vs IMD station and IMD gridded checks at benchmark points; zone map |
| 2B | Sub-daily ratios P(t)/P(24h) by zone: NIH-DHAARA (hourly-based) vs the one-third rule |
| 2C | Grid-to-point factors |
| 2D | Sikkim temporal patterns (Huff curves) |

| Annex | Content |
| --- | --- |
| 2E | Retention percentile depths by zone |
| Form 2-1 | Design Rainfall Sheet |

CHAPTER 3

# Hydrologic Methods

## 3.1 Purpose and scope

3.1.1 This chapter sets out how design rainfall from Chapter 2 is turned into runoff peaks, volumes and hydrographs for:

- (a) drain, inlet and culvert sizing (Chapter 6);
- (b) retention and detention sizing, and the pre- vs post-development comparison (Chapter 4);
- (c) downstream and tailwater analysis (Chapter 5); and
- (d) waterbody, tank (pokhari) and regional facility studies (Chapter 7).

3.1.2 It specifies:

- (a) which method may be used for which purpose and catchment size (Clause 3.4);
- (b) how the pre- and post-development land surfaces are defined (Clause 3.3);
- (c) the parameters of each method: runoff coefficients, time of concentration, soils, curve numbers, unit hydrographs and routing (Clauses 3.5–3.12);
- (d) when continuous simulation and model calibration are required (Clauses 3.13 and 3.15);
- (e) the step-by-step pre- vs post-development comparison (Clause 3.14); and
- (f) software acceptance and documentation (Clauses 3.16 and 3.17).

3.1.3 Rainfall inputs (depth, duration, areal reduction, climate factor, temporal pattern and antecedent moisture) are governed by Chapter 2 and shall not be varied in this chapter.

> **Commentary.** The CPHEEO (2019) Manual on Storm Water Drainage Systems gives a full Rational Method procedure and names SWMM for hydrograph work, but it is a drain-sizing guide. It does not say how a regulator should define "pre-development" or which method must be used to test a development against it (CPHEEO Part A §4.4, §8.5.1). APWA Section 5600 does both: it limits the Rational Method, names baseline hydrograph methods, and fixes the land-use assumptions for existing and proposed conditions (KC Metro APWA 5600, 2011, §5602.2–5602.3; Version 2025.01, §5603.4). This chapter follows that model.

## 3.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Pre-development condition | The reference land surface defined in Clause 3.3.2, against which post-development runoff is tested. It is not the existing condition. |
| Post-development condition | The land surface after the proposed works are complete, as defined in Clause 3.3.3. |
| Point of comparison (POC) | A location where site runoff leaves the site, at which pre- and post-development flows are compared (Clause 3.14). |

| Term | Meaning in this Manual |
|---|---|
| Time of concentration (Tc) | The time for runoff to travel from the hydraulically most distant point of the catchment to the point of interest. |
| Lag (tL) | The time from the centroid of rainfall excess to the peak of the runoff hydrograph. |
| Hydrologic soil group (HSG) | The NRCS classification (A, B, C, D) of a soil by its minimum infiltration rate when wet (USDA NRCS, NEH Part 630, Ch. 7). |
| Curve number (CN) | The NRCS parameter that combines soil group, land cover and antecedent moisture into a single runoff-potential index (USDA NRCS, NEH Part 630, Ch. 9–10). |
| Antecedent moisture condition (AMC) | The soil wetness at the start of a storm: AMC I (dry), II (average), III (wet). |
| Directly connected impervious area (DCIA) | Impervious surface that drains to a drain, pipe or channel without first flowing over a pervious surface. |
| Disconnected impervious area | Impervious surface whose runoff flows as sheet flow over a pervious surface before reaching the drainage system, and meets Clause 3.9.3. |
| Peak rate factor (PRF) | The constant in the unit hydrograph peak equation (484 in US customary units; 0.208 in the SI form of Clause 3.11.2). |
| Continuous simulation | A model run over a long rainfall record (years), with soil moisture, storage and tank levels carried forward between storms. |
| Tank cascade | A chain of tanks (pokharis) in which the surplus of one tank feeds the next. |

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## 3.3 Pre-development and post-development land surface

3.3.1 **Same site, same storm.** Pre- and post-development runs shall cover the same area draining to each POC, and use the same design storms (Clause 2.11.1). They shall differ only in the land-surface parameters of this clause, the resulting Tc, and the stormwater controls.

3.3.2 **Pre-development condition.** The pre-development land surface shall be **greenfield: open land in good condition for the mapped hydrologic soil group**, as follows:

- (a) All land within the site, including land that is now built on, paved, compacted or cultivated, is treated as open land (grass cover > 75%) in good condition. **Existing impervious cover shall not be counted.**
- (b) The curve number is the TR-55 value for "open space, good condition" for the HSG of Clause 3.7: **CN 39 (A), 61 (B), 74 (C), 80 (D)** at AMC II (Table 3.5).
- (c) The HSG is the natural HSG of Clause 3.7, including the dual-group rule for high water table (Clause 3.10.1). No HSG improvement for drainage works is allowed.
- (d) Tc is computed on the pre-development ground surface using unchannelled overland and shallow concentrated flow and natural channels only (Clause 3.6). Existing pipes, lined drains and kerbs are ignored.
- (e) Existing waterbodies, tank waterspreads up to the full tank level (FTL), natural channels and supply or surplus channels are kept as they are, and modelled as water surfaces or channels, not as open land.

3.3.3 **Post-development condition.** The post-development land surface shall represent the proposed works at full build-out:

- (a) Impervious areas shall be measured from the site plan, separately for roofs, paved surfaces, roads and other sealed surfaces, and classified as directly connected or disconnected (Clause 3.9). Lot-size residential rows of TR-55 shall not be used for the site itself.

- (b) Pervious areas disturbed by construction (graded, filled or trafficked) shall be assigned one HSG lower in infiltration capacity than the natural HSG (A to B, B to C, C to D), unless post-construction infiltration tests (Clause 3.7.3) show otherwise. Soil disturbed by construction shall never be classed as HSG A.
- (c) Rainwater harvesting (RWH) sumps shall be treated as full at the start of storms of 12 hours or more, and the roof area draining to them as directly connected for those storms (Chapter 4).
- (d) Retention and detention facilities shall be represented explicitly as storage (Clause 3.12), not by lowering CN.

3.3.4 **Redevelopment.** The pre-development condition of Clause 3.3.2 applies to redevelopment as well. A site that is already fully paved is tested against greenfield, not against its existing state. For the constrained-redevelopment route of Clause 4.5.6, the existing condition shall also be modelled, with existing impervious areas as surveyed, so that the 50% minimum can be checked.

3.3.5 **Off-site areas.**

- (a) For conveyance design (Chapter 6), areas upstream of the site shall be taken at their ultimate land use under the approved master plan or development plan. Where no plan exists, upstream undeveloped land shall be assumed to be at least 35% impervious.
- (b) For the pre- vs post-development comparison, off-site run-on shall be modelled identically in both runs, at its existing condition (Clause 3.14.2).

> Commentary. A greenfield reference stops each redevelopment from being judged against an already degraded baseline. The UK non-statutory standards and KC APWA take the same approach in different forms: APWA caps existing agricultural land at no more than "good condition pasture, grassland or range (C = 0.30, CN = 74)" for HSG C, and forbids disturbed soils from being classed as HSG A or B (KC Metro APWA 5600, 2011, §5602.3A and E). The TR-55 "open space, good condition" values used in (b) are identical to TR-55's "pasture, grassland or range, good" values (USDA SCS TR-55, 1986, Tables 2-2a and 2-2c), so this Manual's pre-development CN equals the APWA cap on HSG C soils. The one-class downgrade for disturbed soils in 3.3.3(b) is set by this Manual as a simpler, less strict version of the APWA rule, suited to the thin brown hill soils and colluvium over the phyllites, schists and gneisses of the Daling Group and the Higher Himalaya, the boulder and gravel terraces of the Teesta and Rangit valley floors, and the cut-and-fill ground of the ridge towns, where an HSG A to C jump would be excessive. The 35% minimum imperviousness for unplanned upstream land in 3.3.5(a) is the APWA value (2011, §5602.3E.2). Using the master-plan land use for conveyance follows CPHEEO, which requires C to reflect "ultimate development of the catchment as per the master plan" (CPHEEO 2019, Part A §4.4.1.5).

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## 3.4 Selection of method

3.4.1 The method shall be selected from Table 3.1 by purpose and catchment size. Figure 3.1 shows the same rules as a flowchart.

**Table 3.1 — Permitted hydrologic methods**

| Purpose | Catchment / condition | Permitted method | Clause |
|---|---|---|---|
| Peak flow for one conveyance element (inlet, pipe reach, drain reach, culvert) | ≤ 16 ha contributing, no upstream storage, no backwater | Rational Method | 3.5 |
| Peak flow for conveyance | > 16 ha, or any upstream storage, tank or pond | Hydrograph method (SCS-CN with SCS unit hydrograph, SWMM or HEC-HMS) | 3.8–3.12 |
| Retention, detention, any storage; pre- vs post-development comparison | Any size | Hydrograph method; **Rational Method not permitted** | 3.8–3.12, 3.14 |

| Purpose | Catchment / condition | Permitted method | Clause |
|---|---|---|---|
| Pipe or drain network with backwater, tidal or tank tailwater | Any size | Hydrograph method with dynamic-wave hydraulic routing | 3.12.4; Chapter 5 |
| Catchment-scale flows | 25–5,000 km² in CWC subzone 2(a) (North Brahmaputra) | HEC-HMS or SWMM, benchmarked against the CWC synthetic unit hydrograph (SUH) | 3.11.4 |
| Regional facilities | Draining > 25 km² | Design-storm hydrograph method **plus** continuous simulation | 3.13 |
| Tank (pokhari) cascades | Any size | Design-storm hydrograph method **plus** continuous simulation | 3.13 |
| Tier B: small sites under Chapter 1 | Within the limits of the design aid | Design aids issued under Chapter 4, which are themselves derived by the methods of this chapter | 3.4.4 |
| Small sites, any authority | ≤ 1 ha, within the limits of Clause 4.14.3 | Fixed-coefficient route of Chapter 4 (fixed release coefficients, rainfall-mass storage) | 3.4.4; 4.14.3 |

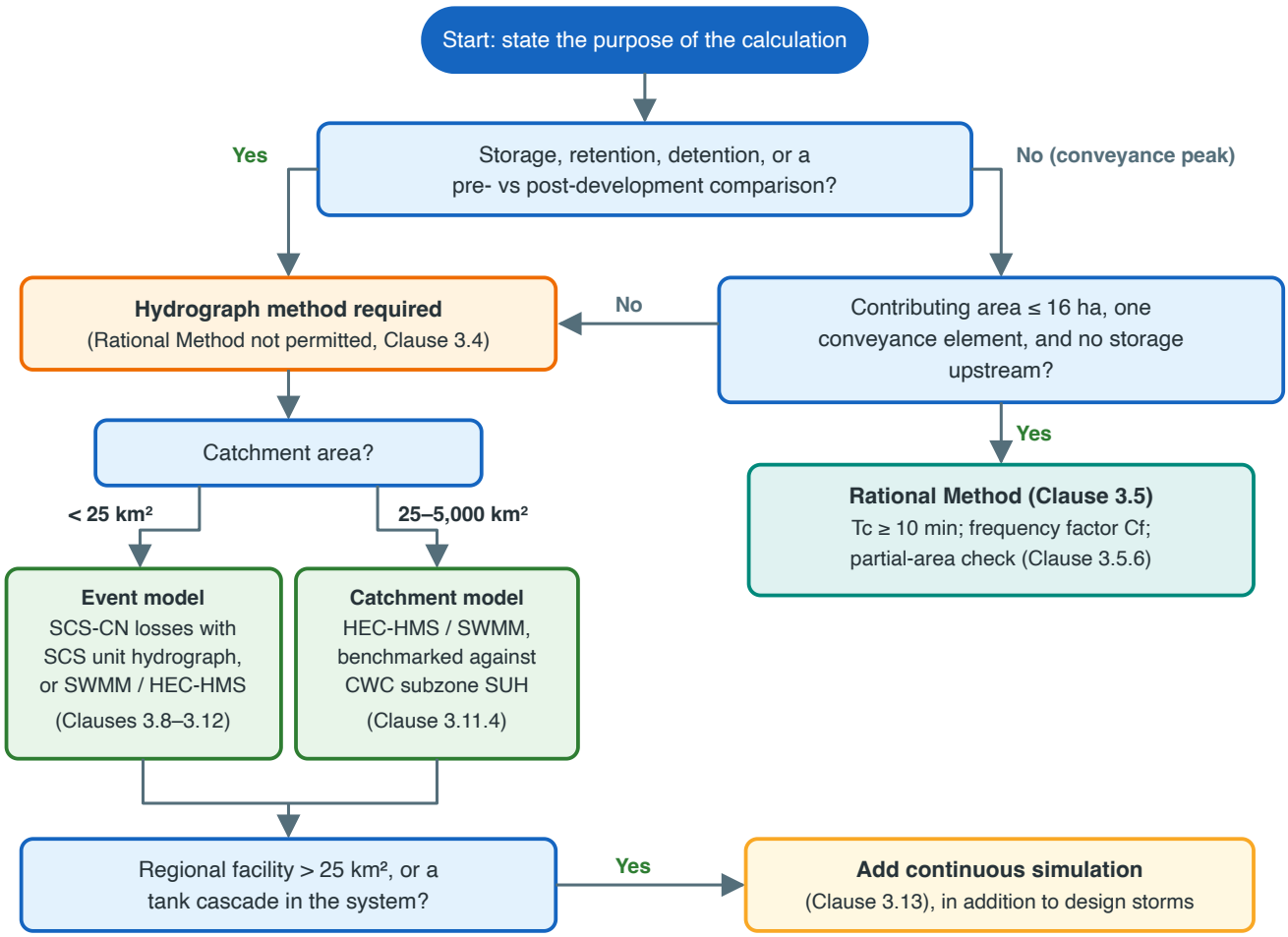


*Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).*

3.4.2 **Rational Method limits.** The Rational Method shall be used only for catchments of **16 ha or less** and only to compute the peak flow to a **single conveyance element**. It shall **never** be used to size retention, detention or any other storage, nor to derive a hydrograph or runoff volume.

3.4.3 **Hydrograph methods.** Above 16 ha, and for every storage calculation, a hydrograph method shall be used: SCS-CN losses with the SCS (NRCS) unit hydrograph, EPA SWMM, or HEC-HMS. For 25–5,000 km² the CWC synthetic unit hydrograph shall also be computed as a benchmark (Clause 3.11.4).

3.4.4 **Simplified routes.** In Tier B areas (Chapter 1), sites within the limits stated on a design aid issued under Chapter 4 may use that design aid in place of a site-specific hydrograph model. In any area, sites of 1 ha or less may use the fixed-coefficient route of Clause 4.14.3; it is the only exception to the rule in 3.4.2 that rainfall-based peak methods shall not be used for storage. The Rational Method remains available for conveyance under 3.4.2.

3.4.5 **Catchments above 5,000 km².** These are outside the scope of this Manual and require a basin study approved by the Water Resources Department (WRD).

> **Commentary.** The 16 ha limit and the single-element rule follow APWA 5600 Version 2025.01, which cut the Rational Method from 200 ac to 40 ac and restricted it to "a single pipe segment". The MARC Policy Supplement adds that it "cannot be used to size runoff reduction practices or determine retention volumes and detention volumes" (MARC, APWA Stormwater Standards Supplement, 2025). CPHEEO (2019, Part A §4.4.1.3) allows the Rational Method up to 8–10 km², which is too large for a method that assumes uniform rainfall intensity over the whole catchment for the whole of Tc and gives no volume. The Rational Method is excluded from storage design because it gives a peak, not a hydrograph, and storage depends on volume and timing.

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## 3.5 Rational Method

3.5.1 **Equation.** The peak flow shall be computed as:

$$Q = C \cdot Cf \cdot i \cdot A / 360$$

where Q is the peak flow (m³/s); C is the runoff coefficient (Table 3.2); Cf is the frequency factor (Table 3.3), with $C \cdot Cf \le 1.0$; i is the rainfall intensity (mm/h) for a duration equal to Tc, from Chapter 2 (with the climate factor of Clause 2.8); and A is the contributing area (ha).

> **Commentary.** This is the CPHEEO equation Qp = 10 C I A, with Qp in m³/h (CPHEEO 2019, Part A §4.4.1.1–4.4.1.3), converted to m³/s.

3.5.2 **Runoff coefficients.** C shall be taken from Table 3.2. Within a range, the designer shall use the upper half of the range unless site data justify a lower value.

**Table 3.2 — Runoff coefficient C (for AEP of 10% or more frequent)**

| Surface or land use | C | Source |
|---|---|---|
| Commercial | 0.70–0.95 | CPHEEO 2019, Table 4.2 |
| Industrial | 0.60–0.90 | CPHEEO 2019, Table 4.2 |
| Institutional | 0.70–0.95 | CPHEEO 2019, Table 4.2 |
| Residential, high density | 0.60–0.75 | CPHEEO 2019, Table 4.2 |
| Residential, low density | 0.40–0.60 | CPHEEO 2019, Table 4.2 |

| Surface or land use | C | Source |
|---|---|---|
| Recreational | 0.10–0.25 | CPHEEO 2019, Table 4.2 |
| Asphalt | 0.70–0.95 | CPHEEO 2019, Table 4.2 |
| Concrete | 0.80–0.95 | CPHEEO 2019, Table 4.2 |
| Brick paving | 0.70–0.85 | CPHEEO 2019, Table 4.2 |
| Roofs: tiles | 0.80–0.90 | CPHEEO 2019, Table 4.2 |
| Roofs: metal | 0.70–0.90 | CPHEEO 2019, Table 4.2 |
| Roofs: concrete | 0.70–0.90 | CPHEEO 2019, Table 4.2 |
| Lawns, sandy soil, flat (≤ 2%) | 0.05–0.10 | ASCE/WPCF 1969 |
| Lawns, sandy soil, average (2–7%) | 0.10–0.15 | ASCE/WPCF 1969 |
| Lawns, sandy soil, steep (> 7%) | 0.15–0.20 | ASCE/WPCF 1969 |
| Lawns, heavy (clay) soil, flat (≤ 2%) | 0.13–0.17 | ASCE/WPCF 1969 |
| Lawns, heavy soil, average (2–7%) | 0.18–0.22 | ASCE/WPCF 1969 |
| Lawns, heavy soil, steep (> 7%) | 0.25–0.35 | ASCE/WPCF 1969 |
| Undeveloped land (maximum for any condition) | 0.30 | KC APWA 5600 (2011), §5602.3E |

3.5.3 **Frequency factor.** For design AEPs rarer than 10%, C shall be multiplied by Cf from Table 3.3. The product C · Cf shall not exceed 1.0.

**Table 3.3 — Frequency factor Cf**

| Design AEP (return period) | Cf |
|---|---|
| 10% (10-yr) and more frequent | 1.00 |
| 4% (25-yr) | 1.10 |
| 2% (50-yr) | 1.20 |
| 1% (100-yr) | 1.25 |

3.5.4 **Composite C.** Where a catchment contains more than one surface, C shall be the area-weighted value $C = \Sigma(C_j \cdot A_j) / \Sigma A_j$, computed from the measured areas of each surface. Cf is applied to the composite C.

3.5.5 **Time of concentration and networks.**

- (a) Tc shall be computed by Clause 3.6 and shall not be less than **10 minutes**.
- (b) For each reach of a network within the 16 ha limit, the peak shall be computed with the cumulative $\Sigma(C \cdot A)$ upstream of that reach and the longest Tc to that reach. Peaks from upstream reaches shall not be added.

3.5.6 **Partial-area check.** Where a compact, highly impervious part of the catchment has a much shorter Tc than the whole, the peak shall also be computed for that part alone, using its own area, C and Tc. The larger peak governs.

> **Commentary.** The developed-surface coefficients in Table 3.2 are CPHEEO Table 4.2, which CPHEEO adapted from ASCE/WPCF (1969). CPHEEO keeps C constant for all return periods. Table 3.3 instead adopts the APWA antecedent-precipitation factors (KC Metro APWA 5600, 2011, §5602.2A: K = 1.1, 1.2 and 1.25 for 4%, 2% and 1% storms, with C·K ≤ 1.0). These factors matter here because Sikkim's rare storms arrive on wet ground (Clause 2.11.4). The 10-minute minimum Tc matches the minimum design duration of Clause 2.5.1. APWA 2011 bounds

inlet time between 5 and 15 minutes (§5602.7A). The partial-area check follows CPHEEO's treatment of "partial area effect" (CPHEEO 2019, Part A §4.4.1.7). This Manual requires the upper half of each range in 3.5.2 because Indian urban plots are typically more densely covered than the US land uses behind the ASCE ranges.

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## 3.6 Time of concentration

3.6.1 **General.** Tc shall be computed separately for the pre- and post-development conditions, along the flow path that gives the longest travel time to the point of interest, as the sum of travel times in each flow segment. Tc shall not be less than **10 minutes** for either condition.

3.6.2 **NRCS velocity (segment) method.** The NRCS segment method is the default for all catchments. Tc = Tt(sheet) + Tt(shallow) + Tt(channel), where:

- (a) **Sheet flow:**

  > Tt = 0.091 (n · L)^0.8 / (P2^0.5 · S^0.4)

  where Tt is in hours; n is the sheet-flow roughness from Table 3.4; L is the sheet-flow length (m); P2 is the present-day 50% AEP (2-yr) 24-hour rainfall (mm) from Clause 2.3, without the climate factor; and S is the land slope (m/m).

- (b) **Sheet-flow length.** In urban areas, and for all post-development conditions, the sheet-flow length shall not exceed **30 m**. For pre-development greenfield surfaces, up to 90 m may be used only where survey shows unchannelled planar ground; otherwise 30 m applies.

- (c) **Shallow concentrated flow:** Tt = L / (3,600 V), with V = 4.918 S^0.5 (unpaved) or V = 6.196 S^0.5 (paved), V in m/s, L in m and S in m/m.

- (d) **Channel and pipe flow:** Tt = L / (3,600 V), with V from Manning's equation at bank-full or pipe-full flow.

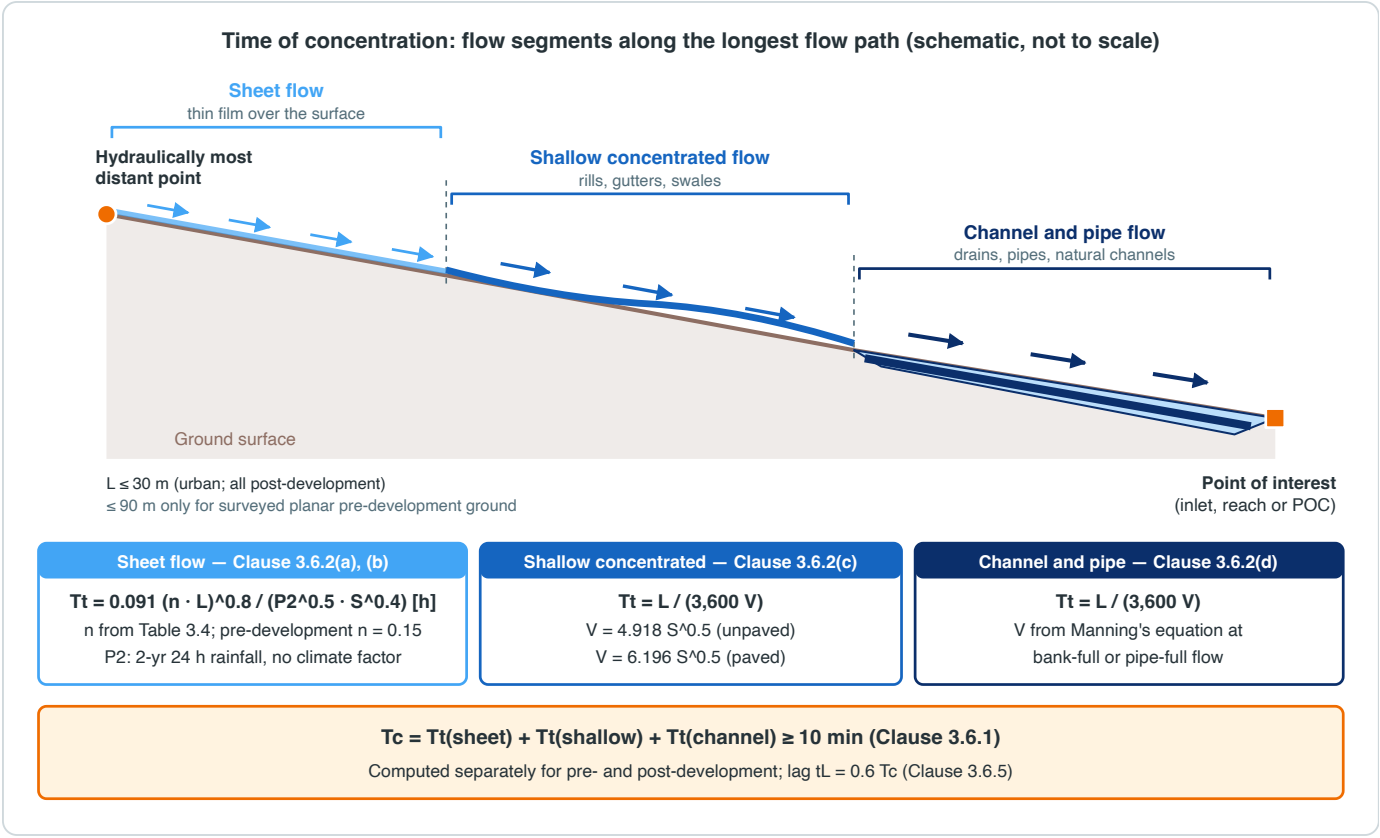


*Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986), Ch. 3, and USDA NRCS, NEH Part 630, Ch. 15 (2010).*

**Table 3.4 — Manning's n for sheet flow (USDA SCS TR-55, 1986, Table 3-1)**

| Surface | n |
|---|---|
| Smooth surfaces (concrete, asphalt, gravel, bare soil) | 0.011 |
| Fallow (no residue) | 0.05 |
| Cultivated, residue cover ≤ 20% | 0.06 |
| Cultivated, residue cover > 20% | 0.17 |
| Grass: short-grass prairie | 0.15 |
| Grass: dense grasses | 0.24 |
| Range (natural) | 0.13 |
| Woods: light underbrush | 0.40 |
| Woods: dense underbrush | 0.80 |

3.6.3 **Pre-development roughness.** For the pre-development greenfield surface of Clause 3.3.2, sheet-flow n shall be **0.15** unless the designer justifies another Table 3.4 value from the natural vegetation of the area.

3.6.4 **Kirpich formula.** The Kirpich formula may be used only as a cross-check, or for pre-development rural catchments with a defined main channel:

> tc = 0.0195 L^0.77 S^−0.385

where tc is in minutes, L is the length of the main flow path (m) and S is its average slope (m/m). It shall not be used for urban or post-development catchments.

3.6.5 **Lag.** Where a unit hydrograph method requires lag, tL = 0.6 Tc.

3.6.6 **Check.** Post-development Tc shall normally be shorter than pre-development Tc. Where it is longer, the designer shall explain why in the submittal.

> Commentary. The segment method and its equations are from TR-55 (USDA SCS, 1986, Ch. 3) and NEH Part 630, Ch. 15 (USDA NRCS, 2010). The SI constants are direct conversions of the US equations: 0.007 becomes 0.091 with L in m and P2 in mm, and 16.1345 and 20.3282 ft/s become 4.918 and 6.196 m/s. TR-55 (1986) allowed sheet flow up to 300 ft (≈ 90 m). NEH 630 Ch. 15 states that sheet flow typically lasts no more than about 100 ft (≈ 30 m) before becoming shallow concentrated flow (citing Merkel, 2001), and many US agencies now cap it there. This Manual sets the 30 m urban limit in 3.6.2(b) on that basis: in Indian urban plots, flow reaches a drain, kerb or compound-wall weep hole within a few metres. The undisturbed P2 is used in the sheet-flow equation because P2 is a parameter of the travel-time relationship, not a design load. The default n = 0.15 for greenfield is the TR-55 short-grass value; this Manual adopts it to avoid long pre-development Tc values that would make Q_pre artificially low. The Kirpich formula is the SI form given by Chow, Maidment and Mays (1988, Table 15.1.2), from small agricultural catchments in Tennessee (Kirpich, 1940), so it does not suit urban surfaces. The lag ratio 0.6 is the NRCS value, also used by APWA (2011, §5602.7C).

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## 3.7 Soils and hydrologic soil groups

3.7.1 **Mapping.** HSG shall be assigned from the soil series mapped by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) or the State soil-survey agency of Sikkim [TBC], using the soil-series-to-HSG lookup of Annex 3A. The source map and its scale shall be stated.

3.7.2 **Assignment rule.** Where Annex 3A is not yet available for a series, the HSG shall be assigned from the measured saturated hydraulic conductivity and depth to an impermeable layer or water table using the criteria of NEH Part 630, Ch. 7. Until Annex 3A is published, this Manual sets the following interim groups for Sikkim: the thin brown hill soils over the weathered phyllite, schist and gneiss of the Daling Group and the Higher Himalaya, on the slopes of sub-areas SK-B and SK-B1 and the hillsides of sub-area SK-A, HSG C, and HSG D for design on natural slopes of more than 10°, whatever group the soil itself would take; bedrock, road surfaces and compacted ground, HSG D; the colluvial debris fans, HSG B for runoff, because their material drains freely, but with no infiltration credit, because they are slide-prone (Clause 4.11, hill rule); the boulder and gravel terraces of the Teesta, the Rangit and the Rongni Chu in sub-area SK-A, HSG A or B where the seasonal high water table stands more than 2 m below ground in the monsoon season, with infiltration practices on them only under Clause 4.11 (recharge rule), and HSG C where it stands within 2 m; the river bed and terraces raised by the flood of October 2023, HSG C, whatever the depth to water, with no infiltration credit (Clause 4.11, valley-floor rule); urban fill and the cut-and-fill ground of the ridge towns, HSG C, and HSG D where it is clayey or compacted; and the alpine soils and moraine of sub-area SK-C, HSG C or D by test, and HSG D when frozen or under snow. A field infiltration test is required on every site larger than the limits of the simplified method of Clause 4.14.1, at the depth of the proposed facility; on smaller sites, a soil that has not been tested shall be given the less permeable of the groups listed for it. Whether an infiltration practice may be built at all is governed by the three infiltration rules of Clause 4.11 (the hill rule, the valley-floor rule and the recharge rule), not by its HSG. Clause 3.10.1 applies to all of these groups.

3.7.3 **Site verification.** For every site that relies on retention by infiltration (Chapter 4), the mapped HSG shall be verified by site infiltration tests at the location and depth of each infiltration facility. Where the tests show a lower infiltration capacity than the mapped HSG, the test result governs for both the retention design and the post-development CN. Where they show a higher capacity, the pre-development HSG shall not be changed without the approval of the authority.

3.7.4 **Disturbed and filled ground.** Clause 3.3.3(b) applies.

Commentary. NBSS&LUP soil maps are typically at 1:250,000 to 1:50,000 scale and classify soils by series and taxonomy, not by HSG. A lookup table is therefore needed (Annex 3A). Site tests matter most where one site can span two groups: at the foot of the slopes above Rangpo, Singtam, Melli, Majitar and Jorethang, where colluvium and debris fans pass onto the boulder and gravel terraces and the water table rises towards the river; on the terraces themselves, where gravels that drain freely can lie under fine flood deposits, or over a water table that the Teesta or the Rangit raises in the monsoon season; and on hill sites beside a jhora (झोरा; a natural watercourse or ravine stream), where a high rate in a pit dug in colluvium, fill or slide debris can be water entering a slope that cannot take it, as the seepages and springs (dhara, धारा; a spring or spring spout) of the hillsides show (Clause 4.11). No HSG map or table for Sikkim, no soil-series data of NBSS&LUP for the State, no SCS-CN calibration and no measured infiltration rate for any site in Sikkim were found during research for this Manual [TBC]. The interim groups follow the ground as the sources describe it. In East Sikkim the rocks are "gneiss, schists, quartzites, phyllites, limestones, sandstones, shales, meta-sedimentaries", with groundwater "in fractured and jointed zones … and in weathered zones" (CGWB, aquifer mapping of East Sikkim, as quoted); in South Sikkim the "Daling group of rocks is dominant" (CGWB, as quoted), although the same source elsewhere names the Gorubathan Formation as dominant, and the two statements conflict; and Gangtok's slopes stand on "Precambrian rocks which contain foliated schists and phyllites" (a landslide-susceptibility study, as summarised). Over them lie thin brown hill soils and colluvium: the soil plate of the CWC subzone 2(a) report (Plate 6) shows brown hill soil in its legend, although its Sikkim polygon was not checked (NEER reading). Groundwater is "largely in disconnected localized pockets and in deeper fracture zones", "springs are the main source", and on steep terrain it emerges "as seepages and springs wherever the land surface intersects local ground water body" (CGWB, as quoted). Such ground does not take water away; it carries it along the slope to the next seepage. The stability-zone notification of the Mines and Geology Department (No. 17/DMG/20-21, 19 March 2021) records the hydrology of the ground as "Dry/nil" in zone 1, "Wet" in zone 3, "Dripping" in zone 4 and "Flowing" in zones 5 and 6, and Gangtok Smart City Development Ltd (GSCDL) told the National Green Tribunal (NGT) that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (reply affidavit in NGT OA 38/2022). The thin hill soils may themselves test as HSG C, but on a slope they lie thin over rock and pass their water to the slope below, so they are designed as D above 10°. The colluvial debris fans drain freely as a material, which is why they are B for runoff, but the Daling Group, "especially the Gorubathan Formation, appears more prone to landslides than Quaternary deposits and Higher Himalayan gneisses and schists" (as reported), and water put into a fan raises the pore pressure in the slope, so they earn no infiltration credit (Clause 4.11, hill rule). The boulder and gravel terraces of the valley floors are the only ground where water can soak away, and only where the water table is deep: the terraces at Rangpo, Melli and Jorethang are gravels with a high water table in the monsoon season (NEER reading), no depth to water has been measured on any of them [TBC], and the flood of October 2023 raised the bed of the Teesta "by an average of 7-8 meters" (State Government's pre-project report on GLOF risk mitigation in the Lhonak valley, annexed to its affidavit of 28 February 2026 in NGT OA 171/2023), so a terrace that stood well above the river before 2023 may now stand beside a raised and wet bed. The only regional measure of losses is the design loss rate of the CWC subzone 2(a) report, 0.24 cm/h (2.4 mm/h), the modal value of about 233 flood events on 21 foothill and plains catchments gauged at railway bridges (Annex 3E). It is a plains value: thin soils over rock may lose less than this in a wet monsoon, and more in the pre-monsoon storms of April and May, which fall on drier ground (NEER reading). It shall be used only in rural SUH runs under Clause 3.11.4, as a check at the scale of a basin, not to assign an HSG, not in an urban SCS-CN or SWMM model and not to size an infiltration practice. The interim groups of Clause 3.7.2, the 2 m water-table condition on the terraces, the design of slopes of more than 10° as group D, the treatment of the debris fans and of the ground raised in 2023, and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Sikkim. Steep ground matters as much as soil.

The SBCR 1991 bar allotment only on slopes "exceeding or around 70 (Seventy) degree" (reg. 35), and the stability zones run from slopes of "<15°" in zone 1 to more than 45° in zones 5 and 6; on flow paths of 30–60%, the Kirpich and Kerby formulae give times of concentration of 1–5 minutes (NEER's computation, as in the mountain editions of this series). The following rules are set by this Manual. (a) Tc shall be found by the velocity-based segment method of Clause 3.6.2, segment by segment, and shall not be taken below the 10-minute minimum of Clause 3.6.1, which matches the shortest design duration of Chapter 2; the Kirpich formula, derived from small farm catchments of moderate slope, shall not be used even as a cross-check where the average slope of the flow path exceeds 10%. (b) The sheet-flow segment over bare rock, a road cut or a paved hill street shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (c) Urban and jhora catchments below 25 km² are modelled by the Rational Method within the limits of Clause 3.4.2, or by a hydrograph model such as SWMM or HEC-HMS, with the Tc of (a); the CWC unit hydrograph does not apply to them. A ridge town, such as Gangtok, Pakyong, Namchi or Gyalshing, is delineated by jhora, not by ward, because one ward drains to several jhoras and each jhora has its own outfall. (d) A catchment that runs from a hill flank onto a valley floor, such as the jhoras and side streams that leave the slopes onto the terraces and the raised bed of the Teesta at Singtam, Rangpo and Melli or of the Rangit at Majitar and Jorethang, shall be split at the break of slope and the hill sub-area modelled on its own, so that a flatter lower reach does not average away the fast response of the hill. (e) At a valley-floor town two design cases are run, and the more severe governs: a short burst on the hillside with the river low, which sets the peak in the town's drains and jhoras; and a storm of 24 to 72 hours with the river at the design tailwater of Chapter 5, which sets the storage and the outfall (Clause 5.8.5(b)). (f) In a lined drain, chute or trained jhora on a steep slope the flow is supercritical; the conveyance design of Chapter 6 allows for air entrainment, which bulks the flow, and for splash and superelevation at bends, and uses stepped or baffled chutes, drop structures and an energy dissipator at every fall to a jhora or onto a slope (Clause 6.3.6; Chapter 9). (g) Catchments that drain to a hydropower reservoir, or to a reach below its dam, are modelled with storage routing and the operator's release scenarios, not by a peak-flow method alone; the full and maximum levels and the release rules of the reservoirs were not found [TBC] (Clause 3.12; Clause 5.8.5(c)). (h) No method of this chapter applies to a catchment with permanent snow, a glacier or a mapped glacial lake, or to the Teesta trunk; their floods, including a glacial lake outburst flood (GLOF), rain on snow and debris flow, need a site-specific study under Clause 2.3.6(i). (i) No method of this chapter predicts debris flow; in steep catchments the design flow is bulked for sediment and debris, and inlets and culverts are protected against blockage, under Clause 6.3.6 and Chapter 9; no Sikkim debris or bulking allowance was found [TBC].

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## 3.8 SCS curve number (SCS-CN) loss method

3.8.1 **Runoff equation.** Runoff depth shall be computed by:

> $Q = (P - I_a)^2 / (P - I_a + S)$ for $P > I_a$; $Q = 0$ otherwise $S = 25{,}400 / CN - 254$

where Q is runoff depth (mm), P is the cumulative rainfall depth (mm), S is potential maximum retention (mm) and Ia is initial abstraction (mm). In hydrograph models the equation is applied to the cumulative rainfall at each time step to obtain incremental rainfall excess.

3.8.2 **Curve numbers.** CN at AMC II shall be taken from Table 3.5, for the HSG of Clause 3.7.

**Table 3.5 — Runoff curve numbers, AMC II, Ia = 0.2S (USDA SCS TR-55, 1986, Tables 2-2a and 2-2c)**

| Cover type | HSG A | HSG B | HSG C | HSG D |
|---|---|---|---|---|
| **Pre-development reference (Clause 3.3.2):** open space, good condition (grass > 75%) | 39 | 61 | 74 | 80 |
| Open space, fair condition (grass 50–75%) | 49 | 69 | 79 | 84 |
| Open space, poor condition (grass < 50%) | 68 | 79 | 86 | 89 |
| Impervious: roofs, paved parking, driveways, paved roads with kerbs and drains | 98 | 98 | 98 | 98 |
| Paved roads with open ditches (including right-of-way) | 83 | 89 | 92 | 93 |
| Gravel roads (including right-of-way) | 76 | 85 | 89 | 91 |
| Dirt roads (including right-of-way) | 72 | 82 | 87 | 89 |
| Newly graded areas (pervious, no vegetation) | 77 | 86 | 91 | 94 |
| Fallow, bare soil | 77 | 86 | 91 | 94 |
| Meadow (continuous grass, protected from grazing) | 30 | 58 | 71 | 78 |
| Brush, good condition | 30 | 48 | 65 | 73 |
| Woods, good condition | 30 | 55 | 70 | 77 |
| Woods, fair condition | 36 | 60 | 73 | 79 |
| Woods, poor condition | 45 | 66 | 77 | 83 |
| Water surfaces, tank waterspreads, wet detention basins | Runoff = rainfall (no losses) | | | |

3.8.3 **Use of Table 3.5.**

- (a) Post-development CN shall be built up from measured surfaces (Clause 3.9). The TR-55 urban district and residential lot-size rows shall not be used for the site.
- (b) Pervious areas in the post-development condition shall use "open space" in the condition the landscape plan will achieve. Where no landscape plan is submitted, fair condition applies.
- (c) Cultivated rows of TR-55 may be used for off-site existing conditions, but never for the pre-development reference of Clause 3.3.2.

3.8.4 **Antecedent moisture.** AMC shall follow Clause 2.11.4: AMC III for every design storm, whatever its duration, from 1 May to 30 September at a site in any sub-area of Annex 2A (SK-A, SK-B, SK-B1 or SK-C); AMC III for every design storm from 1 April to 31 October on valley-floor land below the 1% AEP flood level of the Teesta, the Rangit, the Rongni Chu or another river, on the river bed and terraces raised by the flood of October 2023, wherever the seasonal high water table is within 2 m of the ground, and in stability zones 3 to 6 of the Mines and Geology Department's notification of 2021, whose ground it records as "Wet", "Dripping" or "Flowing"; AMC III for every design storm at any time of year in a catchment that drains to a hydropower reservoir or its backwater (among them Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Jorethang, Tashiding, Rangit-III and Rongnichu), to a reach below a dam into which the dam releases water, or to a river reach whose CWC gauge stands above its warning level; at any other site or time, AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm; and AMC II for every other storm. AMC I is not used. CN for AMC I and III shall be obtained from AMC II by:

> $CN(I) = 4.2\,CN(II) / (10 - 0.058\,CN(II))$ $CN(III) = 23\,CN(II) / (10 + 0.13\,CN(II))$

The conversion shall be applied **to the pervious component only**. Impervious surfaces stay at CN 98 for all AMC. Composite CNs shall not be converted directly.

*Illustrative — not design values.* Pre-development reference CNs at AMC III are: HSG A 59.5; HSG B 78.2; HSG C 86.7; HSG D 90.2.

3.8.5 **Initial abstraction.**

- (a) **Default:** Ia = 0.2S, with the CNs of Table 3.5.
- (b) **Sensitivity run (mandatory):** every storage design shall also be run with Ia = 0.05S. For this run, S shall be converted as S0.05 = 1.33 · S0.20^1.15 (S in inches), which in SI is:

  > S0.05 = 25.4 × 1.33 × (S0.20 / 25.4)^1.15 (mm)

- (c) The design shall be based on the default run. The sensitivity results shall be reported on Form 3-2. Where the sensitivity run increases the required retention volume or water quality volume, the larger value governs for that volume.

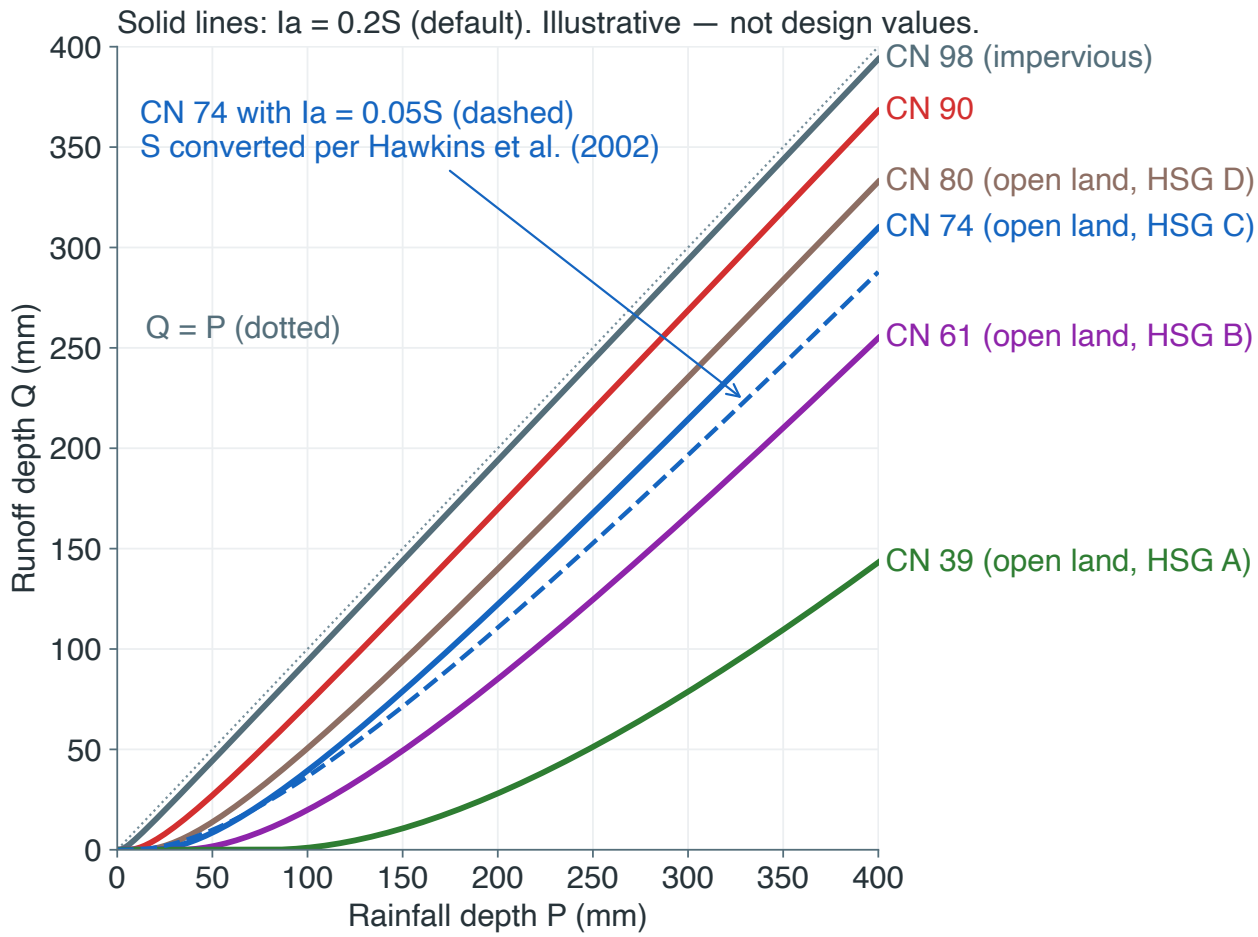


*Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion of Hawkins et al. (2002). Illustrative — not design values.*

**Commentary.** Table 3.5 reproduces standard NRCS TR-55 (1986) values. They were derived from US catchments and have not been calibrated in Sikkim. The AMC conversion equations are the standard NEH-4 relationships as given by Chow, Maidment and Mays (1988, §5.5). Converting only the pervious component follows APWA, which states that "direct conversion of composite antecedent moisture conditions is not appropriate" (KC Metro APWA 5600, 2011, §5602.2C). Converting a composite CN would wrongly lower the CN of the impervious part.

Ia = 0.2S is the original NRCS ratio. Analysis of US rainfall–runoff data found that 0.05S fits better on average (Hawkins et al., 2002; Woodward et al., 2003), and gave the conversion of 3.8.5(b). NRCS has not formally replaced 0.2S, so this Manual keeps it as the default. Figure 3.3 shows why the sensitivity run is needed: for CN 74, the 0.05S case gives **more** runoff for small storms (about 2.0 mm vs 0.5 mm from 25 mm of rain) but **less** for large storms (about 242 mm vs 262 mm from 350 mm). *Illustrative — not design values.* The ratio therefore matters most for retention and water quality volumes, and the default 0.2S is the conservative choice for peak and detention design. The rule in 3.8.5(c) that the larger retention or water-quality volume governs has no direct precedent; this Manual sets it because the 0.05S case gives more runoff from the small storms that set those volumes.

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## 3.9 Impervious connectivity

3.9.1 **Classification.** Every impervious surface in the post-development condition shall be classified as directly connected (DCIA) or disconnected, and shown on the drainage plan.

3.9.2 **Preferred representation.** In hydrograph models, DCIA and pervious areas shall be modelled as separate sub-areas (or as the separate impervious and pervious fractions of a SWMM subcatchment), each with its own loss parameters. The runoff from disconnected impervious areas shall be routed onto the receiving pervious area.

3.9.3 **Disconnection criteria.** An impervious area may be classed as disconnected only if all of the following hold:

- (a) its runoff discharges as sheet flow onto a pervious area, without a pipe, channel or kerb;
- (b) the pervious flow path is at least as long as the impervious flow path draining to it;
- (c) the pervious area is not compacted, not HSG D, and is protected from paving by the approved plan; and
- (d) for storms of 12 hours or more, it does not drain to an RWH sump or tank (Clause 3.3.3(c)).

3.9.4 **Composite CN.** Where a single composite CN is used instead of 3.9.2, it shall be computed as:

- for directly connected impervious area: $CNc = CNp + (Pimp / 100)(98 - CNp)$;
- where total impervious area is below 30% and part of it is disconnected: $CNc = CNp + (Pimp / 100)(98 - CNp)(1 - 0.5\,R)$,

where CNp is the pervious CN, Pimp is the percentage of impervious area and R is the ratio of disconnected to total impervious area. The composite CN shall not be used for retention or water quality volumes.

**Commentary.** The composite equations are from TR-55 (USDA SCS, 1986, Ch. 2, Figures 2-3 and 2-4). This Manual prefers separate representation in 3.9.2 because a composite CN spreads the impervious response over the whole area, which suppresses runoff from small storms. For a site that is 50% directly connected impervious on HSG B open space (CNp 61), 25 mm of rain gives about 9.9 mm of runoff when the two parts are modelled separately, but only about 1.8 mm with the composite CN 79.5. At 200 mm the two methods agree (139.5 mm vs 138.4 mm). *Illustrative — not design values.* The error is largest for the frequent storms that set retention and water-quality volumes. The disconnection criteria of 3.9.3 are set by this Manual, drawing on common practice in US runoff-reduction manuals. Criterion (d) follows the rule of Clause 3.3.3(c) that RWH sumps are full at the start of monsoon storms.

## 3.10 Groundwater, high water table and tank backwater

3.10.1 **High water table (dual HSG).** Where the seasonal high groundwater table is within 0.6 m of the ground surface, the soil shall be assigned HSG D for both the pre- and post-development runs, whatever its texture, unless it is permanently drained by works that are maintained under Chapter 10. This rule applies in every case to storms of 12 hours or more, which are run at AMC III (Clause 2.11.4).

3.10.2 **Water-table data.** The seasonal high water table shall be taken as the highest level recorded in the monsoon season (April–October), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or WRD observation well, adjusted for ground level.

3.10.3 **Infiltration-based losses.** Where Green–Ampt, Horton or soil-moisture-accounting losses are used instead of SCS-CN, the cumulative infiltration in any storm shall not exceed the storage available in the soil above the seasonal high water table.

3.10.4 **Tank and waterbody backwater.** Where a site or sub-catchment drains to a tank, pokhari, marsh or other waterbody:

- (a) the water level in the receiving waterbody shall be applied as the downstream boundary of the model, per Chapter 5 and Chapter 7;
- (b) land below the level of the receiving waterbody in the design event (including the tank foreshore below FTL) shall be modelled as water surface or storage, with no losses; and
- (c) where the outfall is submerged by the waterbody level, the routing shall use the dynamic-wave method of Clause 3.12.4.

Commentary. The dual-group rule follows NEH Part 630, Ch. 7 (USDA NRCS, 2009), which places wet soils with a water table within 60 cm (24 in) of the surface in group D in their undrained state, with a dual group (A/D, B/D, C/D) where drainage is feasible. This Manual applies the undrained group to long storms because some land in Sikkim is wet in the monsoon season, although most of the State is hard rock on steep slopes. Groundwater there is "largely in disconnected localized pockets and in deeper fracture zones", and "springs are the main source" (CGWB, as quoted); no CGWB depth to water, observation-well record or extraction figure for Sikkim was read for this Manual, because the CGWB's Sikkim reports could not be reached [TBC]. The wet land is of four kinds. The first is the valley floors and river terraces of sub-area SK-A at Rangpo, Singtam, Melli, Majitar and Jorethang, gravels with a high water table in the monsoon season (NEER reading), beside a river whose bed the flood of October 2023 raised by metres: NHPC estimated the rise at about 7.44 m at the Teesta Low Dam IV project, 7.29 m at Teesta Low Dam III, 6.00 m at Teesta-V and 2.00 m at Teesta-VI, and at Toong Naga, where the left bank "consists of loosely compacted soil mixed with boulders", 155 households "have been mandated for relocation" (State Government's pre-project report on GLOF risk mitigation in the Lhonak valley, annexed to its affidavit of 28 February 2026 before the National Green Tribunal (NGT)). The second is the seepage zones of the slopes, where groundwater emerges "as seepages and springs wherever the land surface intersects local ground water body" (CGWB, East Sikkim, as quoted). The third is the ground of stability zones 3 to 6 of the Mines and Geology Department's notification of 2021, whose hydrology it records as "Wet" in zone 3, with groundwater "Medium to high", "Dripping" in zone 4 and "Flowing" in zones 5 and 6 (Notification No. 17/DMG/20-21, 19 March 2021). The fourth is the margins of the pokharis (पोखरी; pond, lake or tank) and of the hydropower reservoirs. No monsoon water-table depth for any site in Gangtok, Namchi, Rangpo, Singtam or Jorethang, and no map of the seasonal high water table, was obtained [TBC]; Annex 3A is to supply them. Clause 3.10.4 reflects the State's receiving waters: jhoras with no gauges, which in Gangtok the Gangtok Municipal Corporation (GMC) has its waste agency clear under its contract of 2024 (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024); a few rivers with CWC sites; and reservoirs whose levels were not found. The CWC levels, as transcribed by SANDRP (as reported), are: the Teesta at Khanitar, a highest level of 297.7 m on 18 September 1974, raised to 298.4 m at 09:00 on 4 October 2023; the Teesta at Melli, a warning level of 226.0 m and a danger level of 227.0 m, an old highest level of 225.25

m, and a peak on 4 October 2023 given as 225.5 m (04:00) in SANDRP's text but as 228.0 m in a CWC daily bulletin of 2024 (as quoted), two figures that conflict and are not resolved here; the Rongni Chu at Singtam, a danger level of 355.09 m and a highest level of 356.09 m, with no date; and the Rangit at Majitar, a highest level of 279.29 m on 17 October 1985. No datum is stated for any of them [TBC], no CWC level was found for Rangpo [TBC], and the sites upstream on the Teesta stopped recording between 22:00 and 23:00 on 3 October 2023 (as reported). After October 2023 every highest flood level needs a post-2023 survey, because the bed beneath it has moved (Clause 5.8.5(b)). The hydropower reservoirs, Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rangit-III and Rongnichu, with Teesta-III at Chungthang under restoration, hold a water surface that their operators control; a site that drains to one applies Clause 3.10.4(b) to the land below the reservoir's starting level, which is set in the Commentary to Clause 3.12.

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## 3.11 Unit hydrographs and runoff transformation

3.11.1 **Permitted transforms.**

- (a) SCS (NRCS) dimensionless unit hydrograph, curvilinear or triangular, for catchments below 25 km² and for any sub-area of a larger model;
- (b) the SWMM non-linear reservoir with kinematic overland flow;
- (c) Clark or ModClark unit hydrograph in HEC-HMS, where parameters are calibrated under Clause 3.15; and
- (d) the CWC synthetic unit hydrograph, for 25–5,000 km² (Clause 3.11.4).

3.11.2 **SCS unit hydrograph.** The peak and time to peak of the unit hydrograph shall be:

> $q_p = PRF' \cdot A \cdot Q / t_p$, with $PRF' = 0.208$ (SI form of the standard peak rate factor 484) $t_p = \Delta t / 2 + t_L$, $t_L = 0.6\ T_c$

where $q_p$ is the peak flow (m³/s); $A$ is the area (km²); $Q$ is the runoff depth (mm), equal to 1 mm for the unit hydrograph; $t_p$ is the time to peak (h); and $\Delta t$ is the computation interval (h).

3.11.3 **Computation interval and sub-areas.**

- (a) $\Delta t$ shall not exceed 0.133 $T_c$ of the smallest sub-area, nor the hyetograph time step of Clause 2.9.1.
- (b) Sub-areas shall be reasonably uniform in HSG, land cover and slope. Pervious and directly connected impervious areas shall be separate sub-areas, per Clause 3.9.2.

3.11.4 **CWC synthetic unit hydrograph.** For catchments of 25–5,000 km² in CWC subzone 2(a) (North Brahmaputra), which covers the whole State but whose isopluvial plates draw no contour north of Gangtok, so that in sub-areas SK-B1 and SK-C no CWC point rainfall exists for the cross-check of Clause 2.3.3(b) and the depths of Clause 2.3.6(c)(ii) and (c)(iii) apply instead; its unit hydrograph is not applied to a catchment with permanent snow, a glacier or a mapped glacial lake, or to the Teesta trunk, which need a site-specific study (Clause 2.3.6(i); Annex 3E):

- (a) the SUH parameters, design storm duration, loss rate, base flow, areal reduction and time distribution shall be taken from the applicable CWC Flood Estimation Report, using the catchment's physiographic parameters measured from survey or a DEM;
- (b) the 24-hour design rainfall shall follow Clause 2.3.3(b) and Clause 2.7.3, and the climate factor of Clause 2.8 shall be applied;
- (c) the SUH result shall be reported alongside the HEC-HMS or SWMM result for the existing natural condition; and
- (d) where the hydrograph model gives a lower 1% AEP peak than the CWC SUH, the designer shall either justify the model by calibration under Clause 3.15 or adopt the CWC SUH peak.

3.11.5 **Peak rate factor for flat coastal land.** The standard factor (484; PRF' = 0.208) is the default. A lower factor may be used only:

- (a) for unchannelled, flat coastal-plain land without piped or lined drainage;
- (b) in the same way in both the pre- and post-development runs for any land that stays unchannelled; and
- (c) after the authority adopts calibrated values in Annex 3D.

Land drained by pipes, lined drains or kerbs in the post-development condition shall use the standard factor.

> Commentary. The SCS unit hydrograph, the 0.6 lag ratio and the 0.133 Tc interval are from NEH Part 630, Ch. 16 (USDA NRCS, 2007). The interval follows from the unit hydrograph geometry: with tp = Δt/2 + 0.6 Tc and Tc + Δt = 1.7 tp, Δt = 0.133 Tc. The SI constant 0.208 is the direct conversion of 484 (cfs, mi², in, h). APWA uses the SCS dimensionless unit hydrograph as its basis (2011, §5602.5). The CWC Flood Estimation Reports give regression equations for SUH parameters, a design storm duration, a constant loss rate and ARF and time-distribution curves for each subzone (CWC 1991; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the report of 1991 (its 21 representative catchments are rural bridge sites of the North Frontier Railway in the foothills and plains of the subzone, with slopes of about 1–10 m/km; none lies in Sikkim, which had no railway in the report's period, by NEER's reading, the report's catchment table not having been checked [TBC]), so they represent pre-development conditions, not urbanised ones. That is why the SUH is used as a benchmark rather than as the post-development model. Clause 3.11.4(d) mirrors the floor principle of Clause 2.3.3. HEC-HMS has been calibrated against CWC subzone SUH responses in Indian studies, which shows the two can be linked.
>
> The lower-factor option of 3.11.5 is based on the NRCS Delmarva unit hydrograph, which uses a peak rate factor of 284 (PRF' ≈ 0.122) for flat, poorly channelled coastal-plain catchments on the Delmarva Peninsula (Welle et al., 1980, as adopted by NRCS; New Jersey Department of Agriculture, Delmarva bulletin, which uses 285). A lower factor gives a lower, later peak. Used only in the pre-development run, it would lower Q_pre and make the release cap stricter; used in a piped post-development run, it would understate Q_post. Clause 3.11.5(b) prevents both biases.

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## 3.12 Routing

3.12.1 **Storage routing.** Routing through detention and retention facilities, tanks, ponds and any storage behind embankments shall use level-pool (modified Puls, storage-indication) routing with:

- (a) a stage–storage relationship from the design grading or survey;
- (b) a stage–discharge relationship for every outlet (orifices, weirs, surplus weirs, pumps), including the minimum orifice and trash screen of Chapter 4; and
- (c) the tailwater boundary of Chapter 5, where the tailwater affects the outlet rating.

3.12.2 **Channel routing.** Routing through channels and drains shall use the Muskingum–Cunge method, or the Muskingum method with parameters K and X that are derived from channel geometry or calibration. For the Muskingum method, the routing interval Δt shall satisfy $2KX \le \Delta t \le 2K(1 - X)$.

3.12.3 **Incidental storage.** Storage behind road embankments, culverts or boundary walls that is not part of an approved facility shall not be counted in the design unless the authority is satisfied that it will be maintained for the design life.

3.12.4 **Dynamic-wave routing.** Dynamic-wave (full Saint-Venant) routing, in SWMM or HEC-RAS unsteady flow, shall be used where:

- (a) the outfall is under tidal, river or tank backwater (Chapter 5, Clause 3.10.4);
- (b) flow can reverse, or the network has loops or overflow links; or
- (c) the network surcharges in the design event and the hydraulic grade line sets the design.

3.12.5 **Tank cascades.** Tanks in a cascade shall each be routed by Clause 3.12.1, with the surplus weir and sluice ratings and the documented operating rule of Chapter 7. The starting water level in each tank shall be FTL unless continuous simulation (Clause 3.13) supports a lower level.

**Commentary.** Modified Puls routing for storage and Muskingum–Cunge for channels are the APWA requirements (KC Metro APWA 5600, 2011, §5602.8). APWA also excludes "incidental detention" behind embankments unless it will be maintained, which 3.12.3 adopts. CPHEEO's detention procedure uses the same three inputs as 3.12.1: an inflow hydrograph, a stage–storage curve and a stage–discharge curve (CPHEEO 2019, Part A §8.5.3). The Muskingum stability limits are standard (Chow, Maidment and Mays, 1988, §8.4). This Manual starts pokharis and reservoirs at their full or maximum level in 3.12.5 because Sikkim's heavy rain falls on waterbodies that are already full or held up for power, not drawn down for drainage. The Manual's monsoon season runs from 1 April to 31 October, and the largest falls come at its start and its end as well as in its middle: at Gangtok the highest 24-hour falls are 138.9 mm in April (25 April 1981), 310.3 mm in May (30 May 1975), 223.8 mm in June (9 June 1997), 111.4 mm in July, 136.8 mm in August, 141.0 mm in September (25 September 2005) and 201.0 mm in October (3 October 1996), and Tadong's highest is 212.5 mm on 25 September 2005 (IMD *Extremes*). The wettest month on record was June 1997 at Gangtok, with 1,281.3 mm, and June 1998 at Tadong, with 1,082.4 mm (IMD *Extremes*). The starting levels are as follows.

- **Hydropower reservoirs.** The reservoirs of the Teesta and Rangit projects (Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rangit-III and Rongnichu) are held for power, and no full reservoir level, maximum water level or release rule for any of them was found for this Manual [TBC]. Each shall be started at its maximum water level as its operator gives it in writing, with the datum stated. Until the operator does so, no starting level is set from any other figure: the outfall is treated as having an unknown tailwater and as closed for the durations of Clause 5.8.5(c), and the work is sited above the surveyed mark of the flood of October 2023. Teesta-III at Chungthang has been "non-operational since 4th Oct 2023" (as quoted) and was reported to the NGT to be "Under restoration & first phase of wet commissioning is expected by 31st MAY 2026 through coffer dam", with no live storage in that phase (State Government's affidavit of 28 February 2026); its present state was not found [TBC]. When it again holds water it is started in the same way.
- **Pokharis and other lakes.** No pokhari, lake or pond in the towns was found with a published outlet level, operating rule or level record [TBC]. Each shall be started at its surveyed spill or outlet crest level, and the small rain-fed and spring-fed pokharis of the towns and villages are started full throughout the monsoon season. Where the outlet of a pokhari is held up by a river, a reservoir or a blocked jhora, the pokhari is started full to its outlet and kept there until the outfall falls, so that none of its storage below the outlet level is counted (Clause 5.8.5(f)).
- **Glacial lakes.** A glacial lake keeps its own name, even where the name contains "Pokhari", as Bhalay Pokhari and Doodh Pokhari do (State Government's affidavit of 28 February 2026). It is a hazard source under Clause 2.3.6(i) and Chapter 7, never storage, and no starting level, storage credit or routing of this chapter applies to it.

A gated reservoir is modelled with its gate rule from its operator, and a waterbody is modelled below these levels only where a continuous simulation under Clause 3.13 or a notified operating rule supports it. The window of 1 April to 31 October in Clause 3.13.5(a) is set by this Manual and is the Manual's monsoon season. It starts on 1 April because Gangtok's wet season starts then: April brings 296.9 mm on 15.2 rainy days and May 496.4 mm on 20.1 rainy days (IMD normals, 1981–2010), and the 24-hour records of Gangtok (310.3 mm, 30 May 1975) and of Singhik (504.2 mm, 12 May 1981; CWC subzone 2(a) report, Table 7) both fell in May. IMD's normal dates of onset and withdrawal of the south-west monsoon over Sikkim were not found [TBC], and this Manual gives none. The window ends on 31 October because October storms are a real threat, such as Gangtok's 201.0 mm on 3 October 1996, the storm of 2–5 October 1968 over Sikkim and Darjeeling (as reported) and the South Lhonak lake outburst and Teesta flood of 3–4 October 2023. Pumps, gates and debris screens are on standby from 1 April to 31 October (Chapter 10).

## 3.13 Continuous simulation

3.13.1 **When required.** Continuous simulation shall be carried out, in addition to the design-storm analysis, for:

- (a) regional facilities draining more than 25 km²; and
- (b) any system that includes a tank cascade whose storage is counted in the design (Chapter 7).

The authority may also require it for any facility where the starting storage level governs the design.

3.13.2 **Rainfall input.**

- (a) The longest available hourly record from IMD or another approved recording gauge representative of the catchment shall be used.
- (b) Where hourly data are shorter than 30 years, the record shall be extended with the IMD 0.25° gridded daily data. The full gridded record (1901 to present) should be used; at least the most recent 30 years shall be. The daily data shall be disaggregated to hourly by a method stated in the submittal and checked against the hourly gauge for the overlapping years. Grid values shall be converted to point values under Clause 2.7.1 where applicable.
- (c) A future-climate run shall scale the record by the climate factors of Clause 2.8.

3.13.3 **Model content.** The model shall include soil-moisture accounting with evaporation (IMD pan evaporation or equivalent), groundwater or base flow, tank storage with operating rules and irrigation withdrawals, and the tailwater series of Chapter 5 (predicted tides plus a surge allowance for coastal outfalls).

3.13.4 **Use of results.** Annual maxima of water level, storage and volume, and the duration of outfall closure, shall be extracted and fitted by frequency analysis. Results shall be compared with the design-storm results. The more severe result at each AEP governs. Peak flows in drains and channels with a response time of less than one day shall be taken from the design-storm analysis where the continuous record was disaggregated from daily data, because the disaggregated hourly peaks are synthetic.

3.13.5 **Two-step approach.** The continuous simulation need not use the full hydraulic model. It may use a simplified hydrologic and storage model, at a daily or hourly step, that represents the soil moisture, groundwater, tank storage, operating rules and tailwater of 3.13.3. Its results shall then be passed to the design-storm runs of the full hydraulic model as:

- (a) the **starting level of each tank**, taken as the level exceeded on 10% of the days from 1 April to 31 October over the record; and
- (b) the **antecedent soil-moisture condition**, taken from the same days and compared with the AMC rule of Clause 3.8.

The designer shall show that the simplified model reproduces the water balance of the full model for at least one recorded event.

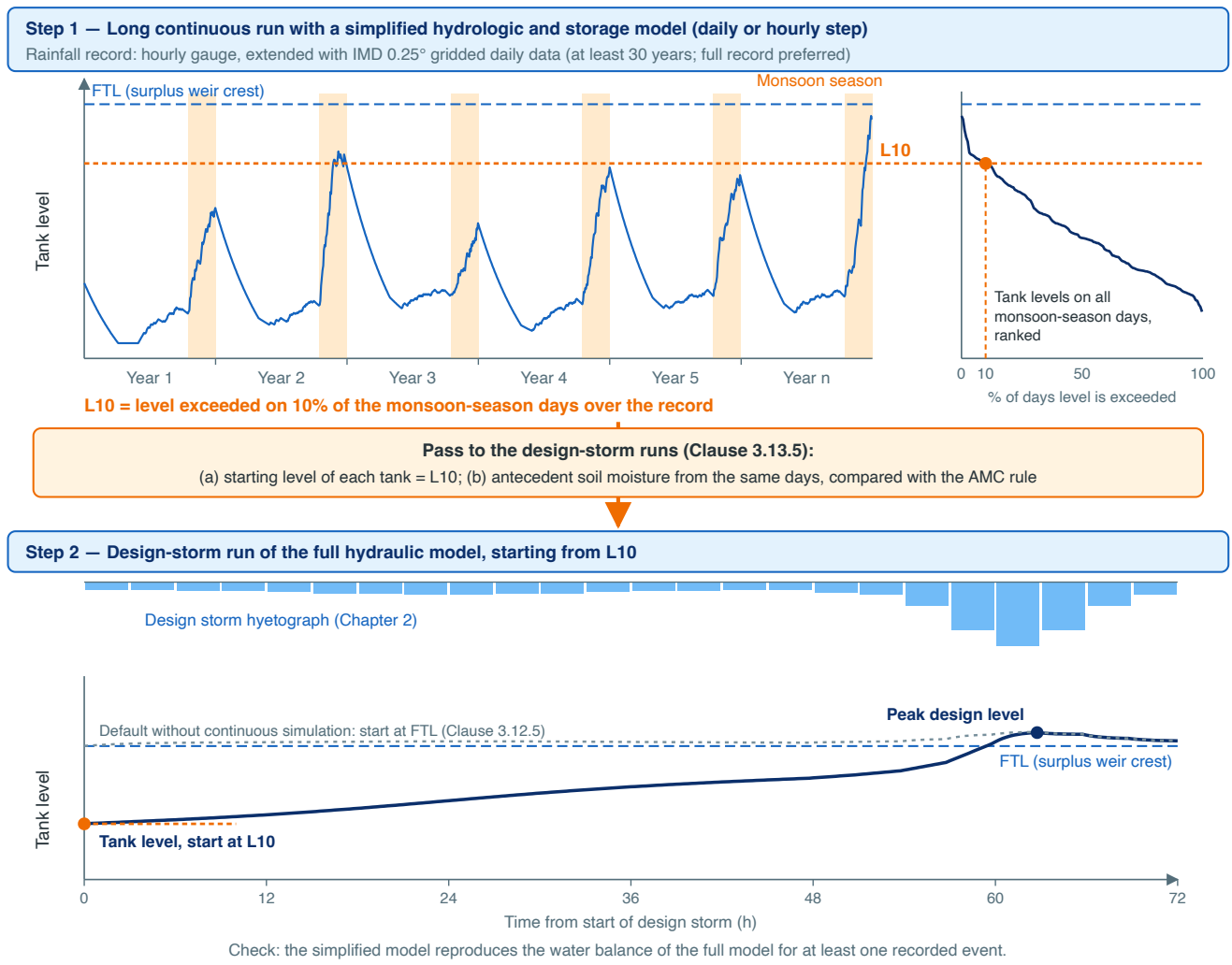


*Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 April to 31 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place of the default start at FTL of Clause 3.12.5. Schematic, not real data. Original drawing for this Manual, illustrating the two-step approach set by this Manual in Clause 3.13.5.*

**Commentary.** Design storms assume one starting condition, but in a tank cascade the governing variable is how full the tanks are when the storm arrives, which depends on the weeks of rain before it. An Australian study of 20 real on-site detention systems found that designs based on one temporal pattern, or even an ensemble of ten, "cannot reliably produce an OSD system design that will always be effective" under real rainfall, and continuous simulation showed frequent-event peaks exceeding pre-development levels (Water Science and Engineering, 2019). The 30-year minimum in 3.13.2(b) matches the station IDF rule of Clause 2.3.2; a longer record is better, and the IMD gridded daily record, which starts in 1901, is the practical long series for Sikkim. The record length matters less than what the simulation is for. Its main purpose here is to find how full the tanks and soils usually are when a monsoon season storm arrives, and how often heavy rain coincides with a closed outfall. A design storm cannot answer either question, because it starts from one assumed condition. It is not intended to replace design storms for the peak flow in urban drains. Clause 3.13.5 therefore allows the long run to be made with a simple storage model, which takes minutes, and passes the starting tank levels to the detailed hydraulic model, which is then run only for the design storms. Running a detailed 1D–2D city model continuously for decades is rarely practical and is not required. The 10% exceedance level in 3.13.5(a) is set by this Manual: it represents a

wet but not exceptional monsoon, so that the design storm arrives on tanks that are already well filled, as they were in June 1997, when Gangtok recorded 1,281.3 mm in the month, its wettest month on record, with 223.8 mm on 9 June (IMD *Extremes*), although no pokhari or reservoir level for that month was found [TBC].

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## 3.14 Pre- vs post-development comparison procedure

3.14.1 The comparison required by Clause 2.11 and Chapter 4 shall be carried out by the following steps. The results shall be recorded on Form 3-2.

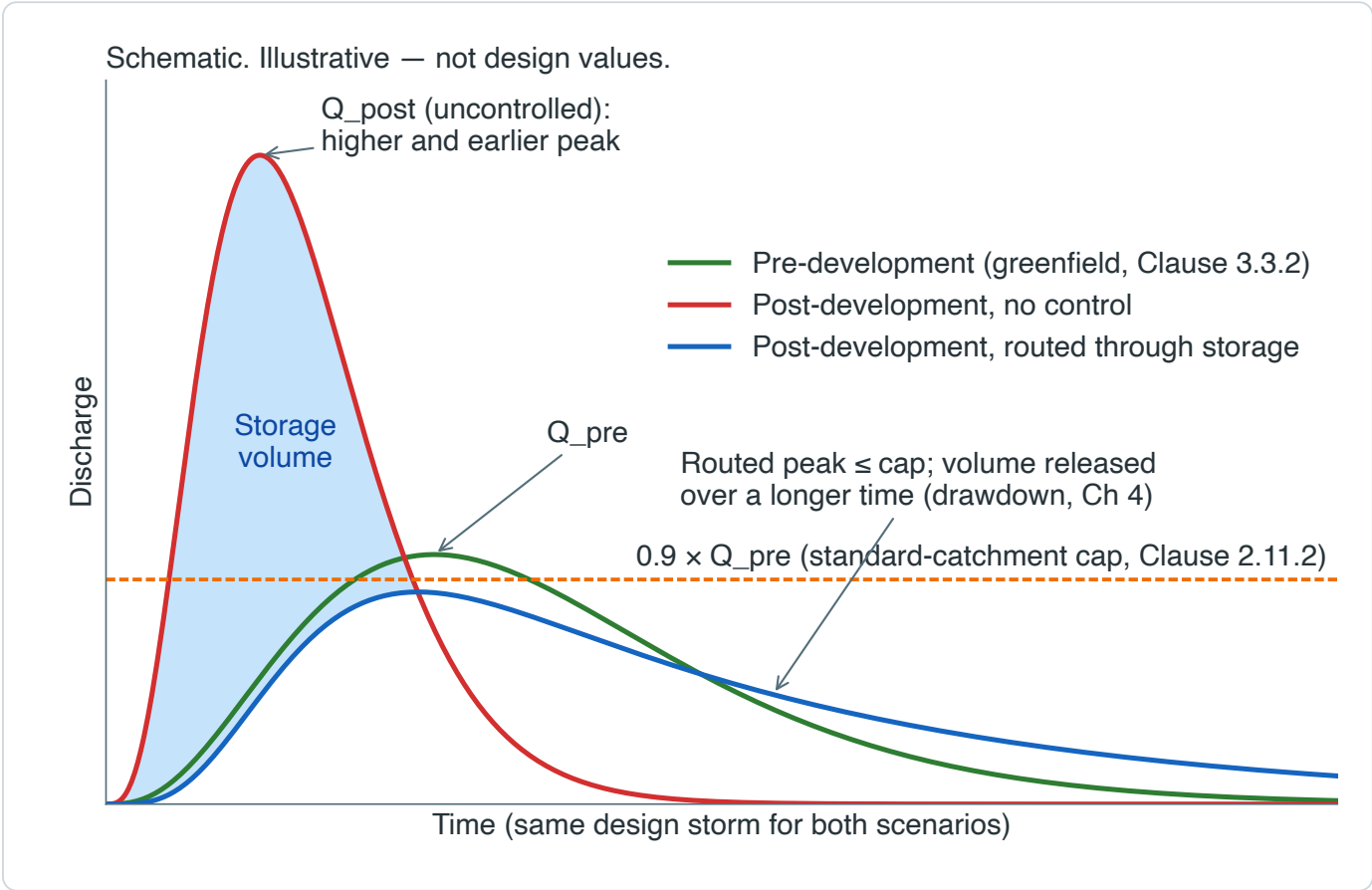


*Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro APWA Section 5600, 2025.01. Schematic. Illustrative — not design values.*

3.14.2 **Step 1 — Define the site, catchments and points of comparison.**

- (a) Delineate the site and every area that drains to it, from survey.
- (b) Identify each POC where runoff leaves the site. Each POC shall be tested separately. Runoff shall not be diverted from one natural catchment to another to meet the criterion.
- (c) Model off-site run-on identically in both runs, at its existing condition (Clause 3.3.5(b)). Where it passes through the site's storage, the criterion applies to the total outflow at the POC.

3.14.3 **Step 2 — Soils.** Map HSG (Clause 3.7), apply the high-water-table rule (Clause 3.10.1) and record the infiltration tests.

3.14.4 **Step 3 — Pre-development model.** Build the pre-development model per Clause 3.3.2: greenfield CN (Table 3.5), Tc (Clause 3.6, with n = 0.15), and existing waterbodies and channels. Compute CN at AMC II and AMC III.

3.14.5 **Step 4 — Post-development model.** Build the post-development model per Clause 3.3.3: measured impervious areas, connectivity (Clause 3.9), disturbed-soil HSG, CN, Tc, and the proposed retention, detention and outlets as storage (Clause 3.12.1).

3.14.6 **Step 5 — Design storms.** From Chapter 2, prepare for each required AEP (50%, 10% and 1%; 2-, 10- and 100-yr) and each duration in {1, 2, 3, 6, 12, 24, 48, 72 h}:

- the depth with the climate factor (Clause 2.8), ARF = 1.0 for the site (Clause 2.7.4);
- the hyetograph (Clause 2.9); and
- the AMC (Clause 2.11.4).

The same storms shall be used in both runs (Clause 2.11.1).

3.14.7 **Step 6 — Run the pre-development model** for every storm and tabulate $Q_{pre}(T, d)$. For flood-sensitive catchments, identify the largest 10% AEP pre-development peak over all durations; that value is the cap of Clause 2.11.3.

3.14.8 **Step 7 — Run the post-development model without controls** and tabulate $Q_{post}(T, d)$ and runoff volumes. This shows the size of the problem and is reported, not tested.

3.14.9 **Step 8 — Add retention and detention.**

- (a) Represent the retention volume of Chapter 4 as storage that is lost to infiltration or reuse (not released to the POC) within the period verified under Chapter 4.
- (b) Route the remaining hydrograph through the detention storage and outlets (Clause 3.12.1).
- (c) Apply the tailwater of Chapter 5, including the joint cases of Clause 2.12, where the outfall is tidal or under backwater.
- (d) Adjust storage and outlets until Step 9 is met.

3.14.10 **Step 9 — Test the criterion** at each POC, for every AEP and every duration:

- (a) standard catchments: $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$ for the 50%, 10% and 1% AEP (Clause 2.11.2);
- (b) flood-sensitive catchments: $Q_{post}(1\%\ AEP) \le Q_{pre}(10\%\ AEP)$, and $Q_{post}(50\%\ AEP) \le Q_{pre}(50\%\ AEP)$ (Clause 2.11.3).

The governing duration for storage is the one that needs the largest storage or gives the highest water level; the 24, 48 and 72 h runs are always reported (Clause 2.5.2).

3.14.11 **Step 10 — Sensitivity runs.** Repeat Steps 6–9 for the governing storms with $I_a = 0.05S$ (Clause 3.8.5) and, where a lower peak rate factor is used, with the standard factor (Clause 3.11.5). Report the change in peaks and required storage.

3.14.12 **Step 11 — Associated checks.** Using the final routed model, check the drawdown times, minimum orifice and emergency spillway of Chapter 4, the outfall-closed storage check of Chapter 5, and the downstream analysis of Chapter 5.

3.14.13 **Step 12 — Document** the results on Forms 3-1 and 3-2 (Clause 3.17).

> Commentary. The step sequence follows the standard event-based workflow: delineate; set pre-development CN and Tc; set post-development CN and shorter Tc; run identical storms through a unit hydrograph or kinematic model; compare peaks and volumes; and size storage by modified Puls routing. It adds the Sikkim elements: the 48–72 h storms, AMC III, and tailwater. Figure 3.5 shows why the long-duration runs matter: the routed peak can

meet the cap while the storage holds the volume difference between the post- and pre-development hydrographs, which must then drain within the Chapter 4 limits. The ban on diverting runoff between catchments in 3.14.2(b) stops a site meeting the rule at one POC by moving flow to a neighbour's drain.

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## 3.15 Model calibration and validation

3.15.1 **When required.** Calibration and validation are required for:

- (a) catchment models of 25 km² or more;
- (b) regional facilities and continuous simulation under Clause 3.13;
- (c) city or basin drainage master plans; and
- (d) any model whose parameters differ from the defaults of this chapter (for example a Clark transform or a lower peak rate factor).

3.15.2 **Data.** Calibration shall use observed rainfall (gauges, and radar where available) and observed flows or water levels (WRD gauging sites, GMC or SSDMA level sensors, tank gauges, or surveyed flood marks).

3.15.3 **Events.** At least three independent events shall be used for calibration and at least one further event for validation. At least one event shall be a long-duration monsoon or cyclone event (for example 9 June 1997 at Gangtok (223.8 mm in 24 hours, in the wettest month of the station's record, IMD), 25 September 2005 at Tadong (212.5 mm in 24 hours, IMD) or the rain of 12–13 June 2024 in Mangan district, for which no IMD station rainfall was found [TBC], where data exist).

3.15.4 **Performance.** The submittal shall report, for each event, the observed and modelled peak, volume and time to peak, and for continuous models the Nash–Sutcliffe efficiency (NSE) and percent bias. As a guide, a calibrated model should reproduce event peaks and volumes within ±25%, and a continuous model should achieve NSE ≥ 0.5 and percent bias within ±25%.

3.15.5 **Limits on calibration.** Calibration shall not be used to justify design flows lower than those given by the default methods of this chapter, unless site-specific factors are thoroughly examined and documented and the authority agrees.

3.15.6 **Reasonableness check.** Design peak flows shall be plotted as discharge per unit area against catchment area and compared with the CWC SUH results, regional gauged estimates and known historical floods.

> Commentary. Clauses 3.15.5 and 3.15.6 follow APWA, which states that "model calibration shall not be used to justify discharge estimates that are lower than those provided by the baseline unit hydrograph method" and requires unit discharges to be plotted against tributary area and compared with regression, gauge and historical values (KC Metro APWA 5600, 2011, §5602.9). The event-count and performance values in 3.15.3 and 3.15.4 are set by this Manual. The NSE ≥ 0.5 and ±25% bias thresholds are the "satisfactory" streamflow ratings of Moriasi et al. (2007), which were developed for monthly continuous simulation; their use for event peaks and volumes here is an extension.

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## 3.16 Software acceptance

3.16.1 **Accepted software.** The following are accepted without further demonstration, in a version current at the time of submittal:

- (a) EPA Storm Water Management Model (SWMM 5.x);

- (b) USACE HEC-HMS and HEC-RAS;
- (c) USDA NRCS WinTR-55 and WinTR-20; and
- (d) spreadsheets for the Rational Method and single-area SCS-CN calculations, where every formula and input is shown.

3.16.2 **Other software.** Commercial packages built on the SWMM or HEC engines are accepted if the engine and version are stated. Any other method or software is accepted only if the designer reports, for every sub-area, the peak flow, lag, runoff volume and equivalent CN from both that method and a baseline method of 3.16.1, identifies every difference greater than 5%, and justifies every difference that gives a less conservative result.

3.16.3 **Benchmark problems.** The authority shall publish benchmark test problems (Annex 3C). Software not listed in 3.16.1 shall reproduce them within the stated tolerance.

3.16.4 **Model files.** Native model input and output files shall be submitted with every hydrograph-based design.

> Commentary. The 5% equivalence test is the APWA rule for alternative methods (KC Metro APWA 5600, 2011, §5602.2D). APWA names TR-55, TR-20, HEC-1 and HEC-HMS as baseline methods (§5602.2B). CPHEEO names SWMM for hydrograph and continuous modelling (CPHEEO 2019, Part A §4.4.2). Submitting native model files lets the authority rerun the model and is the main safeguard against unreviewable black-box results.

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## 3.17 Documentation

Every hydrologic submittal shall include:

1. **Form 3-1, Hydrologic Calculation Summary**, stating the method used and why (Table 3.1), the software and version, and the computation interval.
2. **Catchment maps** for the pre- and post-development conditions, showing sub-areas, flow paths used for Tc, POCs, and off-site run-on.
3. **Soils:** the HSG map and its source and scale (Clause 3.7), water-table data (Clause 3.10), and infiltration test results.
4. **Parameter tables** for each sub-area and condition: area, impervious area by type and connectivity, HSG, CN at AMC II and III (or C and Cf), Tc worksheets, and n values.
5. **Rainfall:** the Design Rainfall Sheet (Form 2-1) and the hyetographs used.
6. **Results:** hydrograph tables and plots for each storm; stage–storage and stage–discharge tables; routed outflows; and peak water levels.
7. **Form 3-2, Pre- vs Post-Development Comparison**, with Q_pre, Q_post (uncontrolled and routed) and the criterion for each POC, AEP and duration, and the sensitivity runs of Clause 3.14.11.
8. **Calibration report**, where Clause 3.15 applies.
9. **Model files** (Clause 3.16.4).
10. **A statement by the responsible engineer** that the methods and parameters of this chapter have been used, with any departures listed and justified.

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## References (chapter)


- MoHUA / CPHEEO (2019). Manual on Storm Water Drainage Systems, Volume I, Part A: Engineering Design. Ministry of Housing and Urban Affairs, New Delhi. §4.4 (Rational Method, Table 4.2 runoff coefficients, time of concentration, partial area effect), §8.5 (detention).
- Kansas City Metro Chapter APWA (2011). Section 5600 Storm Drainage Systems and Facilities (Feb 16, 2011), §5602.2–5602.9.
- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01, §5603.4. https://kcmetro.apwa.org/wp-content/uploads/sites/23/2026/01/APWA-Section-5600_Storm-Drainage-Systems-Facilities.pdf
- Mid-America Regional Council (2025). APWA Stormwater Standards Supplement (Policy Supplement). https://www.marc.org/document/apwa-stormwater-standards-supplement
- USDA Soil Conservation Service (1986). Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55), 2nd ed. Tables 2-2a, 2-2c, 3-1; Figures 2-3, 2-4, 3-1.
- USDA NRCS. National Engineering Handbook, Part 630 Hydrology: Ch. 7 Hydrologic Soil Groups (2009); Ch. 9 Hydrologic Soil-Cover Complexes; Ch. 10 Estimation of Direct Runoff from Storm Rainfall (2004); Ch. 15 Time of Concentration (2010); Ch. 16 Hydrographs (2007). https://directives.nrcs.usda.gov/
- Hawkins, R.H., Jiang, R., Woodward, D.E., Hjelmfelt, A.T. and Van Mullem, J.A. (2002). Runoff curve number method: examination of the initial abstraction ratio. Proc. Second Federal Interagency Hydrologic Modeling Conference, Las Vegas.
- Woodward, D.E., Hawkins, R.H., Jiang, R., Hjelmfelt, A.T., Van Mullem, J.A. and Quan, Q.D. (2003). Runoff curve number method: examination of the initial abstraction ratio. World Water & Environmental Resources Congress, ASCE.
- Welle, P.I., Woodward, D.E. and Moody, H.F. (1980). A dimensionless unit hydrograph for the Delmarva Peninsula. American Society of Agricultural Engineers paper. See also New Jersey Department of Agriculture, Delmarva Unit Hydrograph bulletin. https://nj.gov/agriculture/divisions/anr/pdf/DelmarvaBulletin.pdf
- Chow, V.T., Maidment, D.R. and Mays, L.W. (1988). Applied Hydrology. McGraw-Hill. §5.5 (SCS method, AMC), §8.4 (Muskingum), Table 15.1.2 (Kirpich).
- Kirpich, Z.P. (1940). Time of concentration of small agricultural watersheds. Civil Engineering 10(6), 362.
- Merkel, W.H. (2001), as cited in USDA NRCS NEH Part 630, Ch. 15 (2010), on the length of sheet flow.
- ASCE and WPCF (1969). Design and Construction of Sanitary and Storm Sewers. ASCE Manual of Practice No. 37.
- Texas Department of Transportation. Hydraulic Design Manual, Ch. 4, §12 Runoff Coefficients. https://www.txdot.gov/manuals/des/hyd/chapter-4--hydrology/section-12--rational-method/runoff-coefficients.html
- Central Water Commission (1991). Flood Estimation Report for North Brahmaputra Subzone 2(a), Design Office Report No. NB/18/1991, placed before the Flood Estimation Planning and Co-ordination Committee at its 49th meeting (24–25 October 1990); isopluvials "supplied by I.M.D." (title block of the plates). Read from the Internet Archive copy (94 pages, scanned, read by optical character recognition): the unit hydrograph relationships, the design loss rate and base flow, and the table of ratios of t-hour to 24-hour rainfall checked against the page images; Table 7 (highest daily rainfall, with the Sikkim stations Singhik and Dikchu) and Plates 8, 9 and 10 read from the page images over Sikkim; the coverage text (pp. 8 and 28) and the river table (p. 29) read by optical character recognition; the areal reduction curves, the time distribution of rainfall, the worked example, the simplified formulae and the table of calibration catchments not checked [TBC]. http://web.archive.org/web/20160412153137id_/http://www.cwc.gov.in:80/main/downloads/North%20Brahmaputra%20subzone%202%20(a).Pdf
- Central Water Commission. "Regional Flood Estimation Report" download page (no separate report for the Teesta or for Sikkim). https://cwc.gov.in/regional-flood-estimation-report
- Moriasi, D.N. et al. (2007). Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Trans. ASABE 50(3), 885–900.
- "OSD for Australian development projects: does it meet frequent flow management objectives?" Water Science and Engineering (2019). https://www.sciencedirect.com/science/article/pii/S1674237019300213

- India Meteorological Department. *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)*: Gangtok (42299, rainfall data 1958–2012) and Tadong (22209, data 1978–2007), monthly and seasonal 24-hour and monthly records, page M190.
- India Meteorological Department, Meteorological Centre Gangtok. *Mean monthly meteorological parameters of Gangtok, 1981–2010* (M.O. Gangtok, 27°20' N 88°38' E, 1,765 m). https://mausam.imd.gov.in/gangtok/mcdata/climatology_gangtok.pdf
- Central Ground Water Board. Aquifer mapping of East Sikkim (annual action plan 2022–23), the report for South Sikkim and the State assessment, as quoted in search summaries; the reports themselves could not be reached for this Manual [TBC].
- Department of Mines and Geology, Government of Sikkim. Notification No. 17/DMG/20-21 of 19 March 2021 (Sikkim Government Gazette Extraordinary No. 86, 6 April 2021), site stability zonation parameters; read as Annexure R/2 to the counter-affidavit of the State respondents of 25 February 2022 in NGT (EZ) OA 5/2022, *Dr. Bina Basnett v. State of Sikkim & Ors.* https://www.greentribunal.gov.in/sites/default/files/news_updates/Counter%20Affidavit%20on%20behalf%20of%20R-,4,7,9%20in%20OA%205%20of%202022%20(EZ)%20(Dr.%20BINA%20BASNETT%20vs%20State%20of%20Sikkim%20&%20Ors.).pdf
- Gangtok Smart City Development Ltd. Reply affidavit in NGT (EZ) OA 38/2022 (spring water and landslides at natural jhoras). https://www.greentribunal.gov.in/sites/default/files/news_updates/Reply%20Affidavit%20filed%20by%20R-2,%20GSCDL,%20page%20698-1006.pdf
- Government of Sikkim. Additional affidavit of 28 February 2026 in NGT (EZ) OA 171/2023 (the Teesta-III breach), with the pre-project report "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (Annexure R-5: the raised Teesta bed, NHPC's estimates of bed rise, Toong Naga, the glacial lakes) and the status of the Teesta dams. https://www.greentribunal.gov.in/sites/default/files/news_updates/Additional%20affidavit%20on%20behalf%20of%20R-1,%20State%20of%20Sikkim,%20page%201038-1178.pdf
- Gangtok Municipal Corporation. Waste-agency contract, Memo No. GMC/6727/III/2024/OL/01 of 8 October 2024 ("Clearing of Jhoras"), as annexed to the State's six-monthly report in NGT (PB) OA 606/2018. https://www.greentribunal.gov.in/sites/default/files/news_updates/SIX%20MONTHLY%20REPORT%20BY%20GOVT%20OF%20SIKKIM%20IN%20OA%20NO.%20606%20OF%202018%20FOR%20STATE%20OF%20SIKKIM%20(COMPLIANCE%20OF%20MSW%20MGT%20RULES,%202016%20AND%20OTHER%20ENVIRONMENTAL%20ISSUES).pdf
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*. doi:10.1126/science.ads2659 (accepted manuscript read).
- SANDRP transcriptions of CWC site tables for the Teesta, the Rongni Chu and the Rangit, and of the levels of 3–4 October 2023 (Khanitar, Melli, Singtam, Majitar), and a CWC daily bulletin of 2024 seen only as a search snippet (as reported).
- A landslide-susceptibility study of Gangtok (as summarised), and reports on the geology of the Daling Group and the Gorubathan Formation (as reported).
- US EPA. Storm Water Management Model (SWMM 5). US Army Corps of Engineers, Hydrologic Engineering Center. HEC-HMS and HEC-RAS.


## Annexes and forms

| Annex / Form | Content |
|---|---|
| 3A | Sikkim soil series to HSG lookup; seasonal high water table map |
| 3B | Sikkim CN calibration and supplementary land covers (forest, terraced fields, slide scars, debris fans and hill-road cuts and fills, bare rock and scree, alpine pasture, moraine and snow, boulder-bed jhoras, the river bed raised in October 2023, and pokhari and reservoir beds) |
| 3C | Benchmark test problems for software acceptance |

| Annex / Form | Content |
|---|---|
| 3D | Peak rate factor study for flat coastal land |
| 3E | CWC SUH parameters for subzone 2(a), with worked example |
| Form 3-1 | Hydrologic Calculation Summary |
| Form 3-2 | Pre- vs Post-Development Comparison |

CHAPTER 4

# Site Runoff Control: Retention and Detention

## 4.1 Purpose and scope

4.1.1 This chapter sets the performance standard that every regulated development shall meet for runoff leaving the site. It covers:

- (a) the order in which runoff-control measures are to be applied (Clause 4.3);
- (b) retention of frequent rainfall, and how retained volume is credited against detention (Clause 4.4);
- (c) release-rate criteria for standard and flood-sensitive catchments (Clause 4.5);
- (d) the procedure for sizing detention storage and outlets (Clauses 4.6 to 4.9);
- (e) facility types, rainwater harvesting (RWH) accounting, and high-groundwater sites (Clauses 4.10 to 4.12);
- (f) regional detention and fee-in-lieu (Clause 4.13);
- (g) simplified methods for small sites: the Tier B tables and the fixed-coefficient route (Clause 4.14); and
- (h) public safety (Clause 4.15).

4.1.2 This chapter applies to land disturbance of **0.1 ha or more**, or new or replaced impervious area of **500 m² or more**, as set in Chapter 1. Single dwellings below that threshold, and road resurfacing that adds no impervious area, are exempt. The existing RWH mandate of section 186 of the Sikkim Municipalities Act, 2007 (a rainwater harvesting structure in every building owned or occupied by the State Government, a statutory body or a company or institution owned or controlled by the State Government, "in such manner as may be specified by the State Government or the Municipality from time to time"; no such manner has been specified as far as found, no rule requires rainwater harvesting in a private building, and the Commentary to Clause 4.11 discusses both) continues to apply to every building it covers, whether or not this chapter applies.

4.1.3 Rainfall inputs come from Chapter 2. Hydrologic methods come from Chapter 3. Tailwater, downstream analysis and the outfall-closed check come from Chapter 5. Water quality volume (WQv) treatment comes from Chapter 8. Where this chapter and those chapters overlap, the more stringent requirement governs.

> Commentary. No Indian national rule or Sikkim rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or "zero run-off". No Sikkim document found sets a design storm, a return period, a runoff coefficient or a time of concentration for any drain. The building rules are the Sikkim Building Construction Regulations, 1991 (SBCR 1991; Urban Development and Housing Department (UD&HD) Notification No. 29(202)UD&HD/90/295 of 19 March 1991, made under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985), as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001 of 16 October 2001). They "extend to all the notified areas in Sikkim" (reg. 1(2)); applications go to the Secretary of the department, now the Urban Development Department (UDD) (reg. 4), and inside Gangtok building-plan approval passed to the Town Planning Cell of the Gangtok Municipal Corporation (GMC) in 2017, still under the 1991 Regulations (GMC's counter-affidavit before the National Green Tribunal (NGT) in OA 5/2022 (EZ); the transfer notification was not seen [TBC]). Rural land outside the notified areas has no building permission under them (NEER reading; the list of notified areas was not found [TBC]). A Sikkim Building Construction (Amendment) Regulation, 2022 was reportedly published on 12 April 2023 (as reported); it was not read, and it may change what follows [TBC]. The drainage provisions that can be found protect the building, the road and the drain line, not the

catchment. The site plan shows the "position of sewer line, water main pipe line, electricity line" (reg. 5(f)), and the blue-print plan the "drainage including connection to main outlet and the slopes of the roof" and the "sanitary/plumbing layout … drainage system … sewerage disposal system/septic tank and soak pit" (reg. 6); at least 25 per cent of the roof is "sloped gabled of traditional roofing … with rain water gutter" (reg. 6); gutters and down pipes are "of such design and capacity that the water will neither spill out of them nor leak through them", connected "to the storm water plinth protection drain of the building" (reg. 21); a "Pucca storm water/plinth protection drain shall be provided leading to the road side drain or to adjoining permanent drains or jhora to drain off the surface water" (reg. 25(iv)), the jhora (झोरा) being a natural watercourse or ravine stream; "No occupation certificate shall be issued … if the drain has not been provided to main outlet/jhora or if the septic tank/soak pit has not been properly built/connected/ventilated" (reg. 13(iii)); dumping of spoil on "Public Street, road, drains, gullies and jhoras" is prohibited, with a fine of ₹500 at least (reg. 22), and a security of ₹5,000 is held against spoil and damage to the road "including drainage system" (Form III, cl. 15); and no allotment is made "in any sinking area, landslide prone or in areas having scars of old landslides or in slope exceeding or around 70 (Seventy) degree" (reg. 35). Setbacks are measured from the road (27 feet from the centre of the road, and 10 feet "or as indicated in approved Master Plan of the area", reg. 18); there is no setback from a jhora or a khola (खोला; a river or large stream). None of these sets a design storm, a release rate, a detention volume or an overflow path. Height is set by the stability zones of the Mines and Geology Department (reg. 17(i), as substituted in 2001), whose parameters of 2021 grade each zone partly by the state of its jhoras, from zone 1, where the "Training of jhoras/drains have been completed and done properly (with safe distance)", to zone 4, with an "Untrained jhora/ erosional potential jhora", and make "Proper channelization of surface runoff by providing catchment drains especially during the rainy seasons and connect it to natural waterways/Jhora" a condition for reviewing a site's zone (Notification No. 17/DMG/20-21, 19 March 2021). Regulations 6, 13(iii), 21 and 25(iv) and the 2021 condition on catchment drains are the only hooks for this chapter; reg. 39 (2001) lets the Government relax any provision, and the State relaxed the height of a car park of Gangtok Smart City Development Ltd (GSCDL) "subject to confirmation of a Geotechnical investigation and Report" (GMC's counter-affidavit), which shows how a technical condition can be attached. The Sikkim Municipalities Act, 2007 treats a jhora as a drain ("a jhora or water-course of natural drainage line", s.2(24)) and as "any natural watercourse, whether on a public land or on a private land" (s.163(b)); a jhora on public land other than forest land within a municipal area vests in the Municipality (s.172(1)), and "the Municipality shall protect any jhora, whether on a public land or on a private land, within the municipal area" (s.172(2)); the State may "specify the limits of any jhora, watercourse or channel within a municipal area" by notification (s.173), and none has been found; the Municipality shall "provide a safe and sufficient outfall … in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187); and rain water shall go in "an entirely separate drain" and "be connected with the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (s.193). Chapter XXXII of the Act sets up a building-permit system ("No person shall undertake any building activity without obtaining" a permit, s.271) with rules that may cover "infrastructure in relation to building activity" (s.287), but no such rules were found, and whether GMC applies that system or the 1991 Regulations is not clear (NEER reading). The Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024), enacted in 2024 and amended in 2025, not yet commenced, would require development plans with "proposals for water supply, drainage, sewage and solid waste disposal" and "proposals for flood control, land stability and sloped linked controls"; no commencement notification, Board or plan under it was found. The State's annual notices that ban "construction involving earth excavation" in the monsoon (6 May–30 September 2019; 1 June–30 September 2020) are the hook for construction-phase sediment control (Chapter 8). No published highest flood level exists for any Sikkim town [TBC], and the 1991 Regulations have no flood plinth; this Manual supplies the method (surveyed flood marks, the surveyed mark of the flood of October 2023 or the modelled 1% AEP level, Chapter 5).

No design basis is in use. GSCDL has tendered "Construction of drainage and jhora training works" in Gangtok, for about ₹13.41 crore (as reported); the Sikkim Integrated Urban Development Project of the Asian Development Bank (ADB), with UDD as executing agency, includes "Improving about 60 km roads in seven towns with junction improvements, improved pavement and stormwater drains" and infrastructure master plans for four towns other than Gangtok (ADB, due-diligence report of December 2024); and the drainage and landslip works of the Gangtok City Development Plan of 2006 "were not taken up" (CAG, Report No. 3 of 2016, para 2.3.9.2). No return period, rainfall source or runoff coefficient was seen for any of them. These works convey water; this Manual adds

storage first. It requires on-site detention under this chapter, and keeps pokharis (पोखरी; pond, lake or tank), wetlands and flat benches as storage first (Chapters 4, 7 and 11), for three reasons: (i) every litre sent faster down a jhora arrives sooner, with more energy and more debris, on a slope that the 2021 stability zones already treat as unstable where a jhora is "untrained" or "erosional"; (ii) the jhoras end in a Teesta whose bed rose "by an average of 7-8 meters" in October 2023 (State Government's pre-project report on GLOF risk mitigation in the Lhonak valley, 2026), and whose valley-floor towns, Singtam, Rangpo and Melli, receive everything the ridge towns send; and (iii) section 187 of the Municipalities Act already makes the flooding of "any area surrounding the outfall" a matter of municipal duty. Where a project's own terms govern a design, the designer states on the submittal which governs; the Manual does not override a contract.

Basements are not regulated for flooding: no basement rule that addresses flooding was found in the SBCR 1991 read for this Manual [TBC]. This Manual therefore adds its own requirements for every basement: no detention storage in a habitable basement (Clause 4.10.1); the crest of every basement ramp and the sill of every basement opening at least 0.5 m above the 1% AEP flood level, with basement drainage pumped to the surface drain through a non-return valve (Clauses 6.11.1 and 6.11.4); and no basement in Zone 2 (Clause 7.5.2). In the flood-sensitive catchments of Clause 4.5.3.2, in any catchment notified under Clause 4.5.4, and on the valley-floor land of Clause 4.12.1, it recommends that no basement be permitted where the 1% AEP flood level, or on the Teesta valley floor the surveyed mark of the flood of October 2023, stands above the surrounding ground; where one is permitted on the valley floor it is watertight and checked for flotation with the design groundwater level at ground level (Clause 4.12.3); and wherever a basement or lower floor is cut into a slope, it shall carry the geotechnical certificate of the hill rule of Clause 4.11, with the water behind its walls drained to a lined drain and not to the ground (all set by this Manual). For a sloping site, this chapter also supplies what regulations 21 and 25(iv) leave open: runoff from the catchment above the site shall be intercepted and carried round the building in the design storms of Chapter 6, and every flow from the site shall discharge to a lined drain, the road drain or a trained jhora through an energy dissipator, never onto an unprotected slope or into fill (Clause 6.3.6(l)). These are the Manual's proposals, not rules of the SBCR 1991. This chapter is written so that it can supply, as a technical companion to the SBCR 1991, the stability-zone conditions of 2021, the Municipalities Act and, once the 2024 Act commences, its development plans, the design storm, release rates and storage volumes that they leave open; a competent authority could adopt it for that purpose, but none has. In practice the storm drains of most towns carry sewage effluent: every building treats its sewage "in septic tanks built within the site" unless a public sewer is available (reg. 25(i)–(ii)); Gangtok's sewage treatment plants treated 15.22 MLD in September 2025 against an estimated urban sewage generation of 29.51 MLD in the State (State Government's affidavit of 19 December 2025 in NGT (PB) OA 673/2018); in Soreng "most of the houses have adopted the practice of onsite disposal by constructing septic tank/soak pits with effluent discharging into open surface drains" (ADB, due-diligence report of December 2024); and the NGT recorded in its order of 4 July 2024 that "treated sewage is entering in to river/ rivulets/ jhoras and this is not permissible under the Water Act", to which the State replied that "No sewage is disposed off in the rivers or fast flowing water bodies" (both as quoted in the State's report in NGT (PB) OA 606/2018) (Clause 8.9). Retention and detention apply in full on every site whatever the drain carries: every litre a site releases at the peak of a storm takes up capacity in a drain that is already part-filled with sullage. The CPHEEO (2019) manual describes limiting outflow to the pre-development peak as typical practice, but it uses no "shall" and names no storm frequencies (CPHEEO Part A §8.5.1). This chapter turns that description into a development-control requirement.

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## 4.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Retention | Permanent removal of runoff from the surface drainage system by infiltration, evapotranspiration or reuse, so that the water never reaches the outfall. |

| Term | Meaning in this Manual |
|---|---|
| Retention depth | The 90th percentile wet-day 24-hour rainfall depth for the site's zone (Clause 2.10, Annex 2E). |
| Required retention volume (RRV) | The runoff volume from the retention depth over the post-development site (Clause 4.4.2). |
| Detention | Temporary storage of runoff, released through a controlled outlet at a rate set by Clause 4.5. |
| Retention credit | The reduction in required detention storage that results from retention practices, determined by routing under Clause 4.4.6. It is **not** the same as the retained volume. |
| Permissible site discharge (PSD) | The maximum rate at which a site may discharge for a stated AEP, in L/s or L/s/ha. |
| Site storage requirement (SSR) | The detention storage required per hectare of site under the simplified method of Clause 4.14. |
| Multi-stage outlet | An outlet structure with separate openings at different levels, each controlling a different AEP (Figure 4.2). |
| Drawdown time | Time from the peak stored volume until the stated fraction of that volume has been released. |
| Emergency spillway | A secondary overflow that passes flows above the primary outlet capacity, or all flow when the primary outlet is blocked, without overtopping the embankment. |
| Freeboard | Vertical distance between the maximum design water level and the embankment crest or other critical level. |
| Flood-sensitive catchment | A catchment listed in Clause 4.5.3 or notified under Clause 4.5.4. |
| Authority | The approving authority under Chapter 1 (the competent authority for the area: in Gangtok, the Gangtok Municipal Corporation (GMC), which has approved building plans under the SBCR 1991 since 2017 and owns and protects its drains and jhoras under sections 172 and 187 of the Sikkim Municipalities Act, 2007; in another notified area, the Urban Development Department (UDD) or the urban local body that approves plans there (how approval is split between UDD and the urban local bodies outside Gangtok was not found [TBC]); for a scheduled river's bank under the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, the Forest Department; for a public work, the department or agency that executes it (the Roads and Bridges Department / PWD, NHIDCL, BRO, WRD, PHED, RMDD, UDD or GSCDL); and on land outside every notified and municipal area, where the SBCR 1991 give no building permission, none, so that there this Manual is guidance, except for public works and for any body that adopts it, as applicable). |
| Tier A / Tier B | Adoption tiers defined in Chapter 1. Tier A: the Gangtok Municipal Corporation (GMC), for its whole area, and, once a development plan under the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced) is published for a planning area, every approving authority within that planning area, whichever has jurisdiction over a site (no such plan has been published). Tier B: Municipal Councils, Nagar Panchayats and other approving authorities under the regulations. |

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## 4.3 Order of measures

4.3.1 Every site runoff-control design shall apply measures in the following order, and shall document in the submittal why each earlier step could not do more:

1. **Preserve.** Keep existing waterbodies, pokharis, natural drainage lines, wetlands, and permeable soils and vegetation. Avoid fill in flood storage (Chapter 7).
2. **Retain.** Retain the RRV on site by infiltration, reuse or evapotranspiration (Clause 4.4).

3. **Detain.** Detain the remaining runoff so that the release-rate criteria of Clause 4.5 are met for every design storm and duration (Clauses 4.6 to 4.9).
4. **Convey.** Convey the 1% AEP (100-yr) flow safely through the site to the receiving system on a defined overland path (Chapter 6), and check the receiving system downstream (Chapter 5).

4.3.2 Preservation and retention reduce the detention required (Clauses 4.4.6 and 4.4.7). They do not relieve the site of the release-rate criteria of Clause 4.5 or of the downstream analysis of Chapter 5.

> Commentary. This order follows the "layers of stormwater management" adopted in the Kansas City Metro APWA Section 5600 Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet; MARC Supplement, Nov 2025). Maintenance is the fifth layer and is set in Chapter 10. The 2025.01 manual credits retention and natural-area preservation against detention size (MARC Supplement, Nov 2025). Clause 4.4.6 adopts that credit, and defines it so that it cannot be claimed twice.

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## 4.4 Retention

### 4.4.1 Requirement

The site shall retain the RRV. Retention shall be achieved by one or more of the following:

- infiltration practices (soakaways, infiltration trenches, permeable pavement with an infiltration base, bioretention);
- rainwater reuse that is drawn down by a demonstrated non-potable demand;
- green roofs and landscape areas that do not drain to the outfall in the retention-depth storm.

The limits of Clause 4.4.4 apply.

### 4.4.2 Computation of the RRV

> $RRV\ (m^3) = 10 \times Q_R \times A$

where:

- $Q_R$ (mm) is the runoff depth from the retention depth $P_R$ (Annex 2E). It is computed with the SCS-CN method for the post-development cover of each sub-area, at AMC II, with $Ia = 0.2S$ (Chapter 3); and
- A (ha) is the area of the site that drains to the outfall.

$Q_R$ shall be computed for each sub-area separately and summed. An area-weighted CN shall not be used where impervious and pervious areas differ by more than 20 CN points.

The volumetric method $RRV = 10 \times P_R \times Rv \times A$, with $Rv = 0.05 + 0.009 \times I$ (I = percent impervious), may be used for sites under 0.5 ha and under the Tier B method.

> Commentary. The Rv formula is the one used in the KC water quality volume (MARC BMP Manual 2012). It is simple to review for small sites. The SCS-CN form is required for larger sites so that the retention computation uses the same runoff model as the detention routing. That keeps the credit computation of Clause 4.4.6 consistent.

### 4.4.3 Verification

Retention by infiltration shall be supported by:

- (a) site infiltration tests at the location and depth of each practice, at the frequency set in Chapter 8;
- (b) a design infiltration rate of no more than **half** of the measured rate; and
- (c) groundwater evidence showing the seasonal high groundwater table at least **1.0 m** below the base of the practice (Chapter 8).

Retention by reuse shall be supported by a demand calculation showing that the RRV is drawn down within 72 hours by a continuous non-potable use, such as toilet flushing, cooling or irrigation.

> Commentary. The factor of 2 on measured infiltration rate has no direct precedent; this Manual sets it to allow for clogging and for the difference between a test pit and a full-scale practice. Chapter 8 may set a different factor; if it does, Chapter 8 governs.

### 4.4.4 Limits on retention

4.4.4.1 Infiltration practices shall not be used:

- where the seasonal high groundwater table is less than 1.0 m below the base (Chapter 8);
- on contaminated land;
- within the setbacks from foundations, wells and septic systems set in Chapter 8; or
- on fill, unless tested after placement.

4.4.4.2 Where the RRV cannot be fully retained, the shortfall shall be stated in the submittal. The shortfall shall be treated as WQv under Chapter 8 and shall get no retention credit.

### 4.4.5 Drawdown of retention

Retention storage shall be emptied by infiltration or reuse within **72 hours** of the end of the retention-depth storm, verified by the tests of Clause 4.4.3.

### 4.4.6 Retention credit: definition and computation

4.4.6.1 **What the credit is.** The retention credit is the reduction in required detention storage that results when the retention practices are included in the post-development routing. It is computed. It is not assumed equal to the RRV.

4.4.6.2 **Tier A method (routing).** For each design storm and duration of Clause 4.6.3:

- (a) model each retention practice explicitly as a storage that is **empty at the start of the storm**, unless Clause 4.11 says otherwise;
- (b) let the practice fill from the front of the storm, and let it lose water during the storm only at the design infiltration or reuse rate of Clause 4.4.3;
- (c) once it is full, route its overflow to the detention facility; and
- (d) size the detention for the residual hydrograph.

The required detention storage is the largest storage over all storms and durations. The credit is the difference between that storage and the storage required with no retention. No further deduction shall be made.

4.4.6.3 **Tier B method (simplified).** The detention storage required by Clause 4.14 may be reduced by:

$$V_{credit} = C_R \times RRV_{provided}$$

where $C_R$ is the retention credit factor from Annex 4B for the zone, soil group and drawdown rate. Until Annex 4B is published, **$C_R = 0$**.

4.4.6.4 Retention that is not verified under Clause 4.4.3 gets no credit.

> **Commentary.** "Credited against detention" (APWA 5600 2025.01) can be read in two ways. One reading subtracts the retained volume from the detention volume, cubic metre for cubic metre. The other routes the storms with retention in place and sees what detention is still needed. The two readings give very different answers in Sikkim, because the mandatory 48- and 72-hour storms (Clause 2.5.2) fill any retention practice on the first day, long before the peak arrives on the last day (Clause 2.9.2). Unless the practice keeps infiltrating during the storm, it is full at the peak and does nothing to reduce the peak storage.
>
> The illustrative example in Clause 4.6.7 shows the size of the effect. A 2 ha site with 552 m³ of retention (no infiltration during the storm) needs 138 m³ less detention for the 24-hour storm. That is a credit of about a quarter of the retained volume. For the 48- and 72-hour storms, which govern, the credit is close to zero. Subtracting the retained volume directly would have under-sized the detention by about 545 m³ (about 19%).
>
> This Manual therefore defines the credit as the result of routing. Retention on fast-draining sandy soils, which keeps infiltrating through a multi-day storm, will earn a real credit. Retention that only fills will earn little. Both outcomes are physically correct. Setting $C_R = 0$ until Annex 4B exists is a safe default for Tier B, not a judgement that retention has no value: retention is still required for water quality and recharge (Chapter 8).

### 4.4.7 Preservation credit

Areas of the site that are permanently preserved in natural cover may be modelled at their pre-development CN in the post-development condition, provided that:

- they are protected by a registered covenant or dedication; and
- their runoff is not concentrated onto impervious surfaces.

This lowers both the RRV and the detention required. No other preservation credit applies.

---

## 4.5 Release-rate criteria

### 4.5.1 General

4.5.1.1 Peak discharge from the site shall be computed by a hydrograph method (Chapter 3) for the pre-development and post-development conditions with identical design storms (Clause 2.11.1). The Rational Method shall not be used for any part of storage sizing.

4.5.1.2 Pre-development is greenfield: open land in good condition for the mapped HSG. Existing impervious cover is not counted (Clause 2.11.5, Chapter 3). This applies to redevelopment as well, subject only to the constrained-redevelopment route of Clause 4.5.6.

4.5.1.3 The criteria apply at each point where runoff leaves the site. Where a site drains to more than one outfall, the criteria apply to each outfall for the area draining to it. Runoff shall not be diverted between catchments.

### 4.5.2 Standard catchments

For each of the 50%, 10% and 1% AEP (2-, 10- and 100-yr) storms, and for every duration in {1, 2, 3, 6, 12, 24, 48, 72 h}:

> $Q_{post}(T, d) \le 0.9 \times Q_{pre}(T, d)$

### 4.5.3 Flood-sensitive catchments

4.5.3.1 In the catchments listed below, the **mixed-frequency rule** of Clause 2.11.3 applies, for every duration in Clause 2.5.2:

> $Q_{post}$(1% AEP, 100-yr) ≤ $Q_{pre}$(10% AEP, 10-yr), and $Q_{post}$(50% AEP, 2-yr) ≤ $Q_{pre}$(50% AEP, 2-yr).

Each cap is the pre-development peak at the duration that maximises it: the 10-yr peak for the 100-yr check, and the 2-yr peak for the 2-yr check. The cap applies to every post-development duration (Clause 2.11.3).

4.5.3.2 The flood-sensitive catchments are:

- (a) **Gangtok's jhoras to the Rani Khola and the Roro Chu**: the catchments of the jhoras of Gangtok, with Tadong and Ranipool, that drain to the Rani Khola and the Roro Chu, including the named jhoras of the city's waterbody network (as reported) and the slide-prone wards above them [TBC];
- (b) **The Teesta valley floor in the October 2023 corridor**: the land of Chungthang, Dikchu, Singtam, Rangpo and Melli, with Toong Naga, that drains to the Teesta at or below the level of the flood of October 2023 and of the river bed it raised, and every jhora and side stream that falls to that land;
- (c) **The Rangit at Jorethang and Majitar**: the land of Jorethang (Nayabazar-Jorethang) and Majitar that drains to the Rangit;
- (d) **The Rongni Chu at Ranipool and Singtam**: the land of Ranipool and Singtam that drains to the Rongni Chu, above its confluence with the Teesta;
- (e) **Mangan town and the slopes of the North Sikkim road**: the land of Mangan town and the catchments of the jhoras that cross the North Sikkim road in Mangan district, where the rain and landslides of June 2024 struck;
- (f) **Lachen and Chaten, and every catchment below a high-risk glacial lake**: the land of Lachen and of Chaten, where the landslide of 1 June 2025 struck, and every catchment that drains from a glacial lake listed as high-risk or very high-risk, down to its confluence with the Teesta;
- (g) **The hydropower reservoirs and release reaches**: the land that drains to the reservoirs of Teesta-III (once restored), Teesta-V, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III, below or near their starting levels of Clause 3.12.5, and the land along the reaches below their dams;
- (h) **The NH-10 corridor along the Teesta**: the land that drains to NH-10 and its drains where the highway runs along the Teesta;
- (i) **Namchi**: the land of the Namchi Municipal Council area and of its jhoras;
- (j) **Soreng**: the land of the Soreng Nagar Panchayat area and of its jhoras; and
- (k) any catchment notified under Clause 4.5.4.

The boundaries shall be those mapped in Annex 4A.

### 4.5.4 Notification of further flood-sensitive catchments

4.5.4.1 The Authority may propose that a catchment be notified as flood-sensitive where one or more of the following is documented:

- (a) buildings or arterial roads flooded in an event of 1% AEP or more frequent, on at least two occasions in the previous 20 years;
- (b) receiving drains or channels with capacity below the 10% AEP flow under existing conditions;
- (c) an outfall that is held up by the Teesta, the Rangit or the Rongni Chu in flood, such as the outfalls of Singtam, Rangpo, Melli, Majitar and Jorethang, where the flood of October 2023 raised the river bed by metres, or by a hydropower reservoir held near its full level or a release from a dam upstream, or that is buried or blocked by the boulders, slide debris and garbage of a jhora, for part of the monsoon season (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and pokhari storage in the catchment since the earliest available survey; or
- (e) a basin master plan that relies on limiting site discharge.

4.5.4.2 The procedure shall be:

1. The Authority prepares a technical note with the catchment boundary in GIS form and the evidence for 4.5.4.1.
2. The State-level technical committee constituted under Chapter 1 reviews the note.
3. The draft notification and map are published for public comment for at least 60 days.
4. The Government notifies the catchment and the map is added to Annex 4A.
5. The rule applies to applications received **6 months** or more after notification. Applications received earlier are assessed under Clause 4.5.2.

4.5.4.3 A notified catchment may be de-notified only by the same procedure, and only after a basin study shows that the downstream system meets Chapter 5 with all development under Clause 4.5.2.

> Commentary. The 0.9 factor is derived from the Denver (MHFD) analysis. In that analysis, ten basins each releasing 100% of the historic 100-yr peak still produced 106% of the historic peak at the outlet; releasing 90% at each gave 97% (UDFCD Full Spectrum Detention Release Rate Memorandum, 2012). The mixed-frequency rule has no direct precedent; the nearest is the Malaysian DID (2008) checklist, which required post-development 2-, 10-, 50- and 100-yr peaks below the pre-development 2-yr peak. The specific "100-yr post ≤ 10-yr pre" form appears in a New Berlin, Wisconsin planning discussion (not an adopted rule). The Gangtok entry follows the city's jhoras to its two receiving streams, the Rani Khola and the Roro Chu: Gangtok's 24-hour record is 310.3 mm (30 May 1975), its wettest month on record is June 1997 (1,281.3 mm, with 223.8 mm on 9 June), and in that month landslides were reported to have killed 38 people in the city (as reported, from a single source; no official account was found [TBC]) (IMD *Extremes*); the city's waterbody network lists named jhoras, such as the Goshkhan and Hospital jhoras (ICLEI, as reported); GMC has its waste agency clear the jhoras and bars dumping "along Footpath, Roadside and Jhoras" (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024); and the Zone III sewerage of Gangtok is described as "Pollution abatement of Rani chu through Ro-Ro Chu" (State Government's report of September 2025 to the NGT). Which wards stand on slide-prone ground was not found [TBC]. The Teesta valley-floor entry follows the corridor of 3–4 October 2023, when the South Lhonak glacial lake drained into the Teesta after a moraine collapse: at Chungthang "discharge peaked at 5340 $m^3 s^{-1}$ … within ~6 minutes", with a depth of 9 m and a velocity of 9 m/s, the 60 m high Teesta-III dam was destroyed, and Rangpo, about 135 km downstream, was "severely impacted by the debris, burying buildings and automobiles" (Sattar et al., 2025). The cause is disputed: the State's affidavit of 5 April 2024 before the NGT attributed the flood "primarily to a cloudburst", while a committee constituted by the National Dam Safety Authority found a lake outburst (as reported) and Sattar et al. found 29–39 mm of rain over the lake from 28 September to 5 October in the ERA5 reanalysis, and no cloudburst near the lake; this Manual takes no side. The toll is also stated two ways: 55 dead and 74 missing (SSDMA's multi-stakeholder survey, as cited by Sattar et al.), and 79 dead and 44 missing (the post-disaster needs assessment of SSDMA with the National Disaster Management Authority (NDMA), annexed to the State's affidavit of 28 February 2026). The river bed rose "by an average of 7-8 meters", NH-10 "has become

prone to submergence and subsidence", and at Toong Naga 155 households "have been mandated for relocation" (State Government's pre-project report, 2026). The Rangit entry follows its valley floor: the CWC site at Majitar has a highest level of 279.29 m (17 October 1985; as reported), and the land chosen for the Jorethang sewage works was "fully flooded during monsoon" (CAG, Report No. 3 of 2016). The Rongni Chu entry follows the river through Ranipool, where the CWC site has no published highest level, to Singtam, where it has a danger level of 355.09 m and a highest level of 356.09 m (as reported), and where the flood of October 2023 damaged the sewage treatment plant (State Government's compliance report to the NGT). The Mangan entry follows the rain and landslides of 12–13 June 2024 in Mangan district, in which 6 people were reported killed in the first reports and 9 in a later one (as reported; the figures conflict), between 1,200 and 2,000 tourists were stranded at Lachung and the Sangkalang bridge collapsed, after about 250 mm of rain across the State in 1–13 June, "54% above the normal 162 mm" (as reported); no station rainfall for Mangan was found [TBC]. The Lachen entry follows the landslide of about 19:00 on 1 June 2025 at the army camp at Chaten near Lachen, in which 3 people were killed and 6 were missing and after which 1,678 tourists were evacuated from Lachung and Chungthang (as reported), and the glacial lakes above: NDMA "has identified 40 high-risk glacial lakes in Sikkim, out of which 16 are classified as very high risk" (13 in Mangan district and 3 in Gyalshing district; 12 in the Lachen Chu watershed), and "Shako Chho has habitations and Army establishments just 15 km downstream" (State Government's affidavit of 28 February 2026). These catchments are screened under Clause 2.3.6(i); no drain is sized for a lake outburst. The reservoir entry follows the hydropower reaches: Teesta-III was destroyed in 2023, the High Court of Sikkim closed WP(PIL) 4/2017, which followed a release from the Dikchu project in 2017 without warning (as reported), with the direction "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" and that the authorities "undertake periodic inspection and review" (judgment of 1 March 2021), and a committee constituted by the National Dam Safety Authority reported an inflow of about 10,000 m³/s at Teesta-III against a spillway capacity of 7,500 m³/s (as reported); no full or maximum level or release rule was found for any reservoir [TBC]. The NH-10 entry follows the highway along the Teesta, which was submerged by the river in July 2025 (as reported) and whose drainage, damaged by the railway works, the High Court warned IRCON to correct in June 2025 (as reported). The Namchi entry follows a ridge town on the southern slopes, where the 2(a) plates read higher than at Gangtok (Clause 2.3.6(c)(i)) and whose sewerage "has remained stalled since the year 2013" (State Government's affidavit of 19 December 2025), so that its drains carry septic effluent to its jhoras. The Soreng entry follows the town where "most of the houses" discharge septic effluent "into open surface drains", and "untreated wastewater into the open storm water drains ultimately discharging into the farmland / water bodies" (ADB, due-diligence report of December 2024); its plate value was not read [TBC]. Pakyong, Gyalshing (Geyzing), Ravangla and Pelling are candidates for notification under Clause 4.5.4, and a notification of jhora limits under section 173 of the Municipalities Act, or the flood-control proposals of a development plan once the 2024 Act commences, would be evidence for it. The notification triggers in 4.5.4.1 have no direct precedent and are set by this Manual. The 6-month lead time follows the update rule of Clause 2.14.2. Clause 4.16 explains why releases below pre-development are needed at all.

### 4.5.5 Minimum outlet and short-duration 2-yr checks

4.5.5.1 Where the PSD for any AEP and duration is less than the discharge of a **50 mm** orifice (Clause 4.8.2) at the corresponding stage, the 50 mm orifice is deemed to comply for that AEP and duration.

4.5.5.2 Where meeting the 2-yr criterion at a duration of 3 hours or less would require a low-flow orifice so small that the drawdown requirement of Clause 4.7 cannot be met, the designer shall:

- size the low-flow orifice as the smallest opening that meets Clause 4.7; and
- report the resulting 2-yr exceedance for those durations.

The Authority may accept the design if the exceedance is below the discharge of the 50 mm orifice at the 2-yr stage, or if the downstream analysis of Chapter 5 shows no adverse effect.

> Commentary. Under AMC II, a greenfield site produces almost no runoff in a 1- or 2-hour, 2-yr storm, because most of the rain is lost to initial abstraction. A pre-development peak of a few litres per second, compared duration by duration, then forces a very small low-flow orifice. That orifice cannot release the 10-yr volume within 48 hours. Checked as if it were outside a flood-sensitive catchment, the illustrative example of Clause 4.6.7 would need a low-flow orifice of about 75 mm to match the 1-hour, 2-yr pre-development peak. 90% drawdown of the 10-yr volume would then take about 84 hours even with a clean orifice, against the 48-hour limit. The 170 mm orifice that meets drawdown with 50% blockage exceeds the 1-hour, 2-yr pre-development peak by about 11 L/s. Clause 4.5.5.2 resolves that conflict in favour of drawdown, because a basin that is still partly full when the next monsoon storm arrives fails in the event that matters more. KC APWA 5600 (2006) used a 75 mm (3 in) minimum orifice with trash racks. This Manual sets a 50 mm minimum (Clause 4.8.2).

### 4.5.6 Constrained redevelopment sites

4.5.6.1 **Eligibility.** The relief route of this clause is available only for **redevelopment** where all of the following hold:

- (a) the existing site is at least **60% impervious**, as surveyed before demolition;
- (b) the site is **1 ha or less**; and
- (c) the designer shows, in a Constraint Statement submitted with Form 4-1, that the greenfield criteria of Clauses 4.5.2 or 4.5.3 cannot be met on the site. The statement must show that every storage option of Clause 4.10 has been assessed: rooftop and podium storage, tanks under parking or landscape, permeable paving with sub-base storage, and landscape depressions. It must also give the storage each option can provide.

New development on undeveloped land is never eligible.

4.5.6.2 **Minimum on-site performance.** An eligible site shall provide all of the following on site:

- (a) the full retention volume (Clause 4.4) and the WQv treatment (Chapter 8), with no relief;
- (b) post-development peak discharge no more than **50% of the existing-condition peak** for the 50%, 10% and 1% AEP storms, at each duration of Clause 2.5.2. The existing condition is modelled under Clause 3.3.4; and
- (c) no increase in the 1% AEP water level at any building or road downstream (Chapter 5).

4.5.6.3 **Shortfall.** The shortfall is the detention storage required to meet the greenfield criteria (Clause 4.6) minus the storage provided on site under 4.5.6.2. The applicant shall pay for the shortfall as a fee-in-lieu at the unit rate of Clause 4.13.3. The fee shall be:

- (a) paid into the ring-fenced account of the basin in which the site lies;
- (b) spent only on regional detention or on restoring pokhari or tank flood storage identified in the basin stormwater master plan (Chapter 11); and
- (c) recorded in the public ledger of Clause 4.13.4, which shall show the volume owed and the volume delivered in each basin.

Where no basin master plan has yet been approved, the fee shall be held for up to **5 years**. If no plan is approved in that time, it shall be spent on restoring tank flood storage in the same basin, with WRD agreement.

4.5.6.4 **Flood-sensitive catchments.** In the catchments of Clause 4.5.3, the route is available under the same conditions. The Authority may, however, refuse it where the downstream analysis of Chapter 5 shows existing flooding of buildings in the 10% AEP event within the analysis extent.

> Commentary. Greenfield is the target for all redevelopment, because a dense city only reduces its runoff as it rebuilds. On small, fully built plots in areas such as central Gangtok round MG Marg (as reported), or the town centres of Namchi, Jorethang and Rangpo [TBC], there is often no space for the full greenfield storage. A rule that cannot be met invites variances and non-compliance, which help no one downstream. This clause follows the

> approach of the UK Non-statutory Technical Standards for Sustainable Drainage (Defra, 2015, S2–S3). For previously developed sites, those standards require peak runoff "as close as reasonably practicable to the greenfield runoff rate" and never above the pre-redevelopment rate. The fixed 50% minimum reduction has no direct precedent; this Manual sets it to give reviewers a clear number in place of a "reasonably practicable" judgement. The fee-in-lieu turns the shortfall into regional storage in the same basin, so the basin still receives greenfield-equivalent control in total. Retention and water quality get no relief, because they are small volumes that almost every site can hold.

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## 4.6 Detention sizing procedure

### 4.6.1 Method

Detention shall be sized by hydrograph routing through the stage–storage–discharge relationship of the facility, by level-pool (Modified Puls) or an equivalent numerical method (SWMM, HEC-HMS). Fixed-ratio and Rational-based storage formulae shall not be used. The simplified methods of Clause 4.14 (the Tier B tables and the fixed-coefficient route) are the only exceptions.

### 4.6.2 Steps

1. Delineate the site and sub-areas. Map HSG and confirm by testing (Chapter 3).
2. Extract design rainfall for 50%, 10% and 1% AEP and every duration in Clause 2.5.2, with the climate factor (Chapter 2, Form 2-1).
3. Build design hyetographs: alternating block for ≤ 24 h; the "peak day last" pattern for 48 and 72 h (Clause 2.9).
4. Compute pre-development hydrographs (greenfield CN; AMC III for storms of every duration from 1 May to 30 September in every sub-area, from 1 April to 31 October on valley-floor land below the 1% AEP flood level, on the 2023 aggradation zone, where the seasonal high water table is within 2 m and in stability zones 3 to 6, at all times in catchments draining to a hydropower reservoir, its backwater, a release reach below a dam or a river reach above its CWC warning level, and at other sites and times after a 5-day total of more than 53 mm, AMC II otherwise).
5. Compute the release caps for each AEP and duration under Clause 4.5.2 or 4.5.3.
6. Compute post-development hydrographs with the same storms and AMC, including retention practices (Clause 4.4.6).
7. Choose a trial facility geometry (stage–storage) and a multi-stage outlet (Clause 4.6.5).
8. Route every storm and duration. Use a time step of no more than **5 minutes**, and no more than Tc/3 of the post-development catchment.
9. Check every release against its cap, and check drawdown (Clause 4.7). Adjust the outlet and storage and repeat.
10. Check the tailwater condition of Clause 4.6.6 and the downstream analysis of Chapter 5.
11. Size the emergency spillway and set freeboard (Clause 4.9).
12. Report the governing storm for storage, for each outlet stage, and for the spillway (Clause 4.17).

### 4.6.3 Storms to be routed

Every facility shall be routed for the full matrix:

**Table 4.1 — Design storms to be routed for detention sizing**

| AEP | Durations (h) | AMC |
|---|---|---|
| 50% (2-yr) | 1, 2, 3, 6, 12, 24, 48, 72 | II for ≤ 6 h; III for ≥ 12 h |

| AEP | Durations (h) | AMC |
|---|---|---|
| 10% (10-yr) | 1, 2, 3, 6, 12, 24, 48, 72 | II for ≤ 6 h; III for ≥ 12 h |
| 1% (100-yr) | 1, 2, 3, 6, 12, 24, 48, 72 | II for ≤ 6 h; III for ≥ 12 h |

The 24-, 48- and 72-hour runs are mandatory whatever the critical-duration result (Clause 2.5.2). Where Ia = 0.05S sensitivity is required by Chapter 3, it shall be run for the governing storage case.

### 4.6.4 Initial conditions

Each run shall start with:

- detention storage empty, down to the invert of the lowest outlet;
- any permanent pool full;
- retention practices empty, except as limited by Clause 4.11; and
- RWH storage full (Clause 4.11).

The 48- and 72-hour storms already contain their antecedent rain, so no further pre-filling is applied.

### 4.6.5 Multi-stage outlet design

4.6.5.1 The outlet shall have a separate control for each criterion, normally stacked as in Figure 4.2:

- **Stage 1**, at the invert: the low-flow orifice. It releases the WQv over 24–48 h (Chapter 8) and controls the 2-yr release.
- **Stage 2**: an orifice or slot set at or near the maximum 2-yr level. It controls the 10-yr release.
- **Stage 3**: a weir, riser crest or larger orifice set at or near the maximum 10-yr level. It controls the 100-yr release.
- **Emergency spillway**: separate from the primary outlet (Clause 4.9).

Stages may be combined where routing shows that every cap is met.

4.6.5.2 Orifices shall be computed with a discharge coefficient of 0.60 unless a rated device is used. Weirs shall use a coefficient appropriate to their shape. Submerged-outlet and tailwater effects shall be included (Clause 4.6.6).

4.6.5.3 Vortex flow controls and other proprietary devices may be used where the supplier provides a certified head–discharge curve and the minimum clear opening is at least 50 mm.

### 4.6.6 Tailwater on the outlet

The outlet shall be routed against the tailwater of the receiving system, not free outfall, wherever the receiving water level can rise above the outlet invert. The tailwater shall be:

- for a receiving drain: its water level in the same storm, from the Chapter 5 analysis or, for Tier B, the drain obvert;
- for tidal or backwater-affected outfalls: the levels and joint cases of Clause 2.12 and Chapter 5, including the outfall-closed check (Clause 5.10).

Where tailwater governs, a flap gate shall be fitted to the outlet (Clause 5.11). The storage below the tailwater level shall not be counted as available unless the routing includes the gate closure.

### 4.6.7 Illustrative example

**Illustrative — not design values.** This example shows the procedure and the sizes it produces. The inputs are invented to be plausible for a hillside colony in Gangtok draining to a jhora. They are not NIH-DHAARA values and must not be used for design.

Inputs:

- Site: 2.0 ha, flood-sensitive catchment (Clause 4.5.3).
- Land cover: pre-development all pervious, CN 70. Post-development as two sub-areas (Clause 3.9.2): 1.57 ha of directly connected impervious surface at CN 98, never converted for AMC, and 0.43 ha of pervious open space at CN 70, on the same soil as pre-development; the area-weighted CN at AMC II is 92. For storms of 12 h and longer the pervious CN only is converted to AMC III: CN_III = 23·CN / (10 + 0.13·CN) = 84.3 (Clause 3.8.4).
- Time of concentration (Tc): 45 min pre-development, 15 min post-development (used for both sub-areas). SCS triangular unit hydrograph; 5-minute time step.
- 24-h depths: 110, 200 and 350 mm for 2-, 10- and 100-yr (the same 10- and 100-yr values as Clause 2.11).
- Shorter durations: P(t) = P24·(t/24)^0.40, an assumed ratio set and not Annex 2B.
- Longer durations: 48-h and 72-h depths taken as 1.25 and 1.40 × P24, laid out per Clause 2.9.2.
- Storage: vertical-walled, 2,500 m² plan area.
- Outlet, sized so that drawdown is met with the low-flow orifice 50% blocked (Clause 4.8.3). Annex 4C shows the trial outlet that failed this check.
    - Stage 1: 170 mm orifice at the invert.
    - Stage 2: 460 mm orifice with its invert 0.53 m above the floor.
    - Stage 3: none needed, because the 100-yr cap is met by Stages 1 and 2.

Results (discharges in L/s; storage in m³):

**Table 4.2 — Illustrative example: peak discharges and storage used, by duration (Illustrative — not design values)**

| Duration (h) | 2-yr pre | 2-yr post, detained | 10-yr pre | 10-yr post, detained | 100-yr post, uncontrolled | 100-yr post, detained | 100-yr storage used | 10-yr drawdown, 50% blocked (h) |
|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 15 | 51 | 28 | 922 | 42 | 1,426 | 31.3 |
| 2 | 14 | 20 | 84 | 34 | 961 | 79 | 1,911 | 32.1 |
| 3 | 19 | 22 | 104 | 37 | 981 | 139 | 1,999 | 32.8 |
| 6 | 32 | 25 | 150 | 41 | 1,010 | 194 | 2,154 | 34.2 |
| 12 | 127 | 30 | 302 | 46 | 1,074 | 276 | 2,512 | 39.0 |
| 24 | 149 | 32 | 327 | 49 | 1,081 | 320 | 2,766 | **45.3** |
| 48 | 173 | 34 | 349 | 82 | 1,087 | 343 | **2,913** | 44.8 |
| 72 | 180 | 34 | 356 | 84 | 1,089 | 343 | 2,911 | 44.7 |

How to read it:

- **100-yr cap.** The cap is the largest pre-development 10-yr peak, 356 L/s (72 h). Every 100-yr detained peak is at or below it; the largest is 343 L/s.
- **2-yr cap.** The site is flood-sensitive, so the 2-yr cap is the largest pre-development 2-yr peak, 180 L/s (72 h; Clause 4.5.3.1). The largest 2-yr detained peak is 34 L/s. At 1, 2 and 3 hours the detained 2-yr peak is above the pre-development peak of the same duration (15 against 4 L/s, 20 against 14 L/s, and 22 against 19 L/s). That comparison is not required here. It would be for a site under Clause 4.5.2, and Clause 4.5.5.2 would then apply.

- **Governing storage.** Storage is governed by the **48- and 72-hour** storms: 2,913 m³, which is 0.146 m³ per m² of site, at a maximum depth of 1.17 m. A design that checked only the critical-duration peak storm (1–3 h here) would have provided about 2,000 m³, roughly two-thirds of what is needed.
- **Drawdown.** With the low-flow orifice 50% blocked (Clause 4.8.3), 90% of the 10-yr storage drains in at most 45.3 h (the 24-hour storm), within the 48 hours of Clause 4.7. A 120 mm orifice would drain it in about 42 h when clean but 54 to 75 h when half blocked, so it fails. Annex 4C shows that trial and the routing step by step.
- **Retention credit.** With an illustrative retention depth of 40 mm, RRV = 552 m³, computed for each sub-area (Clause 3.9.4). Modelled as filling from the start of the storm with no infiltration during it, the retention reduces the 24-hour storage by 138 m³ and the 48- and 72-hour storage by 7 m³ or less. The credit under Clause 4.4.6 is therefore effectively zero for this site.

The order of magnitude, about 0.15 m³ per m² of site, is consistent with the indication in Clause 2.11.

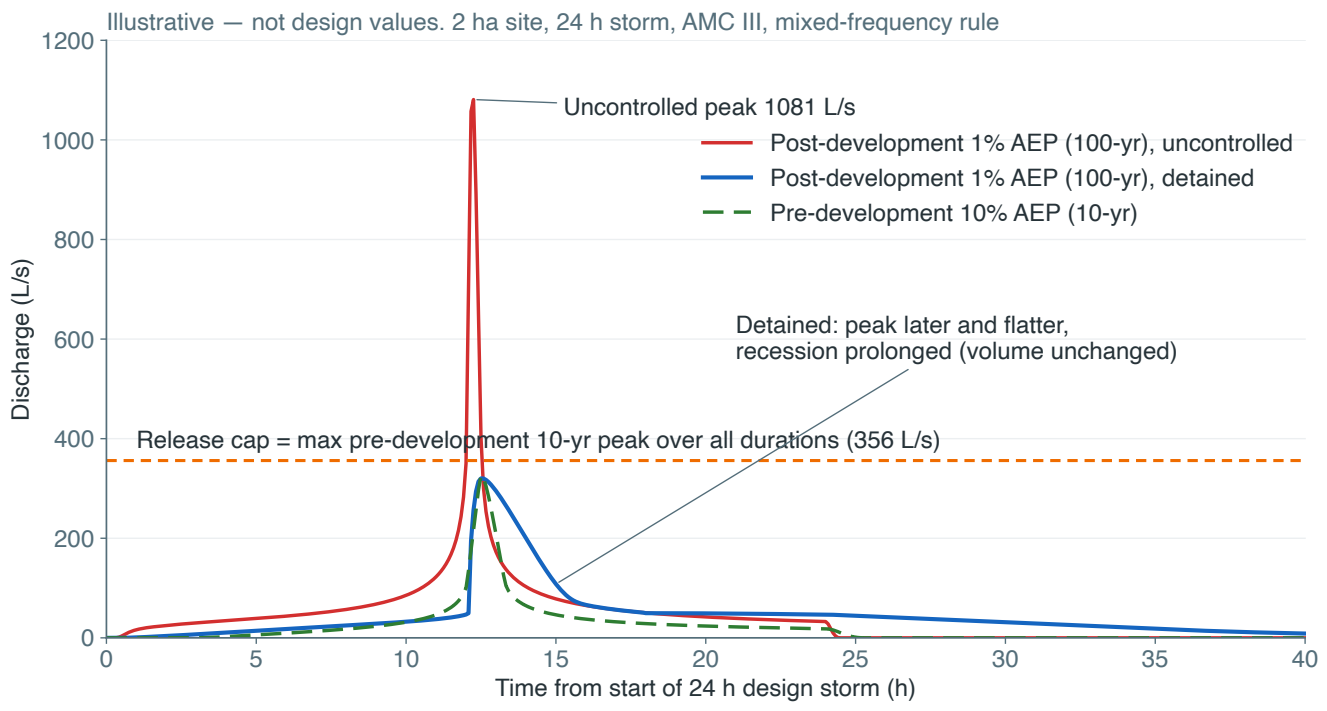


*Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA Section 5600 and the Georgia Stormwater Management Manual (2016).*

> **Commentary.** Figure 4.1 shows what detention does and does not do. It cuts and delays the peak. It does not reduce the volume: the area under the detained curve equals the area under the uncontrolled curve, more than twice the pre-development 10-yr volume. The extra volume leaves the site over many hours after the storm. That prolonged release can coincide with the peak of the larger catchment downstream (Clause 4.16), and it must still drain when the outfall is tide-locked (Chapter 5).

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## 4.7 Drawdown

4.7.1 **Detention.** At least **90%** of the maximum volume stored in the 10% AEP (10-yr) storm of each duration shall be released within **48 hours** of the time of maximum storage, by gravity, with the tailwater of Clause 4.6.6.

4.7.2 **Water quality volume.** The WQv shall be released over not less than 24 hours and not more than 48 hours (Chapter 8).

4.7.3 **Retention.** Retention storage shall be emptied within 72 hours by infiltration or reuse (Clause 4.4.5).

4.7.4 **Tidal outfalls.** Where gravity drawdown is prevented by tide for part of each cycle, the 48-hour limit applies with the tidal tailwater modelled. Where it cannot be met by gravity, pumped drawdown shall be provided under Clause 5.12.

> Commentary. KC APWA 5600 (2006) required dry basins to release at least 80% of storage within 24 hours of the inflow peak and to empty within 72 hours. Singapore PUB requires detention to be restored within 4 hours. The 48-hour, 90% rule is longer than PUB's because Sikkim storage must hold multi-day volumes. It is still short enough that a basin filled by one monsoon depression will have most of its volume back before the next, which in June 1997, when Gangtok's 223.8 mm of 9 June fell in a month of 1,281.3 mm, its wettest on record (IMD *Extremes*), and June 2024, when about 250 mm fell across the State in 1–13 June before and during the rain of 12–13 June in Mangan district (as reported) followed within days.

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## 4.8 Outlet structures

4.8.1 **General.** Primary outlets shall be:

- unattended, with no moving parts, valves or pumps, except where Clause 5.12 permits pumped drawdown;
- accessible for inspection and cleaning from the surface without confined-space entry, where practicable; and
- built of durable materials. In coastal areas these shall be corrosion-resistant (Clause 4.12.5).

4.8.2 **Minimum orifice.** No control orifice shall be smaller than **50 mm** in diameter, or 50 mm in least dimension for a slot.

4.8.3 **Trash racks and screens.** Every orifice and weir shall be protected by a trash rack or screen. The rack shall:

- have a clear bar spacing no greater than half the smallest opening it protects, and not less than 25 mm;
- have a clear open area at least **10 times** the area of the opening it protects;
- be inclined, or set as a cage around the riser, so that debris rises with the water and does not pin against the bars;
- be removable or hinged for cleaning; and
- for routing, be assumed **50% blocked** at the low-flow orifice when checking drawdown.

4.8.4 **Anti-vortex devices.** Riser crests and orifices that may run under more than 1.5 times their diameter of head shall have an anti-vortex plate or hood (Figure 4.2).

4.8.5 **Outlet barrels.** Outlet barrels through embankments shall:

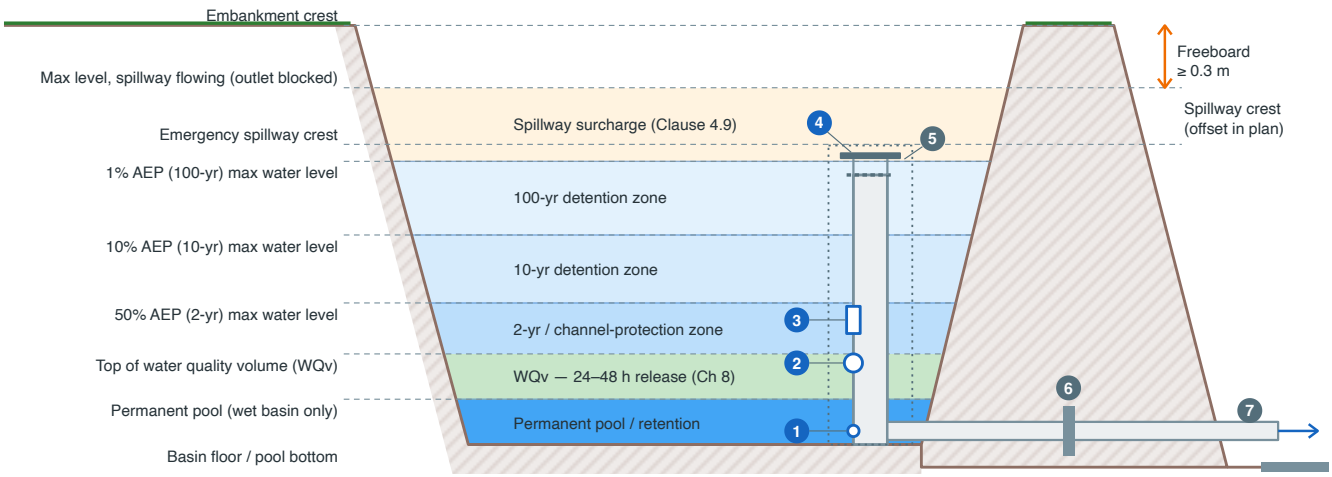
- be at least 300 mm in diameter (Chapter 6);
- have watertight joints;
- have a filter diaphragm or seepage collars over the length within the embankment; and
- have an energy-dissipating outfall (Chapter 9).

4.8.6 **Isolation.** Facilities serving more than 1 ha shall have a means of isolating the outlet for maintenance, such as a stop-log slot or penstock. In normal service it shall be left fully open.

> Commentary. The 50 mm minimum is smaller than the 75 mm (3 in) of KC APWA 5600 (2006), so the trash-rack requirements are correspondingly stricter. The ratios in 4.8.3 (bar spacing at half the opening, open area 10 times the opening, 50% blockage for the drawdown check) have no direct precedent and are set by this Manual. The

> blockage factor matches the 50% grate clogging factor for sag inlets in Chapter 6. Indian urban drains carry heavy loads of solid waste, so a low-flow orifice without an effective rack will block within one season.

**Storage stack and multi-stage outlet — schematic section, not to scale**




**Key**

1 Stage 1 low-flow orifice (≥ 50 mm, Clause 4.8.2) — releases WQv over 24–48 h
2 Stage 1 second orifice — with 1, controls 50% AEP (2-yr) release
3 Stage 2 orifice or weir slot — controls 10% AEP (10-yr) release
4 Stage 3 riser crest / overflow grate with anti-vortex plate — controls 1% AEP (100-yr) release
5 Trash rack enclosing all openings (Clause 4.8.3)
6 Seepage collar or filter diaphragm on outlet barrel
7 Outlet barrel, energy dissipation and outfall apron
Levels and zone thicknesses are diagrammatic only.

*Figure 4.2 — Detention storage stack (permanent pool, WQv, 2-yr, 10-yr and 100-yr zones, spillway surcharge and freeboard) and multi-stage riser outlet. Schematic, not to scale. Original drawing for this Manual, adapted from the multi-stage outlet and storage-zone concepts in MARC/KC APWA Section 5600 (2006, 2025.01) and the Mile High Flood District Urban Storm Drainage Criteria Manual, Volume 2 (full-spectrum detention).*

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## 4.9 Emergency spillway, freeboard and embankment safety

4.9.1 **Spillway capacity.** Every detention facility formed wholly or partly by an embankment, or whose overflow would reach buildings, shall have an emergency spillway that passes the **1% AEP (100-yr) peak inflow**:

- with the primary outlet assumed fully blocked;
- with the facility full to the spillway crest at the start of the storm; and
- with at least **0.3 m freeboard** from the maximum water level to the embankment crest.

4.9.2 **High-hazard facilities.** A facility is high-hazard if its failure or overflow could:

- endanger life;
- flood a habitable building or critical facility; or
- close an arterial road.

High-hazard facilities shall also be checked for the **0.2% AEP (500-yr)** peak inflow under the conditions of 4.9.1, with the embankment not overtopped.

4.9.3 **Spillway crest.** The spillway crest shall be at or above the 1% AEP maximum water level from routing with the primary outlet working. The recommended clearance is 0.15 m.

4.9.4 **Spillway location.** The spillway shall be:

- on natural ground or a reinforced section, not on fill, unless protected against erosion for the full design flow;
- discharging to the 1% AEP overland flow path of Chapter 6; and
- placed so that its flow does not reach a building.

4.9.5 **Underground and enclosed facilities.** Tanks, vaults and podium storage shall have an overflow route that operates when the outlet is blocked. The route shall carry the 1% AEP inflow to the overland path without surcharging any building, basement or lift pit.

4.9.6 **Embankments.**

- (a) Embankments more than **2 m** high (measured from the downstream toe to the crest) shall be designed by a qualified geotechnical engineer. The design shall include stability, seepage and settlement analysis.
- (b) Side slopes shall be no steeper than 3H:1V on any face that is mown or accessible to the public. Slopes shall be flatter where Clause 4.15 requires.
- (c) Embankments shall have:
  - a crest width of at least 3 m;
  - compacted, engineered fill with a core or cut-off where required by the seepage analysis; and
  - no trees or large shrubs.
- (d) An embankment structure that falls within the Dam Safety Act, 2021 is subject to that Act in addition to this Manual.

4.9.7 **Excavated facilities.** Facilities wholly below the surrounding ground, with no embankment, need not meet 4.9.6. They shall still meet 4.9.1, with the overflow route treated as the spillway.

> **Commentary.** The spillway criterion (1% inflow, outlet blocked, basin full, 0.3 m freeboard; 0.2% for high hazard) follows the KC APWA 5600 (2006) rule: the spillway passes the 1% storm with 1 ft (0.3 m) freeboard to the top of the dam, assuming zero storage and a clogged primary outlet, with the crest at least 0.5 ft (0.15 m) above the 1% maximum water surface. KC designed dams above 10 ft (3 m) to SCS TR-60 Class C. The 2 m embankment trigger, the 3H:1V slope (KC wet ponds), and the 3 m crest width have no direct precedent and are set by this Manual.

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## 4.10 Facility types

4.10.1 **General.** Any storage that meets Clauses 4.5 to 4.9 may be used. Surface storage that is visible and can be inspected without confined-space entry is preferred. Storage shall not be placed in a habitable basement or in any space whose flooding would endanger life.

4.10.2 **Underground tanks and vaults.**

- (a) Gravity outlet is required where the receiving drain allows it. Pumped outlets are permitted only under Clause 5.12, with a registered maintenance declaration (Chapter 10).
- (b) Access openings shall be provided over the outlet chamber and over every inlet. In tanks over 500 m², they shall be no more than 30 m apart.
- (c) The floor shall fall at least 1% to a sump at the outlet, with a sediment pocket below the low-flow orifice invert.
- (d) The tank shall be ventilated.
- (e) Inlets shall pass through a silt trap or gross pollutant trap (Chapter 8).
- (f) Flotation and groundwater ingress shall be checked under Clause 4.12.

4.10.3 **Rooftop detention.**

- (a) It is permitted on flat roofs designed for the full ponded load with the outlet blocked. The ponding depth shall not exceed **150 mm** unless a structural engineer certifies a greater depth.
- (b) Each roof outlet shall have a flow-control ring or weir with a certified rating, and every roof area shall have at least one overflow scupper, independent of the controlled outlets, that passes the 1% AEP inflow.
- (c) Roofs used for RWH collection may also provide rooftop detention. The detained volume is released through the control, not into the RWH sump.

4.10.4 **Podium and landscape-deck detention.**

- (a) It is permitted above ground level or above a basement car park, provided the structure is designed for full saturation and ponding, and waterproofed.
- (b) The release, overflow and safety rules for rooftop detention (4.10.3) apply.

4.10.5 **Parking-lot detention.**

- (a) It is permitted only on surface parking. Ponding depth shall not exceed:
  - **200 mm** in the 10% AEP storm and **300 mm** in the 1% AEP storm at any parking bay;
  - zero on accessible routes, ramps and pedestrian crossings; and
  - zero in the 10% AEP storm on fire-tender access routes.
- (b) Signs shall warn that the area floods.
- (c) Ponding shall not reach a building wall unless the wall is waterproofed above the 1% level plus freeboard (Chapter 6).

4.10.6 **Multi-use detention (parks, playfields, open space reservation).**

- (a) Open space land may be used for detention, provided its primary use remains available in at least the 50% AEP storm.
- (b) The storage areas shall be graded to drain fully within the times of Clause 4.7.
- (c) A low-flow channel or underdrain shall carry dry-weather and frequent flows, so that the park is not waterlogged.
- (d) The depth and slope limits of Clause 4.15 apply.
- (e) Play equipment and seating shall be placed above the 10% AEP level.

4.10.7 **Ponds and wet basins.**

- (a) A permanent pool shall be at least 1.2 m deep over most of its area to discourage weed growth and mosquito breeding, with a vegetated safety bench at the edge (Clause 4.15).
- (b) Only storage above the permanent pool counts as detention.

> Commentary.
>
> - The rooftop depth (150 mm) and parking depths (200 and 300 mm) have no direct precedent. This Manual sets them so that a blocked outlet is noticed before it becomes dangerous.
> - The 1.2 m pool depth equals the 4 ft minimum permanent pool of KC APWA 5600 (2006). This Manual adopts it mainly for weed and mosquito control.
> - Pumped detention tanks need maintenance declarations in Singapore (PUB Addendum No. 3, April 2025). This Manual adopts the same approach through Chapter 10.
> - Using open space for multi-use detention fits what the SBCR 1991 already ask of a site, a front setback of 10 feet "or as indicated in approved Master Plan of the area" and an open area of 5 feet (reg. 18), but the regulations set no share of the plot as soft cover or permeable ground (NEER reading). On the tested river-terrace gravels of sub-area SK-A above the 1% AEP flood level and outside the ground raised in October 2023, on flat ground, a detention area graded into the open space below the level of the road keeps it pervious and usable, which is what 4.10.6 requires, and can also infiltrate under Clause 4.11 (recharge

rule). Everywhere else the position is different. Ground on a natural slope of more than 10°, a terrace held up by a retaining wall, land within twice the height of a cut or wall downslope of it, colluvium, fill and slide debris, land in stability zones 3 to 6, and land that is sinking or landslide prone (reg. 35) are not to be used for ponding, because water held there soaks into the slope (Clause 4.11, hill rule); and valley-floor land below the 1% AEP flood level, the river bed and terraces raised in 2023 and land where the seasonal high water table is within 2 m are not to be used for unlined ponding, because there the river and the water table fill the storage first (Clause 4.11, valley-floor rule). On such sites, detention is provided in lined tanks, open or closed, with an orifice outlet and an overflow to a lined drain, on rooftops and podiums under 4.10.3 and 4.10.4, or on a level open space only where it stands on rock or on ground that the geotechnical certificate of the hill rule covers; an excavated pond or basin on a slope is not accepted, and any permeable paving there is laid on a lined or non-exfiltrating base with an underdrain. Four kinds of land are not open space for this purpose. A pokhari or a dhara (धारा; a spring or spring spout) on the land is preserved under step 1 of Clause 4.3.1; a pokhari is modelled as a water surface (Clause 3.3.2(e)) that starts at its spill level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows; and a natural or community pokhari is never turned into a detention pond. The bank of a scheduled river, which the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 places under the Forest Department "as if it were a forest" (s.29(9)), and the Manual's corridor of Chapter 7 along every jhora and khola are flood land already: water reaches them first, so they are not counted as detention for the development beside them. And land kept open on purpose, such as a slip reserve notified for stabilisation under section 29(2) of the 1988 Act, the notified green belt of the 1985 Act (s.2(f)), or a spring-recharge area above a town's or village's intake (the spring rule of Clause 8.8.1), is not graded or paved for detention. The signs and depth markers of Clause 4.15.5, and the flood-warning signs of 4.10.5(b), are in Nepali and English; where the local body's own public notices also use another official language of the State, such as Bhutia, Lepcha or Limbu, the signs carry that language too, because a sign must be readable by the people it warns (set by this Manual).

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## 4.11 Rainwater harvesting versus detention accounting

4.11.1 **No double counting.** RWH storage (sumps, tanks, recharge pits and wells provided under the RWH mandate) shall **not** be counted as detention.

4.11.2 **RWH sumps assumed full.** For all routing under this chapter, RWH sumps and tanks shall be assumed **full at the start of every storm**, in every season. Their overflow shall be routed to the detention facility, or directly to the outfall if it bypasses detention. In the latter case the bypass flow counts against the PSD.

4.11.3 **Combined tanks.** A single tank may provide both RWH and detention only if:

- (a) the detention zone lies wholly **above** the RWH overflow level;
- (b) the detention zone is drained by its own gravity control orifice set at the RWH overflow level, meeting Clauses 4.7 and 4.8;
- (c) no pump, valve or user action can hold water in the detention zone; and
- (d) the two zones and the orifice level are shown on the drawings and in the maintenance declaration.

Only the volume between the RWH overflow level and the detention overflow level counts as detention.

4.11.4 **Recharge structures.** Recharge pits, trenches, shafts and wells may count as **retention** (not detention) if they meet Clauses 4.4.3 to 4.4.5. In particular, the seasonal high groundwater table shall be at least 1.0 m below their base. In the routing they are treated under Clause 4.4.6 with the groundwater level for the monsoon season.

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of section 186 of the Sikkim Municipalities Act, 2007 and any manner of rainwater harvesting that the State Government or a Municipality specifies under it, any condition of a building permission, or any rainwater harvesting rule or direction of an approving authority

(no rainwater harvesting rule for private buildings was found).

Commentary. Rainwater harvesting in Sikkim is required by one provision, which reaches only public buildings and does not size it. Section 186 of the Sikkim Municipalities Act, 2007 reads: "In every building owned or occupied by the State Government or a statutory body or a company or an institution owned or controlled by the State Government, rain water harvesting structure shall be provided in such manner as may be specified by the State Government or the Municipality from time to time." No such manner has been specified as far as found (NEER reading). A reply in the Rajya Sabha in 2019 lists Sikkim as "NA asked to take up rain water harvesting structure for Government buildings" (as quoted), and GSCDL has sought expressions of interest for a rainwater harvesting project in Gangtok (as reported). The SBCR 1991 require no rainwater harvesting: their only roof-water provisions are that at least 25 per cent of the roof is sloped "with rain water gutter" (reg. 6) and that gutters and down pipes carry the water to the plinth drain (reg. 21). A gutter is not storage. No rule requires rainwater harvesting in a private building (NEER reading). In Sikkim rainwater harvesting is storage and reuse, not recharge: "about 80%" of rural Sikkim is reported to depend on springs, and "half of the perennial springs have already dried up or have become seasonal" (as reported). This Manual therefore sets three infiltration rules and one sizing rule for credit (all set by this Manual), and credits rainwater storage as follows:

- An RWH tank provided under section 186, or provided voluntarily, is RWH storage. It is not detention (Clause 4.11.1), and it is assumed full at the start of every storm (Clause 4.11.2), because in the monsoon season it is full after the first heavy rain. A tank may also provide detention only if it is built as a combined tank under Clause 4.11.3, with a detention zone above its RWH overflow level that drains through its own orifice; only that zone counts.
- **RWH credit rule.** Because section 186 sets no volume, and no rule sets one for a private building, RWH storage shall hold at least 25 L per m² of roof area (about 25 mm of rain over the roof) to earn credit under this Manual. The value is the North-East value of this series; the 20 L per m² of the mountain editions is the precedent, raised because Sikkim's towns and villages depend on springs that run low in the dry months. It counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or washing, demonstrated under Clause 4.4.3; watering a garden is not a continuous use in the monsoon season. The tank is then modelled under Clause 4.4.6 like any other retention practice; it is assumed full at the start of every monsoon design storm and is never counted as detention. For a building that section 186 covers, the rule makes the section measurable; for a private building it is a condition of this Manual wherever the Manual applies, not a statutory duty. A larger tank is always allowed. On hill-rule ground, which is most of the State, storage and reuse is the way retention is provided, and the 25 L per m² is the first part of it.
- Recharge pits, trenches, shafts and wells count as retention only where they meet Clause 4.11.4 and the recharge rule below: they are credited only to the extent that they drain within 72 hours at half the rate measured in a site test (Clauses 4.4.3 and 4.4.5), with their base at least 1.0 m above the seasonal high water table, and the credit is found by routing under Clause 4.4.6, not by deducting their volume. The recharge rule's 2.0 m separation is stricter than Clause 4.11.4's 1.0 m, and both apply.
- **Hill rule.** In sub-areas SK-B, SK-B1 and SK-C of Annex 2A, and on every natural slope of more than 10° in sub-area SK-A, no deliberate infiltration practice (soakaway, soak pit for storm water, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited: on natural ground sloping more than 10°; on colluvium, fill or slide debris, whatever its slope; in stability zones 3 to 6 of the Mines and Geology Department's Notification No. 17/DMG/20-21 of 19 March 2021; in any area that is sinking, landslide prone or has scars of old landslides (SBCR 1991, reg. 35); or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope; and in stability zones 4 to 6 not at all, whatever certificate is offered. On such sites roof runoff goes to rainwater storage under the credit rule above, with overflow by a lined, stepped drain through a silt trap and an energy dissipator to a trained jhora or the road drain, never onto an unprotected slope. The ground gives the reason. On steep terrain groundwater emerges "as seepages and springs wherever the land surface intersects local ground water body" (CGWB, as quoted); the 2021 notification records the ground of zone 3

as "Wet", of zone 4 as "Dripping" and of zones 5 and 6 as "Flowing", and judges zone 4 "Not suitable for habitation unless immediate protective measures"; and GSCDL told the NGT that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora", and was advised to channel the groundwater it met through "multiple drains connecting to nearby Jhoras" (reply affidavit in NGT OA 38/2022). Water put into such a slope does not recharge an aquifer; it raises the pore pressure in the slope. The rainfall thresholds proposed for landslide warning in Sikkim, I = 43.26 D^−0.78 for the State and I = 100 D^−0.92 for Gangtok (I in mm/day, D in days; *Landslides*, 2019, as summarised), show how little rain over a few days the slopes can take; they are cited here as commentary only and are not used for design. The landslides of Gangtok in June 1997, in which 38 people were reported killed (as reported, single source), came in the wettest month of Gangtok's record (1,281.3 mm, IMD *Extremes*). The hooks are in the building rules and the zone notification: gutters and down pipes "of such design and capacity that the water will neither spill out of them nor leak through them" (reg. 21); a "Pucca storm water/plinth protection drain … leading to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)); no occupation certificate "if the drain has not been provided to main outlet/jhora" (reg. 13(iii)); no allotment on sinking or landslide-prone land (reg. 35); and the zone-review condition of "Proper channelization of surface runoff by providing catchment drains especially during the rainy seasons and connect it to natural waterways/Jhora which also improves the stability of the area due to reduced erosions and percolation of water" (2021). On these sites retention is provided by storage and reuse, and detention by lined tanks, not by ponds or basins on the slope (Commentary to Clause 4.10). The 1.0 m groundwater separation of Clause 4.4.3 does not make an infiltration practice acceptable on a slope: perched water and pore pressure in a slope are the hazard, not the depth to the water table.

- **The septic soak pit: a conflict, stated.** Regulation 25(i) has every building treat its sewage "in septic tanks built within the site", and regulations 6 and 13(iii) require the septic tank and soak pit to be shown on the plan and properly built before occupation. On a wet slope that soak pit puts water into the ground that the hill rule protects. This Manual does not override the regulations, which govern sewage, not storm water. It states the conflict plainly: no storm water, roof water or sullage is put into a soak pit under this Manual, and a soak pit earns no infiltration credit. It recommends that no new soak pit be placed in stability zones 3 to 6, and that one on a slope of more than 10° be sited by a geotechnical engineer, downslope of buildings and cuts (set by this Manual, as in the mountain editions of this series); where a soak pit falls on hill-rule ground, the conflict is recorded on the site submission, and the sewage itself is dealt with under Clause 8.9.
- **Valley-floor rule.** In sub-area SK-A, no deliberate infiltration practice shall be built or credited on land below the 1% AEP flood level of the Teesta, the Rangit, the Rongni Chu or another river; on the river bed and terraces raised by the flood of October 2023; on the margins of a pokhari or reservoir (its Zone 1 and Zone 2 under Chapter 7); or wherever the seasonal high water table, the highest level from April to November, is less than 2.0 m below ground. On such land roof runoff goes to storage, and detention is provided in lined storage, checked for flotation with the design groundwater level at ground level (Clause 4.12.1). The ground gives the reason: the terraces at Rangpo, Melli and Jorethang are gravels with a high water table in the monsoon season (NEER reading), and no depth to water has been measured on any of them [TBC]; the land chosen for the Jorethang sewage works was "fully flooded during monsoon" (CAG, Report No. 3 of 2016); and the State itself says that the raised bed of the Teesta "poses a heightened risk of flooding during the monsoon season" (pre-project report, 2026).
- **Recharge rule.** Recharge is not a design objective in Sikkim. Deliberate recharge is allowed only on tested river-terrace gravels of sub-area SK-A above the 1% AEP flood level and outside the zone raised by the flood of October 2023, and on benches of 10° or less in stability zone 1 that a geotechnical certificate shows to be stable; there it needs a silt trap, a filter and a first-flush diverter ahead of the structure, a field infiltration test, a seasonal high water table at least 2.0 m below ground and the separation of Clauses 4.11.4 and 4.12. Groundwater in the State is "largely in disconnected localized pockets and in deeper fracture zones" (CGWB, as quoted), and no CGWB depth or extraction figure for Sikkim was read for this Manual [TBC]. Everywhere else rainwater harvesting is storage and reuse.
- **Springs (dhara).** A dhara is protected under the spring rule of Clause 8.8.1: no storm outfall, soakaway or drain discharge within 15 m of it, no storm water routed into or immediately above it, no drain, cut or fill that intercepts, buries or crosses its outlet, and no paving and no infiltration of road runoff in the recharge area

above a town's or village's intake (set by this Manual). Springshed recharge, such as the trenches and ponds of the Dhara Vikas programme of the Rural Management and Development Department (RMDD), is a water-supply programme, not a stormwater credit: this Manual credits none of it, and allows recharge works of that kind under its rules only where the geology is mapped and the slope is stable, never above a known slide, a road cut or a building. That condition is a limit on where water may be put into a slope, not a judgement of the programme. A dhara is never used as storage.

- **Polluted runoff.** Runoff from fuel stations, workshops, quarries and the like, and from any drain that carries sewage or septic effluent, as many of the drains of the towns do (Commentary to Clause 4.1), shall not be recharged; road and parking runoff shall be recharged, where the recharge rule allows it at all, only through a surface practice with a filter, such as a vegetated basin or trench, never directly into a pit, bore or well (Chapter 8).

On the ridges, water put into the ground goes into the slope, and on the valley floors it meets a water table that the river raises. In the monsoon season an RWH tank is full after the first heavy rain. Treating RWH as detention would therefore credit storage that does not exist when it is needed. That is why this Manual assumes RWH tanks are full at the start of every storm. Applying the assumption to every season keeps one simple rule. The combined-tank provision (4.11.3) lets an owner build one structure, as long as the detention part is empty when the storm arrives. The 25 L per m² credit rule, the hill rule, the valley-floor rule, the recharge rule, the treatment of the soak-pit conflict and the polluted-runoff rule are set by this Manual. No Sikkim source sets a slope threshold for infiltration: the "around 70" degrees of reg. 35 is a limit on allotment, and the slope bands of the 2021 stability zones (zone 1 "<15°", zone 2 16–25°, zone 3 26–35°, zone 4 36–45°, zones 5 and 6 more than 45°) are site classes for building height, not infiltration rules. The 10° limit is set by this Manual, as in the mountain editions of this series, well below those slopes, because a slope that can carry a building can still be destabilised by water put into it; zones 3 to 6 need a certificate because the 2021 notification already records their ground as wet, dripping or flowing; zones 4 to 6 are excluded with no certificate, as the highest landslide-hazard zones are in another North-East hill edition of this series, because the notification judges zone 4 unsuitable for habitation without immediate protective measures and allows no construction in zone 6; and the distance of twice the height of a cut or wall is set by this Manual as a precaution, pending guidance from a geotechnical study for the State [TBC].

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## 4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the valley floors and river terraces of the Teesta, the Rangit and the Rongni Chu in sub-area SK-A (at Rangpo, Singtam, Melli, Majitar and Jorethang), land below the 1% AEP flood level of a river and the river bed and terraces raised by the flood of October 2023, the margins of the pokharis and of the hydropower reservoirs and their backwaters, the seepage zones below springs (dhara) on the slopes, and the ground of stability zones 3 to 6, which the Mines and Geology Department's notification of 2021 records as "Wet", "Dripping" or "Flowing", or any area where the groundwater table lies within 3 m of the surface at any time of year shall establish a design groundwater level (DGWL) for the facility. The DGWL is the seasonal high level during or after the monsoon, from:

- (a) site piezometer readings over at least one full April–November season; or
- (b) where (a) is not available, the higher of the CGWB or WRD record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, khola, jhora, pokhari or reservoir, including the Teesta or the Rangit at a valley-floor town.

For the flotation check of 4.12.3 at sites in the Teesta and Rangit valley floors and river terraces (at Rangpo, Singtam, Melli, Majitar and Jorethang), land below the 1% AEP flood level or on the river bed raised by the flood of October 2023, the pokhari and reservoir margins, and the seepage zones below springs (dhara) on slopes, where (a) is not available, the DGWL shall be taken as existing ground level.

4.12.2 **Lined storage.** Where the DGWL is less than 1.0 m below the base of a storage facility:

- (a) the facility shall be watertight (lined or of watertight concrete), and no infiltration credit applies (Clause 4.4.4); or
- (b) if unlined, the volume below the DGWL shall not be counted as detention, and groundwater inflow shall be added to the routed inflow.

4.12.3 **Uplift and flotation.** Every below-ground tank, vault, lined pond or chamber shall be checked for flotation:

- with the facility empty;
- with groundwater at the DGWL; and
- for coastal sites, with groundwater also at the major-system tailwater level of Chapter 5, where that is higher.

The factor of safety against uplift, counting only permanent dead loads and ignoring wall friction unless supported by geotechnical design, shall be at least **1.2**. Anchoring by ballast, toe extensions or tension piles may be used.

4.12.4 **Shallow and above-ground storage preferred.** On sites where the DGWL is within 1.5 m of ground, storage should be provided above ground where possible: rooftop, podium, landscape or surface storage. Deep tanks should be avoided.

4.12.5 **Durability.** Concrete and metal parts in contact with saline or brackish groundwater or tidal water shall be designed for the exposure class appropriate to coastal conditions under IS 456:2000. Outlet fittings, trash racks and gates shall be of stainless steel, HDPE, FRP or another corrosion-resistant material.

4.12.6 **Sandy soils with deep groundwater.** Where the DGWL is 1.0 m or more below the base, infiltration retention in sandy soils is encouraged. The design infiltration rate of Clause 4.4.3 applies, and the Chapter 8 requirements on pollution of shallow aquifers shall be met.

> Commentary. Sikkim is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3 and the saline exposure of 4.12.5, do not apply in the State, and no saline or aggressive groundwater was reported in the sources read for this Manual [TBC]. Groundwater is "largely in disconnected localized pockets and in deeper fracture zones", and "springs are the main source" (CGWB, as quoted); no CGWB depth to water or observation-well record for Sikkim was read, because the CGWB's Sikkim reports could not be reached, and no State observation-well network was found [TBC]. This Manual names WRD as the State agency for the observation-well records of 4.12.1(b), because WRD is the State's department for rivers and jhora works and monitors river water with CWC and the State Pollution Control Board (set by this Manual); until it keeps such records, the CGWB well, site piezometers and trial pits are the only sources. The wet cases are the valley floors and river terraces of the Teesta, the Rangit and the Rongni Chu at Rangpo, Singtam, Melli, Majitar and Jorethang, gravels with a high water table in the monsoon season (NEER reading); the river bed and terraces raised by the flood of October 2023; the margins of pokharis and of the hydropower reservoirs; the seepage zones below springs (dhara) on the slopes; and the ground of stability zones 3 to 6, which the Mines and Geology Department's notification of 2021 records as "Wet", "Dripping" or "Flowing". There an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when a river in flood, a reservoir at its full level or a pokhari at its spill level raises the water table beside it. The design groundwater level of 4.12.1(b) therefore takes the design flood level of the adjacent river, khola, jhora, pokhari or reservoir where that is higher than the well record, and on the valley floors, the raised bed and terraces, the waterbody margins and the seepage zones it is taken as existing ground level for the flotation check unless piezometers show otherwise. On a hill site a deep tank is not preferred even where groundwater is deep, because a leaking tank on a slope is an infiltration practice by another name: storage on a slope shall be lined and watertight, and its leakage and overflow taken to a lined drain (Clause 4.11, hill rule). The April–November monitoring season of 4.12.1(a) is set by this Manual to cover the Manual's monsoon season of 1 April to 31 October, whose pre-monsoon storms of April and May can raise the water table early, and the high after the season ends; a reading taken in March understates the design level. No monsoon water-table depth for any town site in Sikkim, and no map of the seasonal high water table, was

obtained [TBC]. The factor of 1.2, the 0.5 m allowance and the "ground level" default for the valley floors, the raised bed, the waterbody margins and the seepage zones have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Sikkim were found during research.

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## 4.13 Regional detention and fee-in-lieu

4.13.1 **Where permitted.** In a basin covered by a Basin Stormwater Master Plan approved under Chapter 11, a development may meet all or part of its detention requirement through:

- (a) a regional detention facility identified in the plan; or
- (b) a fee-in-lieu paid toward restoration of pokhari or tank storage identified in the plan.

4.13.2 **Conditions.** Regional detention or fee-in-lieu shall be accepted only where:

- (a) the regional facility or restored tank is operational, or is funded and scheduled to be operational within **3 years**. Until then, interim on-site detention is required.
- (b) the conveyance from the site to the facility carries the 1% AEP post-development flow without increasing water levels at buildings or roads between them (Chapter 5);
- (c) the storage credited at a tank is the **flood storage** only. This is the volume between full tank level (FTL) and the maximum water level the bund and surplus weir can safely hold, plus any volume below FTL that a notified operating rule commits to empty before the monsoon. Storage below FTL that is held for irrigation or supply through April to October shall not be credited.
- (d) the tank meets Chapter 7: surveyed FTL, a documented operating rule, and a maintained surplus weir;
- (e) the site still provides **retention** (Clause 4.4) and **WQv** treatment (Chapter 8) on site; and
- (f) in flood-sensitive catchments, the regional facility meets the mixed-frequency rule for its whole contributing area.

4.13.3 **Fee.** The fee-in-lieu shall be computed as:

> Fee = (detention volume required on site under Clause 4.6, m³) × (unit rate, ₹/m³, notified by the Authority)

The unit rate shall include land, construction and 10 years of maintenance. Fees shall be held in a ring-fenced basin account and spent only on the facilities named in the plan.

4.13.4 **Ledger.** The Authority shall keep a public ledger of:

- detention volume credited to each regional facility;
- volume delivered; and
- fees received and spent.

> Commentary. The Malaysian DID (2008) checklist favoured community ponds over on-site detention for sites above 0.1 ha. Studies of on-site detention show that its benefit depends on location and fades with distance downstream (Colorado State University thesis; McEnroe for Kansas City), and that a pond low in the catchment can synchronise with the main-stem peak (*Water* 2016). Regional storage therefore has to be sited by basin modelling, not simply aggregated.
>
> Sikkim has no tank or lake Act, and no pokhari, lake or reservoir in its towns was found to be operated for flood control under a documented rule. The River Rejuvenation Committee of the Forest and Environment Department has been "notified as the Nodal Agency for all water bodies" (Order No. 205/GOS/F&ED/SECY, 21 January 2021),

but no State Wetland Authority notification and no wetland notified under rule 4 of the Wetlands (Conservation and Management) Rules, 2017 were found [TBC]; Khecheopalri lake became the State's first Ramsar site in February 2025 (as reported), and the published figures for its area conflict, so none is given here. The State's regional storage is of five kinds: the reservoirs of the hydropower projects on the Teesta and the Rangit; the lakes of the hills, such as Khecheopalri and Tsomgo, which are sacred and visited sites rather than flood storage (as reported); the pokharis of the towns and villages; the springs (dhara) that supply most villages; and the river floodplains, which no law zones. Glacial lakes are not among them: the State counts 320 (pre-project report annexed to its affidavit of 28 February 2026), a study of 2024 counts 232 larger than 0.01 km² (as summarised) and an older count gives 266 (as reported), the counts differing with the date and scope of the inventory, and they are hazard sources under Clause 2.3.6(i) and Chapter 7, never storage. Four points follow:

- A pokhari on the record may not be a working pokhari, and a pokhari in the hills is not a detention basin. No inventory of the pokharis, lakes and springs within the municipal areas, with their beds, rims and outlets, was found [TBC]. A pokhari or lake is credited only after a survey shows its bed, rim and outlet, and only for the storage above its spill level; a natural, community or sacred pokhari or lake is never turned into a detention pond, and engineered storage is called a detention pond. A spring-recharge area is not storage for detention (Commentary to Clause 4.11).
- The reservoirs are not spare capacity for a site. They are held for power, no full level, maximum level or release rule was found for any of them [TBC], their releases are set by their operators for the whole river, and in October 2023 the flood came down through them, destroying the dam of Teesta-III and filling the reaches below with debris (Sattar et al., 2025). Their storage below full level is not credited (Clause 4.13.2(c)), and storm water spilled to a reservoir, or to a reach below a dam, can be relied on only with the written agreement of the operator, for a stated flow and level.
- A pond or check dam in the bed of a jhora is not regional detention unless it is designed for debris and garbage. The jhoras carry boulders, slide debris and waste in every large storm; the 2021 stability zones grade sites by whether their jhoras are trained, and GMC contracts for "Clearing of Jhoras"; such a facility is credited only for the storage left after the sediment and debris volume of Chapter 6, with a debris rack or trap at its inlet, a geotechnical check of its bund and abutments, its failure path mapped, and a maintenance budget for clearing it after each large storm (Clause 6.3.6; Chapters 9 and 10). A regional facility on a slope is also subject to the hill rule of Clause 4.11, and one on a valley floor to its valley-floor rule; in sub-area SK-C, and in any catchment below a glacial lake, no regional storage is credited without the site-specific study of Clause 2.3.6(i).
- No notification divides the drains of any Sikkim town among their owners (NEER reading). Until one is made, this Manual follows the working split of Chapter 1: municipal drains, and jhoras on public land other than forest land within a municipal area, as the urban local body's (Municipalities Act ss.172(1) and 189(1)), with every jhora in the municipal area, public or private, under its duty to protect (s.172(2)); the river banks of the 103 scheduled rivers as the Forest Department's (1988 Act, s.29(9)); road drains as the road owner's (the Roads and Bridges Department (PWD) for State roads, and NHIDCL or BRO for national highways, by inference); jhora training as the executing agency's (GSCDL for Smart City works, as reported; WRD for river and jhora works; RMDD in rural areas); sewers and sewage treatment plants as PHED's, and rural and peri-urban sewage as RMDD's; the hydropower reservoirs and their gates as the operators'; springs with no statutory owner, although RMDD's Dhara Vikas programme works on them (as reported); and jhoras outside municipal limits or on forest land with no named owner. Each town keeps a drain and jhora register giving every reach its owner, its land status (municipal, Forest Department, private or road reserve) and its outfall (Chapter 6). This is the Manual's working split, not a statutory one; where land is private, a drainage corridor or easement is secured by agreement or donation, never taken.

The first point is the basis of condition 4.13.2(c) in Sikkim. A pokhari or lake gives flood storage only above its spill level, unless a notified operating rule commits it to be lowered before the monsoon season. The 3-year operational limit and the 10-year maintenance allowance have no direct precedent and are set by this Manual.

## 4.14 Simplified methods for small sites

4.14.1 **Applicability.** Tier B local bodies may permit the simplified method for sites of **2 ha or less** outside flood-sensitive catchments. In flood-sensitive catchments, it may be used for sites of **0.5 ha or less**. All other sites shall use Clause 4.6. Until Table 4.3 (Annex 4B) is published, all Tier B sites shall also use Clause 4.6.

4.14.2 **Method.**

1. Read the PSD (L/s/ha) and SSR (m³/ha) for the site's zone, HSG and post-development imperviousness from **Table 4.3** (Annex 4B).
2. Required storage: V = SSR × A − V_credit (Clause 4.4.6.3).
3. Permissible discharges: Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages.
4. Select the low-flow orifice and upper control from the standard outlet table in Annex 4B (orifice sizes for the PSD at the stated depths), subject to the 50 mm minimum.
5. Provide a spillway or overflow under Clause 4.9, the RWH accounting of Clause 4.11, and the safety provisions of Clause 4.15.
6. Complete Form 4-2 (Tier B site sheet).

**Table 4.3 — Tier B permissible site discharge and site storage requirement (template)**

| Zone (Annex 2A) | HSG | Imperviousness | PSD 2-yr (L/s/ha) | PSD 100-yr (L/s/ha), standard | PSD 100-yr (L/s/ha), flood-sensitive | SSR (m³/ha), standard | SSR (m³/ha), flood-sensitive |
|---|---|---|---|---|---|---|---|
| SK-Z1 Southern hills and valleys: SK-A Lower valleys (Rangpo–Singtam–Melli–Jorethang), at the depths of Clause 2.3.6(c)(i) | A / B / C / D | 50% / 70% / 90% | [TBC] | [TBC] | [TBC] | [TBC] | [TBC] |
| SK-Z1 Southern hills and valleys: SK-B Ridge towns (Gangtok–Pakyong–Namchi–Gyalshing), at the depths of Clause 2.3.6(c)(i) after the record check of Clause 2.3.6(h) | C / D | 50% / 70% / 90% | [TBC] | [TBC] | [TBC] | [TBC] | [TBC] |
| SK-Z2 North Sikkim: SK-B1 Middle Teesta valley (Dikchu–Mangan–Singhik–Chungthang), at the floor of Clause 2.3.6(c)(ii); where a station fit replaces the floor, Clause 4.6 applies | C / D | 50% / 70% / 90% | [TBC] | [TBC] | [TBC] | [TBC] | [TBC] |
| SK-Z2 North Sikkim: SK-C High valleys (Lachen–Lachung–Thangu) | — | — | Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(iii) and (i)) | — | — | — | — |

**Worked example (illustrative — not design values).**

A 0.4 ha residential layout in a Tier B Municipality, in a flood-sensitive catchment, with about 80% directly connected impervious area (area-weighted post-development CN about 92). Suppose Table 4.3 had been computed and gave the per-hectare equivalent of the Clause 4.6.7 example:

- PSD 100-yr = 356 / 2.0 = 178 L/s/ha
- SSR = 2,913 / 2.0 ≈ 1,460 m³/ha
- PSD 2-yr ≈ 17 L/s/ha

Then:

- Storage: V = 1,460 × 0.4 = **584 m³**. C_R = 0, so there is no retention credit.
- 100-yr release: 178 × 0.4 = **71 L/s**.
- 2-yr release: 17 × 0.4 = **7 L/s**. At about 1 m head this needs a low-flow orifice of about 60 mm, above the 50 mm minimum (Clause 4.8.2).
- Layout options:
  - a 400 m² underground tank 1.5 m deep; or
  - 250 m² of podium storage at 0.3 m (75 m³) plus a 350 m² tank 1.5 m deep (525 m³).
  - Rooftop storage at 150 mm over 1,200 m² of roof (180 m³) could replace part of the tank.
- RWH sumps are additional, and are assumed full (Clause 4.11).

> **Commentary.** Australian councils use permissible site discharge and site storage requirement tables in the same way (Sydney Water OSD guide; the Upper Parramatta River Catchment Trust handbook listed SSR of about 455 m³/ha). The illustrative SSR here, about 1,460 m³/ha, is much larger. That is the expected effect of combining a mixed-frequency cap with mandatory 48–72-hour storms at AMC III. MSMA 2 in Malaysia offers a similar simplified OSD method for sites under 5 ha. The MARC policy supplement offers smaller Kansas City municipalities adoptable alternatives within the regional standard; Clause 4.14 follows that model for Tier B.

4.14.3 **Fixed-coefficient route.** As an alternative to Clauses 4.6 and 4.14.2, the designer of any site of **1 ha or less**, under any Approving Authority and in any catchment, may size detention by Clauses 4.14.4 to 4.14.7. The route shall not be used where:

- (a) the site counts tank or waterbody storage in its design (Chapter 7);
- (b) any part of the site lies within a waterbody setback (Chapter 7); or
- (c) the site drains to a tank cascade whose storage is counted in a downstream design.

The route sets the release caps by fixed coefficients and does not need Table 4.3. It may therefore be used before Annex 4B is published. Retention (Clause 4.4), drawdown (Clause 4.7), outlets (Clause 4.8), the spillway (Clause 4.9), the downstream and tailwater checks (Chapter 5) and water quality (Chapter 8) still apply.

4.14.4 **Release caps.** Two caps apply at each point where runoff leaves the site:

$Q_{cap,10} = 2.78 \times C_{10} \times i_{10} \times A$ and $Q_{cap,2} = 2.78 \times C_2 \times i_2 \times A$

where Q_cap is in L/s; A is the site area (ha); i_10 and i_2 are the 10% AEP (10-yr) and 50% AEP (2-yr) rainfall intensities (mm/h) for a **15-minute** duration at the site, from the sources of Chapter 2, with the climate factor of Clause 2.8; and C_10 and C_2 are the fixed coefficients of Table 4.3A for the site's hydrologic soil group (Clause 3.7). For a site with more than one soil group, the coefficients are area-weighted.

**Table 4.3A — Fixed release coefficients (provisional)**

| Hydrologic soil group | C_10 | C_2 |
|---|---|---|
| A (sandy, well drained) | 0.05 | 0.02 |
| B | 0.08 | 0.03 |
| C | 0.15 | 0.08 |
| D (clay, poorly drained) | 0.25 | 0.15 |

Q_cap,10 is the maximum release for **every storm up to and including the 1% AEP (100-yr) storm**, in every catchment. Q_cap,2 is the maximum release for the 50% AEP (2-yr) storm. Where a cap is smaller than the discharge of a 50 mm orifice at the corresponding stage, the 50 mm orifice is deemed to comply (Clause 4.5.5.1).

4.14.5 **Storage.** The detention storage V (m³) is the larger of V_100 and V_2, each the largest over the durations d of Clause 2.5.2 (1 to 72 hours):

V_100 = max over d of [ 10 × C_v × P_100(d) × A − 1.8 × Q_cap,10 × d ]

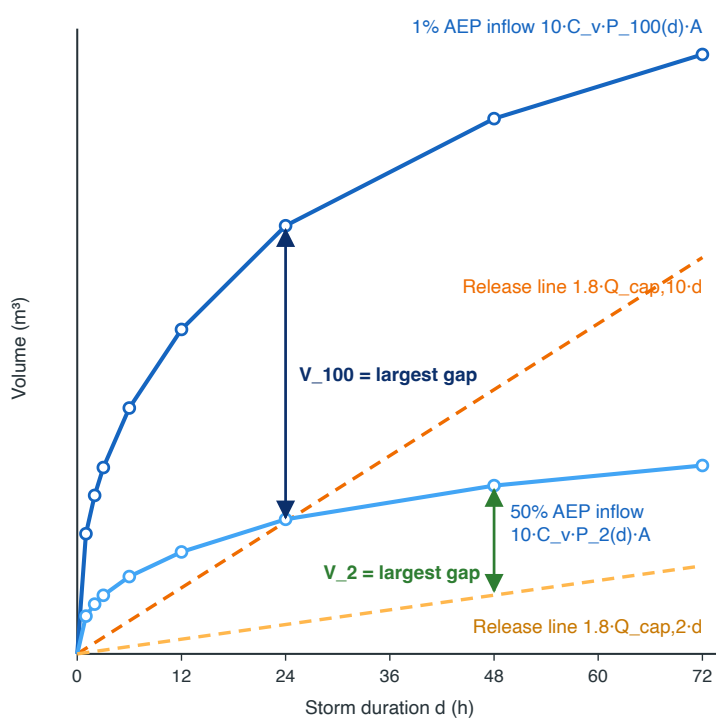
V_2 = max over d of [ 10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d ]

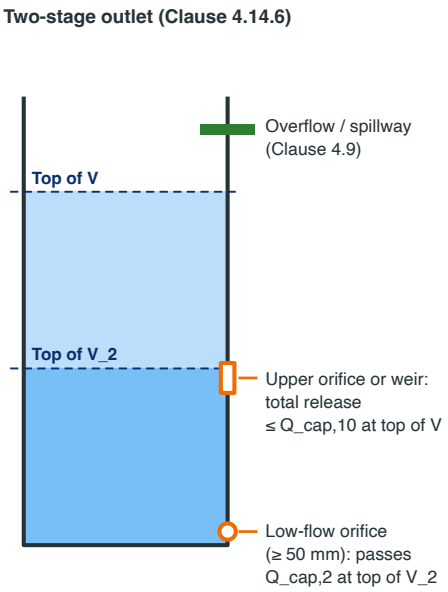
where P_100(d) and P_2(d) are the 1% and 50% AEP rainfall depths (mm) for duration d (hours), with the climate factor; and C_v is the post-development volumetric coefficient: the composite C of Table 3.2 (upper half of each range), multiplied by Cf of Table 3.3 for the 1% AEP. For durations of 12 hours or more, C for every pervious surface shall be taken as not less than **0.50**. The factor 1.8 assumes an average release of half the cap over the storm (3.6 × 0.5).

4.14.6 **Outlet.** The outlet shall be a two-stage control: a low-flow orifice that passes Q_cap,2 when the storage holding V_2 is full, and an upper orifice or weir that limits the total release to Q_cap,10 at the top of V. The outlet table of Annex 4B may be used once it is published.

4.14.7 **Retention.** The retention volume of Clause 4.4 is provided in addition to V. No retention credit (Clause 4.4.6) is taken under this route.

**Fixed-coefficient route for sites of 1 ha or less (Clauses 4.14.3–4.14.7) — schematic, not to scale**




Dots: durations of Clause 2.5.2 (1, 2, 3, 6, 12, 24, 48, 72 h). Pervious C ≥ 0.50 for d ≥ 12 h.

Q_cap,10 = 2.78 × C_10 × i_10 × A ; Q_cap,2 = 2.78 × C_2 × i_2 × A ; (L/s; A in ha; i in mm/h)

C_10, C_2 from Table 4.3A by soil group; i_10, i_2 for a 15-minute duration with the climate factor (Clause 2.8)

V = max(V_100, V_2); V_T = max over d of [ 10 × C_v × P_T(d) × A – 1.8 × Q_cap × d ] (m³) ; 1.8 = 3.6 × 0.5 (average release of half the cap)

*Figure 4.3 — Fixed-coefficient route for sites of 1 ha or less (Clauses 4.14.3 to 4.14.7): the release caps Q_cap,10 and Q_cap,2 from Table 4.3A; the storage V as the largest gap, over the durations of Clause 2.5.2, between the cumulative inflow 10·C_v·P(d)·A and the release line 1.8·Q_cap·d, for the 1% and 50% AEP storms; and the two-stage outlet that passes Q_cap,2 at the top of V_2 and Q_cap,10 at the top of V. Schematic, not to scale. Original drawing for this Manual, adapted from the rainfall mass-curve (inflow minus outflow) storage concept and the single-coefficient peak cap of the PUB Code of Practice on Surface Water Drainage, 7th ed. (cl. 7.1.5).*

> **Commentary.** The fixed-coefficient route follows Singapore, which caps the peak runoff from every development of 0.2 ha or more with one runoff coefficient, C = 0.55, applied to the 10-yr storm (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5, Addendum No. 3, 2025). It is quick to apply and quick to check: the cap needs only the site area, the soil group and two intensities. PUB's 0.55 is not used here, because Singapore's baseline is the existing urban drainage system, while this Manual's baseline is greenfield land (Clause 4.5.1.2). The coefficients of Table 4.3A are set by this Manual from the greenfield curve numbers of Clause 3.3 (CN 39, 61, 74 and 80 for soil groups A to D). They are the ratios of runoff to rainfall that those curve numbers give for 1-hour depths typical of the ridge towns round Gangtok, rounded down. They are therefore **provisional**. The State Stormwater Technical Committee shall confirm or revise them against NIH-DHAARA values for each zone when it issues Annex 4B.
>
> The route is deliberately **stricter** than the full method, so that simplicity costs the developer storage rather than costing the people downstream. The 100-yr release is held to about the greenfield 10-yr peak everywhere, which is the flood-sensitive rule of Clause 4.5.3; the storage assumes the outlet releases only half the cap on average; pervious ground is assumed wet in long storms; and no retention credit is taken. A designer who wants a smaller tank can use the full method of Clause 4.6. The storage formula is the rainfall-mass (inflow minus outflow) method. Clause 3.4.2 otherwise forbids rainfall-based peak methods for storage, because they ignore the shape of the hydrograph; this route is a stated exception because its conservative assumptions cover that error for small sites, and the 24- to 72-hour durations are always checked.

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## 4.15 Safety, fencing and multi-use

4.15.1 **Depth limits for publicly accessible storage.** Where the public has access to a storage area (parks, playfields, open space, school grounds):

- (a) maximum depth in the 10% AEP storm: **0.45 m**;
- (b) maximum depth in the 1% AEP storm: **1.2 m**, except in a fenced zone under 4.15.3;
- (c) side slopes: no steeper than **4H:1V**, with at least a quarter of the perimeter at **6H:1V** or flatter for escape; and
- (d) no vertical drop greater than **0.3 m** within the storage area or at its edge.

4.15.2 **Wet basins.** Permanent pools shall have:

- a safety bench at least 3 m wide, no more than 0.3 m below the normal water level; and
- an emergent planting fringe that deters entry.

4.15.3 **Fencing.** A fence at least **1.2 m** high, of a non-climbable design with a lockable gate, is required around any part of a storage that:

- has a vertical wall or headwall drop greater than **0.6 m**;
- exceeds 1.2 m depth in the 1% AEP storm with slopes steeper than 4H:1V; or
- contains an outlet structure with an opening larger than 300 mm that is not grated.

4.15.4 **Outlets.** Every inlet and outlet opening larger than 300 mm accessible to the public shall be fitted with a grate or rack. The grate shall be designed so that a person pinned against it can escape: low approach velocity, inclined, with a large open area.

4.15.5 **Signs and depth markers.** Every publicly accessible storage shall have signs in Nepali and English stating that the area floods during rain, and a depth marker at the deepest point.

4.15.6 **Confined spaces.** Underground tanks shall have lockable covers. They shall be marked as confined spaces, and the maintenance declaration (Chapter 10) shall state the entry procedure.

4.15.7 **Vector control.** Dry storage shall drain completely (Clause 4.7) and have no low points that pond for more than 72 hours. Wet basins shall meet Clause 4.10.7.

> Commentary. The numeric limits in Clause 4.15 have no single direct precedent. They are drawn from common international practice, for example KC APWA 5600 (2006), which required at least a quarter of a dry-pond perimeter at 5:1 or flatter, a 20 ft (6 m) clearance from property lines and a 15 ft (4.6 m) maintenance strip. They are made somewhat stricter here because multi-use storage on open space land and in schools will be used by children during the monsoon. Standing water in dry basins is a mosquito-breeding risk, so complete drainage (Clause 4.15.7) is a public-health requirement, not an amenity.

---

## 4.16 Basis: why peak matching alone fails

> Commentary. This section has no requirements. It records why this chapter requires release **below** pre-development rates, retention, long-duration checks and a downstream analysis, rather than simple peak matching.
>
> 1. **Timing.** Detention lowers a site's peak but stretches its hydrograph (Figure 4.1). Downstream, the stretched releases from many sites overlap with each other and with the main-stem peak. In Denver's study, ten basins each releasing 100% of the historic 100-yr peak produced 106% of the historic peak at the outlet. Only releasing 90% at each site brought it to 97% (UDFCD memo, 2012). A Colorado State University thesis found that location-blind on-site detention "can actually increase peak flows above post-development peaks". An optimisation study found that a downstream pond performed worse than upstream ponds because its outflow synchronised with the main stem (Water 2016, 8(7):290).
> 2. **Volume.** Detention does not remove volume. In the illustrative example, the post-development 100-yr storm produces about three times the runoff volume of the pre-development 10-yr storm (Clause 2.11). Only retention, or storage that empties to somewhere other than the receiving drain, reduces volume.
> 3. **Scale.** Kansas City modelling (McEnroe, 2005) found that uniform 3 cfs/ac control reduced Q100 by 36% in a 200-ac watershed. With the same control everywhere, Q100 still rose by 40% at 14 sq mi, and the benefit faded beyond about 1–2 sq mi. The KC committee concluded that "'match existing' can harm streams" (MARC Evolution deck). Georgia makes a ten-percent downstream analysis mandatory for the same reason: "Due to peak flow timing and runoff volume effects, some structural practices fail to reduce discharge peaks to pre-development levels downstream" (GSMM 2016).
> 4. **Design-storm dependence.** An Australian study of 20 real on-site detention systems found that designs using even ten temporal patterns "cannot reliably produce an OSD system design that will always be effective" under real rainfall (Water Science and Engineering, 2019). This is why Clause 4.6.3 routes the full duration matrix rather than one critical storm.
> 5. **Closed outfalls.** In Sikkim the governing failure takes three forms. On the valley floors of the Teesta, the Rangit and the Rongni Chu it is a river that stands above the town's outfalls for hours or days: the Teesta at Khanitar reached a new highest level of 298.4 m on 4 October 2023, and at Melli a peak given as 225.5 m in one transcription and 228.0 m in a CWC bulletin, against a danger level of 227.0 m (as reported; the two peaks conflict), and the flood raised the bed itself by metres, so that an outfall set from the old bed may now be buried (State Government's pre-project report, 2026). On the reservoirs and below the dams it is volume with no outlet: the Teesta and Rangit reservoirs are held for power, no level or release rule for any of them was found [TBC], and a release from the Dikchu project in 2017 came without warning (as reported); when a reservoir is high, every drain below it discharges to a water surface that cannot fall until the operator releases. Everywhere in the hills the outfall can also be closed by debris and garbage: the jhoras rise within minutes and carry boulders, slide debris and waste that bury outfalls and block culverts; GMC's waste contract makes its agency responsible for "Clearing of Jhoras", and the SBCR 1991 forbid spoil in "drains, gullies and jhoras" (reg. 22). A flood such as the South Lhonak lake outburst and Teesta flood of 3–4 October 2023 is not an outfall-closed case to be designed for: no drain is sized for it, and the Manual

> deals with it by siting (Clause 2.3.6(i); Clause 5.8.5(d)). No hourly record of how long any river, reservoir or pokhari in Sikkim stays above a town's outfalls was obtained [TBC], and no document was found that sets a design river level for an outfall; Chapter 5 sets the design level and the closure to be assumed (Clause 5.8.5), and Chapters 6 and 9 the debris and blockage allowances. A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.
>
> The response in this Manual is layered:
>
> - release below pre-development (Clause 4.5);
> - retain the frequent storms (Clause 4.4);
> - route long monsoon storms (Clause 4.6.3);
> - prefer regional storage in the pokhari system (Clause 4.13); and
> - check downstream and at the outfall (Chapter 5).
>
> Kansas City's own history shows the price. On a test site, peak matching needed 3.0 ac-ft of storage and the 2011 comprehensive criteria needed 4.9 ac-ft (MARC Evolution deck). Over-detention costs more storage. That is the cost of protecting the catchment rather than only the site boundary.

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## 4.17 Submittal requirements

Every site runoff-control submittal shall include a **Site Runoff Control Report** (Form 4-1) containing:

1. the Design Rainfall Sheet (Form 2-1) and the hydrology inputs (Chapter 3);
2. the evidence for the order of measures under Clause 4.3.1;
3. the RRV computation, infiltration tests, groundwater evidence and drawdown calculation (Clause 4.4);
4. the retention credit computation (Clause 4.4.6);
5. the release-rate criterion applied, standard or flood-sensitive, with the Annex 4A map extract (Clause 4.5);
6. a results table in the format of Clause 4.6.7 for every AEP and duration, with the governing case highlighted;
7. stage–storage and stage–discharge tables and plots, and inflow/outflow hydrographs for the governing cases;
8. the drawdown calculation (Clause 4.7);
9. outlet details, including orifice sizes and levels, trash racks and anti-vortex devices (Clause 4.8);
10. the spillway or overflow calculation, freeboard and hazard classification, and the geotechnical report where required (Clause 4.9);
11. the RWH and detention accounting, with tank sections showing zone levels (Clause 4.11);
12. the design groundwater level and flotation check (Clause 4.12);
13. the downstream and tailwater report (Chapter 5, Form 5-1); and
14. the safety provisions (Clause 4.15) and the draft maintenance declaration (Chapter 10).

Tier B sites using Clause 4.14.2 shall submit Form 4-2 in place of items 6 and 7. Sites using the fixed-coefficient route (Clause 4.14.3) shall submit Form 4-3 in place of items 6 and 7.

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## References (chapter)


- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01 (approved 10 Dec 2025). https://kcmetro.apwa.org/wp-content/uploads/sites/23/2026/01/APWA-Section-5600_Storm-Drainage-Systems-Facilities.pdf
- Mid-America Regional Council (2025). APWA 5600 Stormwater Standards Policy Supplement (7 Nov 2025); APWA 5600 Manual factsheet. https://www.marc.org/document/apwa-stormwater-standards-supplement ; https://www.marc.org/document/apwa-5600-manual-factsheet
- Kansas City Metro Chapter APWA (2006). Section 5600 Storm Drainage Systems and Facilities (5601.8, 5608.4). https://www.kcwater.us/wp-content/uploads/2020/08/Design-Criteria-%E2%80%93-Section-5600-%E2%80%93-Storm-Drainage-Systems-and-Facilities.pdf
- MARC / APWA (2012). Manual of Best Management Practices for Stormwater Quality. https://www.marc.org/sites/default/files/2022-05/Best_Management_Practices_for_Stormwater_Quality.pdf
- MARC. The Evolution of Regional Stormwater Design Standards (presentation; McEnroe 2005 results). https://www.marc2.org/Assets/Environment/WQEC/The_Evolution_of_Regional_Strormwater_Design_Standards.pdf
- Atlanta Regional Commission / Georgia EPD (2016). Georgia Stormwater Management Manual, Volume 1. https://documents.atlantaregional.com/gastormwater/GSMM_2016%20EDITION_FINAL_V1.pdf
- Urban Drainage and Flood Control District (now MHFD) (2012). Full Spectrum Detention Release Rate Memorandum. https://mhfd.specialdistrict.org/files/23cb85ce8/UDFCD_Full_Spectrum_Detention_Release_Rate_Memorandum.pdf
- Mile High Flood District. Urban Storm Drainage Criteria Manual, Volume 2 (Storage).
- Department of Irrigation and Drainage Malaysia (2008). Submission Checklist for Stormwater Management. https://www.water.gov.my/jps/resources/auto%20download%20images/5844dfbba8fc1.pdf
- Department of Irrigation and Drainage Malaysia (2012). Urban Stormwater Management Manual for Malaysia (MSMA), 2nd ed.
- PUB Singapore (2024). On-site Detention Tank Technical Guide, Rev. 3; Code of Practice on Surface Water Drainage, 7th ed., Addendum No. 3 (16 Apr 2025). https://www.pub.gov.sg/-/media/PUB/PDF/detentionTank.pdf
- Sydney Water (2020). On-site Stormwater Detention Guide (SW201). https://www.sydneywater.com.au/content/dam/sydneywater/documents/on-site-stormwater-detention-guide.pdf
- Upper Parramatta River Catchment Trust (2005). On-site Stormwater Detention Handbook, 4th ed.
- "On-site stormwater detention for Australian development projects: does it meet frequent flow management objectives?" *Water Science and Engineering* (2019). https://www.sciencedirect.com/science/article/pii/S1674237019300213
- Optimisation of urban detention (2016). *Water* 8(7):290. https://doi.org/10.3390/w8070290
- Colorado State University. Spatially Dependent On-Site Detention Policies (thesis). https://mountainscholar.org/bitstreams/f4dbec4e-a44f-4933-8d54-a097e741f44a/download
- Forest and Environment Department, Government of Sikkim. Order No. 205/GOS/F&ED/SECY of 21 January 2021, notifying the River Rejuvenation Committee as the "Nodal Agency for all water bodies", as recorded in the State's filings before the NGT.
- Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Act 6 of 1988), as amended by Act 8 of 2000: s.2(m), s.29 (river banks of the scheduled rivers; slip reserves) and the Schedule. https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf
- Government of Sikkim. Additional affidavit of 28 February 2026 in NGT (EZ) OA 171/2023, with the pre-project report "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (glacial lakes, among them Bhalay Pokhari and Doodh Pokhari; the status of the Teesta dams).
- Wetlands (Conservation and Management) Rules, 2017 (no State Wetland Authority notification or rule-4 wetland found for Sikkim [TBC]).
- Kaushik et al. (2024), inventory of the glacial lakes of Sikkim (*Remote Sensing Applications: Society and Environment*), as summarised.

- Reports on the designation of Khecheopalri (Khachoedpalri) lake as a Ramsar site in February 2025, on the lakes of the National Wetland Conservation Programme in Sikkim, and on older counts of glacial lakes (Sikkim Express; other press reports; as reported).
- MoHUA / CPHEEO (2019). Manual on Storm Water Drainage Systems, Part A (§8.5).
- Urban Development and Housing Department, Government of Sikkim. *Sikkim Building Construction Regulations, 1991*, Notification No. 29(202)UD&HD/90/295 of 19 March 1991, under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985, as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001 of 16 October 2001): regs. 1(2), 4, 5(f), 6, 13(iii), 17, 18, 21, 22, 25, 35 and 39 and Form III. Read from a copy hosted by a third party, Sikkim Manipal University. https://smu.edu.in/img/content/dam/manipal/smu/IQAC/SDG/documents/BUILDING%20STANDARDS.pdf ; the Sikkim Building Construction (Amendment) Regulation, 2022, reportedly published on 12 April 2023 (TeamLease, as reported), not read [TBC].
- Department of Mines and Geology. Notification No. 17/DMG/20-21 of 19 March 2021 (Sikkim Government Gazette Extraordinary No. 86, 6 April 2021), site stability zonation parameters and conditions for review; read as Annexure R/2 to the State respondents' counter-affidavit of 25 February 2022 in NGT (EZ) OA 5/2022.
- Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 (Act 11 of 1985), as amended in 2000, 2001, 2007 and 2022: ss. 2(f), 7 and 8. https://prsindia.org/files/bills_acts/acts_states/sikkim/1985/1985SK11.pdf
- Sikkim Municipalities Act, 2007 (Act 5 of 2007), as amended to 2026: ss. 2(24), 163(b), 172, 173, 186, 187, 189, 193, 271 and 287. https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf
- Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024), as amended by Act 24 of 2025, enacted and not yet commenced: the content of development plans. https://prsindia.org/files/bills_acts/acts_states/sikkim/2024/Act10of2024SK.pdf
- Urban Development and Housing Department Notice No. 613/GOS/JCTP/UD&HD of 1 May 2019 and Urban Development Department Notice No. T(1689)/997 of 26 May 2020 (bans on earth excavation in the monsoon), Annexure R/5 to the same counter-affidavit.
- Gangtok Municipal Corporation. Counter-affidavit in NGT (EZ) OA 5/2022 (building-plan approval transferred to GMC in 2017; the GSCDL car park). https://www.greentribunal.gov.in/sites/default/files/news_updates/Counter%20Affidavit%20on%20behalf%20of%20R-10%20in%20OA%205%20of%202022%20(EZ)%20(Dr.%20BINA%20BASNETT%20vs%20State%20of%20Sikkim%20&%20Ors.).pdf ; waste-agency contract, Memo No. GMC/6727/III/2024/OL/01 of 8 October 2024.
- Gangtok Smart City Development Ltd. Reply affidavit in NGT (EZ) OA 38/2022. https://www.greentribunal.gov.in/sites/default/files/news_updates/Reply%20Affidavit%20filed%20by%20R-2,%20GSCDL,%20page%20698-1006.pdf
- Government of Sikkim. Affidavit of 19 December 2025 in NGT (PB) EA 35/2023 in OA 673/2018, with the monthly progress report of September 2025 (sewage generation and treatment); compliance report in the same application; six-monthly report in NGT (PB) OA 606/2018, quoting the order of 4 July 2024. https://www.greentribunal.gov.in/sites/default/files/news_updates/AFFIDAVIT%20BY%20STATE%20OF%20SIKKIM%20IN%20EA%20NO.%2035%20of%202023%20IN%20OA%20NO.%20673%20of%202018%20News%20item%20published%20in%20the%20Hindu.pdf
- Government of Sikkim. Additional affidavit of 28 February 2026 in NGT (EZ) OA 171/2023, with the pre-project report on GLOF risk mitigation in the Lhonak valley and the summary of the post-disaster needs assessment of 2023 (SSDMA with NDMA); the State's affidavit of 5 April 2024 in the same application.
- High Court of Sikkim. WP(PIL) No. 4 of 2017, *In re: Release of water from Dikchu Hydelpower Project*, judgment of 1 March 2021. https://hcs.gov.in/hcs/hg_orders/202600000042017_37.pdf
- Comptroller and Auditor General of India. Report No. 3 of 2016 (Economic Sector, Sikkim), Chapter II, performance audit of JNNURM, para 2.3.9.2 and the Jorethang and Melli findings. https://www.cag.gov.in/uploads/download_audit_report/2017/Chapter_2_Economic_Sector_Sikkim_Report_No_3_of_2016.pdf

- Asian Development Bank. Project 57230-001, Sikkim Integrated Urban Development Project, due-diligence report on the Soreng sewerage (December 2024). https://www.adb.org/sites/default/files/project-documents/57230/57230-001-sddr-en.pdf
- Rajya Sabha. Reply of 2019 on rainwater harvesting (Sikkim "NA"), as quoted in a search snippet. https://rsdebate.nic.in/bitstream/123456789/699645/2/PQ_249_08072019_U1664_p212_p219.pdf
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*. doi:10.1126/science.ads2659.
- "Towards establishing rainfall thresholds for a real-time landslide early warning system in Sikkim, India", *Landslides* (2019), doi:10.1007/s10346-019-01244-1 (as summarised).
- Reports on the drainage and jhora-training tenders of GSCDL, the Gangtok landslides of June 1997, the north Sikkim rain and landslides of June 2024 and June 2025, the submergence of NH-10 in July 2025, the High Court's warning to IRCON on NH-10 drainage (June 2025), the findings of the committee constituted by the National Dam Safety Authority on the flood of 2023, and the springs of Sikkim (Sikkim Express; ThePrint; Business Standard; Scroll; EastMojo; India Water Portal; as reported).
- Bureau of Indian Standards. IS 456:2000 Plain and Reinforced Concrete — Code of Practice.
- Government of India. Dam Safety Act, 2021.
- Chow, V.T., Maidment, D.R. and Mays, L.W. (1988). *Applied Hydrology*. McGraw-Hill (AMC conversion).


## Annexes and forms

| Annex / Form | Content |
|---|---|
| 4A | Flood-sensitive catchment boundaries (GIS); shallow-groundwater zone map |
| 4B | Tier B tables: PSD and SSR (Table 4.3), retention credit factor C_R, standard outlet sizes; confirmed fixed release coefficients (Table 4.3A) |
| 4C | Worked example (Tier A) with full routing tables |
| Form 4-1 | Site Runoff Control Report |
| Form 4-2 | Tier B Site Sheet |
| Form 4-3 | Fixed-coefficient Route Sheet (Clauses 4.14.3 to 4.14.7) |

CHAPTER 5

# Downstream and Tailwater Analysis

## 5.1 Purpose and scope

5.1.1 This chapter sets two checks that every regulated development and every public drainage project must pass.

- **The downstream analysis** (Clauses 5.3 to 5.5) confirms that the project does not make flooding worse below its outfall.
- **The tailwater analysis** (Clauses 5.6 to 5.13) sets the water level the system discharges into, including tide, storm surge, sea-level rise, river backwater and sand-bar closure. It also requires the system to cope when its outfall is closed.

5.1.2 This chapter applies to:

- (a) every site to which Chapter 4 applies;
- (b) every minor- and major-system drainage project under Chapter 6; and
- (c) every regional detention or tank restoration project under Clause 4.13 and Chapter 7.

5.1.3 Rainfall and joint-occurrence inputs come from Chapter 2, in particular Clauses 2.5.3 and 2.12. Hydrologic methods come from Chapter 3. Site release criteria come from Chapter 4. Hydraulic design of gates, culverts and pumps follows Chapter 9.

5.1.4 **No tidal outfalls in Sikkim.** Sikkim is landlocked and mountainous: it has no coast, no tide and no Coastal Regulation Zone. No outfall in the State discharges to the sea, a tidal creek or an estuary, so the provisions of this chapter that depend on tide, storm surge, sea-level rise or a river mouth do not apply in Sikkim: Clause 5.7 and Annex 5A, cases J1 to J3 of Table 5.2, the tidal lock windows of Clause 5.10.3, the seawater requirement of Clause 5.11.3(a) (gates and seats shall still be of corrosion-resistant materials, and shall resist abrasion by gravel, boulders and slide debris), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Sikkim the receiving water is one of six kinds: a steep jhora (झोरा; a natural watercourse or ravine stream), into which most outfalls of the ridge towns fall freely from a slope; a river whose valley floor or terrace a town stands on, such as the Teesta at Rangpo, Singtam, Melli, Dikchu and Chungthang, the Rangit at Jorethang and Majitar and the Rongni Chu at Ranipool and Singtam, now on a bed that the flood of October 2023 raised by metres; the reservoir of a hydropower dam, or the reach of river below one; a glacial-lake outburst flood (GLOF) corridor, which is screened for siting and not used as a design tailwater; a pokhari (पोखरी; pond, lake or tank); or the Teesta and the Rangit where they leave the State; and:

- (a) its tailwater is set by Clauses 5.6 and 5.8, including Clause 5.8.5;
- (b) where Clauses 5.10 to 5.12, Form 5-1 or Chapter 6 refer to the J1 tailwater or the J1 tidal curve, the minor-system tailwater of Clause 5.6.2 or 5.8.5 applies, as a time series where the receiving level varies; where they refer to the J2 tailwater or to HAT + surge + SLA, the major-system tailwater applies: the design-AEP river level of Clause 5.8.4(b), or the major-system tailwater of Clause 5.8.5, whichever is higher at the outfall; and
- (c) the outfall-closed check of Clause 5.10 applies where an outfall is closed by a jhora in flood, a river, a reservoir, a pokhari or a receiving drain, with the locks and closures of Clause 5.8.5(a) to (f) in place of the tidal lock windows.

**Commentary.** The drains of Sikkim's towns fail in places that site design does not see, and on the ridges the failure that matters most is not a flood. Gangtok, Pakyong, Namchi, Ravangla and Gyalshing stand on ridges and slopes of phyllite, schist and gneiss under thin soils and colluvium, and water put into those slopes moves them. The State's own building rule already grades sites by their jhoras: the stability zones of the Mines and Geology Department give zone 1 where the "Training of jhoras/drains have been completed and done properly (with safe distance)" and zone 4 where there is an "Untrained jhora/ erosional potential jhora", with "Gully erosion & collapse of jhora facing slope" (Notification No. 17/DMG/20-21, 19 March 2021). Gangtok Smart City Development Ltd (GSCDL) told the National Green Tribunal that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (reply in OA 38/2022). So the first question at most outfalls on the ridges is not the level of the water below it but whether the water reaches a stable channel at all. The Sikkim Municipalities Act, 2007 already asks that question: the municipality shall provide "a safe and sufficient outfall … in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187), and it makes a jhora a drain in law (s.2(24)). Gangtok's jhoras drain to the Rani Khola and the Roro Chu, a tributary system of the Teesta; none of them is gauged, and there is no river tailwater for most of the city or of the other ridge towns.

The valley floors are different. On the night of 3–4 October 2023 the South Lhonak glacial lake drained into the Teesta after a moraine collapse; the flood destroyed the Teesta-III dam at Chungthang, and at Rangpo, about 135 km downstream, it was "severely impacted by the debris, burying buildings and automobiles" (Sattar et al., 2025). The river bed "has risen by an average of 7-8 meters due to the accumulation of debris and silt from the flood" (the Project Prefeasibility Report (PPR) on GLOF risk mitigation in the Lhonak valley annexed to the State's affidavit to the National Green Tribunal, 28 February 2026). The cause of the event is disputed (Clause 5.8.5(d)). The Central Water Commission (CWC) set new highest flood levels on the Teesta on 4 October 2023 at Khanitar and at Melli, where two conflicting values are reported (Clause 5.8.5(b)), and no CWC level was found for Rangpo at all. Every flood level read before that night now stands on an older, lower bed. Below and between the hydropower dams the river is also an operator's: the High Court of Sikkim closed a public-interest case over a release from the Dikchu project with the direction "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" (WP(PIL) 4/2017, 1 March 2021). And the outfalls belong to one body while the drains above them belong to others: the municipal drains and jhoras to the Gangtok Municipal Corporation (GMC) and the other urban local bodies, the river banks of the scheduled rivers to the Forest Department, the road drains to the Roads and Bridges Department (PWD), NHIDCL or BRO, the river works to the Water Resources Department (WRD), the reservoirs to their operators, and no notification divides them (Chapter 6, Clause 6.9). No document found during research sets a design level for any jhora, river or reservoir outfall in the State, or a design standard for any town drain. A detention tank that meets every release rate in Chapter 4 still fails if its overflow runs onto an unprotected slope, if the jhora below it cannot carry what it receives, or if the Teesta at Singtam stands above its outlet. This chapter makes these failure modes part of the design. Sikkim has no tidal outfall, so Clause 5.1.4 says which of the chapter's coastal provisions fall away and what takes their place.

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## 5.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Analysis point | A location on the downstream system where pre- and post-project conditions are compared (Clause 5.3.3). |
| Contributing catchment | The whole area draining to an analysis point, on and off site. |

| Term | Meaning in this Manual |
|---|---|
| Major drain | A channel listed as a major drain in the basin plan or Annex 5B, or any river, WRD canal, the Rani Khola and the Roro Chu below Gangtok and the jhoras that feed them, the jhoras of Pakyong, Namchi, Ravangla, Gyalshing, Pelling, Soreng and the other ridge towns, every drain that discharges through a flap gate on the valley floors of Rangpo, Singtam, Melli, Majitar, Jorethang or Dikchu, any drain built or held by the Gangtok Municipal Corporation or another urban local body, GSCDL, the Roads and Bridges Department (PWD), NHIDCL, BRO, WRD, the Public Health Engineering Department (PHED) or the Rural Management and Development Department (RMDD) with an internal width of 1.0 m or more, and every jhora, khola or other natural channel that drains 8 ha or more, whether or not it has been trained, or a tidal creek. |
| Chart datum (CD) | The datum of the published tide tables and nautical charts, to which tidal heights are referred. |
| Mean sea level (MSL) | Average sea level over a long period at a tide gauge. |
| MHWS | Mean high water springs: the average of high waters at spring tides. |
| HAT | Highest astronomical tide: the highest level predicted under average meteorological conditions over a full tidal cycle (18.6 years). |
| Storm surge | The rise in sea level above the astronomical tide caused by wind and low pressure, mainly during cyclones. |
| Still-water level | Astronomical tide plus surge, excluding individual waves. |
| Sea-level allowance (SLA) | The allowance added to present-day tidal levels for sea-level rise over the design life (Clause 5.7.4). |
| Tailwater | The water level at the downstream end of a drain, outlet or storage. |
| Tide-lock | The condition in which the tailwater is at or above the upstream water level, so a gravity outfall cannot discharge. |
| Lock window | A period during which the outfall-closed check of Clause 5.10 sets gravity discharge to zero. |
| Sand bar | A bar of beach sand that partly or fully closes a river mouth or creek inlet. |
| Project datum | The levelling datum used on the project drawings. It must be tied to a Survey of India benchmark (Clause 5.7.2). |

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## 5.3 Extent of the downstream analysis

5.3.1 The downstream analysis shall start at each site or project outfall. It shall continue downstream to the **first** of:

- (a) the point at which the project area is **10% or less** of the contributing catchment;
- (b) the next **tank, pokhari** or other waterbody with a surplus weir or controlled outlet; or
- (c) the next **major drain**, or the sea.

The end point itself shall be analysed (Figure 5.1).

5.3.2 Where the analysis ends at a tank or pokhari under 5.3.1(b), it shall report:

- the change in the tank's maximum water level; and
- the change in surplus-weir discharge, for the AEPs and durations of Clause 5.4.3.

If the maximum water level rises, the analysis shall continue below the surplus weir to the next end point.

5.3.3 Analysis points shall be set at least at:

- (a) each site outfall;

- (b) each confluence with a drain or channel whose contributing catchment is at least half that of the receiving drain at that point;
- (c) each culvert, bridge or road crossing;
- (d) each location recorded as flood-prone by the local body, GMC, SSDMA or WRD; and
- (e) each building or road segment lying within the 1% AEP flood extent along the route. Representative points may be used where buildings are closely spaced.

5.3.4 **Small sites.** For sites of less than **0.5 ha**, the Authority may accept a simplified downstream statement (Form 5-2) in place of the full analysis, where all of the following hold:

- the receiving public drain has documented capacity for its minor-system design flow (Chapter 6);
- no flood-prone location is recorded within 500 m downstream; and
- the site does not drain to a tidal or backwater-affected outfall.

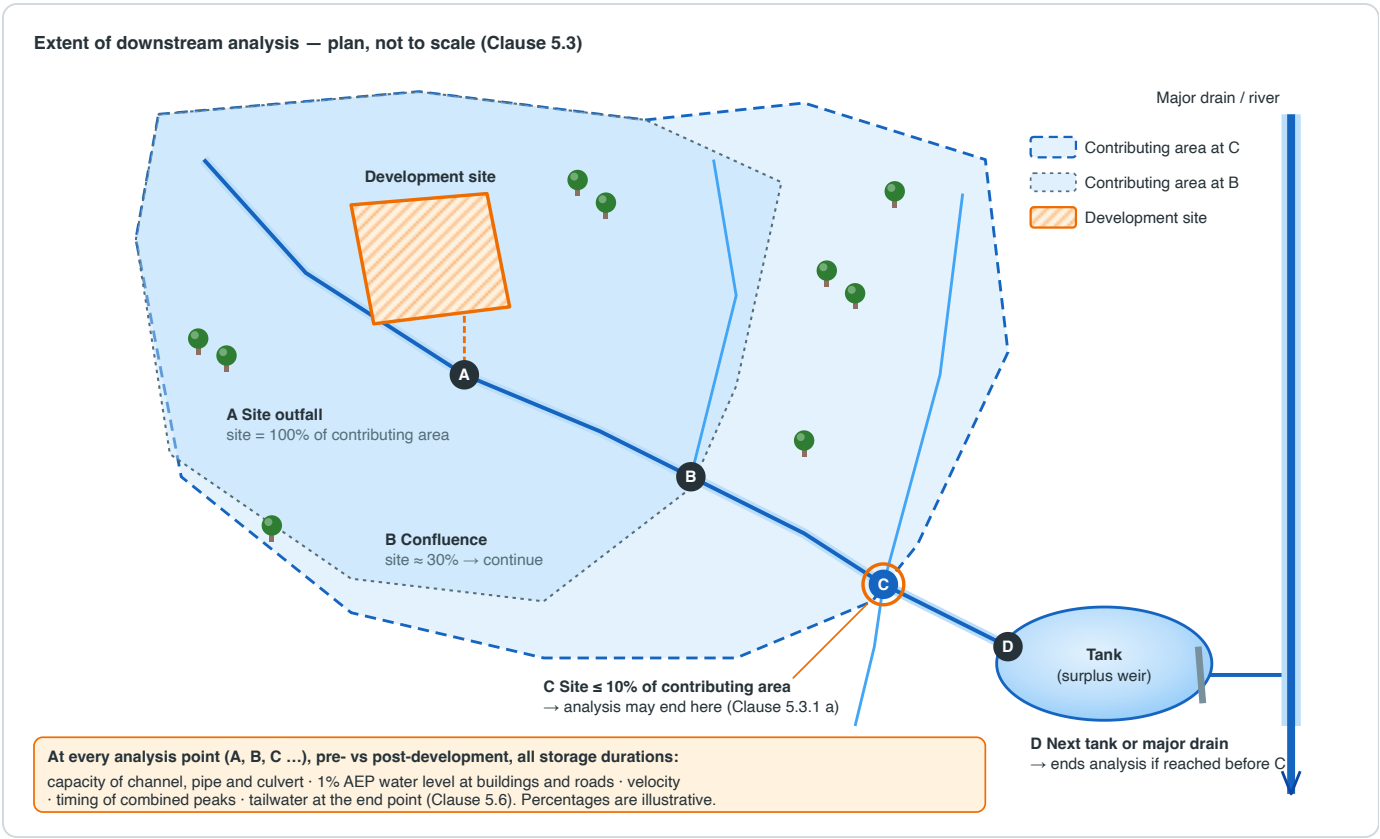


*Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next pokhari or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia Stormwater Management Manual (2016, Vol. 2 §3.1.9) and KC APWA Section 5600 (2006, 5601.5).*

> **Commentary.** The 10% rule has established precedent. KC APWA 5600 (2006) required the downstream system to be analysed "to the point the development's land mass is less than 10% of the total watershed". The Georgia manual makes the ten-percent analysis a mandatory standard (GSMM 2016, Standard #8). The tank or major-drain end point has no direct precedent; this Manual adds it for Sikkim. In the ridge towns, where a colony's drain runs down a jhora to a khola, and the khola to a river far below, as Gangtok's drains run by its jhoras to the Roro Chu and the Rani Khola and on towards the Teesta, and on the Teesta itself, where a valley-floor town's outfall lies among the reservoirs and release reaches of the hydropower dams, the 10% point can lie many kilometres downstream, across several tanks. A tank with a working surplus weir changes the hydrograph completely, so the

analysis is better ended there and the tank level reported. Clause 5.3.2 prevents that end point from hiding a rise in the tank level. The small-site statement (5.3.4) and its 500 m distance have no direct precedent and are set by this Manual.

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## 5.4 What the analysis must check

5.4.1 **Scenarios.** Each analysis shall compare:

- (a) **Existing**: the present downstream system and present land use of the whole contributing catchment, with the project site at its pre-project state; and
- (b) **With project**: the same, with the project and all its controls (Chapter 4) in place.

Where the Authority's basin plan defines future land use, the Authority may also require:

- (c) **Future**: the catchment fully developed under the plan, all to Chapter 4 standards, with and without the project.

5.4.2 **Quantities to be checked at every analysis point:**

- (a) **Capacity**: peak flow against the capacity of every channel, pipe, culvert and crossing, for the minor-system AEP of that element (Chapter 6) and for 1% AEP;
- (b) **Flood levels**: 1% AEP maximum water level at buildings (at the lowest opening) and on roads (at the crown and at the deepest point);
- (c) **Velocities**: peak velocity for 50%, 10% and 1% AEP;
- (d) **Timing of combined peaks**: the hydrograph at each confluence, showing the time to peak of the project outflow and of the receiving drain; and
- (e) **Duration of inundation**: on roads and at buildings, the time above the Chapter 6 depth limits.

5.4.3 **Storms.** The analysis shall use:

- 50%, 10% and 1% AEP;
- the duration set of Clause 2.5.2, at least the durations that give the highest level at each analysis point (these will usually be longer than at the site); and
- the 24-, 48- and 72-hour storms in every case.

The AMC rule of Clause 2.11.4 applies. Areal reduction follows Clause 2.7, applied to the contributing catchment at each analysis point and never to the site storage.

5.4.4 **Method.** The analysis shall:

- use a hydrograph method that combines hydrographs at confluences (SWMM, HEC-HMS, or an equivalent);
- include a hydraulic model with backwater (SWMM dynamic wave, HEC-RAS, or equivalent) wherever tailwater or backwater affects any analysis point; and
- not use the Rational Method at any analysis point, because it cannot represent timing.

Off-site areas shall be modelled at their present land use. Upstream detention shall be included only where it is built, maintained and documented.

5.4.5 **Tailwater.** The downstream end of the model shall use the tailwater of Clauses 5.6 to 5.9 and the sand-bar condition of Clause 5.13 where applicable.

> Commentary. Clause 5.4.2(d) exists because detention changes when the site's water arrives, not only how much arrives (Clause 4.16). A Colorado State University thesis and a *Water* (2016) optimisation study both found that delayed site releases can coincide with the main-stem peak and raise it. Georgia's manual states the result

directly: some structural practices "fail to reduce discharge peaks to pre-development levels downstream" because of "peak flow timing and runoff volume effects" (GSMM 2016). The duration-of-inundation check (5.4.2(e)) matters in the valley-floor towns of Sikkim whose outfalls lie below a river held high for hours or days, on a bed that the flood of October 2023 raised by metres: the State says the raised Teesta bed "poses a heightened risk of flooding during the monsoon season" and that NH-10 along the river "has become prone to submergence and subsidence" (Project Prefeasibility Report annexed to the State's affidavit of 28 February 2026 to the National Green Tribunal), the highway was reported submerged by the Teesta in July 2025 (as reported), and at Toong Naga 155 households were "mandated for relocation" after the 2023 flood (PDNA, 2023, as quoted in the same report), although how long the water stood in any of these events was not found [TBC]. Detention that prolongs releases can lengthen that time even when it lowers the peak.

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## 5.5 Acceptance criteria

5.5.1 The project is acceptable if, at every analysis point and for every AEP and duration of Clause 5.4.3, comparing "with project" to "existing":

- (a) the 1% AEP maximum water level does not rise by more than **10 mm** at any habitable building, at any building's lowest opening, or on any road carriageway;
- (b) no building that is not flooded in the existing case is flooded with the project, and no building or road that meets the Chapter 6 freeboard or depth limits in the existing case fails them;
- (c) peak flow does not exceed the existing peak at the minor-system AEP of each element, or at 1% AEP;
- (d) peak velocity in lined channels stays within the permissible velocity for the lining (Chapter 6: 3.0 m/s maximum); and
- (e) in unlined or natural channels, peak velocity for 50% and 10% AEP does not increase by more than **10%**, unless protection is provided under Chapter 9.

5.5.2 The duration of inundation under 5.4.2(e) shall be reported. The Authority may refuse a project that increases the duration of road closure on an arterial or emergency route.

5.5.3 **Where the criteria are not met**, the project shall do one or more of the following:

- (a) reduce release rates or increase storage (Chapter 4);
- (b) build downstream improvements, with the consent of the owner of the downstream system. These shall not transfer the problem further downstream, and shall be re-analysed under this chapter;
- (c) contribute to a regional facility under Clause 4.13; or
- (d) under Clause 5.5.4, change the release strategy.

5.5.4 **Timing exception.** Where the analysis shows that detention raises downstream levels because of timing, the Authority may vary the site release-rate criteria of Clause 4.5. This applies only where the site discharges within the lower tenth of the contributing catchment, directly to a major drain, tidal creek or the sea, and only on the following conditions:

- (a) the varied strategy meets 5.5.1;
- (b) the retention requirement (Clause 4.4) and WQv treatment (Chapter 8) are met in full; and
- (c) the outfall-closed check (Clause 5.10) is met.

Commentary. The 10 mm tolerance (5.5.1(a)) has no direct precedent. It is meant to be at or below the numerical precision of a typical one-dimensional model, so that "no increase" can be tested without arguing over rounding. The 10% velocity tolerance is likewise set by this Manual. The timing exception in 5.5.4 follows the Georgia manual, where the downstream analysis can show "that peak controls are not needed" and allow them to be

waived (GSMM 2016, Standard #8). It is limited here to sites low in the catchment, which is where synchronisation with the main-stem peak is most likely (*Water* 2016, 8(7):290). It is not available above that, because the evidence on scale (Clause 4.16) shows that early release from many upstream sites raises peaks.

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## 5.6 Tailwater: general and non-tidal outfalls

5.6.1 Every drain, outlet and storage shall be designed against a stated tailwater. A free outfall shall be assumed only where the outlet invert is above the maximum receiving water level for the case being checked.

5.6.2 **Minor-system tailwater, non-tidal.** The tailwater is the receiving system's water level at the time of the minor-system peak, from the downstream model. Where no model exists, use:

- for a receiving pipe, its obvert; or
- for a receiving open drain, its full-bank level less freeboard (Chapter 6).

5.6.3 **Major-system tailwater, non-tidal.** The tailwater is the receiving system's 1% AEP water level, unless Clause 5.8 allows a coincident lower level.

5.6.4 **Tidal and backwater outfalls.** Clauses 5.7 to 5.13 apply in addition.

5.6.5 **Storage elements.** Detention, tanks and pumped sumps shall be routed with a time-varying tailwater (Clause 4.6.6), not a constant level, wherever the tailwater varies with tide or with the receiving system's hydrograph.

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## 5.7 Tidal tailwater: datums, surge and sea-level allowance

5.7.1 **Design tailwater levels.** For outfalls to the sea, tidal creeks, estuaries, backwaters and tidal reaches of rivers and canals:

**Table 5.1 — Design tailwater levels for tidal outfalls**

| Design case | Tailwater |
|---|---|
| Minor-system design (Chapter 6) | **MHWS + SLA** |
| Major-system design and storage design | **HAT + surge + SLA**, with the surge term defined in Clause 5.7.3 |
| Joint case (Clause 2.12(b)) | 1% AEP still-water level + SLA |

The SLA is **+0.3 m minimum** (Clause 5.7.4). The cases to be run are listed in Clause 5.9.

5.7.2 **Sources and datums.**

- (a) **Tidal levels.** MHWS, HAT and MSL shall be taken from the current edition of the Indian tide tables published by the National Hydrographic Office (NHO) or by the Survey of India, for the nearest standard or secondary port, or from the port authority's published tidal levels. The edition and port shall be stated.
- (b) **Datum conversion.** Tide-table heights are referred to chart datum. They shall be converted to the project datum through a documented connection between chart datum, the tide gauge zero and a Survey of India benchmark. The offset and its source shall be stated on Form 5-1.
- (c) **Estuaries, creeks and canals.** For outfalls inside estuaries, creeks, backwaters or tidal canals (for example the estuaries of the coastal States; there is none in Sikkim, Clause 5.1.4), tidal levels may differ from the open coast. Open-coast levels shall be used unless measured levels over at least one spring–neap cycle, or a calibrated

hydrodynamic model, justify a different value. No reduction below open-coast levels shall be taken without such evidence.

- (d) **Interim.** Until Annex 5A is published, the designer shall obtain the values directly from the sources in (a) and record them.

5.7.3 **Storm surge.**

- (a) **Major-system and storage design.** The surge term in "HAT + surge" is the **10% AEP (10-yr) storm surge** for the coastal segment, given in Annex 5A. The 1% AEP surge is used only in the joint case of Clause 2.12(b), with the 10-yr 48-hour storm. That keeps the two cases symmetric, so that a rare rainfall is never paired with a rare surge.
- (b) **Joint case.** The 1% AEP still-water level for Clause 2.12(b) is taken from Annex 5A.
- (c) Until Annex 5A is published, both values shall be taken from a site-specific study using INCOIS, IMD or NCCR surge hindcasts or return-level analyses. The study shall state its source, method and record length.
- (d) Wave set-up shall be added where the outfall faces the open sea without a protected entrance.

5.7.4 **Sea-level allowance.** The SLA shall be:

- (a) **+0.3 m** minimum for every element;
- (b) greater than 0.3 m where the State, a development authority or the Authority adopts a higher projection for the planning area; and
- (c) assessed for the design life of the element. For elements with a design life of more than 50 years, the designer shall report the effect of a sea-level rise of twice the SLA as a sensitivity run.

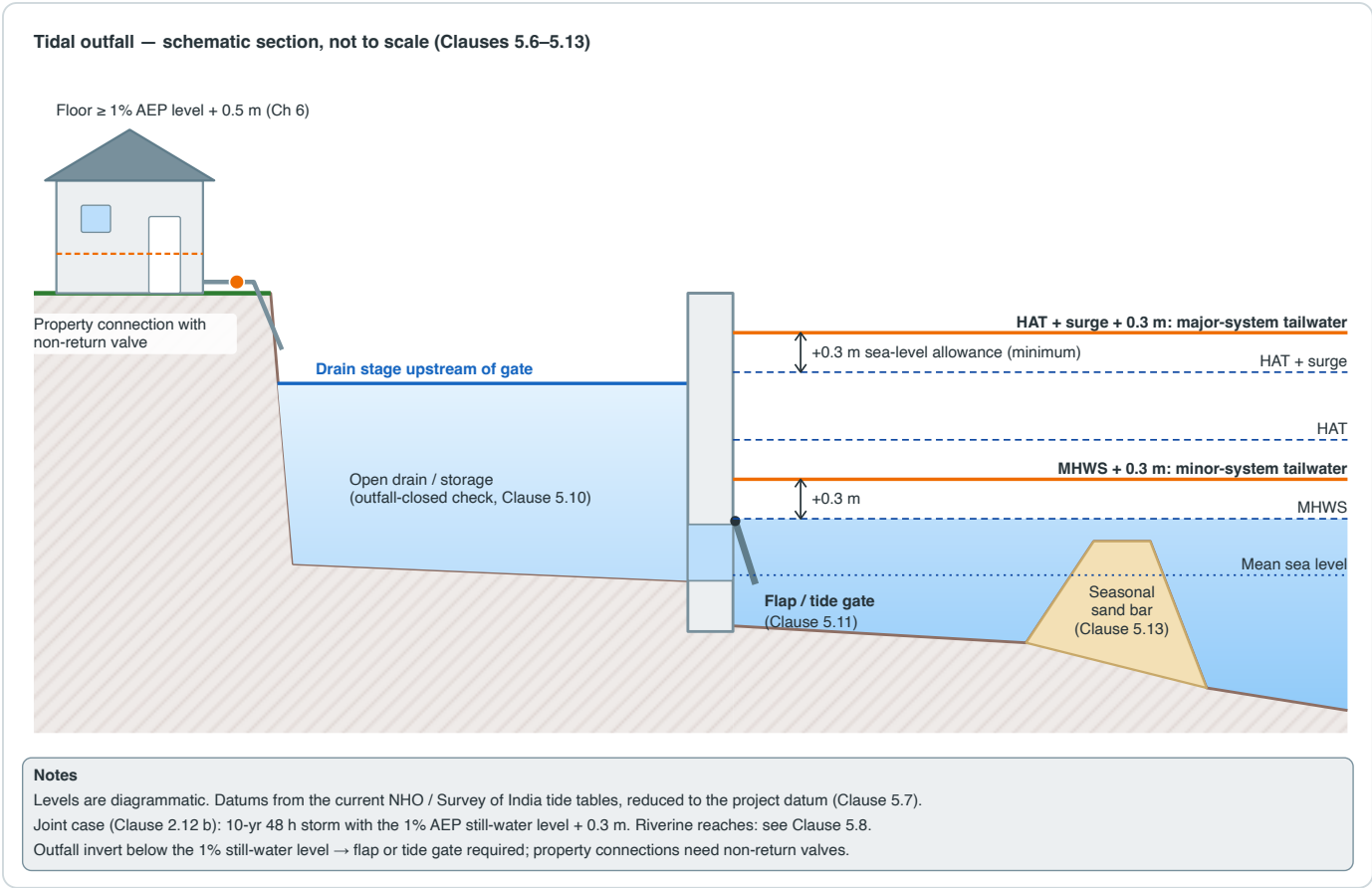


*Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater table in MoHUA/CPHEEO Manual on Storm Water Drainage Systems (2019), Part A, Table 6.2.*

Commentary. CPHEEO (2019) Table 6.2 sets the design tailwater for coastal outfalls as:

- MHWN to MHWS for a minor storm (more frequent than 1 in 5 years);
- MHWS to HAT for a major storm; and
- "Effect of climate change: additional 0.3 m".

CPHEEO also says the joint probability of storm, tide and surge "should" be considered, with the state maritime board consulted. This Manual takes the upper end of each CPHEEO range, adds surge for the major system, and makes the joint case explicit (Clause 2.12). CPHEEO does not require surge to be added; this Manual adds it because the surge records of the coastal States showed why it is needed there; Sikkim has no coast, and the surge term does not arise in the State, whose outfalls fall freely to steep jhoras on the ridges or are held up by the Teesta, the Rangit and the Rongni Chu on the valley floors and by the reservoirs of the hydropower dams, not by the sea (Clause 5.8.5).

Indian tide tables have been published by the Survey of India since the nineteenth century (Survey of India, Tidal Predictions). Current Indian tidal predictions also appear in the NHO's tide tables. One port document describes the current edition as covering 95 Indian ports, based on NHO observations and on data from civil ports, NIO and INCOIS (Adani Ports, Dahej tide table 2025, citing NHO INP-12). INCOIS runs coastal tide gauges and issues storm-surge and swell-surge warnings. None of these is used for design in Sikkim, which has no coast, and Annex 5A is not prepared for the State (Clause 5.1.4).

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## 5.8 Riverine backwater

5.8.1 **Where it applies.** Outfalls to rivers and canals whose water level in a storm can exceed the outfall invert shall be designed with riverine backwater. This includes:

- the jhoras of the ridge towns where an outfall's invert is below the jhora's design level, among them those of **Gangtok** to the **Rani Khola** and the **Roro Chu**, and those of **Pakyong**, **Namchi**, **Ravangla**, **Gyalshing**, **Pelling** and **Soreng** (Clause 5.8.5(a));
- the **Teesta** at **Rangpo**, **Singtam**, **Melli**, **Dikchu**, the riverside of **Mangan** and **Chungthang**, with the CWC sites at Khanitar and Melli; the **Rangit** at **Jorethang** and at the CWC site at **Majitar**; the **Rongni Chu** at **Ranipool** and at the CWC site at **Singtam**; and the **Dik Chu** at the CWC site at Bakcha (Clause 5.8.5(b));
- the reservoirs of the hydropower dams on the Teesta and its tributaries, among them **Teesta-III** at Chungthang, **Teesta-V** at Dikchu, **Teesta-VI**, **Chuzachen**, **Dikchu**, **Rongnichu**, **Jorethang**, **Tashiding** and **Rangit-III**, and the reach of river below each (Clauses 5.8.3 and 5.8.5(c));
- the **Teesta** from the South Lhonak lake through Chungthang, Mangan, Dikchu, Singtam, Rangpo and Melli to the State border, the **Lachen Chu** and the **Lachung Chu**, and every stream below a glacial lake listed as high-risk, as glacial-lake outburst flood (GLOF) corridors screened under Clause 2.3.6(i) (Clause 5.8.5(d));
- the **Teesta** below Melli and the **Rangit**'s lower reach where they form or cross the State border (Clause 5.8.5(e));
- every pokhari that receives a town's drains (Clause 5.8.5(f));
- any drain or jhora of the Gangtok Municipal Corporation or another urban local body, GSCDL, the Roads and Bridges Department (PWD), NHIDCL, BRO, WRD, PHED or RMDD that receives storm water, and the river bank of every river scheduled under the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Clause 5.8.5(g)); and
- elsewhere: any river or WRD channel listed in Annex 5B.

5.8.2 **River levels.** River water levels shall be taken from:

- (a) WRD design flood levels or recorded highest flood levels for the reach, where published; or

- (b) a hydraulic model (HEC-RAS or equivalent) of the river reach. The model shall use:
    - the river design flood from a hydrograph method (Chapter 3), with continuous simulation where Chapter 3 requires it;
    - the tidal boundary of Clause 5.7 at the mouth; and
    - the sand-bar condition of Clause 5.13.

5.8.3 **Reservoir and tank releases.** Where a reservoir or tank upstream can release to the river (for example the Teesta-III dam at Chungthang, under restoration since the flood of October 2023, the Teesta-V dam of NHPC at Dikchu, Teesta-VI, Chuzachen, the Dikchu project, Rongnichu, Jorethang, Tashiding and Rangit-III), the river level shall include the release given by the reservoir's operating rule for the storm being checked. Where there is no published rule, it shall include the largest recorded release.

5.8.4 **Coincidence of site storm and river flood.** Unless a joint-probability study is accepted by the Authority, the more severe of the following governs:

- (a) the site design storm (AEP as required), with the river at its **10% AEP (10-yr)** level; and
- (b) the site **10% AEP** storm, with the river at its design-AEP level (1% AEP for the major system).

The two storms in each pair shall have the same duration and timing where they are generated by the same rainfall event.

5.8.5 **Free outfalls to jhoras on the ridges, the valley-floor towns on the Teesta, Rangit and Rongni Chu, hydropower reservoirs and release reaches, GLOF corridors, the West Bengal reaches, pokharis, and consents and lines.**

- (a) **Jhoras on the ridges.** For an outfall from a ridge or a slope to a jhora, directly or through a drain, down-drain or chute that ends in one, as in Gangtok with Tadong and Ranipool, Pakyong, Namchi, Ravangla, Gyalshing, Pelling, Soreng and the other ridge towns, and on every slope above a valley floor:
    - **No gauge, no level.** No jhora in the State has a gauge or a published flood level [TBC]. The jhoras are steep and short, rise within minutes of a burst of rain and fall within hours of its end, and carry boulders, gravel, slide debris and, below the towns, sullage and garbage. Gangtok's jhoras drain to the Rani Khola and the Roro Chu, and those of the other ridge towns to the Rongni Chu, the Rangit and the Teesta. Most outfalls of the ridge towns fall freely to a jhora: there is no river tailwater for most of Gangtok, Pakyong, Namchi, Ravangla and Gyalshing (NEER reading).
    - **Free-outfall case.** The design case is a free outfall with energy dissipation. The outfall shall end in an energy dissipator designed under Chapter 9, built into the bank of the jhora, and shall be reached from the town drain by a lined drain, chute, stepped channel or closed down-drain, so that no flow of the minor or major system is discharged onto an unprotected slope, fill, retaining wall or the land of a building below (Clause 6.3.6(j)). Where no jhora can be reached within the site or the public land beside it, the flow shall be carried in a closed conduit or lined drain to the nearest road drain or permanent drain that can take it, as regulation 25(iv) of the SBCR 1991 already requires of a building's plinth drain ("leading to the road side drain or to adjoining permanent drains or jhora"), through the land of another person only by a recorded easement or agreement, and not left at the foot of the slope (set by this Manual).
    - **Design level.** Where the jhora can rise above the outfall invert, the tailwater for the major-system and storage cases shall be the higher of: (i) the 1% AEP level at the outfall from a study of the jhora, made with a hydrograph method of Chapter 3 for the whole catchment above the outfall, with the rainfall of its sub-area under Clause 2.3.6 (SK-B for Gangtok), the AMC of Clause 3.8.4 and the bulking factor of Clause 6.3.6(g) on the peak flow, and routed through a hydraulic model (Clause 5.8.2(b)) of the channel as surveyed, net of encroachment, silt, slide debris and solid waste, with the crossings downstream blocked as Clause 6.3.6(h) requires; and (ii) the highest flood level surveyed at the outfall from flood marks, such as debris lines, silt and scour marks and the accounts of residents, of a recorded storm, such as that of June 1997 at Gangtok, or a later storm, and from the records of the local body, the Sikkim State Disaster Management Authority (SSDMA) or the District Collector, with its source stated. No outfall to a jhora that can rise above its invert shall be designed without both items (set by this Manual).

    - **The jhora below the outfall.** The designer shall also check the receiving jhora from the outfall to the next confluence with a jhora or khola of at least equal catchment, to a river, or to the upstream end of a reach trained to Clause 6.3.6(m), whichever comes first: that it carries the post-development 1% AEP flow of its whole catchment, with the bulking factor, within its banks and below the velocity limits of Chapter 9 for its bed and banks; that no bank or slope along that reach is in Mines and Geology stability zone 3, 4, 5 or 6, is sinking, landslide-prone or scarred by old landslides (SBCR 1991, reg. 35), or is undercut, without the geotechnical certificate of the hill rule of Clause 4.11; and that the increase in flow does not reach a road, a building, a dhara (धारा; a spring or spring spout) or a slide. Where the jhora fails any of these checks, the project shall reduce its peak and volume under Chapter 4, or train the reach to Clause 6.3.6(m) with the consent of its owner under item (g) (set by this Manual). This is the downstream check that s.187 of the Sikkim Municipalities Act, 2007 already makes a municipal duty, an outfall "in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall". The stability zone of the outfall and of the reach shall be stated on Form 5-1 and in the drain and jhora register (Clause 6.9).
    - **Bed level, scour and aggradation.** The designer shall survey the bed of the jhora at the outfall and for at least 100 m upstream and downstream, and state the range within which the bed has moved, from past surveys, cross-sections, exposed foundations and pipes, and the records of the local body. The outfall invert, and the seat of any flap gate on it, shall stand at least **0.5 m above the highest bed level** found in that range within 50 m downstream of the outfall, and the foundation of the outfall structure and its apron shall be taken below the scour depth computed under Chapter 9 (Clause 9.6) for the 1% AEP flow with the bulking factor (set by this Manual).
    - **Siting.** An outfall shall be built into the bank and shall not project into the bed or the active channel, taken for this Manual as the land flooded once in 5 years (set by this Manual). It shall discharge in the direction of the stream's flow, with the bank protection that Chapter 9 requires, and no pipe, interceptor or chamber of the drainage system shall be laid along the bed of the jhora. No spoil or building material from the works shall be placed in "drains, gullies and jhoras" (SBCR 1991, reg. 22) or where a storm can carry it into one, and no excavation for an outfall shall be made in the period of the State's monsoon excavation ban (Chapter 10). No outfall shall discharge into or immediately above a dhara, within 15 m of one, or onto the recharge area above it (the spring rule of Chapter 8) (set by this Manual).
    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall-closed check of Clause 5.10 applies with a single lock that lasts for the duration of the design storm plus the jhora's recession, computed under item (i) for the coincident cases of Clause 5.8.4 for as long as the jhora stays above the invert, and **not less than 24 hours**; where the 48- and 72-hour storms of Clause 5.10.2 are run, the lock lasts for the whole storm (set by this Manual).
- (b) **The valley-floor towns on the Teesta, Rangit and Rongni Chu.** For an outfall on a valley floor or river terrace whose river can rise above the outfall invert, such as Rangpo, Singtam, Melli, Dikchu, the riverside of Mangan and Chungthang on the Teesta, Jorethang and Majitar on the Rangit, and Ranipool and Singtam on the Rongni Chu, and for any other outfall on land below the 1% AEP flood level of a river or on the river bed and terraces raised by the flood of October 2023 ("valley-floor land" in this Manual, sub-area SK-A and the valley floors of SK-B1), directly, through a flap gate or through a pumping station, or into a drain that itself discharges in one of those ways:
    - **A raised bed.** The South Lhonak lake outburst and Teesta flood of 3–4 October 2023 left the Teesta on a new bed: it "has risen by an average of 7-8 meters", and NH-10 along the river "has become prone to submergence and subsidence" (PPR annexed to the State's affidavit of 28 February 2026 in OA 171/2023 before the National Green Tribunal); NHPC estimated the rise at about 7.44 m at TLDP-IV, 7.29 m at TLDP-III, 6.00 m at Teesta-V and 2.00 m at Teesta-VI (same affidavit). The State itself says the raised bed "poses a heightened risk of flooding during the monsoon season" (same affidavit). An outfall whose invert was set from a bed surveyed before October 2023 may now be buried, and **every level based on a highest flood level read before that date needs a post-2023 survey** (NEER reading).
    - **Gauges and levels.** CWC's levels for the State's rivers are known for this Manual only from SANDRP's transcriptions of CWC data and from press reports (as reported), and **no datum is stated for any of them** [TBC]. They are: **Khanitar** on the Teesta (East), old highest flood level (HFL) 297.7 m (18 September 1974)

and a new HFL of **298.4 m** at 09:00 on 4 October 2023; **Melli** on the Teesta (Namchi district), warning level 226.0 m and danger level 227.0 m [TBC], old HFL 225.25 m, and an October 2023 peak given as **225.5 m** (04:00, 4 October 2023) in SANDRP's text but as **228.0 m** in a snippet of a CWC daily bulletin of 2024, seen only as a search snippet; SANDRP's own statement that the new level is "2.75 meter higher than the old HFL" does not agree with 225.25 m, and a press report that the river ran "nearly 3 metres above the Danger Level" does not agree with a danger level of 227.0 m and a peak of 228.0 m; **Singtam** on the Rongni Chu, danger level 355.09 m and HFL **356.09 m**, undated; **Majitar** on the Rangit (Namchi district), HFL **279.29 m** (17 October 1985); **Ranipool** on the Rongni Chu and **Bakcha** on the Dik Chu, active, with no HFL; and **Rangpo**, where no CWC level was found [TBC]. The upstream sites at Lachen, Rangma Range, Sankalang, Teesta-III and Teesta-V stopped recording between 22:00 and 23:00 on 3 October 2023 (all as reported). Every level used shall state its gauge, its date, its datum and its connection to the gauge datum of the named CWC site and to a Survey of India benchmark.

- **Melli: the higher value for a check.** Where a check level at Melli is needed, **228.0 m** is used, and 225.5 m is recorded beside it on Form 5-1 (set by this Manual). The two readings cannot both be right, neither source was read in full, and the lower one is the one that its own source's arithmetic contradicts; a check level set on the lower of two unresolved readings could put an outfall below a level the river has already reached. The conflict is to be resolved from CWC's site record [TBC].
- **Design level.** The design tailwater at the outfall, for the major-system and storage cases (Clause 5.8.4(b)), shall be the higher of: (i) the **highest recorded CWC level** at the nearest site on the same river, with the October 2023 values above, transferred to the outfall with the water-surface slope of the flood that set it, from the gauge record or from a model; and (ii) the **surveyed October 2023 flood mark** at the outfall, from debris lines, silt and scour marks, damage records and the accounts of residents, with its source stated and tied to a Survey of India benchmark. Where neither exists, as at Rangpo, the design tailwater is the 1% AEP level at the outfall from a **hydraulic model** under Clause 5.8.2(b) run on the surveyed post-2023 bed, with the river design flood from a site study under Chapter 3 and the releases of item (c); and where such a model is made at any outfall, its result also applies where it is higher. No outfall on valley-floor land shall be designed without item (ii), or, where no flood mark can be found, without the model. The level of the nearest site downstream shall not be carried upstream (all set by this Manual). The 1% AEP rainfall flood is not the design flood for the trunk of the Teesta, and no level of this item protects against a cascade of the kind of October 2023 (item (d)).
- **10% AEP level.** For the cases with the river at its 10% AEP level (Clause 5.8.4(a)), the level shall be taken from the same model or from a frequency analysis of the gauge record; until such an analysis is accepted, it is the danger level where one is reported (Melli 227.0 m, Singtam 355.09 m, as reported; datums [TBC]), and elsewhere the design level of this item (set by this Manual).
- **Inverts above the post-2023 bed.** The designer shall survey the river bed at the outfall and for at least 100 m upstream and downstream after October 2023, and state the range within which it has moved. The outfall invert, and the seat of any flap gate on it, shall stand at least **0.5 m above the highest surveyed post-2023 bed level** within 50 m downstream of the outfall, and its foundation shall be taken below the scour depth computed under Chapter 9 (set by this Manual).
- **Gates and owners.** No flap-gated or pumped storm outfall was found in the State during research [TBC]. Every outfall whose invert is below the design level of this item shall have its own flap gate (Clause 5.11), and the designer shall name the body that will own, operate and maintain it, which is the owner of the drain in the drain and jhora register (Clause 6.9), and state its sill, the crest of any bank or wall it passes, and the river level at which it closes, all on the datum of this item.
- **Two cases, and the lock.** A valley-floor drain shall be checked for two cases: a short burst on the hillside above it with the river low and the drain as surveyed, net of silt, boulders, debris and encroachment; and a multi-day storm with the river at the design tailwater (Chapter 3). In the second case the tailwater at the outfall shall be the higher of the river level beyond the gate and the maximum level in the drain behind it, computed by routing the drain as a closed storage for as long as the river stands above the level behind it, with the inflow of the whole catchment that drains to it, the hill catchments above the valley floor included, its storage as surveyed in its present condition, and an outflow of no more than the pumping capacity that the operator confirms in writing is available in a storm, and in no case more than the installed capacity of

the permanent pumps less the largest pump; portable pumps brought in for an event and capacity not commissioned shall not be counted. The outfall-closed check of Clause 5.10 applies with the river at the design tailwater for the **whole of the 72-hour design storm** of Clause 5.10.2, and the outfall **closed, with no gravity discharge credited, for not less than 72 hours** where a flap would shut (set by this Manual). No stage record of the Teesta, the Rangit or the Rongni Chu was analysed for this Manual; once a stage record of the nearest CWC site is obtained and analysed under Clause 5.10.6, it governs, and a longer lock shall be used where it shows the river above the outfall invert for longer. The lock covers every shorter storm, so that storage and pumping handle the full storm volume (Clause 5.9.4). Pumps (Clause 5.12) shall deliver against the design river level of this item, and every pump, panel and control shall remain operable with the river at that level (Clause 5.12.5). Any stored volume shall be pumped down to its starting level **within 48 hours** of the end of the storm, with the gate still closed (set by this Manual).
    - **Gate failure.** Floor levels and pumped outfalls behind a flap gate shall also be checked for the gate jammed open by gravel, boulders or slide debris, with the drain filled to the river level beyond it, and for the gate buried by the bed.
- (c) **Hydropower reservoirs and release reaches.** For an outfall to the reservoir of a hydropower dam, directly or through a drain or jhora that ends in one, or to a reach of river below a dam:
    - **The dams.** The State listed, in its affidavit of February 2026 to the National Green Tribunal, the Rongnichu project (113 MW, operational, run of the river); **Teesta-III** (1,200 MW, Chungthang), "Under restoration & first phase of wet commissioning is expected by 31st MAY 2026 through coffer dam", with no live storage in the first phase; Dikchu (96 MW); Chuzachen (110 MW, shut down, with restart from 15 February 2026); Jorethang (96 MW); Tashiding (97 MW); **Teesta-VI** (500 MW, expected in September 2029); and Rangit-III (60 MW). Teesta-III was listed as "non-operational since 4th Oct 2023" by the State's power department (as quoted), and its present status was not found [TBC]. **Teesta-V** (510 MW, NHPC; dam at Dikchu) is reported to have been restored, and the restoration of the Teesta-V dam at Dikchu and the Teesta-VI dam was reported to be under way in June 2025 (as reported). The Teesta Low Dam projects III and IV (TLDP-III, TLDP-IV) lie lower on the Teesta; their position in relation to the State border was not confirmed for this Manual [TBC], and where they lie across it the West Bengal edition governs (item (e)).
    - **Levels in writing.** The operator's levels are data for the design, not an approval: the consents of item (g) still apply. **No full reservoir level (FRL), maximum water level (MWL), spillway rating, datum or release rule was found for any dam in the State** [TBC]. The tailwater for the major-system and storage cases shall be the reservoir's **MWL** as its operator states it in writing, or, where only the FRL is given, **FRL plus the surcharge in its design flood**, computed from the rating of its spillway with any gates operated only as the operator's written rule provides; where neither the MWL nor the surcharge has been given, or where the MWL is not above the FRL, the tailwater is **FRL + 0.5 m**. In every case it shall be not less than the highest level recorded at the reservoir. The minor-system tailwater is the FRL. The project's discharge shall be included in the level (Clauses 5.3.2 and 5.12.3) (set by this Manual).
    - **Until the operator gives them.** Until the operator gives its levels in writing, an outfall in a reservoir reach has an unknown tailwater: it shall be **sited above the surveyed October 2023 flood mark** at the outfall, and where it cannot be, its tailwater is the higher of that flood mark, the highest water line surveyed on the shore and the crest of the spillway surveyed at the dam, each tied to a Survey of India benchmark, plus 0.5 m (set by this Manual) [TBC].
    - **Releases, not notices.** No design shall rely on a notice or a warning of a release, on a reservoir being drawn down before a storm, or on a gate being opened early, late or partly: the release scenarios of this item govern (set by this Manual). A release from the Dikchu project in 2017 was reported to have come without warning (as reported); the High Court of Sikkim closed the case with the direction "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" and that the authorities "undertake periodic inspection and review" (WP(PIL) 4/2017, judgment of 1 March 2021). No operating rule or release record of any dam, and no rule linking the operation of any dam to the drains above or below it, was found during research [TBC].
    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall shall be treated as closed for the **whole of the 72-hour storm** of Clause 5.10.2 and of every shorter storm (Clause 5.9.4), with storage and pumping handling the full storm volume, unless the operator's stage record shows the

reservoir below the invert at the start of comparable storms and the Authority accepts it (set by this Manual). Every reservoir starts every design storm at its FRL (Clause 7.7.3); a catchment that drains to a reservoir or its backwater takes AMC III at any time of year (Clause 3.8.4); and the drawdown zone of a reservoir is part of the reservoir, in which no outfall structure, pumping station or storage shall be built without the operator's written agreement.

    - **Release reaches.** For an outfall to a reach of river below a dam, in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) and the 72-hour storm shall be run with the river at the level that results from the largest recorded release of the dams above, routed to the outfall, with the flow of the catchment below the dams as it occurred, and with the release placed before, during and after the site storm, and the lock of item (b) applies for **not less than 72 hours** (set by this Manual). No release record was obtained for any dam [TBC]. Until the operator states the largest recorded release and its duration, the release is the spillway design capacity, and until that is given, the 1% AEP inflow to the reservoir from a site study under Chapter 3, passed with no attenuation by the reservoir (set by this Manual) [TBC]. No attenuation by the storage of any reservoir shall be credited to the river below unless the operator's written rule commits that storage to flood control. The inflow of about 10,000 m³/s at Teesta-III in October 2023 against a spillway capacity of 7,500 m³/s, reported from the committee constituted by the National Dam Safety Authority (NDSA) (as reported), is recorded on Form 5-1 for an outfall below Chungthang; it is the cascade of item (d), not a design release. Every release reach is a hazard-first site under Clause 2.3.6(i).

- (d) **GLOF corridors.** For an outfall, a detention facility, a pumping station or an interception or treatment work on the path of a glacial-lake outburst flood: the Teesta from the South Lhonak lake through Chungthang, Mangan, Dikchu, Singtam, Rangpo and Melli to the State border; the Lachen Chu and the Lachung Chu; and every stream below a glacial lake that NDMA, the Science and Technology Department (nodal for GLOF studies and mitigation since Notification No. 10/Home/2025, 7 February 2025) or the Sikkim Commission on Glacial Hazards lists as high-risk:
    - **Screened, not sized.** These corridors are screened under Clause 2.3.6(i), apart from rainfall design. No drain is sized for a GLOF, and no rainfall tailwater governs on the corridor: the design tailwater of an outfall to the trunk is that of item (b), and the GLOF decides where the asset may stand. NDMA has identified 40 high-risk glacial lakes in Sikkim, 16 of them very high-risk (State affidavit of 28 February 2026), 13 of the very high-risk lakes in Mangan district, 3 in Gyalshing district and 12 in the Lachen Chu watershed; "Shako Chho has habitations and Army establishments just 15 km downstream" (PPR, same affidavit). In the October 2023 flood the water outflow at the lake "peaked at $4.85 \times 10^4$ m³ s⁻¹", with sediment of a further $1.03 \times 10^4$ m³ s⁻¹, "equivalent to a return period exceeding 200 years"; at Chungthang the "discharge peaked at 5340 m³ s⁻¹ … within ~6 minutes", with a depth of 9 m and a velocity of 9 m/s; and GLOF peaks exceeded meteorological floods for about 50 km below the lake (Sattar et al., 2025). **So the 1% AEP rainfall flood is not the design flood for the trunk, and no rainfall-based setback or level protects against the cascade** (NEER reading).
    - **Cause disputed.** The State's affidavit of 5 April 2024 attributed the flood "primarily to a cloudburst"; a committee constituted by the NDSA reportedly found that "all scientific data and satellite images from that period points to GLOF and not a cloudburst" (as reported); and Sattar et al. (2025) found 29–39 mm of rain over the lake from 28 September to 5 October in the ERA5 reanalysis, and a moraine collapse. This Manual takes no side; all the sources agree that the lake drained.
    - **Siting rule.** Every drainage asset that this Manual governs on a GLOF corridor, among them detention storage, outfall structures, pumping stations and treatment and interception works, shall be **sited above the October 2023 flood and aggradation level** surveyed at the site, **and outside the mapped GLOF path** where a map exists, among them the GLOF evacuation maps prepared by SSDMA and the District Disaster Management Authorities with the participatory risk assessments of May 2024, where they cover the site [TBC]; and its outfall to the trunk shall meet item (b) (set by this Manual). Where an outfall must reach the river below that level, its structure shall be designed to be overtopped and buried without loss of the drain behind it, and nothing upstream of its flap gate shall be credited as storage below that level. No setback from a glacial lake or along a GLOF corridor exists in law (NEER reading); the "High-risk Zoning" of floodplains below glacial lakes in the PPR is a proposal, not a rule (Chapter 7).

- (e) **The West Bengal reaches.** The Teesta below Melli and the Rangit's lower reach form or cross the State border, and **the West Bengal edition of this Manual governs those reaches**. Its levels are named here only for that reason, from SANDRP's transcriptions of CWC data (as reported): Sevoke, HFL 147.3 m (12 October 1973) and 145 m on 4 October 2023; Coronation bridge, 156 m (1973) and 149.2 m on 4 October 2023; Domohani, HFL 89.3 m (4 October 1968); Singla Bazar on the Rangit, HFL 311 m (5 September 1980), inactive since 2021; and the Teesta barrage, whose release in October 2023 was reported as "more than 8000 m³/s" (as reported). None of them is a tailwater for any Sikkim town. For an outfall in Sikkim near the border, a level from that edition, or from a CWC site downstream transferred upstream, is a lower bound on the downstream boundary of the model of item (b), not the level at the outfall.
- (f) **Pokharis as receiving storage.** For an outfall to a pokhari, directly or through a drain or jhora that ends in one:
    - **Levels.** No level on a stated datum, and no outlet or overflow level or stage–storage relation, was found for any pokhari in the State, and no pokhari that receives a town's drains was named in the sources [TBC]. Storm water shall not be discharged to a pokhari without the written consent of its custodian (Chapter 7) [TBC]. Until the custodian gives a level, the tailwater is the level at which the pokhari spills, from its outlet or overflow crest surveyed and tied to a Survey of India benchmark, plus the head over that crest needed to pass the 1% AEP inflow, and not less than the highest level recorded at it; the pokhari starts every design storm **full to its outlet**, and an outfall below the tailwater is closed for the whole storm (Clause 5.9.4) (set by this Manual).
    - **Storage first, not a detention pond.** A pokhari is kept as storage under Chapter 7; no storage below its spill level is credited to a project, and no natural pokhari shall be converted into a detention pond. Every drain that discharges to a pokhari shall pass a debris and solid-waste trap and a sediment trap (Clause 6.3.6(f) and Chapter 8) before it reaches it, and no drain that carries sewage shall discharge to one (Clauses 6.3.6(e) and 8.9).
    - **No glacial lake.** A glacial lake keeps its own name, even where the name contains "Pokhari" (Bhalay Pokhari, Doodh Pokhari), and is never a receiving waterbody or storage under this item: it is a hazard source under Clause 2.3.6(i) and Chapter 7, and no outfall shall be designed to one.
- (g) **Consents and lines.** No outfall structure, gate, pumping station or drain shall be built in the bed or bank of a river or jhora, or in a flood-protection work, without the consent of its owner under the drain and jhora register (Clause 6.9): for works in or on a river, that of WRD, whose procedure for such a consent was not found during research [TBC]; for any work in the river bank of a river in the Schedule of the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, that of the Forest Department, under whose control the river bank lies "as if it were a forest" (s.29(9)), unauthorised occupation of which is an offence (s.30); within a municipal area, that of the urban local body for its drains and jhoras, which vest in it where they lie on public land other than forest land and which it "shall protect … whether on a public land or on a private land" (Sikkim Municipalities Act, 2007, ss.172 and 189(1)), and which must provide a safe outfall (s.187); and for a road drain or culvert, that of the road's owner, the Roads and Bridges Department (PWD), NHIDCL or BRO. The operator of a reservoir gives its levels and release records under item (c); that is data, not an approval. A jhora outside municipal limits or on forest land has no named owner (NEER reading); the designer shall record that on Form 5-1 and in the register and obtain the consent of the landholder and, on forest land, of the Forest Department (set by this Manual). Where consent is given, the discharge shall not exceed the rate the consent allows; the tailwater is the higher of the channel's design water level as its owner states it in writing and its level in the coincident case of Clause 5.8.4, computed from all the storm water it receives and with its downstream boundary at the level of items (a) to (f); the channel shall be taken in its present condition, net of silt, boulders, slide debris, encroachment and solid waste and with its narrowest section as surveyed, and a widening, lining or training that has been proposed but not completed shall not be counted; and the outfall shall have a flap gate (Clause 5.11) where the design water level or the computed level is above the outfall invert. The designer shall also check the outfall against the lines that bind at the time of design (Chapter 7): the river bank of a scheduled river, "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (1988 Act, s.29(1)), which is a maximum, not a minimum, and whose high-flood-level line has moved since October 2023; any closure of a river bank notified under s.32 of that Act; and any limits of a jhora notified by the State under s.173 of the Municipalities Act, of which none was found. No statute or regulation sets any line along a jhora: the 2021

stability zones ask only for training "with safe distance", which is not defined (NEER reading). No setback along the Teesta was found to have been notified after October 2023 (NEER reading). The Manual's own corridor (Clause 7.4) is a proposal of this Manual, wider than any line that binds on a jhora.

No pump, gate or dam operation that helps drainage, such as pumping a drain down before a storm, lowering a reservoir before a storm, closing a gate late or opening dam gates early, shall be assumed unless the operator's written records show it. Where the outfall invert is below the tailwater of this clause, the outfall shall have its own flap gate (Clause 5.11) and, where the outfall-closed check requires it, pumping (Clause 5.12), with the pumped volume included in the routing of the drain, the reservoir or the river (Clause 5.12.3). Pumping shall not be used to move water into a pokhari, a reservoir or another catchment without the consent of its custodian, or onto a slope.

Commentary. In large continental river basins, a site storm and a river flood are usually treated as roughly independent. That is the basis of tables of coincident frequencies such as FHWA HEC-22 Table 7.3. Sikkim's rivers break that assumption in two ways. The trunk flood need not come from local rain at all: on 3–4 October 2023 the Teesta rose to new highest levels at Khanitar and Melli (Clause 5.8.5(b)) after the South Lhonak lake drained, while the rain over the lake was 29–39 mm over eight days in the ERA5 reanalysis, with about 5 mm and 14 mm on 3 and 4 October (Sattar et al., 2025); the cause is disputed (Clause 5.8.5(d)). And the tributary floods and the town storms come together: in June 2024 rain over Mangan district brought landslides and floods on the tributaries, with 250 mm statewide in 1–13 June, "54% above the normal 162 mm", and the Sangkalang bridge collapsed (as reported); and the jhoras of a ridge town run full in the same hour as the khola (खोला; a river or large stream) below them. The two cannot be treated as independent, and a local storm can fall before, during or after the river peak. Clause 5.8.4 therefore pairs a design event on one side with a 10-yr event on the other, in the same way as Clause 2.12(b). This pairing has no direct precedent. It is more severe than an independence assumption would give.

Clause 5.8.3 reflects the hydropower dams on the Teesta and its tributaries, among them Teesta-III at Chungthang, Teesta-V at Dikchu, Teesta-VI, Chuzachen, Dikchu, Rongnichu, Jorethang, Tashiding and Rangit-III (State affidavit of February 2026 to the National Green Tribunal). In October 2023 they became a cascade: the flood destroyed the Teesta-III dam ("The 60 m high dam was destroyed"), and downstream dams were affected, among them Teesta-V and Teesta-VI and the Teesta Low Dam projects (Sattar et al., 2025, which names a "Teesta Low Dam VI", probably TLDP-IV (NEER reading)); NHPC estimated that the bed rose by about 6.00 m at Teesta-V and 2.00 m at Teesta-VI (PPR annexed to the State's affidavit of 28 February 2026). A committee constituted by the National Dam Safety Authority is reported to have put the inflow at Teesta-III at about 10,000 m³/s against a spillway capacity of 7,500 m³/s (as reported). Earlier, a release from the Dikchu project in 2017 was reported to have come without warning (as reported), and the High Court of Sikkim closed the public-interest case that followed with the direction "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" and that the authorities "undertake periodic inspection and review" (WP(PIL) 4/2017, judgment of 1 March 2021); the National Green Tribunal sought data on all Teesta dams in January 2026 (OA 171/2023, order of 13 January 2026). No FRL, MWL, spillway rating, operating rule, release record or datum was obtained for any dam, and no rule linking their operation to the drains above or below them was found during research [TBC]. Until they are available, an outfall in a reservoir reach is sited above the October 2023 flood mark, and the spillway design capacity, or failing that the unattenuated 1% AEP inflow, applies as the release, with the flow of the catchment below the dam as it occurred in the same event (Clause 5.8.5(c)). The river levels used in this Manual come from SANDRP's transcriptions of CWC data; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Sikkim the tailwater at a town outfall is set not by the tide but by a jhora that no one gauges and whose bed moves, by a valley-floor river on a bed that a glacial-lake outburst raised by metres, or by a reservoir and the releases below its dam, and no document found during research gives a design level for any of them. No design standard for any town drain in the State was found: the Sikkim Building Construction Regulations, 1991 require a plinth drain "leading to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)) but give no design storm, return period or runoff coefficient (Chapter 4); the drainage and landslip-protection projects of Gangtok's City Development Plan (2006) "were not taken up" (CAG, Report No. 3 of 2016);

and no design storm was seen for the drainage and jhora-training works of GSCDL or for the stormwater drains of the ADB-funded Sikkim Integrated Urban Development Project (Chapter 6). The State has no floodplain zoning law, and no flood level has been published for any town (Chapter 7).

The first case is the free outfall to a jhora. Most outfalls of the ridge towns fall from a slope to a jhora, so item (a) is the general rule on the ridges. Its design case is a free outfall because there is no river tailwater there, but it does not stop at the outfall: the energy dissipator, the lined path to the jhora and the check of the jhora to the next confluence or trained reach are what keep the water off the slopes. The 2021 stability zones already treat a slope beside an "Untrained jhora/ erosional potential jhora" as unstable (zone 4), and s.187 of the Municipalities Act already makes the flooding of "any area surrounding the outfall" a municipal concern; item (a) turns both into a check that a designer can make. The check reach ends at the next confluence with a channel of at least equal catchment, at a river or at a trained reach, because there the project's flow is a small part of the whole or the channel has been built to carry it; it is a check of capacity and stability, not of level. The design level, where the jhora can rise above the invert, comes from a study and from flood marks, as for the ungauged hill streams of the mountain editions of this series, with the bulking and blockage of Clause 6.3.6; and the invert stands 0.5 m above the highest bed level surveyed downstream, a margin set by this Manual for the aggradation that a bouldery bed can show in a single storm. The lock is the storm and the jhora's recession, and not less than 24 hours, because the jhoras are small and fall within hours of the rain stopping, while the storms that fill them can last for days, as in October 1968 and June 2024 (as reported; Chapter 1); where the longer storms of Clause 5.10.2 are run, the lock lasts for all of them. Item (a) also keeps outfalls away from springs (dhara), the main source of water in rural Sikkim (Chapter 8).

The second is the valley floor. Item (b) is the interim valley-floor rule of this Manual. It takes the higher of the highest level CWC has recorded and the surveyed mark of October 2023, because those are the only two levels a designer can find, and because both may now understate the river: the bed rose by about 2 to 7.4 m along the trunk in that flood (NHPC's estimates), so a highest flood level recorded before 2023 stands on an older, lower bed, and the 2023 marks record a cascade, not a rainfall flood. A hydraulic model is required where neither level exists, as at Rangpo, and its result governs wherever it is higher. The Melli readings conflict; the check uses the higher, 228.0 m, because it is the one that SANDRP's own arithmetic ("2.75 meter higher" than 225.25 m) supports, and because a check that rests on the lower of two unresolved values can put an outfall below a level the river has already reached. Inverts are set above the surveyed post-2023 bed for the same reason. The lock is the whole 72-hour storm, and not less than 72 hours, because the rivers that fill the valley floors are fed by storms that last for days over a catchment of more than 10,000 km² (the Tista, 10,616.74 km², FER 2(a)); 250 mm fell statewide in 1–13 June 2024 (as reported), and the October storm of 1968 lasted four days (as reported). No stage record of the Teesta was analysed for this Manual, so the lock is a minimum, and a stage record, once obtained, governs. Flap gates are required wherever a river can close an outfall, and the owner of the gate is named because no gated storm outfall was found in the State and nobody yet holds one.

The third is the reservoir and its release reach. A reservoir at its full level passes its inflow over its spillway, and its level rises above FRL by whatever head the flood needs. Item (c) therefore follows the reservoir rule of the North-East hill editions of this series: the MWL, or FRL plus the design-flood surcharge, with an outfall below it treated as closed for the whole of the 72-hour storm. No FRL or MWL of any dam in the State was found, so until the operator gives them an outfall in a reservoir reach is sited above the October 2023 flood mark, and where it cannot be, it takes the surveyed shore line or spillway crest plus 0.5 m, the freeboard that this Manual uses for floor levels (Clause 6.11.1), as a floor and not as an estimate of the surcharge [TBC]. No release record was obtained either, so the spillway capacity, and failing that the unattenuated 1% AEP inflow, stands in for the largest release; that is conservative by design, because a tailwater set too low floods a reach, while one set too high only costs storage. Notices and warnings are not credited because a release from the Dikchu project in 2017 was reported to have come without one (as reported), and because the High Court's direction of 2021 is on the projects' safety, not on the levels of the drains below them.

The fourth is the GLOF corridor. Item (d) keeps the glacial-lake hazard out of the rainfall design and puts it into siting, because no drain can be sized for it: the October 2023 outflow at the lake was "equivalent to a return period exceeding 200 years", and at Chungthang the discharge peaked within about 6 minutes of the flood's arrival (Sattar et al., 2025), and water alone equalled "a 1–100 year meteorological flood at Chungthang" while the sediment made the total far higher (same work). The cause is disputed between the State's affidavit and the NDSA committee, and item (d) does not depend on it. Siting assets above the 2023 flood and aggradation level and outside a mapped GLOF path is the only rule that protects them; no setback for the cascade exists in law, and the Manual sets none of its own.

The fifth is the West Bengal reaches, the sixth the pokharis and the seventh the consents and lines. Item (e) names the Teesta's levels below Melli only to leave them to the edition that governs them, and makes them a lower bound on a model's boundary, not an outfall level. Item (f) treats a pokhari as storage that starts full, because no pokhari in the State has a published level, and keeps glacial lakes out of it, because a glacial lake is a hazard, not a store. Item (g) asks for the owner's consent and design level because a design that discharges to a channel cannot be checked without them, and because the drains belong to several bodies and no notification divides them (Chapter 6, Clause 6.9). The lines of item (g) decide where an outfall can be built, not its level: the 1988 Act's river bank is "sixty metres … or area within high flood level mark, whichever is less", so on an incised reach it can be a few metres wide; no line exists along a jhora; and the Manual's own corridor (Clause 7.4) is its proposal, not the law.

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## 5.9 Joint-probability cases

5.9.1 Every element draining to a tidal or backwater-affected outfall shall be checked for the cases below. The most severe governs each design quantity: storage, water level, pipe size and pump capacity.

**Table 5.2 — Joint-probability cases for tidal and riverine outfalls**

| Case | Rainfall | Tailwater | Applies to | Basis |
|---|---|---|---|---|
| J1 | Minor-system design AEP, Tc to 24 h | MHWS + SLA (tidal curve) | Minor system | Clause 2.12(a); Clause 5.7.1 |
| J2 | 1% AEP, all durations of Clause 2.5.2 | HAT + surge + SLA | Major system, detention, tanks, pumped systems | Clause 5.7.1 |
| J3 | 10% AEP, **48 h** | 1% AEP still-water level + SLA | Major system, detention, tanks, pumped systems | Clause 2.12(b) |
| J4 | Design AEP, **48 h** (72 h reported) | Tidal curve per J1 with two **6 h lock windows** (Clause 5.10) | All storage and every gated or tide-affected outfall | Clause 5.10 |
| R1 | Site design AEP | River at 10% AEP level | Riverine outfalls | Clause 5.8.4(a) |
| R2 | Site 10% AEP | River at design-AEP level | Riverine outfalls | Clause 5.8.4(b) |

5.9.2 For storage elements, the 48- and 72-hour storms shall be run with the J2 and J3 tailwaters (Clause 2.5.3).

5.9.3 For tidally influenced riverine outfalls, R1 and R2 shall be run with the river model's downstream boundary at the J1 tidal curve. The Authority may also require them at J2.

5.9.4 Where tailwater is constant at a level above the outfall invert for the whole storm, the case is treated as a fully closed outfall. Storage and pumps shall then handle the full storm volume.

> **Commentary.** Clause 2.12 sets two joint cases. Case (a) is design rainfall with MHWS plus the sea-level allowance. Case (b) is the 10-yr, 48-hour storm with the 1% still-water level. This Manual adds HAT plus surge for major-system design (Clause 5.7.1). Case J2 combines these. J4 is the outfall-closed check, which tests the timing of tide against the storm rather than a single level. Rainfall and surge share a cyclone cause, so they cannot be treated as independent (Clause 2.12 commentary). These cases are simple surrogates, to be replaced when a statistical joint analysis of IMD rainfall and tide-gauge records is adopted.

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## 5.10 Outfall-closed (tide-locked) storage check

5.10.1 **Where it applies.** The check applies to:

- every storage facility;
- every minor- and major-system element; and
- every pumped system

whose outfall invert is below HAT + surge + SLA, or which drains to a reach subject to tide-lock or sand-bar closure (Clause 5.13).

5.10.2 **Storm.** Use the 48-hour design storm built per Clause 2.9.2 (peak day last), at:

- the AEP of the element: 1% AEP for detention, tanks and the major system; the minor-system AEP for minor drains; and
- AMC III.

The 72-hour storm shall also be run and reported.

5.10.3 **Lock windows.** Unless a site study under 5.10.6 gives otherwise:

- (a) the outfall is closed for **two consecutive lock windows of 6 hours each**, centred on two consecutive high tides of the local tidal curve. For a semi-diurnal tide, the window starts are therefore about 12.4 hours apart.
- (b) During each lock window, gravity discharge is **zero**.
- (c) Between lock windows, gravity discharge is computed against the J1 tidal curve, including the head loss of the flap gate and any non-return valve.
- (d) The first lock window shall be placed so that it is centred on the peak 1-hour block of the final 24 hours of the storm. A second run with the first window **starting** at that peak block shall also be made. The more severe governs.

5.10.4 **Requirement.** Storage plus pumping (where provided) shall hold the inflow so that, throughout the check:

- (a) the maximum stage in any detention facility stays below its emergency spillway crest, so the spillway does not operate. Where the outfall-closed stage is higher than the 1% AEP maximum water level of the free-outfall design, it becomes the facility's 1% AEP maximum water level for Clause 4.9.3, and the spillway crest, freeboard and wall height are set from it;
- (b) the maximum stage in the minor and major systems meets the Chapter 6 limits: building floor levels, and street depths of no more than 150 mm at the crown and no more than 350 mm at the deepest point; and
- (c) no property connection surcharges above the lowest opening it serves, or a non-return valve is fitted under Clause 5.11.

In volume terms, over each lock window and the full storm:

> V_inflow ≤ V_storage available + V_pumped + V_gravity (between locks)

This shall be demonstrated by routing, not by a single volume balance. The release from each facility after a lock window ends may exceed the release caps of Chapter 4, because the facility is emptying into a drain that has just reopened. That release shall be included in the downstream analysis (Clauses 5.4 and 5.9).

5.10.5 **Drawdown after the storm.** After the second lock window, the storage shall drain under the J1 tidal curve. The drawdown requirement of Clause 4.7 shall be met, with pumping where gravity cannot meet it (Clause 5.12).

5.10.6 **Site study.** A longer or shorter lock may be used where a site study gives a time series of still-water level for the design case. The study may use a calibrated hydrodynamic model, gauge records of past events, or a surge hindcast. Locks shorter than the default require the Authority's approval. A longer lock shall be used where:

- sand-bar closure (Clause 5.13) or river backwater (Clause 5.8) keeps the outfall closed for longer; or
- the gauge record shows tailwater above the outfall invert for more than 6 hours per tide in comparable past events.

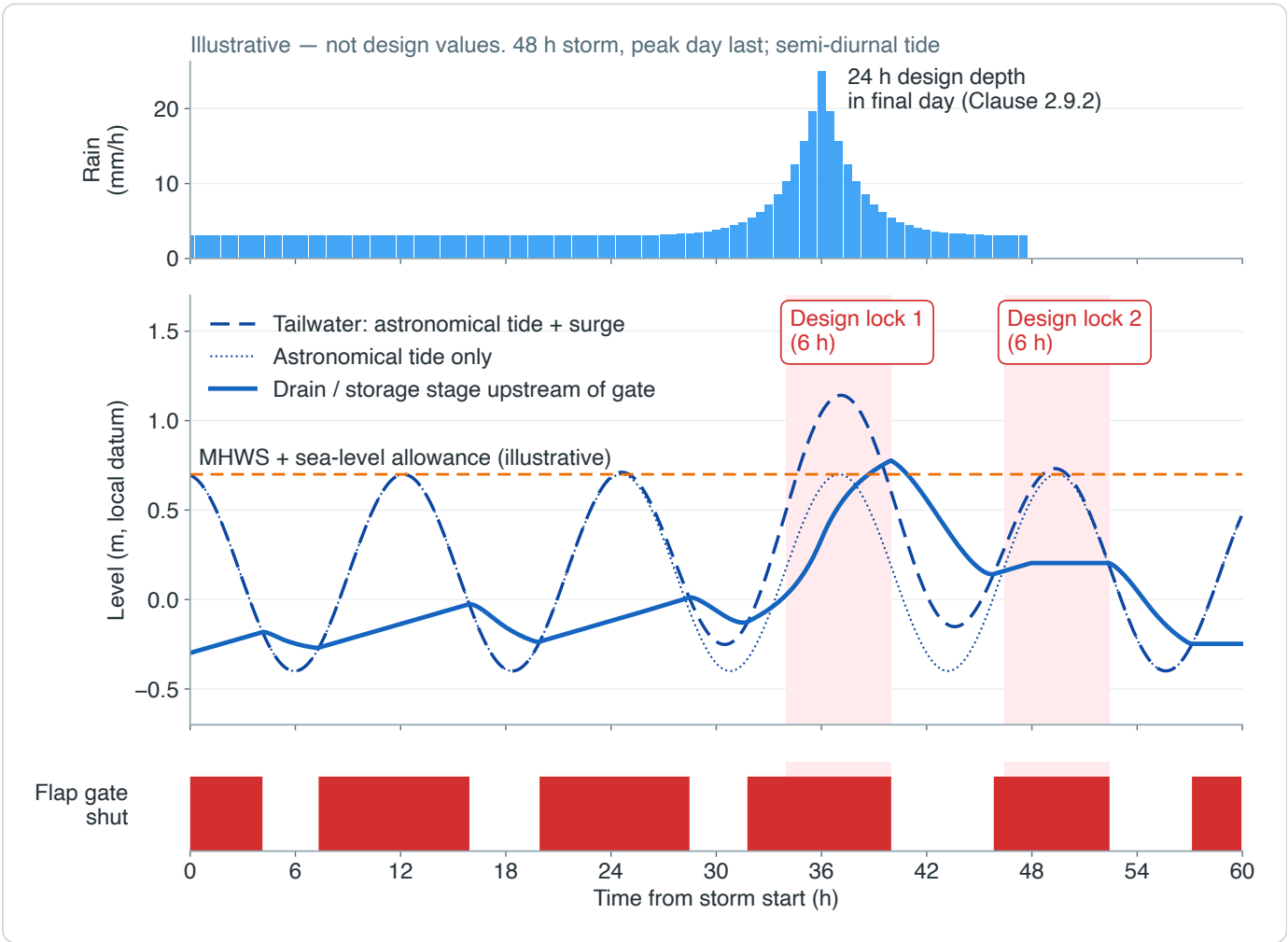


*Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal tailwater and joint-probability concepts of MoHUA/CPHEEO Manual on Storm Water Drainage Systems (2019), Part A, §6.3.6.*

Commentary. The outfall-closed check is the distinctive Sikkim requirement in this Manual. In Sikkim it applies where an outfall is shut not by the tide but by a jhora that has risen over the outlet or buried it in boulders, slide debris and waste, by the Teesta, the Rangit or the Rongni Chu held high on a valley floor, or by a reservoir at its full level or the releases below a dam. The storms that raise the rivers last for days: the October storm of 1968 brought four days of rain over Darjeeling and Sikkim, and 250 mm fell statewide in 1–13 June 2024 (both as reported); Gangtok's wettest month on record, June 1997, brought 1,281.3 mm (IMD). How long the Teesta stood above any outfall was not found, and no stage record was analysed for this Manual [TBC]. The jhoras of the ridge towns rise within minutes and fall within hours, but they can block an outlet with boulders and waste in a single storm. That is why Clause 5.8.5 replaces the two 6-hour windows described below with a lock of the storm and the jhora's recession, and not less than 24 hours, at a ridge-town outfall below its design level; the whole 72-hour storm, with the outfall closed for not less than 72 hours, on the valley floors; and not less than 72 hours on a release reach, with a closure for the whole storm below the design level of a reservoir or a pokhari. A rate rule cannot help when there is no outlet: an orificed basin behind a closed gate simply fills.

The default of two consecutive 6-hour locks has no direct precedent. It represents gravity outfalls failing to discharge for about half of each tidal cycle around the two high tides nearest the storm peak. Figure 5.3 shows why both windows matter. The first lock catches the storm peak. The second arrives before the storage has drained, so the stage rises again.

Placing the first window on the rainfall peak is deliberately unfavourable. Cyclone rainfall and surge share a cause, and Clause 2.12 already treats them as dependent. The check replaces neither the J2 and J3 level checks nor the downstream analysis; it adds a test of timing and volume.

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## 5.11 Flap gates, tide gates and non-return valves

5.11.1 **Where required.** A flap gate, tide gate or equivalent non-return device is required on every outfall whose invert is below the **1% AEP still-water level** (Clause 5.7.3). It is also required on outfalls into irrigation channels under Clause 5.8.5.

5.11.2 **Hydraulics.** The design shall include:

- the gate's head loss and opening head, from the manufacturer's certified head–discharge curve; and
- the reduction in effective outfall capacity when the gate is partly open.

Gates shall not be assumed to seal perfectly in the outfall-closed check unless they are tested.

5.11.3 **Construction.**

- (a) Gates, hinges and seats shall be of corrosion-resistant materials suitable for seawater (Clause 4.12.5).
- (b) The gate shall be set so that sand, silt or debris on the downstream side cannot hold it shut or open. Where the bed is mobile, the gate invert shall be raised above the bed, or the approach shall be protected.
- (c) A trash screen shall be provided upstream where the gate could be jammed by debris.
- (d) A stop-log slot or penstock shall be provided upstream for maintenance isolation on outfalls larger than 600 mm.
- (e) The gate chamber shall be accessible at all tides, with its access above HAT + surge + SLA.

5.11.4 **Non-return valves on property connections.** A non-return valve, or a backwater valve with an accessible cleaning eye, is required on every property drainage connection where the lowest opening served is below:

- the major-system tailwater (J2) at the point of connection; or
- the maximum stage in the outfall-closed check (Clause 5.10).

Basement drainage shall in addition be pumped to a level above both, with its own non-return valve.

5.11.5 **Inspection.** Gates and valves shall be inspected and operated:

- before **31 March** each year;
- after every event in which they closed against a storm flow; and
- as set in the maintenance plan (Chapter 10).

> Commentary. The requirement for gates below the 1% still-water level is set by this Manual. The construction details follow common coastal-drainage practice. A gate that is jammed open by debris lets the tide into the drain. A gate held shut by a sand bank turns a gravity outfall into a dead end. In Sikkim the outfalls do not cross a beach. Most of them fall freely to a jhora, and no flap-gated or pumped storm outfall was found in the State during research [TBC]; but the outfalls of the valley floors at Rangpo, Singtam, Melli, Majitar, Jorethang and Dikchu need flap gates under Clause 5.8.5(b), and there a gate jammed open by gravel, boulders or slide debris lets the river into the town's drains, and a gate buried by a rising bed turns the outfall into a dead end. The flood of October 2023 raised the Teesta's bed "by an average of 7-8 meters" (Project Prefeasibility Report annexed to the State's affidavit of 28 February 2026) and buried parts of Rangpo, "burying buildings and automobiles" (Sattar et al., 2025): a gate set on the old bed would now lie under it. Other outfall reaches lie below hydropower dams, where a release from the Dikchu project in 2017 was reported to have come without warning (as reported); no operating rule or release record of any dam was found, and no rule linking the operation of any dam to the levels of the drains above or below it [TBC]. The dams are held by their operators, while the drains that reach the rivers below them belong to the Gangtok Municipal Corporation and the other urban local bodies, the Roads and Bridges Department (PWD), NHIDCL and BRO, and the river banks of the scheduled rivers to the Forest Department, and no notification divides them (Clause 6.9). A gate and the drains behind it can therefore belong to different bodies, and the drain and jhora register of Clause 6.9 names the owner of each gate. The 31 March inspection date is set ahead of the monsoon.

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## 5.12 Pumped outfalls

5.12.1 **When required.** Pumping shall be provided where gravity discharge cannot meet:

- the outfall-closed check of Clause 5.10;
- the drawdown requirement of Clause 4.7; or
- the J2 and J3 cases.

Pumping shall not be used where a gravity solution meets these requirements.

5.12.2 **Capacity.**

- (a) The duty pumps together, with the storage provided, shall pass every case of Clause 5.9 (including J4), demonstrated by routing.
- (b) **Standby** capacity at least equal to the largest duty pump shall be installed (duty + 1 standby as a minimum).
- (c) Pump capacity shall be stated at the static head for the **J2** tailwater, not at mean tide.

5.12.3 **Effect on the receiving water.** Pumped discharge to a river, canal or creek shall be included in the river or creek level analysis of Clause 5.8. Pumping that raises the receiving water level above the acceptance criteria of Clause 5.5 elsewhere is not permitted.

5.12.4 **Power supply.** Pumping stations shall have either:

- two independent power supplies; or
- standby generation for 100% of the duty capacity, with on-site fuel for at least **72 hours** of duty operation.

Changeover shall be automatic.

5.12.5 **Flood immunity.** Electrical panels, control equipment, generators and fuel storage shall be set above the higher of:

- the 1% AEP flood level + 0.5 m; and
- HAT + surge + SLA + 0.5 m.

Access to the station shall remain usable in the 1% AEP event.

5.12.6 **Discharge arrangement.** Rising mains shall discharge:

- over a level above the J2 tailwater; or
- through a non-return valve and a flap gate.

The arrangement shall prevent back-siphoning.

5.12.7 **Controls and monitoring.** Each station shall have:

- automatic level control;
- remote alarms for high level, pump failure and power failure, sent to the operator; and
- a level and run-time log kept for at least 5 years.

Wet wells shall be sized to keep pump starts within the manufacturer's limits.

5.12.8 **Screens.** Inlet screens shall be provided with a cleaning method that works during a storm (a mechanical rake, or duplicate screens).

5.12.9 **Testing.** Every pumped outfall shall be test-run at full duty, including on standby power, before **31 March** each year. Private pumped systems shall be covered by a registered maintenance declaration (Chapter 10).

> Commentary. Duty + standby, 72 hours of fuel and flood-immune electrics have no single direct precedent and are set by this Manual. The 72-hour fuel figure matches the longest mandatory design storm (Clause 2.5.2). A pump station that depends only on grid power can stop exactly when it is needed, because supply to flooded areas is often switched off for safety. Singapore's April 2025 amendments added annual maintenance declarations for pumped detention tanks (PUB Addendum No. 3). Clause 5.12.9 and Chapter 10 adopt the same approach. Clause 5.12.3 prevents pumping that simply moves water from one tide-locked drain into a tide-locked river.

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## 5.13 Sand-bar closure of river mouths

5.13.1 **Where it applies.** This clause applies to outfalls into any river or creek whose mouth is subject to seasonal sand-bar closure. That includes the mouths of the coastal States (there is none in Sikkim: Clause 5.1.4), and any other mouth listed in Annex 5B.

5.13.2 **Assumption at the start of the monsoon.** The mouth shall be assumed **closed** by a bar at the start of the April–October season, at the crest level of the most recent pre-monsoon survey. This applies unless the Water Resources Department certifies that:

- a mouth-maintenance programme (dredging, bar cutting or training walls) has kept the mouth open at the start of each of the previous three monsoon seasons; and
- the programme is funded for the current season.

5.13.3 **Tailwater with a closed mouth.** With the mouth closed, the tailwater at the outfall shall be the higher of:

- (a) the tidal tailwater of Clause 5.7; and
- (b) the level in the river reach behind the bar, computed with the bar as a weir at its surveyed crest level. That level shall include the river flow of Clause 5.8 and the head needed to pass the flow over or through the bar.

5.13.4 **No credit for emergency cutting.** Bar cutting or breaching during the storm shall not be assumed in design, unless the Water Resources Department has a documented operating procedure, with equipment stationed for it. Where it does, the bar may be assumed lowered to the procedure's target level only after the time the procedure states.

5.13.5 **Outfall-closed check.** Where the closed-mouth level of 5.13.3(b) exceeds the outfall invert for longer than the default lock windows, the lock duration of Clause 5.10 shall be extended to that period.

> Commentary. Sikkim has no coast and no river mouth, so Clause 5.13 does not apply in the State (Clause 5.1.4). Its nearest inland counterparts are the boulders, gravel, slide debris, silt and garbage that the jhoras leave at an outfall or a gate, and the bed that the Teesta raised in October 2023, which buried parts of Rangpo, "burying buildings and automobiles" (Sattar et al., 2025). Gangtok's waste agency is contracted for the "Clearing of Jhoras" and barred from dumping "along Footpath, Roadside and Jhoras" (GMC, Memo No. GMC/6727/III/2024/OL/01, 8 October 2024), and the building rule already forbids dumping spoil in "drains, gullies and jhoras" (SBCR 1991, reg. 22). A flap gate held open or shut by gravel, debris or waste, an outlet buried by a rising bed or left hanging by scour, or a gate that cannot be moved, turns a designed outfall into a dead end or a back-flow path. No rule linking the operation of any gate or dam in the State to the levels of the drains above or below it was found during research [TBC]. Clause 5.8.5 deals with both by setting outfalls above the surveyed range of bed movement and by giving no credit for a gate operation or a storage that the operator's records do not show. Clause 5.13.2 has no direct precedent. It puts the burden of proof on showing that the mouth is open rather than assuming it.

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## 5.14 Documentation

Every project subject to this chapter shall submit a **Downstream and Tailwater Report** (Form 5-1). It shall contain:

1. a plan of the analysis extent showing:
    - the site;
    - each analysis point with its contributing catchment area and the site's percentage of it; and
    - the end point and the reason it was chosen (Clause 5.3);
2. the model description:
    - software and version;
    - the network schematic, with survey sources for the drains and crossings;
    - land use and CN for off-site areas;
    - any upstream detention included; and
    - calibration or validation evidence where available;
3. for each analysis point, AEP and duration, the existing and with-project:
    - peak flow;
    - time to peak;
    - maximum water level and velocity; and
    - duration of inundation (Clause 5.4);
4. the comparison against Clause 5.5, with each failure identified and the remedy adopted;
5. the tailwater derivation:
    - tide-table edition and port;
    - MHWS, HAT and MSL relative to chart datum;
    - the datum connection to the Survey of India benchmark and the project datum;

    - surge source and value;
    - SLA; and
    - river levels and their sources (Clauses 5.6 to 5.8);
6. the joint-case table of Clause 5.9 with results;
7. the outfall-closed check (Clause 5.10):
    - storm and lock alignment;
    - stage hydrographs; and
    - the volume balance for each lock window;
8. a schedule of flap gates, tide gates and non-return valves, with certified head–discharge data (Clause 5.11);
9. pumped outfall design, power supply, flood immunity and controls, where provided (Clause 5.12);
10. the sand-bar assumption and supporting WRD certification, where relevant (Clause 5.13); and
11. inspection and maintenance requirements for Chapter 10.

Small sites under Clause 5.3.4 shall submit Form 5-2 (Simplified Downstream Statement) instead.

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## References (chapter)


- MoHUA / CPHEEO (2019). Manual on Storm Water Drainage Systems, Part A, §6.3.6 and Table 6.2 (coastal tailwater; +0.3 m climate allowance). https://web.archive.org/web/2024/https://mohua.gov.in/upload/uploadfiles/files/VolumeI-Part%20A-Engineering-Design.pdf
- MoHUA / CPHEEO (2013). Manual on Sewerage and Sewage Treatment Systems (pumping stations).
- Kansas City Metro Chapter APWA (2006). Section 5600 Storm Drainage Systems and Facilities (5601.5, ten-percent downstream analysis). https://www.kcwater.us/wp-content/uploads/2020/08/Design-Criteria-%E2%80%93-Section-5600-%E2%80%93-Storm-Drainage-Systems-and-Facilities.pdf
- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01.
- Atlanta Regional Commission / Georgia EPD (2016). Georgia Stormwater Management Manual, Vol. 1 (Standard #8) and Vol. 2 §3.1.9. https://documents.atlantaregional.com/gastormwater/GSMM_2016%20EDITION_FINAL_V1.pdf
- MARC. The Evolution of Regional Stormwater Design Standards. https://www.marc2.org/Assets/Environment/WQEC/The_Evolution_of_Regional_Strormwater_Design_Standards.pdf
- Optimisation of urban detention (2016). *Water* 8(7):290. https://doi.org/10.3390/w8070290
- Colorado State University. Spatially Dependent On-Site Detention Policies (thesis). https://mountainscholar.org/bitstreams/f4dbec4e-a44f-4933-8d54-a097e741f44a/download
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*, doi:10.1126/science.ads2659 (accepted manuscript, White Rose eprint 224098: the outflow peaks at the lake and at Chungthang, the eroded volume, the burial of Rangpo, the ERA5 rainfall over the lake, the downstream dams affected).
- Government of Sikkim. Additional affidavit of Respondent 1 of 28 February 2026 in O.A. No. 171 of 2023 (EZ), National Green Tribunal, with the Project Prefeasibility Report "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (the bed risen "by an average of 7-8 meters"; NH-10 "prone to submergence and subsidence"; NHPC's estimates of the bed rise at TLDP-IV, TLDP-III, Teesta-V and Teesta-VI; Toong Naga; the list and status of the hydropower projects; NDMA's 40 high-risk and 16 very high-risk glacial lakes; Shako Chho; "High-risk Zoning" as a proposal) and the PDNA summary, https://www.greentribunal.gov.in/sites/default/files/news_updates/Additional%20affidavit%20on%20behalf%20of%20R-1,%20State%20of%20Sikkim,%20page%201038-1178.pdf ; and the State's affidavit of 5 April 2024 in the same case (the flood attributed "primarily to a cloudburst").
- SANDRP. Transcriptions of CWC data for the Teesta basin sites (Khanitar, Melli, Singtam, Majitar, Ranipool, Bakcha, the upstream sites that stopped on 3 October 2023, and the West Bengal sites), as reported; the Melli reading of 228.0 m in a CWC daily bulletin of 2024 seen only as a search snippet; and press reports on Singtam's danger level (*Deccan Herald*) and on Melli on 4 October 2023 (*EastMojo*), as reported. The datum and gauge zero of each gauge are to be confirmed with CWC [TBC].
- Central Water Commission (1991). *Flood Estimation Report for North Brahmaputra Subzone 2(a)*, NB/18/1991 (the Tista, 10,616.74 km², p. 29).
- High Court of Sikkim. WP(PIL) No. 4 of 2017, *In re: Release of water from Dikchu Hydelpower Project*, judgment of 1 March 2021, https://hcs.gov.in/hcs/hg_orders/202600000042017_37.pdf (read from a Wayback Machine copy); and the 2017 release as reported (*Summit Times*, 28 May 2017).
- *ThePrint*, 1 October 2024. "Sikkim govt, central panel split over what caused 2023 floods …" (the NDSA-constituted committee: GLOF, about 40 million m³, inflow about 10,000 m³/s against a 7,500 m³/s spillway; as reported), https://theprint.in/india/sikkim-govt-central-panel-split-over-what-caused-2023-floods-at-stake-is-rs-2500-cr-insurance-claim/2291910
- *The Sikkim Municipalities Act, 2007* (Act 5 of 2007), as amended to 2026 (ss.2(24), 172, 173, 187, 189 and 193), https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf
- *The Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988* (Act 6 of 1988), as amended by Act 8 of 2000 (ss.2(m), 29, 30, 32 and the Schedule), https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf

- *The Sikkim Building Construction Regulations, 1991* (UD&HD Notification No. 29(202)UD&HD/90/295, 19 March 1991), as amended in 2000 and 2001 (regs. 22, 25(iv) and 35), read from a copy hosted by Sikkim Manipal University, https://smu.edu.in/img/content/dam/manipal/smu/IQAC/SDG/documents/BUILDING%20STANDARDS.pdf ; and Department of Mines and Geology Notification No. 17/DMG/20-21, 19 March 2021 (stability zones), read as Annexure R/2 to the State's counter-affidavit in O.A. No. 5 of 2022 (EZ), National Green Tribunal, https://www.greentribunal.gov.in/sites/default/files/news_updates/Counter%20Affidavit%20on%20behalf%20of%20R-,4,7,9%20in%20OA%205%20of%202022%20(EZ)%20(Dr.%20BINA%20BASNETT%20vs%20State%20of%20Sikkim%20&%20Ors.).pdf
- Gangtok Smart City Development Ltd. Reply affidavit in O.A. No. 38 of 2022 (EZ), National Green Tribunal ("landslides are caused mainly due to loose soil by spring water generated at natural Jhora"), https://www.greentribunal.gov.in/sites/default/files/news_updates/Reply%20Affidavit%20filed%20by%20R-2,%20GSCDL,%20page%20698-1006.pdf
- Government of Sikkim. Six-monthly report in O.A. No. 606 of 2018, National Green Tribunal (GMC's waste-agency contract, Memo No. GMC/6727/III/2024/OL/01, 8 October 2024), https://www.greentribunal.gov.in/sites/default/files/news_updates/SIX%20MONTHLY%20REPORT%20BY%20GOVT%20OF%20SIKKIM%20IN%20OA%20NO.%20606%20OF%202018%20FOR%20STATE%20OF%20SIKKIM%20(COMPLIANCE%20OF%20MSW%20MGT%20RULES,%202016%20AND%20OTHER%20ENVIRONMENTAL%20ISSUES).pdf ; and the State's affidavit of 19 December 2025 in E.A. No. 35 of 2023 in O.A. No. 673 of 2018 (the Zone III sewerage, "Pollution abatement of Rani chu through Ro-Ro Chu"), https://www.greentribunal.gov.in/sites/default/files/news_updates/AFFIDAVIT%20BY%20STATE%20OF%20SIKKIM%20IN%20EA%20NO.%2035%20of%202023%20IN%20OA%20NO.%20673%20of%202018%20News%20item%20published%20in%20the%20Hindu.pdf
- Comptroller and Auditor General of India. *Report No. 3 of 2016* (Economic Sector, Sikkim), Chapter II (the Gangtok CDP's drainage and landslip works "not taken up"), https://www.cag.gov.in/uploads/download_audit_report/2017/Chapter_2_Economic_Sector_Sikkim_Report_No_3_of_2016.pdf
- India Meteorological Department. *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)* (Gangtok's highest monthly total, June 1997).
- Press reports on the Mangan district storm of June 2024 (*Business Standard*, https://www.business-standard.com/india-news/heavy-rain-landslides-kill-6-in-indias-sikkim-2000-tourists-stranded-124061400418_1.html ; the statewide 250 mm of 1–13 June from a humanitarian situation report), on the October 1968 floods (https://en.wikipedia.org/wiki/1968_Sikkim_floods), on the Teesta barrage release of October 2023, and on the restoration of Teesta-V (all as reported).
- Survey of India. Tidal Predictions: Geodetic and Research Branch. https://www.geographyandyou.com/survey-of-india/tidal-predictions-geodetic-and-research-branch-survey-of-india
- GLOSS. India national report (tide-gauge network and datums). https://gloss-sealevel.org/gloss/gloss/sites/gloss/files/publications/documents/india_ge9.pdf
- Adani Ports (2025). Tide Table 2025, Dahej (notes on NHO INP-12 coverage and data sources). https://www.adaniports.com/-/media/Project/Ports/PortsAndTerminals/Dahej-Port/Marine-Documents/Tide-Table-2025-Dahej.pdf
- INCOIS. Storm-surge and swell-surge warning services. https://incois.gov.in/
- FHWA. HEC-22 Urban Drainage Design Manual (current edition), Table 7.3 (coincident frequencies).
- Purdue University JTRP (2023). Development of a Multiple Water Course Joint Probability Analysis Procedure for Indiana Watersheds, FHWA/IN/JTRP-2023/09. https://docs.lib.purdue.edu/jtrp/1820
- PUB Singapore (2025). Code of Practice on Surface Water Drainage, 7th ed., Addendum No. 3. https://info.corenet.gov.sg/docs/default-source/pub-circulars/pub-circular_cop-7th-ed-addendum-no-3_16-apr-2025.pdf?sfvrsn=5a2c1e1a_2

## Annexes and forms

| Annex / Form | Content |
|---|---|
| 5A | Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment |
| 5B | Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map |
| 5C | Worked example: outfall-closed check for a hillside colony in Gangtok draining to a jhora |
| Form 5-1 | Downstream and Tailwater Report |
| Form 5-2 | Simplified Downstream Statement (small sites) |

CHAPTER 6

# Minor and Major Drainage Systems

## 6.1 Purpose and scope

6.1.1 This chapter sets the level of service and the hydraulic criteria for the conveyance system that carries runoff from a development, a road or a public drainage scheme to a receiving waterway, tank or outfall. It covers:

- (a) the dual drainage concept: a minor system and a major system (Clause 6.3);
- (b) design return periods by land use and road class (Clause 6.4);
- (c) street hydraulics: spread, depth and flow hazard (Clause 6.5);
- (d) inlets, including clogging (Clause 6.6);
- (e) pipes and open and covered drains (Clause 6.7);
- (f) hydraulic grade line analysis (Clause 6.8);
- (g) overland flow paths, ponding at sags and building floor levels (Clauses 6.9 to 6.11);
- (h) culverts and road crossings (Clause 6.12); and
- (i) Sikkim construction-practice requirements for covered drains, silt, solid waste, utilities and desilting access (Clause 6.13).

6.1.2 The detailed hydraulic design of individual structures (culverts, channels, energy dissipators, screens, pumps, gates, manholes) is in Chapter 9. Rainfall is in Chapter 2, runoff methods in Chapter 3, on-site storage in Chapter 4, tailwater in Chapter 5, waterbodies in Chapter 7 and water quality in Chapter 8.

6.1.3 This chapter applies to all public drains, all roads with kerbs or roadside drains, and all private drainage systems in developments that meet the applicability thresholds of Chapter 1. In Tier B local bodies, the simplified procedures and design aids referred to in Chapter 1 may be used for elements serving ≤ 16 ha, but the criteria of this chapter still apply.

> Commentary. Sikkim's drains were not designed against any State or municipal standard: none was found during research, and no document found gives a design return period, runoff coefficient or drain size for any town. The Sikkim Building Construction Regulations, 1991 (SBCR 1991) have drainage clauses without numbers: roof gutters and down pipes "of such design and capacity that the water will neither spill out of them nor leak through them" (reg. 21), a "Pucca storm water/plinth protection drain … leading to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)), and no occupation certificate "if the drain has not been provided to main outlet/jhora" (reg. 13(iii)). The drainage and landslip-protection projects of Gangtok's City Development Plan (2006) "were not taken up" (CAG, Report No. 3 of 2016); Gangtok Smart City Development Ltd (GSCDL) tendered "Construction of drainage and jhora training works", about ₹13.41 crore (as reported); and the ADB-funded Sikkim Integrated Urban Development Project includes "Improving about 60 km roads in seven towns with junction improvements, improved pavement and stormwater drains" (ADB 57230-001); no design storm was seen for either. The drains also work in a setting that the plains editions of this Manual do not meet. In Sikkim a jhora (झोरा; a natural watercourse or ravine stream) is a drain in law ("a jhora or water-course of natural drainage line", Sikkim Municipalities Act, 2007, s.2(24)), and rain water is to be "connected with the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (s.193(b)), so the town drains end in jhoras, the jhoras in a khola (खोला; a river or large stream) and the kholas in the Teesta, the Rangit or the Rongni Chu. The slopes fail when water is put into them: the 2021 stability zones of the Mines and Geology Department grade a site partly by the state of its jhora, from zone 1, where the "Training of jhoras/drains have been completed and done properly (with safe distance)", to

zone 4, with an "Untrained jhora/ erosional potential jhora" (Notification No. 17/DMG/20-21, 19 March 2021), and the springs (dhara, धारा; a spring or spring spout) that the towns and villages drink from emerge on the same slopes. Outside Gangtok's partial sewer network the drains carry the towns' sullage and septic effluent (Clause 8.9). The road drains of the hills are the drains of the land above them. And the drains are divided among owners: the Gangtok Municipal Corporation (GMC) and the other urban local bodies, the Forest Department for the river banks of the scheduled rivers, the Roads and Bridges Department (PWD), NHIDCL and BRO for the roads, the Water Resources Department (WRD), PHED, the Rural Management and Development Department (RMDD), GSCDL and the hydropower operators all build or hold drains and receiving waters, and no notification divides them (see the Commentary to Clause 6.9). A pokhari (पोखरी; pond, lake or tank) that receives drains is kept as storage (Chapter 7). Fixing the rainfall (Chapter 2) is only half the answer. The other half is a second, surface-level system that carries the flows the pipes cannot, without flooding buildings. That is the dual drainage concept of this chapter, taken from Kansas City Metro APWA Section 5600 (5601.8, Levels of Service), which requires every element to have a 1% AEP overflow path.

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## 6.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Minor system | Inlets, pipes, covered drains and open drains that carry runoff up to the minor design AEP of Table 6.1 without surcharge above the limits of Clause 6.8. |
| Major system | The surface flow paths (streets, overland flow paths, open channels, floodways and storage) that carry flow above the capacity of the minor system, up to the 1% AEP (100-yr) event. |
| Overland flow path | A defined surface route, in public land or a recorded easement, that carries major-system flow to a receiving waterway. |
| Spread (T) | Width of flow in the gutter and carriageway, measured from the face of the kerb. |
| Sag | A low point on a road or flow path from which water can leave only through an inlet or by ponding to an overflow level. A trapped sag has no surface overflow route. |
| Clogging factor | The fraction of an inlet's clean hydraulic capacity assumed lost to debris (Clause 6.6.3). |
| Hydraulic grade line (HGL) | The line joining the free-surface levels in a conduit system, or the piezometric levels where the system is under pressure. |
| Covered drain | A rectangular drain, usually beside a road, closed by cast-in-situ or precast cover slabs that form a footpath. |
| Sediment allowance | The depth or area of a drain or pipe assumed filled with silt when its design capacity is computed (Clause 6.7.8). |
| Check event | An AEP rarer than the design AEP at which the combined minor and major system must still meet the limits of Table 6.2. |
| High-density area | An area notified as such by the approving authority under Clause 6.4.4. |
| Class I area | An urban local body with a population of 1 lakh or more (the CPHEEO definition). |

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## 6.3 The dual drainage concept

6.3.1 Every drainage system shall be designed as two systems that work together:

- (a) a **minor system** that carries the minor design flow of Table 6.1 below ground or in drains, keeping streets usable and spread within Table 6.2; and

- (b) a **major system** that carries all flow above the minor-system capacity, up to the 1% AEP (100-yr) flow, on the surface without entering buildings and within the depth and hazard limits of Clause 6.5.

6.3.2 **Every element has a 1% path.** Every inlet, sag, pipe, drain, culvert and storage element shall have an identified 1% AEP overland flow path to a receiving waterway, tank or outfall. The path shall be shown on the drainage plan (Clause 6.15).

6.3.3 **Major-system design flow.** The major system at any point shall carry the 1% AEP peak flow less the minor-system capacity at that point. The minor-system capacity used in this subtraction is the capacity of the inlets after the clogging factors of Clause 6.6.3, or the pipe capacity, whichever is less. At sags and at any location used to set building floor levels, the major system shall also be checked with the minor system **fully blocked** (Clause 6.10.3).

6.3.4 **Rainfall and method.** Design flows shall use the rainfall of Chapter 2 (including the climate factor of Clause 2.8) and the methods of Chapter 3:

- (a) the Rational Method only for catchments ≤ 16 ha and a single conveyance element. It shall not be used to accumulate flows down a network whose total catchment exceeds 16 ha;
- (b) a hydrograph method with hydraulic routing (for example SWMM, HEC-HMS with a hydraulic model, or an equivalent 1D/2D model) for networks above 16 ha and for any network with storage, pumping or a tidal outfall;
- (c) a minimum time of concentration of 10 minutes.

6.3.5 **No transfer between catchments.** Neither the minor nor the major system shall divert flow from one natural catchment to another unless the approving authority accepts a catchment-wide study showing no adverse effect.

6.3.6 **Drains that carry sewage, hill drains and jhora training.** Outside Gangtok's sewered zones, the public drain or jhora that receives storm water from a site or a public drainage project in Sikkim normally also carries sewage and sullage, from septic tanks, soak pits and open connections (Clause 8.9); and on the slopes on which the ridge towns are built, the drains and jhoras also carry silt, gravel, boulders, slide debris and waste, and the water they spill or leak moves the slopes. This chapter applies to the storm-water system up to the point of connection and to every public drain and jhora, with the following additions (all set by this Manual).

Items (a) to (e) apply wherever the receiving drain or jhora carries dry-weather flow of sewage or sullage, whatever its owner calls it:

- (a) **Separation on site.** Storm water and sewage, sullage included, shall be collected in separate systems within the site, each with its own last inspection chamber at the site boundary, so that the storm-water system can be connected to a separate public storm drain, without rework on the site, when one is built or when the sewers of the area are commissioned. Where the Authority allows only one connection to the receiving drain, the two systems shall meet only in a final chamber after both inspection chambers. The law already asks for this: within a municipal area there shall be one drain for sewage and "an entirely separate drain for rain water or unpolluted sub-soil water", and "the rain water shall be connected with the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (Sikkim Municipalities Act, 2007, s.193 and proviso (b)). The building rule has the hooks but does not separate the flows on the ground: the blue-print plan shows "drainage including connection to main outlet" and the "sanitary/plumbing layout … drainage system … sewerage disposal system/septic tank and soak pit" (SBCR 1991, reg. 6), the building connects to the public sewer where one is available (reg. 25(ii)), and no occupation certificate is issued "if the sewerage connection is not fitted with the public sewer where feasible and if the drain has not been provided to main outlet/jhora" (reg. 13(iii)). In Gangtok's sewered zones, the site's sewage goes to the sewer and its storm water to the storm drain, and the two shall not be joined. Clause 6.13.7 applies to every storm drain within the site. No sullage and no roof or paved-area water shall be led to a soak pit or any other infiltration device on ground where the hill rule or the valley-floor rule of Clause 4.11 bars infiltration; this item does not override the septic tank "built within the site" and its soak pit that regs. 6, 13(iii) and 25(i) require, which are dealt with under Clause 8.9.
- (b) **No rise in the peak inflow.** A development to which Chapter 4 applies shall meet Chapter 4 at each connection to a drain or jhora that carries sewage, as at any other site outfall (Clause 4.5.1.3). A development below the thresholds of Clause 1.5.2 shall not raise the peak inflow above that of the site before the development: where it

adds impervious area, the roof water of the added area shall pass through a storage tank sized under the credit rule of Chapter 4, with a controlled overflow before it reaches the connection.

- (c) **Tailwater and backflow.** The HGL of Clause 6.8 shall be started from the level in the receiving drain or jhora at the connection in the coincident event, taken from the owner's model where one exists and otherwise at the drain's obvert or top of bank (Clause 5.6.2). Where the receiving drain ends at an outfall that a jhora, a river, a reservoir or a pokhari can close, the outfall-closed check of Clause 5.10 applies with the lock of Clause 5.8.5. A non-return valve (Clause 6.8.8) shall be fitted on every connection, storm or foul, to a drain that carries sewage wherever the lowest drainage fitting or opening it serves is below the cover or bank level of the receiving drain at the connection.
- (d) **Capacity, velocity, access and odour.** A public drain or jhora that carries sewage shall be designed as a combined channel until the sewers of its area are connected: its storm capacity used in Clause 6.3.3 shall be the capacity left after its dry-weather flow, measured or estimated from the population served; it shall reach the minimum velocity of Clause 6.7.3(a) at its dry-weather flow, or have a low-flow channel in its invert that does, so that sewage solids do not settle between storms; where it is covered, it shall have the access openings of Clause 6.13.2, with covers and vents placed so that odour does not reach homes, steps and footpaths; and it shall be cleanable by machine from those openings, without anyone entering it. Flow above its storm capacity, or above what the inlets admit, shall be carried on the surface by the major system (Clauses 6.3.2 and 6.9), never onto an unprotected slope, and floor levels shall be set under Clause 6.11 with the drain surcharged.
- (e) **Interception and screens before outfalls; separation planned by the Authority.** Every public drain that carries sewage shall have dry-weather-flow interception and a screen before every outfall to a jhora that feeds a dhara, a pokhari or a drinking-water intake, and before every outfall within a town to the Rani Khola, the Roro Chu, the Rongni Chu or the Teesta, designed under Clause 8.9 so that it does not reduce the drain's storm capacity, and no new storm drain shall be brought to a pokhari without that treatment. No drain that carries sewage, and no storm outfall, shall discharge into or immediately above a dhara or within 15 m of one (the spring rule of Chapter 8). Every such screen shall also hold back the solid waste that the drains carry, with machine access and a place to stack what it catches that is not a jhora, a slope or a pokhari margin. The National Green Tribunal recorded, in its order of 4 July 2024 as the State quotes it, that "treated sewage is entering in to river/ rivulets/ jhoras and this is not permissible under the Water Act", and directed analysis of the "water quality of rivers including jhoras receiving sewage"; the State replied that "No sewage is disposed off in the rivers or fast flowing water bodies" (State's six-monthly report in O.A. No. 606 of 2018); this item does not depend on which is right. The Authority shall identify in its master plan (Chapter 11) the areas where a separate public storm drain is feasible, among them Gangtok's sewered zones as their connections are made; in every town, every public drain and jhora below a settlement shall be taken as one that carries sewage until sewers exist; and where a separate public storm drain is available at the site boundary, the site's storm-water system shall be connected to it and not to the drain that carries sewage. The Conveyance Design Report (Form 6-1) shall state whether each receiving drain or jhora carries sewage, the source of that information, and how items (a) to (e) are met.

Items (f) to (m) apply to every element of the minor and major systems that receives runoff from a hill catchment, which in this Manual means land in sub-areas SK-B, SK-B1 and SK-C of Annex 2A, any slope steeper than 10° in sub-area SK-A, any catchment whose natural ground slopes more than 10% on average, and every jhora, khola or other stream that comes down from the hills, including where it crosses valley-floor land; in Sikkim that is nearly every catchment (NEER reading). Throughout items (f) to (m), the drainage clauses of the SBCR 1991 (regs. 6, 13(iii), 21, 22, 25(iv) and 35) and the conditions of the 2021 stability zones are the hooks, and this Manual adds the hydrology and the numbers that they leave out:

- (f) **Debris racks and traps.** Every inlet, drain or pipe entrance and culvert that receives flow from **1 ha or more** of unbuilt hill land (forest, scrub, cultivated slope, bare slope, a cut or fill slope, spoil or a slide scar), or from a jhora or other hill stream whatever its catchment, shall have a debris rack or a debris trap upstream of it, designed under Chapter 9 (Clause 9.8), with machine access and a stable place to stockpile what it catches, which shall not be a slope, a jhora, a pokhari margin or the recharge area of a dhara. With 50% of the rack blocked, the element it protects shall still pass its design flow, and the overflow route shall not send the flow onto a building or an unprotected slope. Racks and traps shall be cleared by 31 March, again by 30 April after the April storms and before May, and after the season by 15 November; above about 2,500 m, where snow or frost prevents the

March works, by 30 April and 31 May, with snow and ice cleared after every snowfall from December to March and the post-season clearance by 31 October (Chapter 10). Solid waste is debris for this item: GMC's waste agency is already responsible for the "Clearing of Jhoras" (GMC, Memo No. GMC/6727/III/2024/OL/01, 8 October 2024), and the blockage of item (h) includes it. The volume of a debris basin is to be set in Chapter 9 [TBC].

- (g) **Bulking factor.** The design flow of every channel, drain, pipe, culvert and crossing that receives flow from a hill catchment shall be the clear-water peak flow of Chapter 3 multiplied by a bulking factor of **1.25**, for the minor design flow, the check event and the 1% AEP flow; elsewhere the factor is 1.0. The factor applies to capacity, freeboard and velocity; it does not apply to the runoff volume used for storage (Chapter 4). A larger factor shall be used where a sediment study of the catchment gives one. No Sikkim debris or bulking allowance exists [TBC]. A catchment that the screening of Clause 2.3.6(i) shows to be prone to debris flow or landslides, such as the jhora gullies and debris fans of Mangan in June 2024 and of Chaten near Lachen in June 2025 (as reported), or that drains a slide scar, a debris path below a cut slope, a fill or a retaining wall, is not designed by a bulking factor: no building, outfall, pumping station or storage shall be placed in that path, and the drains are designed for the bulked flow only [TBC].
- (h) **Blockage.** The blockage check of Clause 6.12.4 shall assume 50% of the inlet area blocked for every culvert and pipe entrance with a span or diameter below **3.0 m**, and 20% for larger ones, whether or not a debris rack is provided. Grate inlets keep the clogging factor of Table 6.5, and kerb openings on grade take the sag value of 20%.
- (i) **Sediment and minimum velocity.** Drains and pipes that receive flow from a hill catchment, or that run across the valley floors and terraces of SK-A, shall reach a velocity of at least **1.0 m/s** at the minor design flow, in place of the minimum of Clause 6.7.3(a). Where the gradient does not allow it, a sediment trap shall be provided upstream and the sediment allowance of Clause 6.7.8 doubled (Clause 6.7.4).
- (j) **Steep drains, steep streets and outfalls onto slopes.** Where the gradient of a drain gives a velocity above the limits of Clause 6.7.3(b), or a Froude number above 0.8, at the design flow, the drain shall be a lined chute, a stepped or baffled channel or a series of drop structures designed under Chapter 9 for the bulked flow of item (g), with the freeboard of Table 6.7 for steep channels and an energy dissipator at every change to a flatter gradient and at the outlet. **Every outfall onto or down a slope**, of a public drain, a road drain or a site, shall end in an energy dissipator and reach a stable natural channel or a jhora trained to item (m) through a lined chute, a stepped channel or a closed pipe, and shall not discharge onto an unprotected slope, fill or retaining wall. No drain shall be unlined on natural ground steeper than 10°, on colluvium, fill or slide debris, or in stability zones 3 to 6, because an unlined drain there is an infiltration path that the hill rule of Clause 4.11 does not allow. On a street steeper than 5%, grate-only inlets shall not be used, and inlets shall be placed by the calculation of Clause 6.6.4 with the bypass flows of a steep gutter; on a street steeper than 10%, the flow shall be intercepted by transverse grated channels or kerb inlets at a spacing that keeps the street flow within the limits of Table 6.3 in the check and 1% AEP events, and where the 1% AEP flow cannot be kept within those limits, the excess shall be carried in a lined side channel or stepped drain and the street, unless it is a notified evacuation route, is treated as closed in that event. Steps and footpaths that carry flow shall have a lined side channel.
- (k) **Hill roads as the minor system.** On every road and street in a hill catchment as this clause defines it, among them NH-10 along the Teesta, which "has become prone to submergence and subsidence" (the Project Prefeasibility Report (PPR) on glacial-lake outburst flood (GLOF) risk mitigation in the Lhonak valley, annexed to the State's affidavit of 28 February 2026 to the National Green Tribunal) and whose drainage the High Court warned IRCON to correct in June 2025 (as reported), the drainage of a road is the minor system for the land above it as well as for the road. Every such road and street shall have, as works of the road's owner, the Roads and Bridges Department (PWD), NHIDCL, BRO or an urban local body: (i) a lined catch-water drain above every cut slope where the land above drains towards the road, discharging to a natural channel or a cross-drainage work and not over the cut; (ii) lined side drains on the hill side (IRC:SP:42-2014, cl. 8.5.1); (iii) a cross-drainage work at every jhora and stream, and culverts or scuppers at intervals such that no side drain exceeds its capacity at the design AEP of Table 6.1 with the factors of items (g) and (h); (iv) at the outlet of every scupper, culvert and side drain on the valley side, a lined chute, cascade or pipe carrying the flow to a stable natural channel, a trained jhora or a public drain, with an energy dissipator, so that road runoff is **never discharged onto an unprotected slope**, fill, retaining wall or the land of a building below, by the Roads and Bridges Department (PWD), NHIDCL, BRO or any

other owner of a road; (v) culverts of at least the size of Clause 6.12.5, designed under Clause 6.12 and not less than IRC:SP:42-2014 cl. 7.1.4 requires for the road; where the drainage provisions of IRC:SP:48-1998, the Hill Road Manual, which were not read for this Manual [TBC], are stricter than this item, they apply; and (vi) no muck, spoil or excavated material from the construction, widening or maintenance of the road, or from hill cutting beside it, placed in or beside a jhora or another line of natural drainage, or on a slope from which a storm can carry it into one, and every jhora or drain that such material has blocked cleared by 31 March. The same items apply to the drainage of a railway formation in a hill catchment, among them the Sevoke–Rangpo line.

- (l) **Sloping sites: the building rule's drains and the hydrology they leave out.** On a site where the land above drains towards a building, its cut or its retaining wall, the runoff of that land shall be intercepted above them by a lined catchment drain sized for the minor design flow of Table 6.1 from the land above it, with the factors of items (g) and (h), with a 1% AEP flow path that does not pass through or against the building. The space between a building and the cut or retaining wall above it shall be paved or lined and drained so that water does not stand against the building or soak into the foot of the cut, and both shall discharge to a public drain, a trained jhora or a stable natural channel as item (j) requires, not onto the slope below. Every retaining wall that holds up a slope shall have weep holes or weep pipes and a subsurface drain that discharge into a lined drain at its foot, not onto the slope below or into the backfill of a wall below. The building rule already sets the path, but not the size: roof water shall not "fall on any road/footpath", and the gutter and down pipe shall be "of such design and capacity that the water will neither spill out of them nor leak through them" and connected "to the storm water plinth protection drain of the building" (SBCR 1991, reg. 21); the "Pucca storm water/plinth protection drain" shall lead "to the road side drain or to adjoining permanent drains or jhora to drain off the surface water" (reg. 25(iv)); and spoil shall not be dumped on "drains, gullies and jhoras", on a fine of ₹500 at the least (reg. 22), with a refundable security of ₹5,000 against spoil dumped "at road side including drain" and damage to "the road including drainage system" (Form III, cl. 15). The 2021 stability zones add the condition for review of a site's zone: "Proper channelization of surface runoff by providing catchment drains especially during the rainy seasons and connect it to natural waterways/Jhora which also improves the stability of the area due to reduced erosions and percolation of water" (Notification No. 17/DMG/20-21, 19 March 2021). This Manual adds what they leave out: every gutter, down pipe, plinth drain, catchment drain and conduit that carries a site's or an uphill site's water shall be sized for the minor design flow of Table 6.1 from its whole tributary area, with the rainfall of Chapter 2, the factors of items (g) and (h) and the freeboard of Table 6.7, and checked for a 1% AEP flow path that does not pass onto a building or an unprotected slope; the jhora or road drain it reaches shall be checked under Clause 5.8.5(a) or (g); and a catchment drain shall reach a jhora only where that jhora is trained to item (m) or passes the check of Clause 5.8.5(a). Roof and paved-area runoff on such a site follows the hill rule of Clause 4.11. No building shall be allotted or regularised "in any sinking area, landslide prone or in areas having scars of old landslides or in slope exceeding or around 70 (Seventy) degree" (reg. 35), and no drain of this item shall discharge to such an area. Outside the notified areas no building permission under the regulations applies: this item reaches public works and any body that adopts this Manual, and is guidance for a household elsewhere (Chapter 1).
- (m) **Jhora training.** Where this Manual, a consent or a stability-zone review requires a jhora to be trained, or where a project trains one, "training" means, for this Manual, all of the following (set by this Manual): (i) a channel that carries the **1% AEP flow** of the jhora's whole catchment, post-development, **with the bulking factor of item (g) and the freeboard of Table 6.7** for steep channels; (ii) **toe and bed protection** against scour, with the foundations of walls and linings taken below the scour depth computed under Chapter 9 (Clause 9.6) for that flow; (iii) **drop structures or check dams with energy dissipation** at each fall, designed under Chapter 9, so that the velocity limits of Chapter 9 for the lining are met between falls; (iv) a **debris basin or debris rack** upstream of every culvert and closed reach (item (f)); (v) a **maintenance access**, with the access width of Clause 6.9.4 where the ground allows it and steps and anchor points where it does not, so that the channel, the falls and the basins can be cleared on the dates of item (f); (vi) **no reduction of the jhora's 1% AEP capacity** at any section, by a wall, a crossing, a pipe, a check dam or the sediment a check dam holds; (vii) **no culverting of an open jhora**, other than a road or path crossing designed under Clause 6.12; and (viii) **no diversion of a jhora** from its course without a corridor for the new course under Chapter 7 and the downstream check of Clause 5.8.5(a). Training shall be done outside the State's monsoon excavation ban, by the agency that executes the work, and recorded in the drain and jhora register (Clause 6.9) with its date and its next inspection. This is the technical content that this Manual

gives to the 2021 stability zones' "Training of jhoras/drains have been completed and done properly (with safe distance)" (zone 1) and to the condition for review "Training of untrained Jhora and maintenance at regular intervals which is located adjacent to the plot" (Notification No. 17/DMG/20-21, 19 March 2021); the Mines and Geology Department could cite it in those conditions, and has not done so. A trained jhora remains a jhora: the municipality's duty to "protect any jhora, whether on a public land or on a private land, within the municipal area" (Sikkim Municipalities Act, 2007, s.172(2)) and the corridor of Chapter 7 apply to it. Training is not a substitute for the storage of Chapter 4, and a jhora shall not be lined, stepped or walled where the check of Clause 5.8.5(a) shows that it is stable and carries the post-development flow as it is.

Commentary. The CPHEEO (2019) manual defines major and minor systems in its glossary but gives no return period for the major system. APWA 5600 (2006, 5601.8) requires the system to convey the 1% peak and, where in-system capacity is less, an overflow system to carry the remainder. Clause 6.3.3 subtracts only the *clogged* inlet capacity, not the full pipe capacity, because in practice the pipes cannot take more water than the inlets admit. The fully-blocked check at sags has no direct precedent; this Manual sets it because of the Gangtok experience that drains under footpaths are often silted or blocked by solid waste when the heaviest rain arrives (CPHEEO 2019 Part A, Ch 1 and 2, Figures 1.2 and 2.1 on solid waste dumping in drains). The prohibition on inter-catchment transfer follows the DID Malaysia 2008 submission checklist, which prohibits inter-catchment diversion. Clause 6.3.6 is set by this Manual for Sikkim, and it has two parts because the State's drains fail in two ways that the criteria of this chapter, which assume clear storm water on gentle ground, do not see. The first is sewage. The State estimates the urban sewage at 29.51 MLD against 22.71 MLD of treatment capacity installed, 17.90 MLD operational and 15.22 MLD actually treated, all of it at Gangtok's plants, and says that "Sewage of towns and areas where there is no Sewage Treatment Plants is treated through anaerobic digestion in the septic tanks of individual households" (September 2025 progress report annexed to the State's affidavit of 19 December 2025 to the National Green Tribunal); the sewerage of Namchi and Jorethang "has remained stalled since the year 2013 and 2015 respectively" (same affidavit); in Soreng the effluent of septic tanks and soak pits goes "into the open storm water drains ultimately discharging into the farmland / water bodies" (ADB due-diligence report, December 2024); and at Melli households that "had constructed their own septic tank … were reluctant to connect" to the new plant (CAG, Report No. 3 of 2016). The National Green Tribunal and the State disagree on whether sewage reaches the jhoras (item (e)). The law already separates the flows on paper: s.193 of the Municipalities Act requires "an entirely separate drain for rain water", and the building rule asks for a public-sewer connection where one is available (SBCR 1991, reg. 25(ii)). Items (a) to (e) follow the combined-sewer rules of the plains editions of this series: a site keeps its storm water separate up to the boundary, so that the town can separate its system street by street as sewers come, without going back into every plot; a development does not add to the peak of a drain that carries sewage; a non-return valve guards every connection, because what comes back up a surcharged drain is sewage; the drain is designed as the combined channel it is, with its capacity taken net of its dry-weather flow and a low-flow channel so that sewage solids do not settle in it between storms; and the outfall to a jhora that feeds a spring, a pokhari or an intake, or to a town's river, is intercepted and screened. Item (a) keeps sullage and roof water out of soak pits on the slopes because the hill rule of Clause 4.11 bars infiltration there, while regs. 6, 13(iii) and 25(i) of the SBCR 1991 still require a septic tank and soak pit for every building without a sewer; the Manual states that conflict and does not resolve it (Clauses 4.11 and 8.9). Item (e) protects the springs (dhara) because "about 80%" of rural Sikkim is reported to depend on them (as reported), and its 15 m is the Manual's Zone 1 width, since Sikkim has no statutory distance from a water source. Separation itself is for the Authority to plan, not for each site.

The second is the hills. The ridge towns stand on phyllite, schist and gneiss under thin soils and colluvium, and the slopes fail when water is put into them. The 2021 stability zones of the Mines and Geology Department say so in their own terms: zone 3 has groundwater "Medium to high" and ground that is "Wet", zone 4 ground that is "Dripping", with "Gully erosion & collapse of jhora facing slope", and is "Not suitable for habitation unless immediate protective measures" are taken (Notification No. 17/DMG/20-21, 19 March 2021); GSCDL told the National Green Tribunal that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (reply in OA 38/2022); and the June 1997 landslides in Gangtok, in a month that brought 1,281.3 mm, Gangtok's highest monthly total, with 223.8 mm on 9 June (IMD), are reported to have killed 38 people (a single

source, as reported). The roads are where the water is concentrated: NH-10 along the Teesta has become "prone to submergence and subsidence" (PPR, 2026), it was submerged by the Teesta in July 2025, and the High Court warned IRCON, which is building the Sevoke–Rangpo railway, to correct damage to NH-10's drainage (June 2025) (both as reported). No Sikkim allowance for debris, bulking or blockage was found during research [TBC], and no Indian guidance on bulking factors, debris racks or debris basins [TBC], so each number in items (f) to (l) is the interim value of the hill and mountain editions of this series, with the same reasons. The 1 ha trigger for a debris rack reflects the few minutes' time of concentration on hill slopes. The bulking factor of 1.25 is the factor for a flow that carries a fifth of its volume as sediment (bulking factor = 1 / (1 − sediment fraction by volume)), about the most that a drain can carry and still behave as a water flood; a flow with more behaves as a debris flow, which no drain can be sized for, so item (g) keeps buildings and outfalls out of its path. The 3.0 m limit in item (h) doubles the core's 1.5 m because boulders, timber and waste block openings that leaves alone do not. The 1.0 m/s minimum in item (i) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm, because hill drains carry gravel. The mid-season clearance of item (f) is due by 30 April, not by 31 May or 15 May as in most other North-East editions of this series, because the two largest 24-hour falls recorded in the State fell in May, at Singhik on 12 May 1981 and at Gangtok on 30 May 1975 (Chapters 2 and 10). IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently, with lined side drains and culverts at closer intervals than in plain areas, and item (k) keeps road runoff off unprotected slopes because water discharged onto a slope raises its pore pressure (Clause 4.11). Item (j) bars unlined drains on steep ground, colluvium, fill and the unstable zones, because an unlined drain there is the infiltration that the hill rule forbids. Item (l) takes the drainage clauses of the SBCR 1991, which fix the path of a building's water (gutter, down pipe, plinth drain, road drain or jhora) but no size, and the catchment-drain condition of the 2021 zones, as the minimum layer, and adds the design storm, capacity and freeboard that they leave out.

Item (m) is new in this series. The State's building rule already ties a site's buildability to its jhora, from zone 1, where the "Training of jhoras/drains have been completed and done properly (with safe distance)", to zone 4, with an "Untrained jhora/ erosional potential jhora", and makes "Training of untrained Jhora and maintenance at regular intervals which is located adjacent to the plot" a condition for reviewing a site's zone; but no document found during research says what "training" or "properly" means in numbers, and no design storm was seen for GSCDL's "Construction of drainage and jhora training works" (about ₹13.41 crore, as reported) [TBC]. Item (m) supplies that meaning. The 1% AEP capacity with bulking matches the major-system standard of this chapter, because a jhora is the major system of a ridge town; toe and bed protection and drop structures are what stop the "Gully erosion & collapse of jhora facing slope" of zone 4; the debris basin and the access keep the trained channel working after the first storm; and the three prohibitions, no loss of capacity, no culverting and no diversion without a corridor, stop training from becoming a way to build over or move a jhora that s.172(2) of the Municipalities Act says the municipality "shall protect". The last sentence of item (m) keeps training to the jhoras that need it: the problem of most jhoras is the water and debris put into them, not their roughness, and storage on the sites above (Chapter 4) comes first.

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## 6.4 Design return periods

6.4.1 The minor system, roads and crossings shall be designed for the AEPs of Table 6.1. Where both a land-use row and a road-class row apply to an element, the **rarer** AEP (longer return period) governs.

**Table 6.1 — Design AEPs for conveyance (matches Clause 2.4)**

| Element | Design AEP (return period) | Check event | Basis |
|---|---|---|---|
| Minor system: Gangtok, Namchi, Jorethang and Rangpo core and other high-density areas | 10% (10-yr) | 1% (100-yr) overland path | This Manual (see Commentary) |

| Element | Design AEP (return period) | Check event | Basis |
|---|---|---|---|
| Minor system: other Class I areas | 20% (5-yr) | 1% overland path | This Manual; CPHEEO Table 4.1 |
| Minor system: other areas | 50% (2-yr) | 1% overland path | This Manual; CPHEEO Table 4.1 |
| Arterial road drainage and crossings | 2% (50-yr) for arterials that are notified evacuation or emergency routes; 4% (25-yr) for other arterials | Next higher AEP: 1% for a 2% design; 2% for a 4% design | This Manual (25–50-yr); split set by this Manual |
| Collector road drainage and crossings | 4% (25-yr) | 2% (50-yr) | This Manual |
| Local road drainage and crossings | 10% (10-yr) | 4% (25-yr) | This Manual |
| Road underpasses and other trapped sags on public roads | 2% (50-yr) | 1% (100-yr) | This Manual (Clause 6.10.5) |
| Airports, railway stations, power stations and other critical infrastructure | 1% (100-yr) in Class I areas; 2% (50-yr) elsewhere | — | CPHEEO 2019 Table 4.1 |
| Major (overland) system, every element | 1% (100-yr) | — | This Manual |
| Building floor levels | 1% level + 0.5 m freeboard | — | This Manual (Clause 6.11) |

6.4.2 **Check events.** At the check event of Table 6.1, the combined minor and major system shall carry the check-event flow within the 1% AEP limits of Table 6.2 and without water entering any building. The 1% overland path requirement of Clause 6.3.2 applies in addition to the check event.

6.4.3 **Higher standards.** An approving authority may adopt a rarer AEP for any element, including through the high-powered committee route in Note 2 of CPHEEO Table 4.1. It shall not adopt a more frequent AEP than Table 6.1.

6.4.4 **High-density areas.** The approving authority shall notify, by map, the high-density areas to which the 10% AEP minor-system standard applies. Until it does, the 10% AEP standard applies to:

- (a) in Gangtok, the sewered zones of the city served by the treatment plants at Adampool, Ranipool, Lower Sichey, Lower Syari and Tathangchen (State affidavit to the National Green Tribunal, December 2025), with MG Marg, whose back drainage GMC was reported to have begun refurbishing (as reported); with the boundary of each, and whether it is densely built, to be confirmed by GMC [TBC]; and in Namchi, Jorethang and Rangpo, the older, densely built core of each town, to be identified by its urban local body [TBC];
- (b) in every other municipal area and notified area, the area that a development plan identifies as the core area once the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced) is in force and such a plan is published, and until then the main bazaar and the densely built centre of the town as its local body identifies them by map [TBC]; and
- (c) any area in a Tier A body where the master plan permits a floor space index above the base value for the zone.

6.4.5 **Retrofit.** Where an existing drain cannot practicably be enlarged to the Table 6.1 AEP, the shortfall shall be made good by upstream storage (Chapter 4), regional storage (Chapter 7) or an improved major-system path. The approving authority shall record the residual level of service.

> **Commentary.** The values in Table 6.1 match the Clause 2.4 summary and add rows for underpasses and critical infrastructure. They exceed the CPHEEO (2019) national advisory minimums of 5-yr for Class I cities and 2-yr elsewhere (CPHEEO Part A, Table 4.1). Note 2 of that table allows a State committee to adopt higher values. The 10-yr tier for high-density areas follows Gupta (IIT Bombay), who recommends "1 in 10 year for residential-high

density", and Malaysia's MSMA 2, which uses 10-yr minor and 100-yr major systems for link houses, apartments, commercial and industrial land. The road values resolve a conflict in Indian codes. IRC:SP:50-2013 recommends 1–2 years for urban road drains. IRC:SP:42-2014 suggests 25 years for urban roadside drains and a check flood at the next higher return period. APWA 5600 (2006) uses 50-yr for arterial, 25-yr for collector and 10-yr for residential street crossings. Table 6.1 adopts the APWA tiers and the IRC:SP:42 check-flood concept. Splitting arterials into 50-yr evacuation routes and 25-yr others has no direct precedent and is set by this Manual. The 50-yr standard for underpasses is likewise set by this Manual, because an underpass is a trapped sag where the failure mode is deep water on a live carriageway. The default high-density areas in Clause 6.4.4 are set by this Manual and apply until the approving authority notifies a map.

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## 6.5 Street hydraulics: spread, depth and flow hazard

6.5.1 **Gutter flow.** Flow in a triangular kerb-and-gutter section shall be computed with the modified Manning (Izzard) equation:

$$Q = (Ku / n) \cdot Sx^{(5/3)} \cdot SL^{(1/2)} \cdot T^{(8/3)}$$

where Q is the gutter flow (m³/s), Ku = 0.376 (SI), n is the Manning roughness of the gutter (Table 6.6), Sx is the cross slope (m/m), SL is the longitudinal slope (m/m) and T is the spread (m). Composite and depressed gutter sections shall be analysed by the methods of FHWA HEC-22 (4th edition, 2024).

6.5.2 **Spread and depth limits.** Street flow shall not exceed the limits of Table 6.2.

**Table 6.2 — Street flow limits**

| Road class | Minor design event (Table 6.1) | Check event and 1% AEP event |
|---|---|---|
| Arterial | Spread shall leave at least one through lane in each direction clear of water. No flow across the crown. | Depth ≤ 150 mm at the crown and ≤ 350 mm at the deepest point; hazard limits of Clause 6.5.3 |
| Collector | Spread T ≤ 3 m. No flow across the crown except at a sag intersection. | As above |
| Local | Spread T ≤ 3 m. Flow shall not overtop the kerb. | As above |
| All classes, at intersections | Cross-flow over the crown ≤ 0.03 m³/s at sag intersections and superelevation transitions; none at mid-block sags. | As above |

6.5.3 **Flow hazard limits.** In the check event and the 1% AEP event, the product of depth (D, m) and velocity (V, m/s) of street and overland flow shall not exceed the limits of Table 6.3.

**Table 6.3 — Flow hazard limits for streets and overland flow paths**

| Location | Required hazard class (Table 6.4) | Limits |
|---|---|---|
| Carriageways of all roads | H2 or better | D·V ≤ 0.6 m²/s; D ≤ 0.35 m (Table 6.2); V ≤ 2.0 m/s |
| Footpaths, pedestrian crossings, school, hospital and transit-stop frontages | H1 | D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s |
| Notified evacuation and emergency routes | H1 | D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s |

| Location | Required hazard class (Table 6.4) | Limits |
|---|---|---|
| Overland flow paths in public open space or easements, away from roads | H3 or better, with warning signs | D·V ≤ 0.6 m²/s; D ≤ 1.2 m; V ≤ 2.0 m/s |

**Table 6.4 — Combined flood hazard vulnerability classes (reproduced for reference)**

| Class | Description | D·V limit (m²/s) | Depth limit D (m) | Velocity limit V (m/s) |
|---|---|---|---|---|
| H1 | Generally safe for vehicles, people and buildings | ≤ 0.3 | 0.3 | 2.0 |
| H2 | Unsafe for small vehicles | ≤ 0.6 | 0.5 | 2.0 |
| H3 | Unsafe for vehicles, children and the elderly | ≤ 0.6 | 1.2 | 2.0 |
| H4 | Unsafe for vehicles and people | ≤ 1.0 | 2.0 | 2.0 |
| H5 | Unsafe for vehicles and people; buildings vulnerable to structural damage | ≤ 4.0 | 4.0 | 4.0 |
| H6 | Unsafe for vehicles and people; all buildings vulnerable to failure | > 4.0 | — | — |

Source: AIDR Guideline 7-3, *Technical flood risk management guideline: Flood hazard* (2014), Tables 1 and 2, modelled after Smith and Wasko (2012).

6.5.4 Depth and velocity for Clause 6.5.3 shall be taken from the gutter-flow calculation for simple sections, or from a 1D or 2D hydraulic model where flow leaves the kerb-and-gutter section.

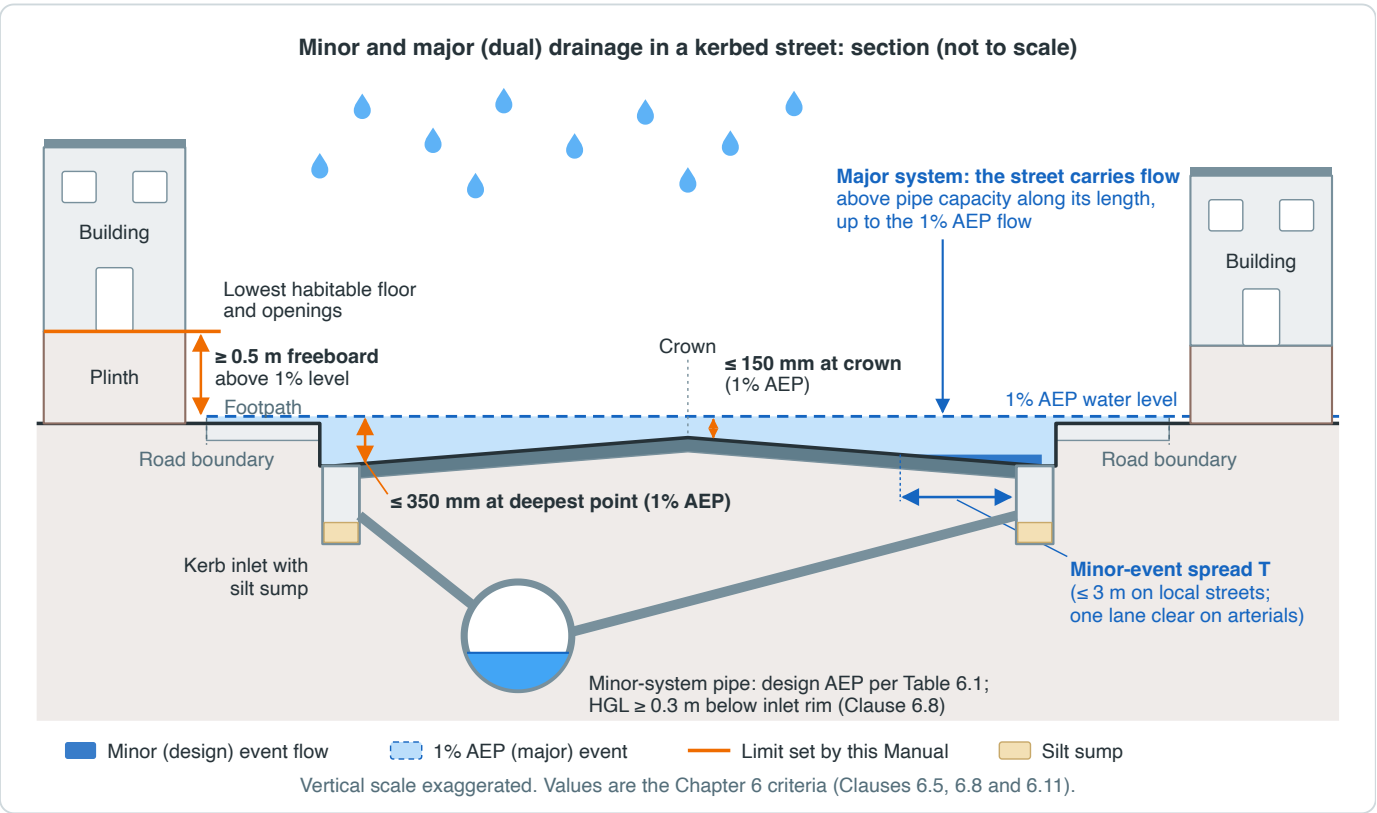


*Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).*

> **Commentary.** The Izzard form of Manning's equation with Ku = 0.376 is used both in FHWA HEC-22 and in the CPHEEO (2019) manual (Part A, Example 5.5, where the constant is written Kc = 0.376). The arterial spread rule (one lane clear) and the 3 m spread for local and collector streets are close to the APWA 5600 (2006, 5604.2) limit of 12 ft (3.66 m) from the back of kerb in each outside lane. The cross-flow limit of 0.03 m³/s is the SI equivalent of the APWA limit of 1.0 cfs at intersection sumps and superelevation transitions, with no cross-flow at mid-block sumps. The 150 mm and 350 mm depth limits are close to the APWA 5600 limits for 1% overflow at road crossings (7 in, about 180 mm, at the crown; 14 in, about 360 mm, at the deepest point). Mumbai's criterion of no flooding above 15 cm (IRC:SP:50-2013, §6.4.1) is a local precedent for the 150 mm crown value.
>
> The hazard classes of Table 6.4 are the combined hazard curves published by the Australian Institute for Disaster Resilience (AIDR Guideline 7-3, 2014), which are modelled after Smith and Wasko (2012). Requiring H2 or better on carriageways means the 1% depth limit of 350 mm (Table 6.2) governs the depth, and the D·V product controls fast, shallow flow on steep streets. H2 is described as "unsafe for small vehicles". Two-wheelers are the dominant vehicles on Sikkim streets, so the 1% event must be treated as a road-closure event on all roads except notified evacuation routes, which must meet H1. The assignment of hazard classes to locations in Table 6.3 has no direct precedent and is set by this Manual.

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## 6.6 Inlets

6.6.1 **Inlet types.** Inlets may be kerb-opening inlets, grate inlets, combination inlets (a grate with a kerb opening) or slotted and trench drains. On public streets:

- (a) kerb-opening or combination inlets shall be used, unless the approving authority accepts grate-only inlets for a specific location;
- (b) inlet openings shall be set at road level, with a gutter depression where practicable, so that water is not held on the carriageway by a raised kerb or footpath;
- (c) grates in carriageways, cycle lanes and footpaths shall be of a bicycle- and pedestrian-safe pattern (Chapter 9, Clause 9.11).

6.6.2 **Inlet capacity.** The clean capacity of inlets on grade and in sags shall be computed by the methods of FHWA HEC-22 (4th edition, 2024), or from tested ratings published by the manufacturer for the exact grate and kerb-opening geometry. The empirical kerb-inlet equations of CPHEEO (2019) Part A §5.6.2 may be used as a cross-check only.

6.6.3 **Clogging factors.** The design capacity of every inlet shall be its clean capacity reduced by the clogging factors of Table 6.5:

**Table 6.5 — Inlet clogging factors (share of clean capacity assumed lost)**

| Inlet type | On grade | In a sag |
|---|---|---|
| Grate | 50% | 50% |
| Kerb opening | 10% | 20% |
| Combination | Apply the grate and kerb factors to each part separately | Apply the grate and kerb factors to each part separately |

Design capacity = (1 − clogging factor) × clean capacity.

6.6.4 **Inlet spacing.** Inlets shall be located by a sequential calculation that starts at the top of each gutter run. At each inlet, the intercepted flow is computed, and the bypass flow is added to the gutter flow arriving at the next inlet. Spacing shall be such that the spread limits of Table 6.2 are met everywhere in the minor design event. In addition:

- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass flow from the last inlet of a run shall not be passed onto a road of a higher class or into private land.

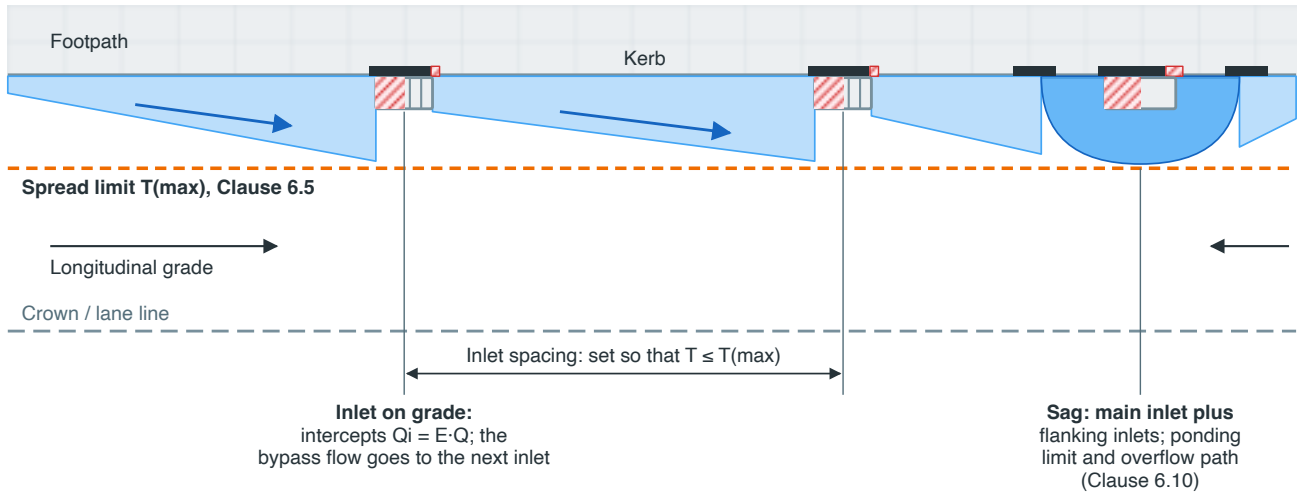
6.6.5 **Sag inlets.** At a sag on a kerbed road:

- (a) the sag inlet's design capacity (after clogging) shall be not less than the total minor design flow arriving at the sag;
- (b) flanking inlets shall be placed on each side of a sag on any road where ponding could spread beyond the Table 6.2 limits, and at every underpass;
- (c) the ponding at the sag shall comply with Clause 6.10.

6.6.6 **Inlet connections.** The pipe connecting an inlet to the main drain shall have a diameter of at least 300 mm and shall be laid at a gradient that gives at least 0.9 m/s at the inlet's design flow.

6.6.7 **Silt sumps.** Every inlet chamber on a public road shall have a silt sump at least 300 mm deep below the invert of its outlet pipe, accessible for cleaning from the surface.

**Gutter spread, inlet interception and clogging: plan (not to scale)**




**Clogging factors (share of clean capacity lost), Clause 6.6**

| Inlet type | On grade | Sag |
|---|---|---|
| Grate | **50%** | **50%** |
| Kerb opening | 10% | 20% |
| Combination | Each part as above | Each part as above |

Gutter flow spread (minor event)
Ponding at sag
Assumed clogged portion
Kerb opening

*Figure 6.2 — Gutter spread, inlet interception and clogging. Original drawing for this Manual, adapted from FHWA, HEC-22 Urban Drainage Design Manual (3rd ed., 2009; 4th ed., 2024) and CPHEEO, Manual on Storm Water Drainage Systems (2019).*

Commentary. The clogging factors are more severe than the APWA 5600 (2006, 5604.2) rating of sump inlets at 80% of theoretical capacity (a 20% reduction), because grates in Sikkim streets are routinely blinded by plastic and leaves. CPHEEO (2019) Part A shows solid waste dumped in drains as a primary cause of drain failure (Figures 1.2 and 2.1). APWA 5600 (2006) allows only kerb-opening inlets on public streets; Clause 6.6.1(a) is less strict because combination inlets are useful on flat roads. No standard inlet, kerb-channel or covered-drain detail of the Roads and Bridges Department (PWD), of GMC or of another urban local body was found during research [TBC]; the building rule asks only that roof water go by gutter and down pipe to "the storm water plinth protection drain of the building" (SBCR 1991, reg. 21) and that the plinth drain lead to "the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)), and it sets no inlet. The 30 m maximum spacing and the treatment of combination inlets in Table 6.5 have no direct precedent and are set by this Manual. Roads on the valley floors of Rangpo, Singtam, Melli, Majitar and Jorethang are flat, which shortens the calculated spacing anyway; on the steep streets of Gangtok, Namchi, Gyalshing and the other ridge towns gutter flow runs fast and passes inlets by, which Clause 6.3.6(j) deals with. A fixed cap stops a single blocked inlet from leaving a long dry gutter run. The 300 mm silt sump is set by this Manual. It matches the 0.3 m sump shown on the CPHEEO catch-basin detail (CPHEEO 2019, Figure 5.9).

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## 6.7 Pipes and open and covered drains

6.7.1 **Uniform flow.** Pipe and drain capacity shall be computed with Manning's equation:

$$V = \frac{1}{n} \cdot R^{2/3} \cdot S^{1/2}; \quad Q = A \cdot V$$

where V is the mean velocity (m/s), n is the Manning roughness (Table 6.6), R is the hydraulic radius (m), S is the friction slope (m/m), A is the flow area (m²) and Q is the discharge (m³/s). Where backwater from a tailwater, a junction or a structure affects the water level, a gradually varied flow (standard step) or hydraulic network model shall be used, and the HGL requirements of Clause 6.8 apply.

6.7.2 **Manning roughness.** Design values of n shall be taken from Table 6.6. For concrete pipes and masonry or concrete drains, the design value shall be not less than the "fair" or "rough" condition value listed, to allow for sediment, biofilm and ageing.

**Table 6.6 — Manning's n for design (from CPHEEO 2019)**

| Material | Condition | n (CPHEEO) | Minimum design n in this Manual |
|---|---|---|---|
| Cement concrete pipe (collar joints) | Good / fair | 0.013 / 0.015 | 0.015 |
| Spun concrete pipe (RCC, PSC) with S/S joints | Manufacturer's design value | 0.011 | 0.013 |
| HDPE / uPVC pipe | — | 0.010 | 0.011 |
| Plastic (smooth), asbestos cement | — | 0.011 | 0.011 |
| Concrete drain, steel trowelled / wood trowelled | — | 0.014 / 0.015 | 0.015 |
| Sand and cement plaster | — | 0.015 | 0.015 |
| Brick masonry | Good / rough | 0.015 / 0.017 | 0.017 |

| Material | Condition | n (CPHEEO) | Minimum design n in this Manual |
|---|---|---|---|
| Masonry | Bad condition | 0.020 | 0.020 |
| Rubble set in cement | — | 0.017 | 0.017 |
| Earth channel | Regular, good / ordinary | 0.020 / 0.025 | 0.025 |
| Earth channel | With stones and weeds / poor | 0.030 / 0.035 | 0.035 |
| Earth channel | Partly obstructed by debris or weeds | 0.050 | 0.050 |
| Gutter: concrete | — | 0.013 | 0.013 |
| Gutter: hot-mix asphalt | — | 0.015 | 0.015 |
| Gutter: sprayed seal | — | 0.018 | 0.018 |

Source of the CPHEEO column: CPHEEO (2019) Part A, Table 5.1 (itself from the CPHEEO Manual on Sewerage and Sewage Treatment Systems, 2013) and Table 5.8 (gutters).

6.7.3 **Velocity limits.** At the minor design flow:

- (a) minimum (self-cleansing) velocity: **0.6 m/s** in open and covered drains and **0.9 m/s** in pipes;
- (b) maximum velocity: **3.0 m/s** in lined drains and in pipes, unless the drain or pipe is designed as a chute under Chapter 9. CPHEEO permits up to 6.0 m/s in plastic or plastic-lined pipes in hilly regions; this may be used in Gangtok, Pakyong, Namchi, Ravangla, Gyalshing, Pelling, Soreng, Mangan, Lachen, Lachung and other hill towns with the approving authority's agreement;
- (c) maximum velocity in unlined and vegetated channels: Chapter 9, Table 9.2;
- (d) the Froude number of flow in open and covered drains shall not exceed 0.8 at the design flow, unless the drain is designed for supercritical flow under Chapter 9.

6.7.4 **Gradient.** Each pipe and drain shall be laid at a gradient that achieves Clause 6.7.3(a). Where flat terrain or a fixed outfall level makes this impossible, the designer shall:

- (a) report the velocity achieved;
- (b) double the sediment allowance of Clause 6.7.8; and
- (c) provide access for mechanical desilting at the spacing of Clause 6.13.2.

6.7.5 **Pipe flow condition.** Pipes shall be sized so that the minor design flow does not exceed the pipe-full capacity. The greater discharge that a circular pipe carries at about 0.95 of its depth shall not be relied on.

6.7.6 **Minimum sizes.**

- (a) Pipes: 300 mm internal diameter; **450 mm** for public mains.
- (b) Open drains: bed width 0.3 m.
- (c) Covered public drains (drains closed by cover slabs): clear internal width **0.6 m** and clear internal depth **0.6 m**.

6.7.7 **Cover to pipes.** Pipes shall have at least 0.6 m of cover to finished level, and at least 0.9 m under carriageways unless a structural design for the traffic load is submitted. Where the seasonal high groundwater table is within 1 m of the pipe crown, the pipe shall be checked for flotation with the pipe empty (CPHEEO 2019, Table 11.2) and anchored where necessary.

6.7.8 **Sediment allowance.** The design capacity of open drains, covered drains and pipes of 600 mm diameter or more shall be computed with the following depth of sediment at the invert:

- (a) open and covered drains: the greater of **75 mm** and **10%** of the clear internal depth;
- (b) pipes of 600 mm diameter or more: **5%** of the internal diameter;
- (c) pipes below 600 mm: no allowance, but Clause 6.7.3(a) shall be met.

The Manning n for the reduced section shall be that of the drain material in Table 6.6.

6.7.9 **Freeboard in open and covered drains.** At the minor design flow, the water surface (computed with the sediment allowance) shall be below the top of the drain wall, or below the soffit of the cover slab in a covered drain, by at least the freeboard of Table 6.7.

**Table 6.7 — Minimum freeboard in open and covered drains**

| Drain | Minimum freeboard | Source |
|---|---|---|
| Bed width up to 300 mm | 100 mm | CPHEEO 2019 Table 5.3 (from IRC:SP:50-2013) |
| Bed width 300–900 mm | 150 mm | CPHEEO 2019 Table 5.3 |
| Bed width 900–1,500 mm | 300 mm | CPHEEO 2019 Table 5.3 |
| Wider drains and engineered channels, Q < 3 m³/s | 450 mm | CPHEEO 2019 Table 5.12 (from IS 7784 (Part 1): 1993) |
| Q 3 to < 30 m³/s | 600 mm | As above |
| Q 30 to < 300 m³/s | 900 mm | As above |
| Q 300 to < 3,000 m³/s | 1,200 mm | As above |
| Q ≥ 3,000 m³/s | 1,500 mm | As above |
| Any roadside drain | Not less than 150 mm | IRC:SP:42-2014 |
| Steep (supercritical) channels | Equal to the flow depth | CPHEEO 2019 §5.3.2 |

At bends, the freeboard shall be measured from the water level on the outside of the bend, including the superelevation $\Delta y = V^2 T / (2\,g\,r_c)$, where T is the top width and $r_c$ the centreline radius (CPHEEO 2019, Eq. 5.29).

6.7.10 **Bends and junctions.**

- (a) The centreline radius of a bend in a drain shall be at least 3 times the drain width (CPHEEO 2019 §5.3.3). In engineered channels it shall be at least 2 times the top width and not less than 30 m (CPHEEO 2019 Table 5.11).
- (b) Where drains meet, a junction sump shall be provided with an internal width of at least twice the width of the outgoing drain. Incoming drains shall enter at less than a right angle to the outgoing flow, and the outgoing invert shall be below the sump floor so that water does not stand in the sump (CPHEEO 2019 §5.3.4).

6.7.11 **Manholes and access chambers on pipes.** Manholes shall be provided at every junction, change of size, alignment or gradient, and at the head of every pipe. Spacing on straight runs shall not exceed Table 6.8.

**Table 6.8 — Maximum spacing of manholes on straight pipe runs**

| Pipe diameter | Maximum spacing |
|---|---|
| 300–600 mm | 40 m |
| 700–1,000 mm | 100 m |
| 1,050–1,400 mm | 150 m |
| 1,500 mm and above | 300 m |

Source: CPHEEO 2019 Table 11.5. Manhole sizes, drops and covers: Chapter 9, Clause 9.12.

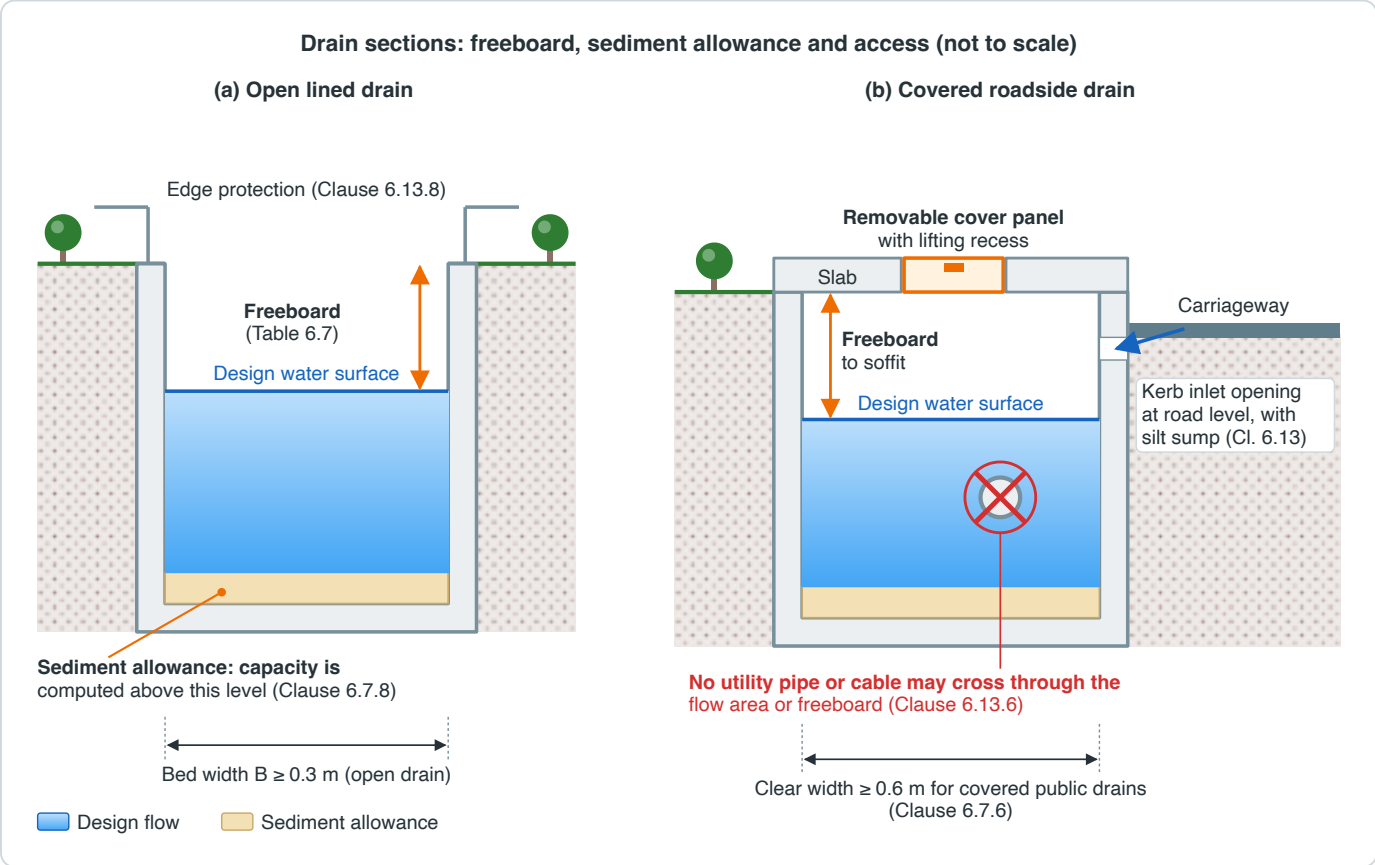


*Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.*

**Commentary.** The n values are those of CPHEEO (2019) Table 5.1. The higher minimum design values have no direct precedent; this Manual sets them because CPHEEO notes that the 0.011 value for spun pipes "may be taken as given by the manufacturer". That is a clean-pipe value, and Sikkim drains carry heavy silt and solid waste. The 0.6 m/s minimum velocity is CPHEEO's (Table 5.2), based on carrying 0.09 mm sand (§5.3.1). The 0.9 m/s value for pipes is stricter, because a silted pipe cannot be cleaned as easily as an open drain. The 3.0 m/s maximum is from CPHEEO Table 5.2 (WPCF/ASCE 1982). The Froude limit of 0.8 is from CPHEEO §5.3, which advises avoiding critical flow because the water surface becomes unstable.

The 0.6 m × 0.6 m minimum for covered drains has no direct precedent and is set by this Manual. A covered drain narrower than this cannot be desilted by hand or by small machines through a cover opening, and silted, inaccessible drains were a recurring finding after the storms of Gangtok, although no survey of the State's drains was found [TBC]: the drainage and landslip-protection projects of the city's development plan of 2006 "were not taken up" (CAG, Report No. 3 of 2016), GMC contracts its waste agency for the "Clearing of Jhoras" and bars it from dumping "along Footpath, Roadside and Jhoras" (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024), and the State's monsoon notice orders building material "lying on the road setback or over drains" to be seized (UD&HD Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019). The 0.6 m minimum cover is the value used in the CPHEEO (2019) worked pipe-design computation sheet (Part A, Chapter 5). The 0.9 m cover under carriageways is set by this Manual.

The sediment allowance values (75 mm or 10% for drains, 5% for large pipes) are set by this Manual. No Indian standard sets a sediment allowance for design. Gangtok's experience is that drains run partly full of silt for much of the year, so a capacity computed for a clean section overstates the real capacity.

The CPHEEO freeboard table (Table 5.3) prints the first row as "Beyond 300 mm bed width". Read with the second row ("Beyond 300 mm & up to 900 mm"), the first row must mean "up to 300 mm"; Table 6.7 is written that way. The CPHEEO manhole spacing table (Table 11.5) gives overlapping ranges (700–1,050 mm and 1,000–1,400 mm); Table 6.8 removes the overlap by assigning 1,050 mm to the 150 m class.

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## 6.8 Hydraulic grade line

6.8.1 **HGL analysis.** For every pipe and covered-drain network, the designer shall compute the HGL for the minor design event and for the check event, starting at the outfall and working upstream. The analysis shall include friction losses and losses at junctions, manholes, bends, inlets, outlets and gates.

6.8.2 **Starting water level.** The starting (tailwater) level at the outfall shall be the higher of:

- (a) the tailwater level of Chapter 5: mean high water springs (MHWS) plus the sea-level allowance of +0.3 m for minor-system design at tidal outfalls, and the level in the receiving drain, river or tank for the coincident event at other outfalls; and
- (b) the level computed at the outlet pipe from the critical depth and the pipe diameter, (dc + D)/2, where the receiving water is lower.

6.8.3 **Minor-event limit.** In the minor design event, the HGL shall be at least **0.3 m below** the rim of every inlet and the cover level of every manhole and access chamber.

6.8.4 **Check-event and 1% limit.** In the check event and the 1% AEP event, the HGL may rise above the inlet rims. Water that leaves the minor system shall then be carried by the major system within the limits of Table 6.2 and shall not enter any building. Manholes that can surcharge above ground in these events shall have bolted or locked covers (Chapter 9, Clause 9.12).

6.8.5 **Structure losses.** Losses at manholes and junctions shall be computed by the energy-based access-hole method of FHWA HEC-22 (2009 or 2024 edition), or by an equivalent method in an approved hydraulic model. A simplified loss-coefficient method ($h = K V^2/2g$) with coefficients from HEC-22 may be used for Tier B networks below 16 ha.

6.8.6 **Invert and soffit levels.** Where pipe size increases at a manhole, the soffits (crowns) of the incoming and outgoing pipes shall be matched, or the outgoing soffit set lower. The outgoing invert shall not be higher than the lowest incoming invert. Vertical drops in manholes shall follow Chapter 9, Clause 9.12.

6.8.7 **Gates and valves.** The head loss through flap gates and non-return valves in the open position shall be included in the HGL (Chapter 9, Clause 9.10).

6.8.8 **Private connections.** Building drainage that connects to a public drain whose 1% HGL is above the building's lowest drainage fitting shall have a non-return valve.

Commentary. The 0.3 m clearance between the minor-event HGL and the inlet rim is set by this Manual. It keeps a margin for losses that a model underestimates, and it stops water from bubbling out of inlets in the event the system is designed for. In Sikkim most town drains on the ridges end in a jhora that falls freely below the outfall, so the free outfall is usually right, but only after the jhora's own 1% AEP level at the outfall has been checked, because the jhoras rise within minutes, carry boulders and slide debris and can stand over a low outlet (Clause 5.8.5(a)). The drains of the valley floors end in rivers held high for days, at Rangpo, Singtam and Melli on the Teesta and at Jorethang on the Rangit, on a bed that the flood of October 2023 raised by about 2 to 7.4 m (Clause 5.8.5(b)); outfalls below a hydropower dam end in a release reach (Clause 5.8.5(c)); and the drains of the towns carry sullage into the jhoras (Clause 8.9). No flood level of any jhora in a town, and no design level of any outfall, was found during research. A drain whose HGL is started from a free outfall without that check, or from a river level read on the bed before 2023, or computed one length at a time without the jhora, river or reservoir level, fails

in exactly that way. An HGL computed from the outfall, with the tidal tailwater of Chapter 5, exposes those errors at design stage. The MHWS plus 0.3 m starting level is from CPHEEO (2019) Table 6.2. The access-hole method is described in HEC-22 from the 2009 edition onward.

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## 6.9 Major system: overland flow paths, easements and drainage reserves

6.9.1 **Streets as the primary major system.** Streets shall be graded so that the 1% AEP major-system flow is carried along the road reserve to a receiving waterway without being trapped, except at sags designed under Clause 6.10.

6.9.2 **Overland flow paths outside streets.** Where a major-system path leaves the road reserve, it shall be:

- (a) in public land, in the open space of a layout, or in an easement recorded on the layout approval and the title;
- (b) at least as wide as the 1% AEP flow top width plus 0.5 m on each side, and not less than 3.0 m;
- (c) kept free of buildings, compound walls, fences, fill, stored materials and planting that would obstruct flow;
- (d) graded to a continuous fall with no sag that lacks an outlet; and
- (e) within the hazard limits of Table 6.3.

6.9.3 **Compound walls.** A compound wall or fence shall not be built across a mapped overland flow path. Where a wall must cross one, it shall have openings with a total area that passes the 1% AEP flow with a 50% blockage, without raising the upstream water level above the limits of this chapter.

6.9.4 **Access along open drains.** Open drains with a top width of 2 m or more shall have a maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m.

6.9.5 **Supply channels, surplus courses and tanks.** Tank supply channels and surplus courses are part of the major system and shall be protected under Chapter 7.

6.9.6 **Drainage reserves.** A drainage reserve is a strip of land, including the drain, kept free of buildings so that the drain can be maintained, widened and used as a flood path. A drainage reserve shall be provided:

- (a) along every public drain or channel with an internal width of 1.0 m or more that runs through or along a layout or site being developed or redeveloped;
- (b) along every drain or channel shown in an adopted Basin Stormwater Master Plan (Chapter 11), at the width of the future drain in that plan; and
- (c) along every new public drain with an internal width of 1.0 m or more built by a public body.

6.9.7 **Width.** The reserve shall be not less than the width in Table 6.9, measured from the drain's internal width W. The width is based on the **required** drain size (for a planned drain, the size in the master plan), not the existing size. Where the access strip of Clause 6.9.4 is wider than the margin in Table 6.9, the wider governs.

**Table 6.9 — Minimum drainage reserve width (adopted from PUB Singapore)**

| Internal width of drain, W | Open drain | Closed (covered) drain |
|---|---|---|
| 1.0 m to 1.2 m | 3.0 m | W + 0.6 m |
| more than 1.2 m to 3.0 m | W + 2.6 m | W + 1.6 m |
| more than 3.0 m to 4.5 m | W + 3.5 m | W + 1.6 m |
| more than 4.5 m to 6.0 m | W + 4.5 m | W + 3.0 m |
| more than 6.0 m to 9.0 m | W + 6.0 m | W + 3.0 m |
| more than 9.0 m to 25.0 m | W + 7.5 m | W + 3.0 m |

| Internal width of drain, W | Open drain | Closed (covered) drain |
|---|---|---|
| more than 25.0 m | W + 12.0 m | W + 3.0 m |

For an open drain, the larger part of the margin shall be on the side used for maintenance access.

6.9.8 **Use and protection.**

- (a) The reserve shall be shown as a separate plot on the layout or site plan and transferred to the Approving Authority free of cost, as roads and open space reservations are. Where the drain is a Water Resources Department channel, the reserve is transferred to the Water Resources Department.
- (b) No building, compound wall, fence, ramp, step, fill or other structure shall be built in the reserve. Compound walls and boundary fences shall stand outside it.
- (c) The access strip in the reserve shall be level and continuous, and connected to a public road. Bollards or posts and chains may be used at entrances to keep out vehicles other than maintenance vehicles.
- (d) Where the reserve is not fenced off, its edge shall be marked with concrete markers at not more than 50 m spacing.
- (e) Services shall cross under the drain, with at least 1.0 m clearance below the invert, or over it on an approved structure. Services shall not run along the reserve inside the drain section.
- (f) A structure within 2 m of the edge of the reserve shall be designed to remain stable when the drain is excavated to 1.0 m below its invert. The design shall be signed by a qualified structural engineer.
- (g) The reserve counts toward the site's open space requirements only where the Approving Authority's rules allow it; it does not reduce any setback required by Chapter 7.

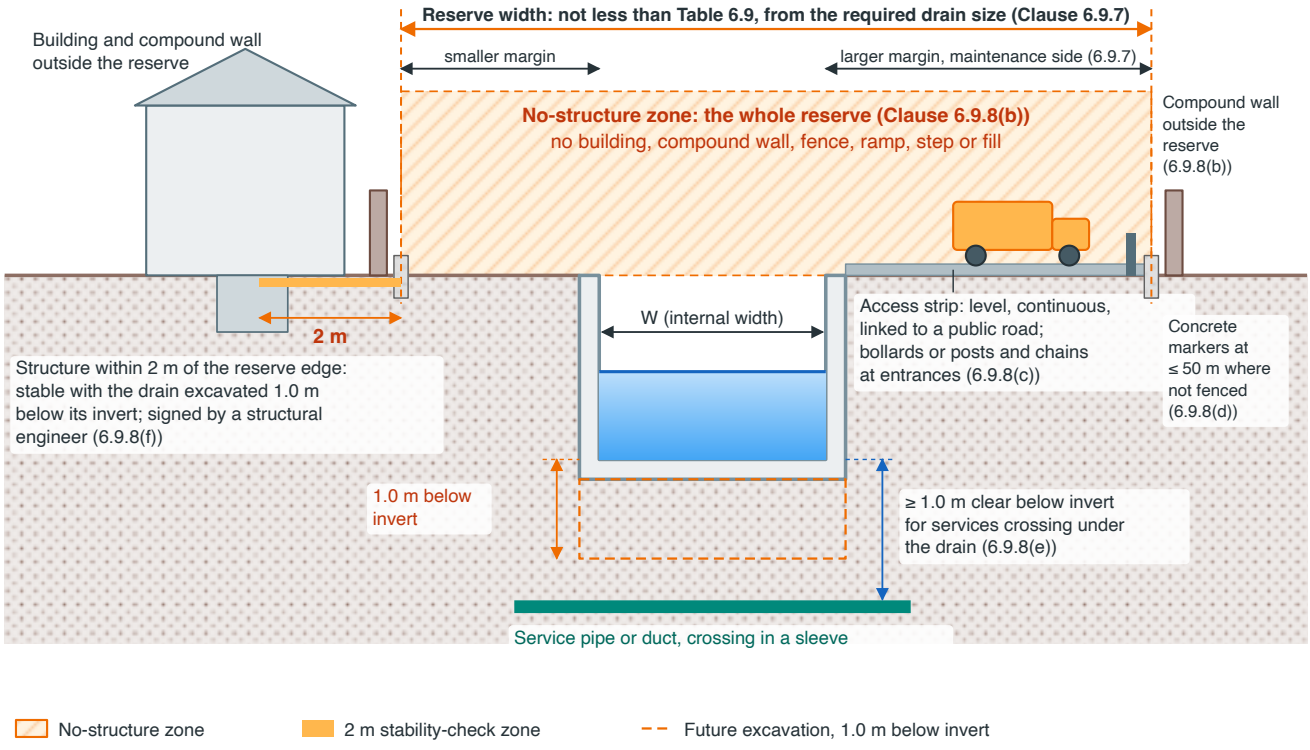


*Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, Code of Practice on Surface Water Drainage (7th ed., with Addendum No. 3, 2025), clauses 5.1, 5.3, 9.6 and 9.7 and Appendix 1.*

Commentary. Drainage reserves follow Singapore, where "the width of a drainage reserve is based on the required drain size" and the reserve is set aside as a separate plot, "kept free of all encumbrances" (PUB Code of Practice on Surface Water Drainage, 7th ed. with Addendum No. 3, 2025, cl. 1.1). Table 6.9 reproduces PUB's Appendix 1 widths. Clauses 6.9.8(b) to (f) follow PUB clauses 5.1 (no structure within a drain or drainage reserve), 5.3 and 5.3.1 (stability for excavation 1.0 m below the invert; engineer's calculations within 2 m of the reserve), 9.6 (level, continuous access, with bollards or posts and chains) and 9.7 (markers at a maximum of 50 m). The 1.0 m clearance for services crossing under a drain is from PUB's development-plan guidance. In Sikkim, buildings and compound walls are often built up to the edge of a drain, so it cannot be widened or desilted by machine. Reserving the land when a plot is developed or redeveloped is the cheapest time to secure it, because widening later needs land acquisition. Basing the width on the master-plan drain size (6.9.6(b)) protects the land a future drain will need. Sikkim has no statutory width along a drain or a jhora, and no floodplain zone of any kind. The lines that exist bind only where they apply, and each has its own status. **Jhoras: no line.** The SBCR 1991 set no setback from a jhora or a river (NEER reading); the 2021 stability zones ask only that the training of jhoras be done "with safe distance" (zone 1), a distance they do not define (Notification No. 17/DMG/20-21, 19 March 2021); the Municipalities Act makes the municipality "protect any jhora, whether on a public land or on a private land, within the municipal area" (s.172(2)) and lets the State Government "by notification, specify the limits of any jhora, watercourse or channel within a municipal area" (s.173), but no such notification was found (NEER reading). **Scheduled rivers: a maximum.** For the 103 rivers in the Schedule of the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, among them the Teesta (no. 1), the Rangeet (no. 2), the Rongni chu (no. 14), the Roro chu (no. 15), the Gangtok chu (no. 62), the Lhonakchu (no. 77) and the Khani Khola at Melli (no. 103), the river bank is "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (s.29(1)), under the Forest Department "as if it were a forest" (s.29(9), inserted in 2000); unauthorised occupation of it is an offence (s.30), and the Government may close a river bank by notification (s.32). "Whichever is less" makes the 60 m a maximum, not a minimum: on an incised reach the high-flood-level line may lie a few metres from the channel, and after October 2023 that line has itself moved (NEER reading). The Act's "river" includes "any stream, channel, jhora, creek" (s.2(m)), but the 60 m applies only to the rivers in the Schedule. **Roads and plots.** A building stands "Minimum 27 feet away from the centre of the road", with a setback of 10 feet "or as indicated in approved Master Plan of the area" (SBCR 1991, reg. 18), and a septic tank at least 4 feet from the building (reg. 25(v)); there is no slope line except the "around 70 (Seventy) degree" of reg. 35. **The Teesta after 2023.** No setback along the Teesta, and no line for the GLOF corridors, was found to have been notified after October 2023 (NEER reading); the "High-risk Zoning" of floodplains below glacial lakes in the Project Prefeasibility Report annexed to the State's affidavit of 28 February 2026 is a proposal, not a rule. **Floodplains.** No floodplain zoning law and no notified flood line exist (NEER reading); the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced) would require development plans with "proposals for flood control, land stability and sloped linked controls", but no commencement notification, rules, Board or development authority was found. None of these gives a reserve width along a jhora or a town drain. For this Manual, as its own proposal and not as the meaning of the rules, the bank of a channel is its top of bank, and on an incised jhora whose bank is a slope steeper than 10°, the crest of that bank slope; the edge of a pokhari, dhara or reservoir is as Chapter 7 defines it; and every jhora, khola and other natural channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whoever maintains it and whether or not it is lined, trained, piped or covered (all set by this Manual). This Manual therefore gives the reserve a width, as its own proposal and not as a statutory width: a **hydraulic corridor** made up of the reserve of Table 6.9, based on the drain size needed to carry the design flow with the bulking factor of Clause 6.3.6(g) (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along every natural channel that drains 8 ha or more and round every pokhari, reservoir and dhara that this Manual covers, the setbacks of Clause 7.4, with a Zone 1 of **not less than 15 m** from the top of bank, or from the crest of the bank slope of an incised jhora steeper than 10°, and a Zone 2 to the 1% AEP extent plus 10 m, which matters on the valley floors, whichever line is wider governing (set by this Manual). On a scheduled river the statutory river bank may be wider or narrower than the Manual's 15 m: where it is wider it binds as well, and where its high-flood-level line is nearer, the Manual's corridor is the stricter; on a jhora no statute sets any line, so the Manual's 15 m is a NEER proposal throughout; and where a notified jhora limit under s.173, a closure under s.32, a development plan, a notified wetland or a court sets a wider line, that line applies for

as long as it binds, and the widest governs (Clause 7.4.5). The corridor applies to new development and redevelopment approved under this Manual, not to existing buildings, and Clause 7.4.7 allows no variance below it. It is a condition of building permission in the notified and municipal areas where this Manual is applied, and a recommendation elsewhere (Chapter 1). **Land.** Jhoras on public land other than forest land within a municipal area already vest in the Municipality (s.172(1)), and the river banks of the scheduled rivers are under the Forest Department (s.29(9)); Zone 1 and reserve land that is private is **secured by agreement with the owner or by donation**, recorded on the layout approval and in the land records, or reserved in a development plan once the 2024 Act commences, and is **never taken**; where it is so secured, the transfer of Clause 6.9.8(a) is made by that recorded agreement rather than by a transfer of title (set by this Manual). Jhoras outside municipal limits and on forest land have no named protector, because s.172 excludes forest land and covers only the municipal area (NEER reading); there the corridor is recorded in the drain and jhora register and secured by agreement with the landholder and, on forest land, with the Forest Department. The corridor should be shown in a development plan once one can be made, and checked when the plan of a building is approved, where the blue-print plan already shows "drainage including connection to main outlet" (SBCR 1991, reg. 6), rather than made a new no-objection certificate.

The reserve matters because the drains of Sikkim's towns are divided among owners, and **no notification divides them** (NEER reading). On the statute, the public and other drains "shall vest in the Municipality, or the concerned Department, or organization, of the State Government, or the agency, as the case may be" (Sikkim Municipalities Act, 2007, s.189(1)); the municipality shall "construct and maintain drains and sewers, and provide a safe and sufficient outfall, in or outside the municipal area" (s.187); and the jhoras of the municipal area vest in it on public non-forest land and are under its protection on any land (s.172). The roads, the river works, the jhora-training works and the sewers are built by others. No drain inventory of any town was found [TBC]. For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows (set by this Manual): the **municipal drains, and the jhoras on public land other than forest land within a municipal area, to the urban local body** (the Gangtok Municipal Corporation in Gangtok; the Namchi Municipal Council and the Nagar Panchayats elsewhere) (ss.172(1) and 189(1)), with **every jhora in the municipal area, public or private, under the urban local body's duty to protect** (s.172(2)); the **river banks of the 103 scheduled rivers to the Forest Department** (1988 Act, s.29(9)); the **road drains to the road's owner**: the Roads and Bridges Department (PWD) for State roads, and NHIDCL or BRO for national highways (NEER reading, by inference from the roads they hold); **jhora training to the agency that executes it**: GSCDL for Smart City works (as reported), WRD for river and jhora works, and RMDD in rural areas (NEER reading), until it hands the work over in writing to the body that holds the drain; the **sewers and the treatment plants to PHED**, "the concern department for sewage management in the State" (State report in O.A. No. 673 of 2018), and **rural and peri-urban sewage to RMDD**, under whose supervision it is (State filing to the National Green Tribunal) (Clause 8.9); the **hydropower dams, their reservoirs and their gates to their operators**, whose levels are data for design, not an approval (Clause 5.8.5(c)); the **springs to no statutory owner**, RMDD's Dhara Vikas programme working on them (as reported); and the **jhoras outside municipal limits or on forest land to no named owner** (NEER reading). Each town shall keep a **drain and jhora register** that gives every reach its owner under this assignment, its land status (municipal, Forest Department, private or road reserve), whether it is a scheduled river's bank, its stability zone, whether it is trained to Clause 6.3.6(m) and when, whether it carries sewage, any flap gate on it and the body that holds the gate, and its outfall (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to WRD is transferred to, or secured for, the Water Resources Department. Where a channel's status is disputed, the corridor follows the channel and not its name: Gangtok's jhoras are at once natural watercourses, drains in law (s.2(24)) and carriers of sullage (Clause 8.9). No approved drainage master plan with a design return period was found for any town in the State. A drain sized to fit the land left beside it cannot be enlarged, which is why the reserve is based on the required size. Until a Basin Stormwater Master Plan is adopted (Clause 6.9.6(b)), the required drain size of Clause 6.9.7 is the size computed by the designer under this chapter. This Manual does not prescribe a lined or an unlined section, except where Clause 6.3.6(j) and (m) and Chapter 9 require lining on steep gradients, on colluvium and fill, and in a trained jhora. It requires the section to meet the velocity limits of Clause 6.7.3 and Chapter 9, and a reserve wide enough for an unlined or vegetated section, where one is allowed, is a reserve that keeps both options open.

> **Commentary.** Requirements 6.9.2(b)–(e), 6.9.3 and 6.9.4 have no direct precedent and are set by this Manual. Compound walls around individual plots are almost universal in Sikkim and are one of the most common ways that overland flow paths get blocked. The 50% blockage assumption for wall openings is set to match the grate clogging factor of Clause 6.6.3. The 3.5 m access width is set by this Manual, sized for a small excavator or desilting vehicle. For comparison, APWA 5600 (2006, 5608.4) requires a 15 ft (about 4.6 m) maintenance access strip for detention facilities.

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## 6.10 Ponding at sags and low points

6.10.1 **Minor event.** At every sag, the minor design flow shall be removed by inlets (after clogging) with ponded spread within Table 6.2.

6.10.2 **1% AEP event.** At every sag:

- (a) the ponded depth shall not exceed 350 mm at the deepest point of the carriageway;
- (b) a surface overflow route shall be provided (for example over a lowered kerb and footpath into a designated overland flow path), so that the ponding level cannot rise above the overflow level; and
- (c) building floor levels around the sag shall comply with Clause 6.11.

6.10.3 **Fully-blocked check.** At sags, the 1% AEP ponding level shall also be computed with the minor system fully blocked and all flow leaving by the surface overflow route. Floor levels around the sag shall be set from the higher of the two ponding levels.

6.10.4 **Trapped sags.** Where a sag has no surface overflow route, the inlets and conduits (after clogging) shall carry the 1% AEP flow, and the approving authority shall agree the arrangement.

6.10.5 **Road underpasses.** Underpasses and other trapped sags on public roads shall:

- (a) be drained by a minor system (with pumping under Chapter 9, Clause 9.9, where gravity drainage is not possible) designed for the 2% AEP (50-yr) flow, checked at the 1% AEP flow;
- (b) have flanking inlets at both approaches to intercept flow before it reaches the low point;
- (c) be protected from inflow from surrounding streets by raised approach crests where practicable; and
- (d) have depth markers and automatic warning or closure signals that operate at 150 mm depth on the carriageway.

> **Commentary.** The fully-blocked check, the trapped-sag rule and the underpass requirements have no direct precedent and are set by this Manual. No record of a flooded road underpass in the State was found during research [TBC]. The roads already act as the major system, and in the hills as its steepest part: NH-10 along the Teesta "has become prone to submergence and subsidence" since the flood of October 2023 (Project Prefeasibility Report annexed to the State's affidavit of 28 February 2026) and was reported submerged by the river in July 2025 (as reported); that flood damaged 31 major bridges and about 18.5 km of road (Sattar et al., 2025); the Sangkalang bridge collapsed in the storm of June 2024, and the bridges at Phidang and Sangkalang were damaged in June 2025 (all as reported). Clause 6.10.5(d) links the 150 mm crown depth limit of Table 6.2 to the point at which traffic should stop.

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## 6.11 Building floor levels

6.11.1 The lowest habitable floor, and every opening through which water could enter a building (doors, ventilators, basement ramps, lift pits and service entries), shall be at least **0.5 m above the 1% AEP flood level**.

6.11.2 The 1% AEP flood level is the highest of:

- (a) the 1% AEP major-system water level in the street or overland flow path next to the building (Clauses 6.9 and 6.10, including the fully-blocked check at sags);
- (b) the 1% AEP flood level of any river, channel, tank or waterbody (Chapter 7); and
- (c) the 1% AEP level with the tailwater of Chapter 5; and
- (d) where the Approving Authority has adopted a 1% AEP flood depth map under Clause 7.3.4, the ground level at the plot plus the mapped 1% AEP depth.

6.11.3 **Default where no level has been computed.** For a plot below the Chapter 1 thresholds, or where no 1% AEP level has been computed for the plot, the lowest habitable floor and openings shall be at least the higher of:

- (a) **0.65 m above the highest crown level of the road on which the plot fronts**; and
- (b) where an adopted 1% AEP flood depth map covers the plot, **the ground level plus the mapped 1% AEP depth plus 0.5 m**.

The Approving Authority may adopt a regional map, such as a State-approved map or a published national map of modelled 1% AEP flood depth (for example the India Flood Atlas), until a local study replaces it. A map that does not model storm surge shall not be used in place of Clause 6.11.6.

6.11.4 **Basements.** The crest of every basement ramp and the sill of every basement opening shall meet Clause 6.11.1. Basement drainage shall be pumped to the surface drain through a non-return valve.

6.11.5 **Services.** Electrical panels, transformers, standby generators, lift machinery and pumps that serve a building shall meet Clause 6.11.1.

6.11.6 **Coastal band.** The coastal band is the land within **500 m** landward of the High Tide Line along the sea front, as defined by the CRZ Notification, 2019, with the High Tide Line as demarcated in the approved Coastal Zone Management Plan. Where the Survey of India Hazard Line lies further inland than 500 m, the band extends to the Hazard Line. Within the coastal band, in addition to Clauses 6.11.1 to 6.11.5:

- (a) the lowest habitable floor and every opening shall also be at least **0.5 m above the coastal flood level**, which is the 1% AEP still-water level (Clause 5.7.3(b), Annex 5A) plus **twice** the sea-level allowance of Clause 5.7.4 (so at least 0.6 m), because buildings have a design life of more than 50 years (Clause 5.7.4(c));
- (b) where the plot fronts the open beach, the coastal flood level shall include wave set-up from a site study;
- (c) no habitable room, electrical service room or plant listed in Clause 6.11.5 shall be placed in a basement; and
- (d) every basement opening, ramp crest and ventilation opening shall meet Clause 6.11.6(a).

Clause 6.11.6 does not authorise any construction that the CRZ Notification prohibits. Where both apply, the stricter governs.

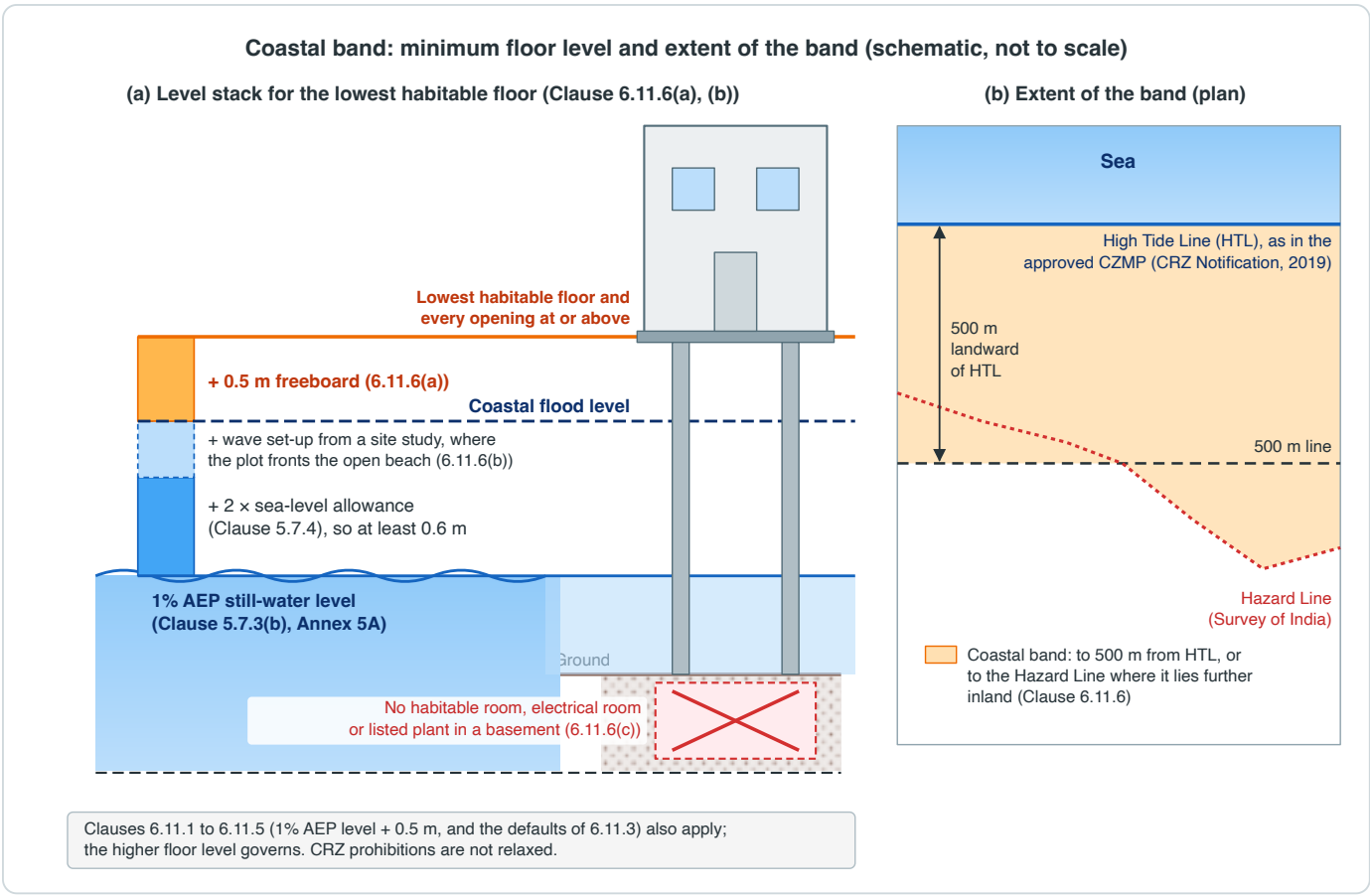


*Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further inland (Clause 6.11.6). Original drawing for this Manual, adapted from the CRZ Notification, 2019 (para 1(i) and Annexure IV) and PUB Singapore, Code of Practice on Surface Water Drainage (7th ed.), cl. 2.1.1.*

**Commentary.** The 0.5 m freeboard above the 1% AEP level follows the DID Malaysia 2008 checklist (platform and lowest floor at 100-yr ARI + 0.5 m). It is more than the APWA 5600 (2006, 5601.8 A2) requirement of 1 ft (about 0.3 m) above the 1% stage. The 0.65 m default in Clause 6.11.3 is derived from the other limits of this chapter, not separately sourced: the 1% water level at the crown may be up to 150 mm (Table 6.2), plus the 0.5 m freeboard. It has no direct precedent and applies to plots where no flood level exists. URDPFI (2015) also links minimum plinth levels to flood frequency in its flood-plain zoning, which is covered in Chapter 7.

Clause 6.11.3(b) lets a small plot use a mapped 1% AEP depth where no local study exists, instead of guessing from the road level alone. Modelled national maps are coarse (about 30 m), and most model rainfall and river flooding but not storm surge, which is why 6.11.3 keeps the road-crown check and Clause 6.11.6 sets a separate coastal rule.

The coastal band of Clause 6.11.6 uses the 500 m line of the CRZ Notification, 2019 (G.S.R. 37(E), para 1(i): "the land area from High Tide Line ... to 500 meters on the landward side"), because every coastal authority already maps it and it needs no new survey. The Hazard Line, demarcated by the Survey of India to show the extent of flooding and shoreline change, extends the band where it lies further inland (CRZ Notification, 2019, Annexure IV). The band takes the coastal level from the joint-case still-water level of Chapter 5 rather than from the rainfall map. The higher standard reflects the setting: a coastal flood rises with the sea, cannot be drained while the tide is up, and will rise further with the sea. Singapore takes the same approach with a fixed minimum platform level of 4.0 m above datum on its southern coast and 4.5 m on its northern coast, whatever the rainfall flood level (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 2.1.1). Each coastal State's tide and surge levels vary too much along its coast for one fixed level, so this Manual uses the computed still-water level instead. Using twice the sea-

level allowance applies the sensitivity case of Clause 5.7.4(c) as the design case, because a building, unlike a drain, cannot easily be raised later. The basement restriction in 6.11.6(c) is set by this Manual: a basement in the coastal band fills from the sea as well as from rain, and cannot be pumped out to a tide-locked outfall. Sikkim has no coast, no High Tide Line and no Coastal Regulation Zone, so the coastal band is empty in the State and Clause 6.11.6 does not apply there. Clauses 6.11.3 and 6.11.4 matter instead. The building rule sets no flood plinth and no floor level above any flood (SBCR 1991; NEER reading), no highest flood level has been published for any town [TBC], and no floodplain zone exists in law (NEER reading); yet the valley-floor towns on the Teesta, the Rangit and the Rongni Chu flood from their rivers, on a bed that the flood of October 2023 raised by metres (Clause 5.8.5(b)). For this Manual, on valley-floor land the 1% AEP flood level of Clause 6.11.2 is computed with the river levels of Clause 5.8.5(b), or, where none has been computed, taken as the highest flood level surveyed from flood marks with its source stated, and the floor levels of Clause 6.11.1, 0.5 m above the 1% AEP level, govern; and on the Teesta valley floor no floor level shall be below the **surveyed October 2023 flood mark + 0.5 m** (set by this Manual). That flood was a cascade, not a rainfall flood, and the 0.5 m above its mark is a siting floor, not a promise that the next cascade will stop there (Clause 5.8.5(d)). Clause 6.11.3, which sets the lowest habitable floor and every opening 0.65 m above the road crown where no flood level has been computed, and Clause 6.11.4, which applies the same level, or 0.5 m above the 1% AEP flood level, to the crest of every basement ramp and the sill of every basement opening, are set by this Manual and add to the regulations. On a hillside the road crown is not always the right reference: the building rule lets a building on the valley side of a road rise "a maximum of one storey only above the road level", with no more than four storeys or 40 feet in all (SBCR 1991, reg. 17(iii)), so its lower floors lie below the road and take the road's runoff; Clause 6.11.2(a) therefore sets the level of each floor and opening on the uphill side from the 1% AEP level of the flow path past it, with the catchment drain and the drained space against the cut of Clause 6.3.6(l) in place, and a floor or basement cut into a slope also needs the geotechnical certificate of the hill rule of Clause 4.11. Along the jhoras and rivers, round the pokharis and springs (dhara) and on the shores of the reservoirs, the lines of Chapter 7 also apply.

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## 6.12 Culverts and road crossings

6.12.1 **Design AEP.** A culvert or bridge that carries a road over a drain or waterway shall pass the design AEP flow of Table 6.1 for that road class without overtopping the road, and with the headwater limits of Chapter 9, Clause 9.4. Where the waterway is a State highway or national highway crossing, the design AEP shall also be not less than that of IRC:SP:42-2014 §7.1.4 for the span. The rarer AEP governs.

6.12.2 **Check event and 1% AEP.** At the check event and at the 1% AEP event, the crossing and the road together shall pass the flow:

- (a) with overtopping depth ≤ 150 mm at the road crown and ≤ 350 mm at the deepest point of the road;
- (b) within the hazard limits of Table 6.3;
- (c) with no overtopping at all of arterial roads that are notified evacuation routes; and
- (d) without raising the 1% AEP flood level at any upstream building or property boundary above the level for the existing condition, unless the affected owners and the approving authority agree.

6.12.3 **Where overtopping is not permitted.** Overtopping in the 1% AEP event is permitted only where the structure span is less than 6 m **and** the 1% AEP peak flow is not more than 7 m³/s, unless a guard rail is installed downstream of the overtopping section. Otherwise, the crossing shall pass the 1% AEP flow without overtopping.

6.12.4 **Blockage check.** The 1% AEP check shall be repeated with a blocked inlet:

- (a) 50% of the inlet area blocked for culverts with a span or diameter below 1.5 m; and
- (b) 20% blocked for larger culverts.

The results of this check shall meet Clause 6.12.2(a) and (d).

6.12.5 **Minimum size.** Culverts under public roads shall be at least 900 mm in diameter, or 900 mm × 900 mm for box culverts.

6.12.6 **Hydraulic design.** Culvert hydraulics, including inlet and outlet control, tailwater, road overtopping and outlet protection, shall follow Chapter 9, Clauses 9.4 and 9.6.

> Commentary. The design AEPs are those of Table 6.1. The overtopping limits are the street-depth limits of Table 6.2. The span and flow threshold in Clause 6.12.3 is the SI conversion of APWA 5600 (2006): overtopping allowed only where the structure span is under 20 ft and the 1% peak is 250 cfs or less, unless a downstream guard fence is installed. IRC:SP:42-2014 (§7.1.4) sets 25-yr for NH/SH culverts up to 2 m span and 50-yr for 2–6 m spans. The blockage percentages in Clause 6.12.4 and the 900 mm minimum size have no direct precedent and are set by this Manual. The 50% value matches the grate clogging factor.

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## 6.13 Sikkim construction-practice requirements

6.13.1 **Covered roadside drains.** Where a roadside drain is covered by slabs that form a footpath:

- (a) it shall be designed as an open channel with the freeboard of Table 6.7 measured to the soffit of the cover slab, and its HGL shall meet Clause 6.8 measured to the footpath and inlet levels;
- (b) road runoff shall enter through openings in the drain wall at road level (Clause 6.6.1(b)), each with a silt sump (Clause 6.6.7), at the spacing of Clause 6.6.4;
- (c) footpath runoff shall enter through slots or grated openings in the cover, not by ponding on the footpath; and
- (d) the clear section shall meet Clause 6.7.6(c).

6.13.2 **Removable covers and access openings.** Covered drains shall have:

- (a) removable cover panels at not more than **10 m** centres, each at least 0.6 m long and spanning the full clear width, with recessed lifting points, liftable by two workers or by a hand-operated lifting device, and flush with the footpath;
- (b) access chambers with a clear opening of at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than **30 m** centres on straight runs; and
- (c) covers rated for the traffic or pedestrian load at their location (Chapter 9, Clause 9.11).

6.13.3 **Silt traps.** In addition to the inlet sumps of Clause 6.6.7, silt trap chambers shall be provided:

- (a) upstream of every culvert under an arterial road;
- (b) upstream of every pump station and detention facility; and
- (c) at every outfall to a tank, river or other waterbody (with the gross pollutant trap required by Chapter 8).

Each silt trap shall be sized to hold the sediment expected between scheduled cleanings, using the sediment yield in Annex 6B, and shall be reachable by a desilting vehicle.

6.13.4 **Garbage and gross pollutant screens.** Screens shall be provided where an open drain enters a covered drain, a pipe or a culvert, and at outfalls under Chapter 8. Each screen shall:

- (a) be designed under Chapter 9, Clause 9.8;
- (b) have a bypass or overflow, so that a fully blinded screen does not flood properties or the road beyond the limits of this chapter; and
- (c) be checked hydraulically with 50% of its area blocked.

6.13.5 **No building over drains.** No structure other than an approved crossing or a removable cover shall be built over a public drain. Shop frontages, ramps and steps that cross a drain shall be removable or shall leave access openings that meet Clause 6.13.2.

6.13.6 **Utilities.** No water main, sewer, power or telecom cable, gas pipe or duct shall be laid along, or pass through, the flow area or freeboard of any drain. A utility that must cross a drain shall:

- (a) cross above the cover soffit or below the drain invert, inside a sleeve; and
- (b) be shown on the drainage plan with its level.

Where an existing utility crossing obstructs a drain, its area shall be deducted from the drain section, with a 50% blockage allowance for the debris it traps, until the utility is relocated. The utility owner shall relocate it when the drain is rebuilt.

6.13.7 **Sewage.** No sewage connection is permitted to a storm drain (Chapter 8). Covered drains shall be built with sealed joints where they run next to sewers.

6.13.8 **Edge protection.** Open drains deeper than 1.0 m beside a footpath, a carriageway or a public open space shall have railings or barriers. Open drains of any depth shall not be left uncovered across a footpath.

6.13.9 **As-built levels.** The as-built invert levels of every public drain, pipe and manhole shall be surveyed and submitted (Chapter 10). Inverts shall be within ±15 mm of design. An HGL re-check shall be submitted where they are not.

6.13.10 **Desilting.** Public drains shall be desilted before the monsoon season each year, as set out in Chapter 10.

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of Sikkim practice. Most urban drains in the State are covered roadside drains under footpaths. They are often built with continuous cast-in-situ slabs and few openings, so they cannot be cleaned and fill with silt and solid waste within a season. CPHEEO (2019) notes that uncovered channels "are prone to the dumping of garbage" (Part A, Ch 2), which is why the drains are covered. Covering without access openings simply moves the problem out of sight. In Sikkim no survey of the towns' drains by type, and no drain inventory of any town, was found during research [TBC], so this Manual cannot say that most urban drains in the State are covered roadside drains under footpaths; what the sources show is that the jhoras are drains in law (Sikkim Municipalities Act, 2007, s.2(24)), that the building rule sends every plinth drain to "the road side drain or to adjoining permanent drains or jhora" (SBCR 1991, reg. 25(iv)), and that the ADB-funded project is building stormwater drains along about 60 km of roads in seven towns (ADB 57230-001). Clause 6.13 applies to every covered drain built from now on. NDMA (2010) recommends that pre-monsoon desilting be complete by 31 March. In Sikkim that date is also the start of the wet season as this Manual defines it, 1 April to 31 October; IMD's normal dates for the onset and withdrawal of the south-west monsoon over Sikkim were not obtained [TBC], and this Manual gives no onset date. The heaviest storms come early: Gangtok averages 296.9 mm in April on 15.2 rainy days and 496.4 mm in May (IMD normals, 1981–2010), and both Gangtok's 24-hour record (310.3 mm on 30 May 1975) and Singhik's (504.2 mm on 12 May 1981) fell in May. Storms also come after the season: Gangtok recorded 201.0 mm on 3 October 1996 and 96.0 mm on 11 November 1995 (IMD), the October storm of 1968 lasted four days (as reported), and the Teesta flood of October 2023 came on 3–4 October. The State already stops earthworks for the season: UD&HD and UDD notices ban "construction involving earth excavation" each monsoon (6 May–30 September 2019; 1 June–30 September 2020), and material "lying on the road setback or over drains" is seized (Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019); but no order of UDD, GMC or another urban local body fixing a date for drain clearance was found during research [TBC]. So Clause 6.13.10 refers to the monsoon season as this Manual defines it, and Chapter 10 requires desilting and the clearance of silt, debris, garbage and slide material from drains, jhora channels, inlets, catch-pits, racks, debris basins and culverts, and of plinth drains and catchment drains, to be complete by 31 March, with retaining-wall weep holes and subsurface drains inspected and cleared and flap gates and any pumps certified ready on the same date (Clauses 5.11.5 and 5.12.9); a mid-season clearance of drains, jhora channels, racks, culvert inlets and debris basins by 30 April, after the April storms and before May; standby from 1 April to 31 October; and a post-season clearance of silt, debris and slide material, with a survey of cut slopes, retaining

walls and trained jhoras, by 15 November. The mid-season clearance is due by 30 April, as in one other North-East hill edition of this series, and not by 31 May or 15 May as in the others, because the two largest 24-hour falls recorded in the State fell on 12 and 30 May: a clearance due by 15 May could come after the first, and one due by 31 May after both. Drainage earthworks are finished before the excavation ban begins, and WRD's works on rivers keep WRD's calendar. Above about 2,500 m (sub-area SK-C, and any site at that height), where snow or frost prevents the works in March, the pre-season works are due by 30 April and the mid-season clearance by 31 May, with the reason recorded on Form 10-7; snow and ice are cleared from inlets, culverts and drains after every snowfall from December to March; and the post-season clearance is due by 31 October, before the first snow. Snow-day statistics were not collected [TBC]. These dates are set by this Manual.

Jhoras are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over: the municipality "shall protect any jhora, whether on a public land or on a private land, within the municipal area" (s.172(2)), and Clause 6.3.6(m) does not allow an open jhora to be culverted. Where a drain is covered, Clause 6.13.2 applies to it in full; where it is open beside a footpath or a carriageway, Clause 6.13.8 applies. In the ridge towns many drains run beside steps and footpaths on steep ground, where an open drain is a fall hazard and a covered one cannot be cleared of boulders and waste without its access openings. Gangtok's waste agency is contracted for the "Clearing of Jhoras" and barred from dumping "along Footpath, Roadside and Jhoras" (GMC, Memo No. GMC/6727/III/2024/OL/01, 8 October 2024).

Clause 6.13.7 is not yet the practice, and outside Gangtok's sewered zones it cannot be until sewers exist. The Municipalities Act already requires one drain for sewage and "an entirely separate drain for rain water or unpolluted sub-soil water" (s.193), but the building rule has every building treat its sewage "in septic tanks built within the site" (SBCR 1991, reg. 25(i)), and in Soreng "most of the houses have adopted the practice of onsite disposal by constructing septic tank/soak pits with effluent discharging into open surface drains" (ADB due-diligence report, December 2024). The State estimates the urban sewage at 29.51 MLD against 15.22 MLD actually treated at Gangtok's plants (September 2025 progress report annexed to the State's affidavit of 19 December 2025), and the sewerage of Namchi and Jorethang "has remained stalled since the year 2013 and 2015 respectively" (same affidavit). Clause 8.9 sets how dry-weather flow in storm drains is surveyed and intercepted until the connections are removed, including the rule that interception shall not reduce the capacity of the drain (Clause 8.9.5(b)).

The 10 m and 30 m spacings and the ±15 mm tolerance have no direct precedent and are set by this Manual. Clause 6.13.6 responds to the common sight of water mains and cables running through drains. Each one traps debris and reduces the section. Mechanical cleaning through cover openings, rather than manual entry, is assumed throughout, consistent with the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013.

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## 6.14 Outfalls

6.14.1 Outfalls shall be designed for the tailwater conditions of Chapter 5. Outfalls below the 1% AEP still-water level shall have flap or tide gates or non-return valves (Chapter 5 and Chapter 9, Clause 9.10).

6.14.2 Outfall protection and energy dissipation shall be designed under Chapter 9, Clause 9.6. Outfalls to tanks and waterbodies shall also meet Chapters 7 and 8.

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## 6.15 Submittal requirements

Every conveyance submittal shall include a **Conveyance Design Report** (Form 6-1) containing:

1. a catchment plan showing sub-catchments, the minor system, inlet locations and the major-system overland flow paths for the 1% AEP event (Clause 6.3.2);
2. the land-use and road-class AEP adopted for each element (Table 6.1), and the high-density area status;
3. design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3;
4. gutter spread, depth and D·V checks for the minor, check and 1% events (Tables 6.2 and 6.3);
5. an inlet schedule with clean capacity, clogging factor, design capacity and bypass flow (Clause 6.6);
6. pipe and drain design tables with n, velocity, sediment allowance and freeboard (Clause 6.7);
7. HGL profiles for the minor and check events, with the tailwater used (Clause 6.8);
8. sag ponding levels, including the fully-blocked check (Clause 6.10);
9. a floor-level schedule for every building (Clause 6.11);
10. culvert and crossing calculations (Clause 6.12 and Chapter 9); and
11. a utilities-crossing schedule and access-opening layout for covered drains (Clause 6.13).

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## References (chapter)


- MoHUA / CPHEEO (2019). *Manual on Storm Water Drainage Systems*, Volume I, Part A: Engineering Design. Tables 4.1, 5.1, 5.2, 5.3, 5.8, 5.11, 5.12, 6.2, 11.2, 11.5; §5.3, §5.6.2, Fig. 5.9. https://www.mohua.gov.in/static/uploads/2025/10/8a2456c722036d78c72a698898ef846d.pdf
- PUB Singapore (2018, with Addendum No. 3, April 2025). *Code of Practice on Surface Water Drainage*, 7th edition. Clauses 1.1, 2.1.1, 5.1, 5.3, 9.6, 9.7 and Appendix 1 (Drainage Reserve Requirements). https://www.pub.gov.sg/-/media/PUB/PDF/Code-of-Practices-and-Submission-Guidelines/Surface-Water-Drainage/Code-of-Practice-on-Surface-Water-Drainage.pdf
- Indian Roads Congress (2013). IRC:SP:50-2013, *Guidelines on Urban Drainage* (First Revision). https://law.resource.org/pub/in/bis/irc/irc.gov.in.sp.050.2013.pdf
- Indian Roads Congress (2014). IRC:SP:42-2014, *Guidelines on Road Drainage* (First Revision). https://law.resource.org/pub/in/bis/irc/irc.gov.in.sp.042.2014.pdf
- Bureau of Indian Standards. IS 7784 (Part 1): 1993, *Code of practice for design of cross drainage works, Part 1: General features* (as cited in CPHEEO 2019 Table 5.12).
- Federal Highway Administration (2024). *Urban Drainage Design Manual*, Hydraulic Engineering Circular No. 22, 4th edition, FHWA-HIF-24-006. (3rd edition 2009, FHWA-NHI-10-009.)
- Kansas City Metro Chapter APWA (2006). *Section 5600 Storm Drainage Systems and Facilities* (5601.8, 5604.2, 5608.4). https://www.kcwater.us/wp-content/uploads/2020/08/Design-Criteria-%E2%80%93-Section-5600-%E2%80%93-Storm-Drainage-Systems-and-Facilities.pdf ; and Version 2025.01 (Dec 2025).
- Australian Institute for Disaster Resilience (2014). *Australian Disaster Resilience Guideline 7-3: Technical flood risk management guideline: Flood hazard*. Tables 1 and 2. https://knowledge.aidr.org.au/media/1891/guideline-7-3-technical-flood-risk-management.pdf
- Smith, G.P. and Wasko, C.D. (2012). *Australian Rainfall and Runoff Revision Project 15: Two-dimensional modelling in urban and rural floodplains*. Engineers Australia.
- Ball, J. et al. (eds) (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Book 6 (Chapters 6 and 7). Commonwealth of Australia (Geoscience Australia).
- Department of Irrigation and Drainage Malaysia (2008). *Submission Checklist for Stormwater Management*; and (2012) *Urban Stormwater Management Manual for Malaysia (MSMA)*, 2nd edition.
- Gupta, K. *Return Period and Rainfall Intensity for Drainage Design in India*. IIT Bombay. https://www.civil.iitb.ac.in/~kgupta/drainagedesign.pdf
- Comptroller and Auditor General of India. *Report No. 3 of 2016* (Economic Sector, Sikkim), Chapter II, performance audit of JNNURM (para 2.3.9.2: the Gangtok CDP's drainage and landslip-protection works "not taken up"; the Melli STP; the Jorethang sewerage), https://www.cag.gov.in/uploads/download_audit_report/2017/Chapter_2_Economic_Sector_Sikkim_Report_No_3_of_2016.pdf
- Asian Development Bank. *Sikkim Integrated Urban Development Project* (57230-001), resettlement and indigenous peoples due-diligence report for Soreng sewerage, December 2024 (the project's roads and stormwater drains in seven towns; Soreng's septic effluent "into the open storm water drains"), https://www.adb.org/sites/default/files/project-documents/57230/57230-001-sddr-en.pdf
- Government of Sikkim. Affidavit of 19 December 2025 in E.A. No. 35 of 2023 in O.A. No. 673 of 2018, National Green Tribunal, with the September 2025 monthly progress report (urban sewage 29.51 MLD; 15.22 MLD treated; Gangtok's treatment plants; Namchi and Jorethang stalled), https://www.greentribunal.gov.in/sites/default/files/news_updates/AFFIDAVIT%20BY%20STATE%20OF%20SIKKIM%20IN%20EA%20NO.%2035%20of%202023%20IN%20OA%20NO.%20673%20of%202018%20News%20item%20published%20in%20the%20Hindu.pdf ; and six-monthly report in O.A. No. 606 of 2018 (the order of 4 July 2024 as quoted; GMC's waste-agency contract, Memo No. GMC/6727/III/2024/OL/01, 8 October 2024), https://www.greentribunal.gov.in/sites/default/files/news_updates/SIX%20MONTHLY%20REPORT%20BY%20GOVT%20OF%20SIKKIM%20IN%20OA%20NO.%20606%20OF%202018%20FOR%20STATE%20OF%20SIKKIM%20(COMPLIANCE%20OF%20MSW%20MGT%20RULES,%202016%20AND%20OTHER%20ENVIRONMENTAL%20ISSUES).pdf

- Government of Sikkim. Counter-affidavit of Respondents 1, 4, 7 and 9 of 25 February 2022 in O.A. No. 5 of 2022 (EZ), National Green Tribunal, with Department of Mines and Geology Notification No. 17/DMG/20-21, 19 March 2021 (Annexure R/2, stability zones and the conditions for review) and the monsoon excavation notices of 2019 and 2020 (Annexure R/5), https://www.greentribunal.gov.in/sites/default/files/news_updates/Counter%20Affidavit%20on%20behalf%20of%20R-,4,7,9%20in%20OA%205%20of%202022%20(EZ)%20(Dr.%20BINA%20BASNETT%20vs%20State%20of%20Sikkim%20&%20Ors.).pdf ; and Gangtok Smart City Development Ltd, reply affidavit in O.A. No. 38 of 2022 (EZ) (spring water at natural jhoras; drains connecting to nearby jhoras), https://www.greentribunal.gov.in/sites/default/files/news_updates/Reply%20Affidavit%20filed%20by%20R-2,%20GSCDL,%20page%20698-1006.pdf
- Government of Sikkim. Additional affidavit of 28 February 2026 in O.A. No. 171 of 2023 (EZ), National Green Tribunal, with the PPR "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (NH-10 "prone to submergence and subsidence"; the raised Teesta bed), https://www.greentribunal.gov.in/sites/default/files/news_updates/Additional%20affidavit%20on%20behalf%20of%20R-1,%20State%20of%20Sikkim,%20page%201038-1178.pdf
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*, doi:10.1126/science.ads2659 (bridges and roads damaged).
- India Meteorological Department. *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)* (Gangtok and Tadong); and Meteorological Centre Gangtok, *Mean monthly meteorological parameters of Gangtok, 1981–2010*, https://mausam.imd.gov.in/gangtok/mcdata/climatology_gangtok.pdf
- Indian Roads Congress (1998). IRC:SP:48-1998, *Hill Road Manual* (drainage provisions not read for this Manual); and IRC:SP:42-2014, cl. 7.1.4 (design return periods for road drains and culverts) and cl. 8.5.1 (drainage of hill roads).
- Press reports on the GSCDL tenders for drainage and jhora-training works; on MG Marg's back drainage (*Sikkim Express*); on the High Court's warning to IRCON over NH-10 drainage (*Sikkim Express*, https://sikkimexpress.com/news-details/sikkim-high-court-warns-ircon-to-fix-nh-10-drainage-issues-or-face-liability ); on NH-10 submerged by the Teesta in July 2025 (*EastMojo*, https://eastmojo.com/sikkim/2025/07/30/sikkim-nh-10-submerges-into-teesta-as-imd-warns-48-hours-of-heavy-rains/ ); on the Gangtok landslides of June 1997 (a single source); on the Mangan district storm of June 2024 (*Business Standard*, https://www.business-standard.com/india-news/heavy-rain-landslides-kill-6-in-indias-sikkim-2000-tourists-stranded-124061400418_1.html ); and on the Chaten landslide of 1 June 2025 (*Scroll*, https://scroll.in/latest/1083080/3-dead-6-missing-as-landslide-hits-army-camp-in-sikkim ) (all as reported).
- National Disaster Management Authority (2010). *National Guidelines: Management of Urban Flooding*.
- MoHUA / TCPO (2015). *URDPFI Guidelines*, Volume I.
- Ministry of Environment, Forest and Climate Change (2019). *Coastal Regulation Zone Notification, 2019*, G.S.R. 37(E), 18 January 2019. Para 1(i) and Annexure IV. https://crz.elaw.in/crz2019.html
- *The Sikkim Building Construction Regulations, 1991* (UD&HD Notification No. 29(202)UD&HD/90/295, 19 March 1991, made under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985), as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001, 16 October 2001) (regs. 6, 13(iii), 18, 21, 22, 25 and 35, and Form III), read from a copy hosted by Sikkim Manipal University, https://smu.edu.in/img/content/dam/manipal/smu/IQAC/SDG/documents/BUILDING%20STANDARDS.pdf . A Sikkim Building Construction (Amendment) Regulation, 2022, reported to have been published on 12 April 2023, was not read and may change what is cited here [TBC].
- *The Sikkim Municipalities Act, 2007* (Act 5 of 2007), as amended to 2026 (ss.2(24), 163(b), 172, 173, 186, 187, 189 and 193), https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf
- *The Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988* (Act 6 of 1988), as amended by Act 8 of 2000 (ss.2(m), 29, 30, 32 and 42(2) and the Schedule), https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf
- *The Sikkim Town and Country Planning Act, 2024* (Act 10 of 2024), as amended by Act 24 of 2025, enacted and not yet commenced (development plans with "proposals for flood control, land stability and sloped linked controls"), https://prsindia.org/files/bills_acts/acts_states/sikkim/2024/Act10of2024SK.pdf

- UD&HD Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019, and UDD Notice No. T(1689)/997, 26 May 2020 (monsoon bans on earth excavation), read as Annexure R/5 to the State's counter-affidavit in O.A. No. 5 of 2022 (EZ).
- Government of India. *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.

## Annexes and forms

| Annex / Form | Content |
|---|---|
| 6A | Standard inlet types for Sikkim with capacity curves (on grade and sag) |
| 6B | Sediment yield for silt-trap sizing and calibration of the sediment allowance |
| 6C | Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump |
| Form 6-1 | Conveyance Design Report checklist |

CHAPTER 7

# Waterbodies, Pokharis, Jhoras, Springs and Setbacks

## 7.1 Purpose and scope

7.1.1 This chapter treats waterbodies as part of the drainage system. It sets the rules for:

- (a) identifying and mapping every waterbody that a development or public work affects;
- (b) the setback zones around waterbodies, and the uses allowed in each zone;
- (c) fill in flood-prone land, and the compensatory storage needed where fill is allowed;
- (d) counting tank (pokhari) storage, including tank cascades, as design storage;
- (e) restoring and desilting tanks and ponds;
- (f) protecting supply channels, surplus courses, inlets and outlets;
- (g) wetlands, marshes and estuaries, which in Sikkim, a landlocked mountain State, means its lakes and pokharis (पोखरी; ponds, lakes or tanks), such as Khecheopalri (Khachoedpalri), reported to have become the State's first Ramsar site in February 2025, and Tsomgo, the hydropower reservoirs with their drawdown zones, the marshy and seepage ground below springs, any wetland notified under the 2017 Rules (none was found notified), and the "534 wetlands covering 7,477 ha" reported for the State (as reported); the glacial lakes are hazard sources under Clause 2.3.6(i), not wetlands to be drained into or counted as storage;
- (h) the interface with encroachment and its removal;
- (i) fee-in-lieu contributions to regional tank storage (with Chapter 4); and
- (j) the safety of tank bunds and other embankments.

7.1.2 This chapter applies to every development and public work to which this Manual applies under Chapter 1 and that:

- (a) adjoins a waterbody or lies wholly or partly within its setback (Clause 7.4);
- (b) discharges to a waterbody, directly or through a drain, within the downstream analysis extent of Chapter 5; or
- (c) alters a waterbody, its bund, sluice, surplus weir, supply channel or surplus course.

7.1.3 Where a statute or statutory rule sets a wider setback or a stricter restriction, the statute governs (Clause 1.3.3). Nothing in this chapter authorises any work that the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, the Sikkim Municipalities Act, 2007, the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 and the Sikkim Building Construction Regulations, 1991 made under it, with the stability zonation notified by the Mines and Geology Department in 2021, the Sikkim Town and Country Planning Act, 2024 once it commences (it was enacted in 2024 and amended in 2025, and has not commenced), the Wetlands (Conservation and Management) Rules, 2017, the Dam Safety Act, 2021, or any other law, prohibits.

> **Commentary.** Sikkim has no Act for the protection of lakes, ponds, springs or jhoras as such, no floodplain zoning law and no notified flood line. Its waters are touched by five instruments. The **Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988** makes the river bank of each of the 103 rivers in its Schedule "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (s.29(1)), under the Forest Department's control "as if it were a forest" since 2000 (s.29(9)); its occupation is an offence (s.30), and the Government may close a river bank, slip reserve or road reserve by notification (s.32). The **Sikkim Municipalities Act, 2007** makes a jhora a drain (s.2(24)) and "any natural watercourse, whether on a public land or on a private land" (s.163(b)); a jhora on public land other than forest land within a municipal area

vests in the Municipality (s.172(1)); "the Municipality shall protect any jhora, whether on a public land or on a private land, within the municipal area" (s.172(2)); the State may notify the limits of any jhora (s.173; none has been notified); and rain water goes in "an entirely separate drain" to "the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (s.193). The **Sikkim Building Construction Regulations, 1991**, made under the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985, apply in the notified areas; they send each building's storm water to "the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)) but set no distance from a jhora or river, and the Mines and Geology Department's stability zonation of 2021 (Notification No. 17/DMG/20-21, 19 March 2021), which sets building height, grades sites partly by the condition of their jhoras. The **Sikkim Town and Country Planning Act, 2024** (Act 10 of 2024, amended by Act 24 of 2025) would require development plans with "proposals for flood control, land stability and sloped linked controls", but it comes into force only on a date to be notified, and none has been. The **Wetlands (Conservation and Management) Rules, 2017** apply to notified wetlands, and none in Sikkim was found notified (Clause 7.12, Commentary). The Forest and Environment Department's **River Rejuvenation Committee** was "notified as the Nodal Agency for all water bodies vide Order No. 205/GOS/F&ED/SECY dated 21.01.2021". In this chapter **WRD** means the Water Resources Department (formerly the Irrigation and Flood Control Department), the State's department for rivers and jhora works; no register of pokharis kept by WRD or any other body was found [TBC], and where a hydropower reservoir is concerned, the levels, rules and freeboard that this chapter attributes to WRD are those of the reservoir's operator, to whom Clause 7.8.4 applies in the same way (Clause 7.8, Commentary). Who approves what, and where this Manual can apply, is set out in Chapter 1.

**This Manual treats every recorded waterbody as drainage infrastructure.** Six features set Sikkim apart, and four Nepali words are used for them throughout this Manual (Annex 7E). The first is the **jhora (झोरा; a natural watercourse or ravine stream)**, the statutory word: every ridge town drains to its jhoras, the 2021 stability zones count an "Untrained jhora/ erosional potential jhora" against a site, and no statute sets any line along one. The second is the **khola (खोला; a river or large stream)** and the river below it: the Teesta, the Rangit and the Rongni Chu, whose valley floors carry the towns of Rangpo, Singtam, Melli, Majitar and Jorethang, and whose trunk, the Teesta, had its bed raised "by an average of 7-8 meters" by the South Lhonak lake outburst and Teesta flood of 3–4 October 2023 (the project report "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (PPR), annexed to the State's affidavit to the National Green Tribunal of 28 February 2026). The third is the **dhara (धारा; a spring or spring spout)**: "about 80%" of rural Sikkim is reported to depend on springs, and the Dhara Vikas programme of the Rural Management and Development Department (RMDD) works to revive them (as reported), but no statute keeps building or drains away from a spring. The fourth is the **hydropower reservoir**: the Teesta and the Rangit are held by a chain of dams (Teesta-III at Chungthang, under restoration since the dam was destroyed in 2023, Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam projects III and IV, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III), whose levels and release rules were not found [TBC]. The fifth is the **glacial lake**: Sikkim has "84 glaciers, and 320 glacial lakes", of which NDMA lists 40 as high-risk and 16 as very high-risk (PPR; State affidavit of 28 February 2026); a glacial lake is a hazard source under Clause 2.3.6(i), never storage, and it keeps its own name even where the name contains "Pokhari", as Bhalay Pokhari and Doodh Pokhari do. The sixth is the **pokhari**: the lakes and ponds of the ridges and benches, from Khecheopalri, reported to be the State's first Ramsar site, to village ponds and the ponds of the springsheds, are few, small and often sacred or communal, and Sikkim has no irrigation tank cascades; its irrigation channels are the **kulo (कुलो; an irrigation channel)**. The tank clauses of this chapter apply to pokharis, to the hydropower reservoirs where their storage is counted, and to any other impounded water. This chapter gives the design rules that protect the storage and conveyance of these waterbodies and keep drainage assets out of the path of the Teesta's floods. It does not replace the 1988 Act, the Municipalities Act, the SBCR 1991, the stability zonation, the monsoon excavation notices, the wetland rules, or the directions of the High Court of Sikkim, the National Green Tribunal and the Supreme Court.

## 7.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Waterbody | A river, such as the Teesta, the Rangit and the Rongni Chu and the other rivers in the Schedule to the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, or khola (a river or large stream, as in the Rani Khola and the Maney Khola); jhora (a natural watercourse or ravine stream, perennial or seasonal, trained or untrained), into which the drains of a ridge town fall; drain; pokhari (a pond, lake or tank, natural or dug, on a bench, a ridge or a valley floor); hydropower reservoir or pondage, such as those of Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam projects III and IV, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III, with its drawdown zone and the reach below its dam; dhara (a spring or spring spout) with its recharge area; glacial lake, which is a hazard source and never storage, whatever its name (Bhalay Pokhari and Doodh Pokhari are glacial lakes); wetland, marsh or seepage ground; kulo (an irrigation channel) or other supply channel; or surplus course, perennial or seasonal (as in Chapter 1). |
| Tank (pokhari) | A waterbody impounded by an earthen bund, fed by its own catchment and/or a supply channel, with a surplus weir and one or more sluices. |
| Tank cascade | A chain of tanks in which the surplus or sluice outflow of one tank feeds the next (as in Chapter 3). |
| Full tank level (FTL) | The crest level of the surplus weir (spillway, overflow or outlet) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling. |
| Maximum water level (MWL) | The highest water level in a tank when the surplus weir passes the tank's design flood. For this Manual, it is the greater of the level recorded by the Water Resources Department and the level computed for the 1% AEP (100-yr) inflow with the climate factor of Clause 2.8 (Clause 7.7.4). |
| Top bund level (TBL) | The crest level of the tank bund. |
| Waterspread | The area of a tank submerged at FTL. |
| Foreshore | The land around a tank between the FTL contour and the MWL contour. Foreshore land is flooded whenever the tank surpluses, and is part of the tank's flood storage. |
| Supply channel (jhora, kulo or feeder channel) | A channel that brings water from a river, anicut or upstream tank into a tank. |
| Surplus course | The channel that carries the overflow of a surplus weir to the next tank, a river, a drain or the sea. |
| Sluice (sluice, spillway gate or regulator) | A controlled outlet through a tank bund, usually to an irrigation channel. |
| Top of bank | For a channel, the break in slope at the edge of the channel. Where it cannot be identified, the edge of the water surface at the 50% AEP (2-yr) flow. |
| 1% AEP flood extent | The land flooded by the 1% AEP (100-yr) flood with the climate factor of Clause 2.8, from a hydraulic model that meets Chapter 3 and Chapter 5, or from a map adopted by the Authority under Clause 7.3.4. |
| Floodway | The waterbody and the adjoining land that must be kept free of obstruction to pass the 1% AEP flood without raising the 1% AEP water level by more than 0.1 m at any point (Clause 7.6.1). For a tank, all land below MWL. |
| Flood fringe | The part of the 1% AEP flood extent outside the floodway. |
| Zone 1 (waterbody protection zone) | The inner setback zone defined in Clause 7.4.3. |
| Zone 2 (flood fringe setback) | The outer setback zone defined in Clause 7.4.4. |
| Setback | Zone 1 and Zone 2 together. |

| Term | Meaning in this Manual |
|---|---|
| Compensatory storage | Excavated storage that replaces flood storage lost to fill, under Clause 7.6.4. |
| Flood cushion | Storage below FTL kept empty, under a documented operating rule, to absorb a flood (Clause 7.8). |

**Sikkim terms.** The following terms are used in this chapter in addition to those above (see also Annex 7E):

| Term | Meaning in this Manual |
|---|---|
| Pokhari | A pond, lake or tank, natural or dug: Turner gives *pokhari* (his spelling पोखरि; modern पोखरी) as "Lake, pool, tank" (Annex 7E). First used in each chapter as "pokhari (पोखरी; pond, lake or tank)"; plural "pokharis". A pokhari with a controlled outlet is a tank under Clause 7.2: its gate is its sluice, and its FTL is the level at which it spills over its outlet with any gate closed, found by survey. A pokhari with an uncontrolled outlet has its FTL at the crest of that outlet. Engineered storage built under this Manual is a "detention pond" ([pokhari] in brackets only where a Nepali reader needs it), never a dhara and never a natural, sacred or community pokhari, which keeps its own name. |
| Glacial lake | A lake held by a glacier or moraine, such as South Lhonak, Shako Chho, Changsang, Khangchung Chho, Gurudongmar and the lakes called Bhalay Pokhari and Doodh Pokhari (PPR, 2026). It is a waterbody for Clause 7.3 and a hazard source under Clause 2.3.6(i); it is **never** a pokhari of the storage clauses, design storage, a flood cushion or a design outfall, whatever its name, and no tank clause of this chapter applies to it. This rule is set by this Manual. |
| Jhora | A natural watercourse or ravine stream, perennial or seasonal: the statutory word of the Sikkim Municipalities Act, 2007, under which a drain includes "a jhora or water-course of natural drainage line" (s.2(24)) and "'jhora' means any natural watercourse, whether on a public land or on a private land" (s.163(b)); Turner marks *jhorā* (झोरा) as a Darjeeling word for "Ravine" (Annex 7E). Every jhora that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whatever its name, whether it is dry for most of the year, and whether it is trained, lined, piped or covered. A jhora carries boulders, debris and slide material in flood: its inlets and culverts take the racks, bulking and blockage of Clause 6.3.6(f)–(h), and its top of bank is the edge of its active bed where that is wider than the edge of the 50% AEP flow. This definition is set by this Manual. |
| Trained jhora | A jhora improved to the standard of Clause 6.3.6(m): a channel that carries the 1% AEP flow with bulking and freeboard, toe and bed protection against scour, drop structures or check dams with energy dissipation at each fall, a debris basin or rack upstream of every culvert, and a maintenance access. Training does not reduce the jhora's Zone 1: a trained jhora keeps its corridor under Clause 7.4, because the 2021 stability zonation's zone 1 asks for training "with safe distance" and the corridor is the distance. |
| Khola; scheduled river | A khola (खोला) is a river or large stream (Annex 7E), as in the Rani Khola and the Maney Khola. A scheduled river is one of the 103 rivers in the Schedule to the 1988 Act (among them 1 the Teesta, 2 the Rangeet, 14 the Rongni chu, 15 the Roro chu, 62 the Gangtok chu, 77 the Lhonakchu and 103 the Khani Khola at Melli), whose river bank is "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (s.29(1)). That bank is a **maximum, not a minimum** (NEER reading): where the high flood level lies within 60 m of the channel, the statutory bank ends at the high flood level. Whether the Rani Khola is the scheduled "Rongni chu" is a NEER reading to be confirmed [TBC]. |
| Top of bank of an incised jhora or khola | Where the bank of a jhora or khola is a slope steeper than 10°, the top of bank for Clauses 7.4.3 and 7.13.1 is the **crest of that bank slope**: the first marked break in slope above the channel at the top of the bank that the stream has cut, found by survey and shown on Form 7-1. Where no crest can be identified, it is the edge of the active bed, and a geotechnical report under the SBCR 1991 or the stability-zone review states whether a wider line is needed. Zone 1 is measured from that line, because a slide of the bank starts at its crest. This rule is set by this Manual. |
| Recorded waterbody | A pokhari, lake, reservoir, river, khola, jhora, dhara or wetland shown in any source of Clause 7.3.3(a): an LR&DMD land record, a Forest Department river-bank record, a Municipality's record of what vests in it, a notified-area or stability-zone map, a master-plan map, an operator's reservoir record, a Dhara Vikas spring inventory or a town's drain and jhora register. A recorded waterbody is part of the drainage system for this Manual. Where it is proposed to be filled, in whole or part, a drainage assessment under Chapters 3 to 5 shall show the storage and flow paths lost and their effect upstream and downstream, and the lost storage shall be replaced under Clause 7.6.4 before any design relying on the filling is approved. This definition and rule are set by this Manual. |

| Term | Meaning in this Manual |
|---|---|
| Boundary of a pokhari or reservoir | For Clauses 7.3.3 and 7.13.1, the boundary of a pokhari or lake is the largest of its recorded boundary, its surveyed FTL and the outer edge of its water in the season of 1 April to 31 October shown by dated imagery or survey of recent years; and the boundary of a hydropower reservoir is the higher of its full reservoir level and the highest level its operator states, stated to the datum of Clause 7.3.5. No full reservoir level, maximum water level or release rule was found for any Sikkim reservoir [TBC]; until the operator states them in writing, the boundary is fixed by survey of the highest water line, and an outfall in the reservoir reach is sited above the surveyed October 2023 flood mark (Clause 5.8.5(c)). The drawdown land of a reservoir below that level is part of the reservoir. This reading is set by this Manual. |
| Dhara; spring recharge area | A dhara (धारा) is a spring or spring spout, often with a small basin or chamber (Annex 7E). A dhara is a waterbody for Clause 7.3, and its Zone 1 under Clause 7.4 is measured from its outlet or the edge of its basin or chamber. Its recharge area is the area upslope from which it is fed, as a hydrogeologist maps it, using the Dhara Vikas village spring atlas where it covers the site. The spring rule of Clause 8.8.1, item (iv), applies: no storm outfall, soakaway or drain discharge within 15 m of a dhara; no storm water routed into it or onto the slope immediately above it; no drain, cut or fill that intercepts its flow, buries its outlet or crosses it; and, above a town's or village's intake, a recharge area with no paving except for access, no road runoff led into the ground and no infiltration facility, soak pit or septic tank. No storm drain or sewer is laid within Zone 1 of a dhara except a lined drain below its outlet that carries its overflow away. This definition and these rules are set by this Manual. |
| Hazard-first ground: GLOF corridors and the Teesta valley floor | The land that Clause 2.3.6(i) screens apart from rainfall design: the path of a glacial lake outburst flood (GLOF) along the Teesta from the South Lhonak lake through Chungthang, Mangan, Dikchu, Singtam, Rangpo and Melli to the State border, along the Lachen Chu and the Lachung Chu, and along every stream below a glacial lake listed as high-risk; and the Teesta valley floor at or below the level of the October 2023 flood and the bed it raised. **No setback for a glacial lake, a GLOF path or the Teesta after October 2023 exists in law** (NEER reading; none was found), and this Manual sets none of its own for the cascade, because no rainfall rule can. It requires instead that every drainage asset it governs — detention storage, outfall structures, pumping, treatment and interception works — be sited **above the October 2023 flood and aggradation level and outside the mapped GLOF path where a map exists** (the evacuation and risk maps of SSDMA and the District Disaster Management Authorities, where they exist [TBC]), with outfalls to the trunk that meet Clause 5.8.5(b) and (d). No drain is sized for a GLOF. A developed-fringe area under Clause 7.6.6 is not notified on this ground. This rule is set by this Manual. |
| Floor levels on the valley floors | No flood plinth is set by the SBCR 1991, and no highest flood level has been fixed for any town [TBC]. The lowest habitable floor and every opening of a building approved under this Manual near a river, khola, jhora, pokhari or reservoir is not less than 0.5 m above the 1% AEP flood level (Clause 6.11), and on the Teesta valley floor not less than 0.5 m above the surveyed October 2023 flood mark at the site, whichever is higher. This rule is set by this Manual. |
| Fill on the valley floors | Compensatory storage under Clause 7.6.4 applies to any fill placed below the 1% AEP flood level on the valley floors of the Teesta, the Rangit and the Rongni Chu or beside any khola, and to any filling of a recorded pokhari or of the margin of a jhora. Fill placed on the river bed or terraces raised in October 2023 is fill like any other: the raised bed gives no credit, and on an incised jhora or khola whose 1% AEP flow stays within its banks the whole extent is floodway, in which no fill is placed (Clauses 7.6.1 and 7.6.2). Spoil and muck in "drains, gullies and jhoras" are already prohibited (SBCR 1991, reg. 22), and on a scheduled river's bank they are also a matter for the Forest Department under the 1988 Act. This rule is set by this Manual. |
| Land in Zone 1 | A jhora on public land other than forest land within a municipal area already vests in the Municipality (Municipalities Act, s.172(1)), and the river bank of a scheduled river is under the Forest Department (1988 Act, s.29(9)). Zone 1 land that is private is **secured by agreement with the owner or by donation**, or reserved in a development plan once the 2024 Act commences, and is **not taken**. Jhoras outside municipal limits, and jhoras on forest land, have no named protector (s.172 excludes forest land) (NEER reading). This rule is set by this Manual. |
| Gram Panchayat | The rural local body for this chapter and its annexes. Sikkim's panchayat law and the records, if any, that panchayats keep of village waters were not researched for this Manual [TBC]; the rural sewage of the State is "under the supervision of Rural Management Department" (State's filings before the National Green Tribunal). |

## 7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with the Water Resources Department and the Land Revenue and Disaster Management Department, shall maintain a GIS layer of every waterbody in its area (Annex 7A). For each waterbody it shall record:

- (a) its type (Clause 7.2), name and survey numbers;
- (b) its custodian (the Municipality (the Gangtok Municipal Corporation (GMC), the Namchi Municipal Council or a Nagar Panchayat), in which a jhora on public land other than forest land within the municipal area vests, and which must protect every jhora within that area, "whether on a public land or on a private land" (Sikkim Municipalities Act, 2007, s.172), the Forest and Environment Department (for the river bank of a scheduled river, which is under its control "as if it were a forest" under section 29(9) of the 1988 Act, for forest land, slip reserves and road reserves, and through its River Rejuvenation Committee, notified as "the Nodal Agency for all water bodies"), the Water Resources Department (for river and jhora works), the hydropower operator (for its reservoir, its dam and the reach below it: NHPC, whose estimates of the bed raised in October 2023 cover Teesta-V, Teesta-VI and the Teesta Low Dam projects III and IV, and the company that holds each other project), the Public Health Engineering Department (PHED; for water-supply sources and intakes), the Rural Management and Development Department (RMDD; for rural sewage, and for the springs and ponds its Dhara Vikas programme works on, which no statute assigns to it), the Roads and Bridges Department (PWD), NHIDCL or BRO (for the drains and culverts of their roads), the Gram Panchayat (for village waters outside municipal limits [TBC]), a private owner or a community (for land and water held by them; customary custodians of lakes were not researched [TBC]), a colony developer (for the drains of a layout until they are handed over), the State Wetland Authority (for a notified wetland; none was found), or another body; a jhora outside municipal limits or on forest land has no named protector, and this is recorded as such);
- (c) its boundary as recorded in Revenue records;
- (d) for tanks: FTL, MWL, TBL, the surplus weir crest length and type, sluices, the supply channel and the surplus course, each with its datum;
- (e) its position in any tank cascade, with the upstream and downstream tanks;
- (f) the 1% AEP flood extent, where mapped; and
- (g) known encroachments, with the date recorded.

7.3.2 **Project mapping.** Every drainage report shall include a Waterbody Sheet (Form 7-1) showing all waterbodies:

- (a) within the site;
- (b) within 100 m of the site boundary; and
- (c) downstream, to the extent of the downstream analysis of Chapter 5.

The sheet shall show, on a plan at a scale of 1:1,000 or larger for (a) and (b):

- the Revenue record boundary;
- the surveyed FTL or top of bank;
- the MWL contour (tanks) and the 1% AEP flood extent;
- Zone 1 and Zone 2 (Clause 7.4); and
- every supply channel, surplus course, sluice and surplus weir.

7.3.3 **Sources.** Waterbodies shall be identified from all of the following. Where they conflict, the larger waterbody extent governs:

- (a) land records and maps of the Land Revenue and Disaster Management Department (LR&DMD) and the District Collectors, kept by revenue block (NEER reading [TBC]; no land record was read for this Manual); the Forest Department's records of the river banks of the 103 scheduled rivers under the 1988 Act, which are under its control, and of its slip reserves and road reserves; the jhoras that vest in each Municipality under section 172(1) of the Sikkim Municipalities Act, 2007, and any limits of a jhora notified under section 173 (none was found); the maps of the notified areas kept by the Urban Development Department (UDD) and the Mines and

Geology Department's stability-zone maps of regulation 17 of the SBCR 1991; the GIS master plans of the Sikkim Integrated Urban Development Project for four towns other than Gangtok, and of the Namchi Planning Area, once prepared; the hydropower operators' records of reservoir levels and reservoir land; the spring inventories of RMDD's Dhara Vikas programme and its village spring atlas (whose counts conflict, as reported); the evacuation and risk maps of the Sikkim State Disaster Management Authority (SSDMA) and the District Disaster Management Authorities for the GLOF corridors, where they exist [TBC]; and each town's drain and jhora register (Chapter 6);

- (b) WRD and Gram Panchayat tank registers and records of FTL and MWL;
- (c) the Authority's inventory (Clause 7.3.1) and any list published under court directions;
- (d) historical topographic maps and satellite imagery, including the ISRO National Wetland Inventory and Assessment; and
- (e) a site survey by a licensed surveyor, levelled to the datum stated in Clause 7.3.5.

7.3.4 **Flood extent maps.** The Authority may adopt 1% AEP flood extent or flood depth maps for its area. A depth map adopted under this clause also sets floor levels under Clause 6.11. Where a map has been adopted, it shall be used unless a site hydraulic study under Chapters 3 and 5 shows a larger extent. Where no map has been adopted, the Applicant shall determine the 1% AEP extent by a hydraulic study for:

- (a) any site in a flood-sensitive catchment (Chapter 1);
- (b) any site of 1 ha or more adjoining a waterbody; and
- (c) any site where the Authority so requires.

For other sites, the fixed-width setback of Clause 7.4.6 may be used.

7.3.5 **Datum.** All levels in this chapter shall be stated to one datum, stated on every drawing. Where WRD records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> Commentary. Sikkim has no floodplain law and no flood line. No floodplain zoning Act, Bill or notified flood line was found (NEER reading); the Sikkim Town and Country Planning Act, 2024 would require development plans with "proposals for flood control, land stability and sloped linked controls" and regional plans that show the "natural disaster-prone area", but it has not commenced, and no plan has been made under it. The State itself says that the raised bed of the Teesta "poses a heightened risk of flooding during the monsoon season", and the project report on GLOF risk in the Lhonak valley annexed to its affidavit of 28 February 2026 suggests "High-risk Zoning" of the floodplains below glaciers and glacial lakes to keep critical infrastructure off them; that is a proposal, not a rule. No setback along the Teesta after the flood of October 2023 was found in that affidavit, in the orders of the High Court of Sikkim read for this Manual or in searches (NEER reading). The rivers are gauged only at a few sites, and their levels are known for this Manual only as SANDRP transcribed them from CWC (as reported): on the Teesta at Khanitar an old highest level of 297.7 m (18 September 1974) and a new one of 298.4 m (09:00, 4 October 2023); at Melli a warning level of 226.0 m and danger level of 227.0 m, an old highest level of 225.25 m, and a peak on 4 October 2023 given as 225.5 m in SANDRP's text but 228.0 m in a CWC bulletin of 2024 seen as a snippet (the figures conflict, and SANDRP's "2.75 meter higher than the old HFL" fits neither); on the Rongni Chu at Singtam a danger level of 355.09 m and a highest level of 356.09 m (undated); and on the Rangit at Majitar a highest level of 279.29 m (17 October 1985). No CWC level was found for Rangpo [TBC], and the sites above Dikchu stopped reporting between 22:00 and 23:00 on 3 October 2023. No source read for this Manual states the datum of any of these levels. Every one of them was set on a bed that has since moved: the bed rose "by an average of 7-8 meters" (PPR, 2026), and NHPC estimated rises of about 7.44 m at the Teesta Low Dam project IV, 7.29 m at project III, 6.00 m at Teesta-V and 2.00 m at Teesta-VI. The best evidence of flood extent on the valley floors is therefore the surveyed flood and debris marks of October 2023 at each site, with the post-2023 bed, and in the GLOF corridors the evacuation and risk maps prepared with the participatory risk assessments of SSDMA and the District Disaster Management Authorities in May 2024, where they exist [TBC]. Clause 7.3.4 lets the Authority adopt flood maps once they exist; until then the Applicant must produce the 1% AEP extent for larger and flood-sensitive sites, with the bulking of Clause 6.3.6(g) on jhoras and kholas and the tailwater of Clause 5.8.5(b), and every highest flood level used shall be checked against a post-2023 survey. On

> the GLOF corridors the 1% AEP extent is not the governing line: siting above the October 2023 flood and aggradation level governs (definitions after Clause 7.2). Levels shall be stated to one datum (Clause 7.3.5), with the gauge and its datum named. Clause 7.3.3 makes the larger of the recorded and surveyed extents govern, because the Revenue boundary and the surveyed water edge often differ, and either may have been reduced by encroachment. The 100 m search band in Clause 7.3.2 is set by this Manual.

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## 7.4 Setbacks

7.4.1 **Waterbodies to which setbacks apply.** Setbacks apply to:

- (a) every waterbody recorded under Clause 7.3.1 or found under Clause 7.3.3, whatever its size; and
- (b) every natural channel, whether recorded or not, that drains **8 ha** or more at the site.

7.4.2 **Two zones.** The setback has two zones, shown in Figure 7.1:

- **Zone 1 (waterbody protection zone)**, next to the waterbody; and
- **Zone 2 (flood fringe setback)**, outside Zone 1.

7.4.3 **Zone 1 width.** Zone 1 is measured outward from the FTL contour (tanks, lakes and ponds) or from the top of bank (channels). Where both apply, use whichever gives the wider zone. Zone 1 extends to the **greatest** of:

- (a) **15 m**, the minimum set by this Manual along every natural channel draining 8 ha or more, every jhora and khola among them, and round every pokhari, reservoir and dhara, measured from the top of bank or, on an incised jhora or khola whose bank is a slope steeper than 10°, from the crest of that bank slope (wider lines govern under Clause 7.4.5 where they bind: the river bank of a scheduled river under section 29(1) of the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 is "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less", a maximum that may be wider or narrower than 15 m; no statute, regulation or notification sets any line along a jhora; the SBCR 1991 set no distance from a jhora or river; no limits of a jhora have been notified under section 173 of the Sikkim Municipalities Act, 2007; and no setback along the Teesta was found after the flood of October 2023; see the Disclosure below);
- (b) the outer edge of the floodway (Clause 7.6.1); and
- (c) for a tank, the MWL contour.

7.4.4 **Zone 2 width.** Zone 2 extends from the outer edge of Zone 1 to the **1% AEP flood extent plus 10 m**. Where the 1% AEP flood extent lies inside Zone 1, Zone 2 is 10 m wide.

7.4.5 **Statutory and approval setbacks.** Where a statute, a statutory rule, a condition of planning permission or the river bank of a scheduled river under section 29(1) of the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (sixty metres on either side of the river or the area within the high flood level mark, whichever is less), which is under the control of the Forest Department, a closure of a river bank, slip reserve or road reserve notified under section 32 of that Act, or a river added to its Schedule by notification; the limits of a jhora, watercourse or channel notified under section 173 of the Sikkim Municipalities Act, 2007 (none has been); a condition of the Municipality or of UDD on a building permission under the SBCR 1991, including the setbacks of regulation 18 and the conditions of the stability zone and of a zone review under the Mines and Geology Department's notification of 2021; a condition of the Water Resources Department for a work in or on a river or a jhora it has trained; the consent of a hydropower operator for a work that drains to, or lies next to, its reservoir or the reach below its dam; a flood-control or slope-linked control in a development plan once the Sikkim Town and Country Planning Act, 2024 commences (it has not); the views or permission of the Forest and Environment Department or the State Wetland Authority for a work in or next to forest land or a notified wetland; an order of a District Collector, SSDMA or a District Disaster Management Authority fixing a GLOF corridor or a relocation area, such as the relocation of 155 households at Toong Naga in the

post-disaster needs assessment (PDNA) of 2023 (no order setting a line was found); or a direction of the High Court of Sikkim, the National Green Tribunal or the Supreme Court sets a setback wider than Zone 1 or Zone 2, the wider setback governs for the uses it restricts.

7.4.6 **Fixed-width setback where no 1% AEP extent is available.** Where Clause 7.3.4 does not require a hydraulic study and no map has been adopted, the setback (Zone 1 plus Zone 2) shall be not less than the following, measured as in Clause 7.4.3:

**Table 7.1 — Fixed-width setback where no 1% AEP extent is available**

| Waterbody | Total setback (Zone 1 + Zone 2) | Of which Zone 1 |
|---|---|---|
| Channel draining 8 ha to 65 ha | 25 m | 15 m |
| Channel draining 65 ha to 20 km² | 40 m | 15 m |
| Channel draining more than 20 km², and rivers | 50 m | 20 m |
| Tank, lake or pond | MWL contour + 25 m | to MWL contour, and not less than 15 m from FTL |
| Marsh, estuary or backwater | as notified by the Authority, and not less than 50 m | 15 m |

This table is the alternative S-3 of the Policy Supplement (Annex 1C) and may be adopted under Clause 1.7.

7.4.7 **Minimum in all cases.** No setback under this chapter, and no variance under Clause 1.10, shall reduce Zone 1 below 15 m (Clause 1.10.3(c)).

> Commentary. The 15 m minimum is set by this Manual, as the floor of a hydraulic corridor where no wider line binds. Sikkim has one statutory line along water, and it is a maximum: for the 103 rivers in the Schedule to the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, the river bank "means and includes an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (s.29(1)), and since 2000 it has been "under the administrative control of the Forest Department as if it were a forest" (s.29(9)). Because the narrower of the two lines governs, the statutory bank on an incised reach whose high flood level lies a few metres from the channel may be only a few metres wide (NEER reading), and after the flood of October 2023 the high flood level itself has moved. The Act's "river" includes "any stream, channel, jhora, creek" (s.2(m)), but its 60 m applies only to the rivers in the Schedule. No statute, regulation or notification sets any line along a jhora: the SBCR 1991 have none; zone 1 of the Mines and Geology Department's stability zonation of 2021 asks only that jhoras be trained "with safe distance", which it does not define; and no limits of a jhora have been notified under section 173 of the Sikkim Municipalities Act, 2007. The 15 m floor applies along every natural channel draining 8 ha or more and round every pokhari, reservoir and dhara. On an incised jhora or khola whose bank is a slope steeper than 10°, the threshold of the hill rule of Clause 4.11, it is measured from the crest of that bank slope, not from the edge of the water, because a slide of the bank starts at its crest and a cut, a fill or a soak pit near the crest can bring it down (set by this Manual). It applies to new development and redevelopment approved under this Manual, not to existing buildings; it is proposed as a condition of building permission in the notified and municipal areas and as a recommendation elsewhere; and where Zone 1 land is private, it is secured by agreement or donation, or reserved in a development plan once the Sikkim Town and Country Planning Act, 2024 commences, and is not taken. It is this Manual's proposal, not a statutory width, and it never reduces a wider line (see the Disclosure below). Extending the setback to the mapped 1% AEP extent plus a margin follows the Kansas City Metro APWA Section 5600 (2025.01) two-zone structure:
>
> - APWA Zone 1 (streamside) is measured from top of bank, and only utility and road crossings are allowed in it.
> - APWA Zone 2 is the 1% AEP flood extent plus 10 ft (about 3 m), for streams draining 20–40 acres.

- APWA lowered the trigger for stream setbacks from 40 acres to 20 acres (about 8 ha) in 2025.01.

(MARC, APWA 5600 Policy Supplement, Nov 2025.) Clause 7.4.1(b) adopts the 8 ha trigger. This Manual's 10 m margin is wider than APWA's 10 ft and has no direct precedent. This Manual sets it because Sikkim flood maps are mostly coarser than US maps, where they exist at all (none was found for any Sikkim town), and the only level land in a Sikkim town is usually a river terrace or valley floor beside the Teesta, the Rangit or the Rongni Chu, as at Rangpo, Singtam, Melli, Majitar and Jorethang, a bench cut into a slope, or the margin of a pokhari or reservoir, while the Teesta's bed, raised by the flood of October 2023 into "a flattened, more expansive river profile than the typical V-shaped valley" (PPR, 2026), is now wider and flatter than before (so a small error in level moves the flood edge a long way), and the margin gives room for maintenance access along the waterbody.

The fixed-width table in Clause 7.4.6 is set by this Manual. Its channel widths are scaled from the 2006 APWA default stream buffers, which were 40 ft, 60 ft, 100 ft and 120 ft (12, 18, 30 and 37 m) for drainage areas of less than 40 acres, 40–160 acres, 160–5,000 acres and more than 5,000 acres (KC APWA 5600, 2006, §5605.3). They are rounded up and floored at the 15 m minimum. APWA offered a fixed-width table for the same reason: communities objected that the 1% extent is often unmapped for small drainage areas (MARC Supplement, 2025). The table should be replaced by mapped extents as soon as the Authority adopts them.

URDPFI (2015) reserves the area flooded at a 10-year frequency for parks and playgrounds, and allows residential use in the 25-year flood zone only on stilts, with minimum plinth levels and no basements. This chapter is stricter. It keeps habitable buildings out of the whole 1% AEP extent plus margin, because the 1% AEP (100-yr) event is the major-system standard of this Manual (Chapter 6).

Sikkim's one distance from water is a forest law's, and it is a maximum. Under the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Act 6 of 1988), "river banks in relation to rivers enumerated in the Schedule means and includes an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (s.29(1)). The Schedule lists 103 rivers, from 1 the Teesta and 2 the Rangeet through 14 the Rongni chu, 15 the Roro chu, 62 the Gangtok chu and 77 the Lhonakchu to 103 the Khani Khola (Melli), and "104. Any other river that may be included by the Government, by notification". Since the amendment of 2000 (Act 8 of 2000) the river bank "shall be under the administrative control of the Forest Department as if it were a forest" (s.29(9)); unauthorised occupation is punishable (s.30); the Government may "by notification, declare that any slip reserve or road reserve or river bank shall be closed" (s.32); and rules may "prohibit the closing up or obstructing of the bank of any river" (s.42(2)(g)), though none prescribing widths was read. The Act's "river" includes "any stream, channel, jhora, creek or other channel, natural or artificial" (s.2(m)), but the 60 m applies only to the rivers in the Schedule. Because the line is the nearer of 60 m and the high flood level, it is a maximum, not a minimum (NEER reading): on an incised reach the statutory bank may end a few metres from the water, and after the flood of October 2023 the high flood level itself has moved. **Along a jhora there is no statutory line at all.** The SBCR 1991 set no distance from a jhora or river; the Mines and Geology Department's stability zonation of 2021 asks, for zone 1, that "Training of jhoras/drains have been completed and done properly (with safe distance)", without saying what the distance is; and the State has not notified the limits of any jhora under section 173 of the Sikkim Municipalities Act, 2007, though section 172(2) makes the Municipality "protect any jhora, whether on a public land or on a private land, within the municipal area". The other lines in force are not lines from water: regulation 18 of the SBCR 1991 keeps a building "Minimum 27 feet away from the centre of the road", with a set back of "10 feet (or as indicated in approved Master Plan of the area)"; regulation 25(v) keeps a septic tank at least 4'0" from the building; and regulation 35 bars allotment or regularisation "in any sinking area, landslide prone or in areas having scars of old landslides or in slope exceeding or around 70 (Seventy) degree". **No setback along the Teesta after the flood of October 2023 was found**, in the State's affidavit to the National Green Tribunal of 28 February 2026, in the orders of the High Court read for this Manual or in searches (NEER reading); the "High-risk Zoning" of floodplains below glacial lakes in the project report annexed to that affidavit is a proposal, and the relocation of 155 households at Toong Naga in the PDNA of 2023 is a relief decision, not a line. The 2024 Act would put flood-control and slope-linked controls into development plans, but it has not

commenced. These rules leave gaps for drainage: the jhoras, into which every ridge town drains, have no line; the scheduled rivers have a line that shrinks to the flood mark on the reaches where the towns stand above an incised channel; and the springs have none. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

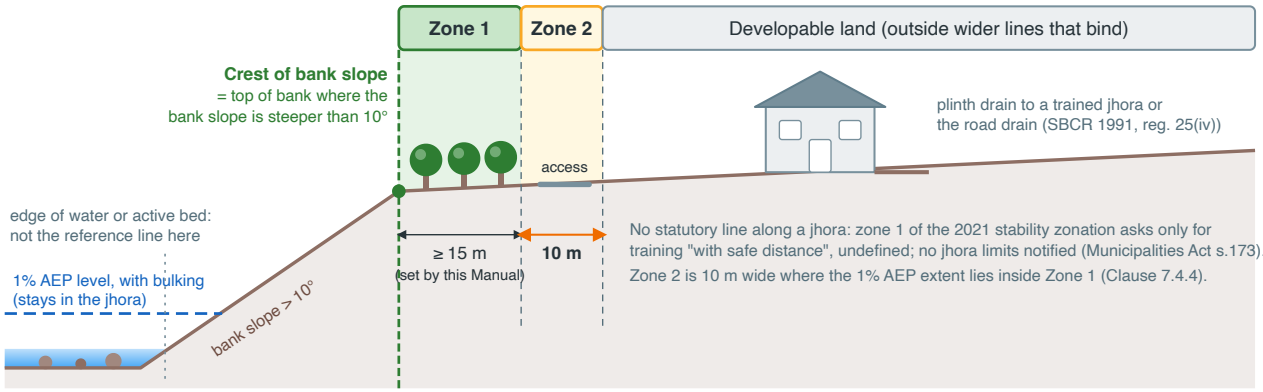
**Disclosure.** Sikkim **has one statutory distance from water, and it is a maximum; along its jhoras it has none**. The river bank of a scheduled river under section 29(1) of the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 is "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less", under the Forest Department's control; no statute, regulation or notification sets any line along a jhora; no limits of a jhora have been notified under section 173 of the Sikkim Municipalities Act, 2007; **no setback along the Teesta exists after the flood of October 2023**; and no floodplain zone or flood line has been notified. The **15 m minimum** Zone 1 of Clauses 7.4.3 and 7.4.7, and every value derived from it in Table 7.1, is **set by this Manual** as a hydraulic corridor where nothing wider binds: along every natural channel draining 8 ha or more, every jhora and khola among them, measured on an incised jhora or khola from the crest of its bank slope, and round every pokhari, reservoir and dhara. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, the floor levels on the valley floors, the siting of drainage assets above the October 2023 flood and aggradation level and outside a mapped GLOF path, and the rules on jhoras, dharas, glacial lakes and fill (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule**, and no government body has adopted or endorsed them. On a scheduled river the statutory bank (up to 60 m, or the high flood level line where that is nearer) **may be wider or narrower** than the Manual's 15 m: where it is wider, it binds as well, and governs for the uses it restricts (Clause 7.4.5); where the high flood level line is nearer, the Manual's corridor is the stricter. On a jhora no statute sets any line, so the 15 m is a NEER proposal throughout. The corridor applies to **new development and redevelopment approved under this Manual, not to existing buildings**; Clause 7.4.7 allows no variance below it; it is proposed as **a condition of building permission in the notified and municipal areas and a recommendation elsewhere** (Chapter 1); and where Zone 1 land is private, it is **secured by agreement with the owner or by donation**, or reserved in a development plan once the 2024 Act commences, **never taken**. Jhoras on public land other than forest land within a municipal area already vest in the Municipality (s.172(1)); the river banks of the scheduled rivers are under the Forest Department (1988 Act, s.29(9)); and jhoras outside municipal limits, or on forest land, have no named protector. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The 1988 Act.** The river bank of the 103 scheduled rivers (s.29(1)), a maximum, and any river added by notification; occupation of a river bank an offence (s.30); closure of a river bank, slip reserve or road reserve by notification (s.32); slip reserves, "denuded areas … required to be conserved or preserved for stabilization" (s.29(2)), which keep drains and fill off the land notified. Where the statutory bank is narrower than Zone 1 the Applicant states it on Form 7-1; it never governs alone.
- **The Sikkim Municipalities Act, 2007.** The Municipality's duty to "protect any jhora, whether on a public land or on a private land" (s.172(2)); the State's power to "specify the limits of any jhora, watercourse or channel within a municipal area" (s.173), not yet used; the duty to provide "a safe and sufficient outfall … in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187).
- **The SBCR 1991 and the stability zonation.** The road setbacks of regulation 18; regulation 35's bar on "sinking", "landslide prone" land and slopes "exceeding or around 70 (Seventy) degree"; and the 2021 zone conditions, under which a site's zone depends partly on whether its jhoras are trained "with safe distance" and a zone review asks for the "Training of untrained Jhora and maintenance at regular intervals which is located adjacent to the plot". The distance is undefined; this Manual's Zone 1 is the distance it proposes.
- **Plans and orders.** A development plan's flood-control and slope-linked controls once the 2024 Act commences (none yet); an order of a District Collector, SSDMA or a District Disaster Management Authority fixing a GLOF corridor or relocation area (none setting a line was found); a hydropower operator's line at its reservoir; the Water Resources Department's at its river works; and the orders of the High Court of Sikkim, the National Green Tribunal and the Supreme Court as they stand. The "High-risk Zoning" of the floodplains below glacial lakes in the project report of 2026 is **a proposal only**, cited as expert guidance, never as binding.

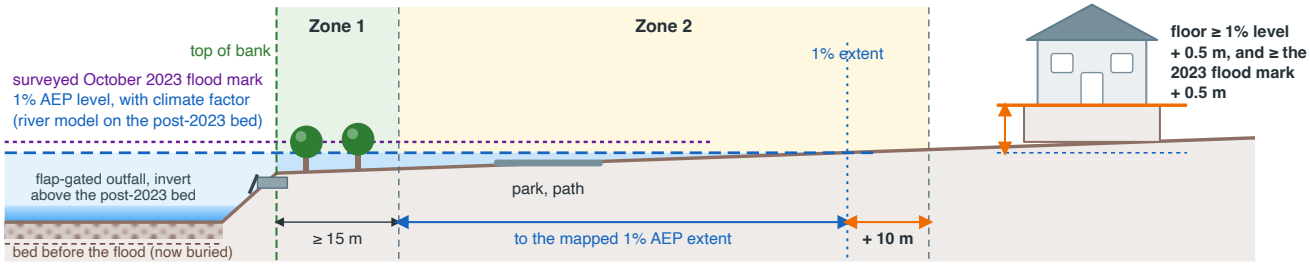
This Manual sets 15 m as the floor because the jhoras, which carry every ridge town's storm water and much of its sullage, have no line in law; because the scheduled rivers' line ends at the flood mark wherever that is nearer than 60 m; because 15 m is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled; and because a jhora needs room for the boulders, debris and slide material it carries in flood and for the people and machines that clear and train it. The record is the reason for the corridor: the stability zonation of 2021 already treats an "Untrained jhora/ erosional potential jhora" with "Gully erosion & collapse of jhora facing slope" as a mark of zone 4, "Not suitable for habitation unless immediate protective measures"; Gangtok Smart City Development Ltd (GSCDL) told the National Green Tribunal that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (OA 38/2022); and on the valley floors the flood of October 2023 raised the Teesta's bed by 7–8 m and buried parts of Rangpo, so that no rainfall-based line protects against the cascade (Clause 2.3.6(i)). On the valley floors Zone 2 and the floor levels (definitions after Clause 7.2) do the work; on the GLOF corridors siting does. Until a statute, rule, notification, development plan or court adopts it, the 15 m minimum is this Manual's recommended standard, and the 1988 Act, the Municipalities Act, the SBCR 1991, the stability zonation and the orders above remain the only legal rules. Approving authorities should state in each approval which was applied.

**Waterbody setback: Zone 1 and Zone 2, with Sikkim's lines (sections, not to scale)**

**A — Incised jhora on a ridge slope: Zone 1 measured from the crest of the bank slope**




**B — Scheduled river on a valley floor, its bed raised by a past flood: Zone 2 to the 1% AEP extent + 10 m**




**C — Lines that exist in Sikkim, with their status (each binds only where it applies)**

- 1988 Act, s.29(1): river bank of a scheduled river = 60 m or the area within the high flood level mark, whichever is less — a maximum, under the Forest Department; may be wider or narrower than Zone 1
- ? Jhora: no statutory line (SBCR 1991 none; 2021 zone 1 "with safe distance", undefined; s.173 limits none notified)
- No setback along the main river after the flood of October 2023 exists in law; none is drawn here
- Road: 27 ft from the road centre and a 10 ft setback (SBCR 1991, reg. 18) — a road line, not a line from water
- GLOF corridor and raised valley floor: siting, not a setback — drainage assets above the October 2023 flood and aggradation level and outside a mapped GLOF path (set by this Manual)

**Zone 1:** no buildings, fill, paving, retaining walls or dumping. Crossings, utilities, flood works and native vegetation only.

**Zone 2:** no habitable buildings. Parks, unpaved paths, open-sided structures; fill only with 1:1 compensatory storage.

**Spring rule (this Manual):** no outfall, soakaway or drain discharge within 15 m of a dhara; its recharge area protected.

**Whichever is wider governs:** Zone 1 from top of bank (the crest of the bank slope on an incised jhora), the 1% AEP extent + 10 m, and any wider line that binds. New development and redevelopment only; private land secured by agreement, not taken. The 15 m minimum is this Manual's proposal, not a statutory width.

*Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).*

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## 7.5 Uses permitted in each zone

7.5.1 **Zone 1.** No building, fill, paving, retaining wall, boundary wall, compound wall, dumping of earth, debris or solid waste, storage of materials, or construction-stage stockpile shall be placed in Zone 1. Only the following are permitted, each subject to the custodian's NOC:

- (a) road, rail and utility crossings that meet Clause 7.10.3;
- (b) flood and drainage works: outfalls, inlet structures, gross pollutant traps, sluices, surplus weirs, bund strengthening and bank protection;
- (c) native vegetation, planting and habitat works;
- (d) unpaved or permeable footpaths and maintenance tracks at existing ground level; and
- (e) waterbody restoration under Clause 7.9.

7.5.2 **Zone 2.** No habitable building, basement, school, hospital, fuel store or hazardous-material store shall be placed in Zone 2. The following are permitted:

- (a) all uses permitted in Zone 1;
- (b) parks, playgrounds, open-air sports fields and urban agriculture;
- (c) open-sided structures (shelters, pavilions) with no walls that obstruct flow;
- (d) surface parking with permeable surfacing at existing ground level, where the 1% AEP flood depth is not more than 0.3 m;
- (e) retention, detention and water quality facilities under Chapters 4 and 8, provided they are outside the floodway and their storage is not counted twice (Clause 7.6.5); and
- (f) fill, only for (a) to (e) or for essential public infrastructure, and only with compensatory storage under Clause 7.6.4.

7.5.3 **Fences.** Fences in Zone 1 and Zone 2 shall be open (chain-link or railing) with no plinth wall above existing ground level, so that they do not obstruct flow or trap debris.

7.5.4 **Open space reservation.** Zone 2 land may be counted toward the open space required by the Sikkim Building Construction Regulations, 1991, where the Authority agrees. Zone 1 land shall be handed over to the custodian or kept free of private use, as the Authority decides.

> **Commentary.** The permitted uses follow APWA 2025.01: in Zone 1, only utility and road crossings; in Zone 2, linear utilities, trails and open-sided structures; no clearing, grading, fill or paving in either zone without approval (MARC Supplement, 2025). Clause 7.5.2 adds parks and playgrounds, the uses URDPFI (2015) allows in the 10-year flood zone. The ban on walls in Clauses 7.5.1 and 7.5.3 responds to hill-town practice: compound walls along channels and tanks act as dams in floods, and are often the first step toward encroachment. The 0.3 m depth limit for parking in Clause 7.5.2(d) has no direct precedent and is set by this Manual.

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## 7.6 Floodway, flood fringe and compensatory storage

7.6.1 **Floodway delineation.** The floodway shall be delineated by a hydraulic model of the 1% AEP flood (with the climate factor), using the encroachment method: the conveyance of the flood fringe is removed equally from both banks until the 1% AEP water level rises by 0.1 m. Where the floodway has not been delineated, the whole 1% AEP flood extent shall

be treated as floodway. For a tank, all land below MWL is floodway.

7.6.2 **No fill in the floodway.** No fill, building, embankment, raised road or other obstruction shall be placed below the 1% AEP flood level within the floodway, except the works permitted in Zone 1 under Clause 7.5.1(a) and (b). Those works shall be shown by hydraulic analysis to raise the 1% AEP water level by no more than 0.01 m, upstream or downstream, outside the Applicant's land.

7.6.3 **Fill in the flood fringe.** Fill below the 1% AEP flood level in the flood fringe is permitted only:

- (a) for uses permitted under Clause 7.5.2, or outside the setback where the Authority has notified a developed-fringe area under Clause 7.6.6; and
- (b) with compensatory storage under Clause 7.6.4.

7.6.4 **Compensatory storage.** Where fill is placed in the flood fringe, compensatory storage shall be provided that (Figure 7.2):

- (a) replaces at least **1.0 m³ of storage for each 1.0 m³ of fill** placed below the 1% AEP flood level;
- (b) is provided at **equivalent levels**: the volume lost and the volume replaced shall be balanced in each elevation band of not more than **0.3 m**, from the normal water level (or the 50% AEP level, where higher) up to the 1% AEP flood level;
- (c) is in the same reach of the same waterbody, hydraulically connected to it, and not further downstream than the fill;
- (d) drains freely by gravity back to the waterbody as the flood recedes, with no pumping and no permanent pool below the normal water level;
- (e) is built before, or at the same time as, the fill is placed; and
- (f) is secured by a covenant or handover so that it is never filled later.

7.6.5 **No double counting.** Compensatory storage shall not be counted as detention or retention storage under Chapter 4. Detention and retention storage placed within the 1% AEP flood extent shall be counted only for the volume above the 1% AEP flood level, unless a model of the joint event (Clause 2.12) shows that it is available.

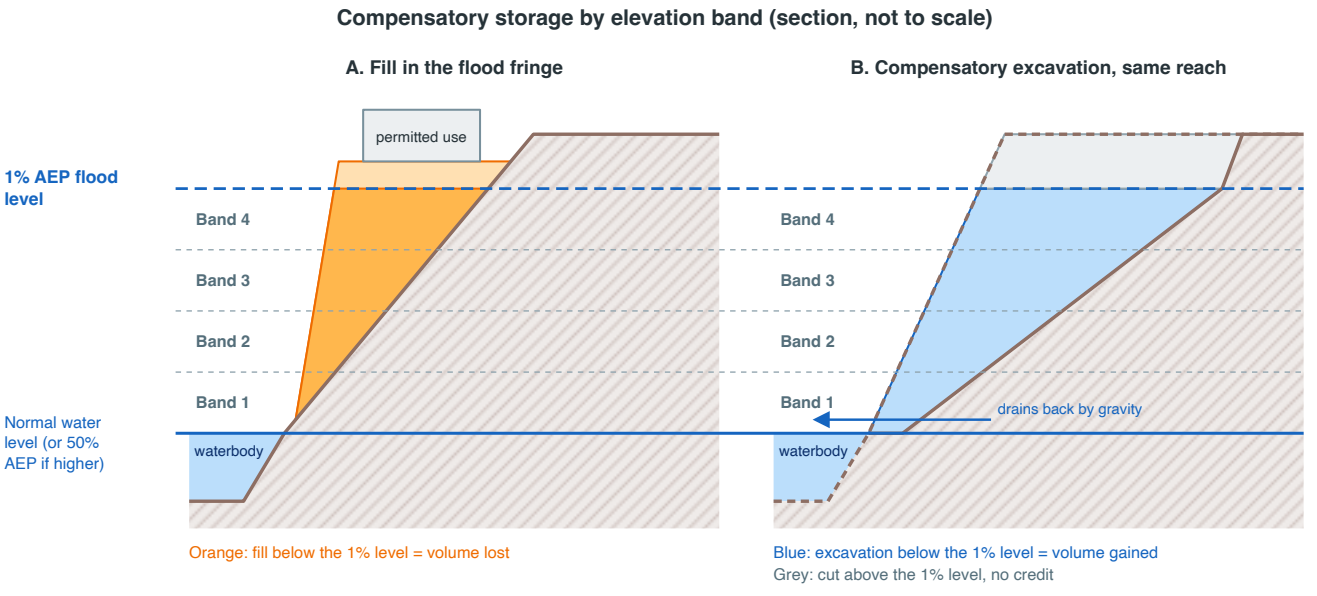
7.6.6 **Developed-fringe areas.** The Authority may notify, by map, areas of existing built-up land within the 1% AEP flood extent but outside the floodway, where it is impractical to apply Zone 2 to redevelopment. In a notified developed-fringe area:

- (a) redevelopment may be approved without the Zone 2 restriction;
- (b) the lowest habitable floor and all openings shall be at least 0.5 m above the 1% AEP flood level (Chapter 6);
- (c) basements are not permitted;
- (d) the redevelopment shall cause no net loss of flood storage below the 1% AEP flood level (Clause 7.6.4), and stilt construction may be used for this; and
- (e) Zone 1 continues to apply in full.

> **Commentary.** The 1:1 compensatory storage at equivalent levels is set by this Manual. A simple volume balance is not enough: storage excavated below the normal water level is full before the flood arrives and gives no flood benefit. Storage gained high up does not replace storage lost low down, because the low storage is used in every flood and the high storage only in the largest. Balancing volume within each elevation band avoids both problems. The 0.3 m band, the 0.01 m allowance for crossings, and the use of the encroachment method in Clause 7.6.1 are set by this Manual; the encroachment method is the standard way to delineate a floodway in a one-dimensional hydraulic model. The 0.1 m limit on the rise in the 1% AEP water level is tighter than the 1 ft (about 0.3 m) used by the US National Flood Insurance Program. Sikkim's valley floors, the river terraces of the Teesta, the Rangit and the Rongni Chu at Rangpo, Singtam, Melli, Majitar and Jorethang, and the Teesta's bed raised by the flood of October 2023, are flat, unlike the slopes around them, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.

In Sikkim the line from which a setback is measured must come from this Manual, because no level has been fixed for any pokhari, lake or reservoir. The hydropower reservoirs move through the year and have changed since 2023: no full reservoir level, maximum water level or release rule was found for any of them [TBC]; Teesta-III at Chungthang, whose 60 m dam was destroyed on the night of 3–4 October 2023 (Sattar et al., 2025), is "Under restoration & first phase of wet commissioning is expected by 31st MAY 2026 through coffer dam", with no live storage in that phase (State affidavit to the National Green Tribunal, February 2026; its present state is [TBC]); and the bed of the Teesta below it rose by 2 to about 7.4 m at the downstream dams (NHPC's estimates, in the PPR of 2026). A line drawn from the water's edge in the dry months, or from a pre-2023 survey, would leave the reservoir's own bed, or the river's new one, open to building. This Manual gives every pokhari, lake and reservoir a boundary measured from a high level, not from the water's edge on the day of survey: the edge of a pokhari in the season and the operator's highest level of a reservoir are part of its boundary, and on the Teesta valley floor the surveyed flood mark of October 2023 is the reference for siting (definitions after Clause 7.2); the foreshore up to MWL is the waterbody's flood storage. Treating all land below MWL as floodway (Clause 7.6.1) means that no new building or fill is approved in a tank foreshore.

The developed-fringe mechanism of Clause 7.6.6 is set by this Manual. Large parts of the valley-floor towns on the Teesta, the Rangit and the Rongni Chu, such as Rangpo, Singtam, Melli, Majitar and Jorethang, with Dikchu and Chungthang upstream, where the bed of the Teesta "has risen by an average of 7-8 meters" since the flood of October 2023 (PPR, in the State's affidavit to the National Green Tribunal, 2026), Rangpo was "severely impacted by the debris, burying buildings and automobiles" (Sattar et al., 2025) and 155 households at Toong Naga were "mandated for relocation" (PDNA, 2023), though no flood extent has been mapped for any of them (NEER reading), already lie within the 1% AEP extent. A blanket Zone 2 ban on redevelopment there would stop the replacement of older, lower buildings with buildings raised above flood level. The mechanism follows the URDPFI (2015) approach for the 25-year flood zone (stilts, minimum plinth, no basements), applied here to the 1% AEP extent.




Bands of not more than 0.3 m, from the normal water level to the 1% AEP level. Volume gained ≥ volume lost in every band (Clause 7.6.4(b)).

*Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation draining back to the waterbody by gravity. Band-by-band calculation on Form 7-3. Original drawing for this Manual, illustrating the method of Clause 7.6.4, which is set by this Manual.*

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## 7.7 Tank cascades as design storage

Sikkim has no tank Act and no irrigation tank cascades, and its standing waters range from a village pokhari a few metres across to the hydropower reservoirs on the Teesta. The storages that matter for drainage are of four kinds, and a fifth kind of lake is never storage at all. The first is the **hydropower reservoirs and pondages**: Teesta-III (1,200 MW, Chungthang), "non-operational since 4th Oct 2023" (as quoted from the State's power department) and under restoration; Teesta-V (510 MW, NHPC; dam at Dikchu), reported restored; Teesta-VI (500 MW, expected in September 2029); the Teesta Low Dam projects III and IV; Chuzachen (110 MW; shut down, to restart from 15 February 2026); Dikchu (96 MW); Jorethang (96 MW); Tashiding (97 MW); Rongnichu (113 MW); and Rangit-III (60 MW) (State affidavit, February 2026, and as reported). No full reservoir level, maximum water level, stage–storage curve or release rule was found for any of them [TBC]. Their releases enter a design as inflow and tailwater (Clauses 5.8.3 and 5.8.5(c)), and they are not tanks for these clauses unless their storage is counted. The second is the **lakes** of the ridges, such as Khecheopalri (Khachoedpalri), reported to be the State's first Ramsar site, and Tsomgo, both in the National Wetland Conservation Programme's list (as reported); no level, area or outlet record usable for design was found for either (Khecheopalri's reported areas conflict, and none is used) [TBC], so they are protected as waterbodies and wetlands and are not counted as storage. The third is the **village pokharis and the ponds of the springsheds**, including those built under RMDD's Dhara Vikas programme (as reported), which are modelled as existing features where they intercept runoff but are never counted as storage, because they are not surveyed, have no controlled outlet and are full by the time of the peak storm. The fourth is the **dharas**, which are protected for their water and never counted as storage. The fifth is the **glacial lakes**, 320 of them in the State's count (PPR, 2026; other inventories count differently), held behind moraines at 4,740 to 5,470 m in the case of the sixteen A-category lakes, with volumes of 0.5 to 106 million m³ (South Lhonak's given as 84 million m³ in 2022) and 178 million m³ for the Gurudongmar complex (PPR and State affidavit, 2026): they are hazard sources under Clause 2.3.6(i), and no storage credit, flood cushion or clause of this section applies to them, even where their names contain "Pokhari" (Bhalay Pokhari, 4 million m³; Doodh Pokhari, 0.5 million m³). In a ridge town every drain ends in a jhora and every jhora in a khola or river that runs to a valley-floor reach or a reservoir; Figure 7.3 shows these waterbodies together. Any pokhari, lake or reservoir whose storage is to be counted is subject to Clause 7.7.1 in full, with its operator or other custodian, and the custodian of each pokhari and lake shall be confirmed for the inventory (Annex 7A) [TBC].

7.7.1 **When tank storage may be counted.** The storage of a tank or tank cascade may be counted as design storage (in a basin plan, a regional facility or a fee-in-lieu scheme under Clause 7.11) **only** where all of the following are met:

- (a) **Surveyed levels.** FTL, MWL, TBL, the surplus weir crest and length, and the sluice sill levels have been surveyed to the datum of Clause 7.3.5 within the previous 5 years.
- (b) **Stage–storage curve.** A stage–storage curve has been derived from a bathymetric and topographic survey of the waterspread and foreshore within the previous 5 years, or after the last desilting, whichever is later.
- (c) **Operating rule.** A documented operating rule has been agreed with the custodian (Clause 7.8).
- (d) **Maintained structures.** The surplus weir, sluices and bund are maintained under an O&M plan (Chapter 10), and the latest pre-monsoon inspection found them serviceable.
- (e) **Custodian concurrence.** WRD, or the other custodian, concurs in writing.

Storage in a tank that fails any of (a) to (e) shall not be counted, though the tank shall still be modelled as an existing feature (Chapter 3).

7.7.2 **Modelling.** Tank cascades shall be modelled under Clause 3.12.5 (level-pool routing of each tank, with surplus weir and sluice ratings) and Clause 3.13 (continuous simulation). The whole cascade, from the uppermost tank whose surplus can reach the site or facility to the next river, major drain or sea outfall, shall be modelled together, including, for a ridge town, every drain and jhora that falls from the ridge and its slopes to the khola or river below, any pokhari on a bench with its inlets and outlet, the dharas below the town with their recharge areas, and the river itself down to the valley-floor reach or reservoir whose level sets the tailwater of the jhoras (Clause 5.8.5), as shown in Figure 7.3.

7.7.3 **Starting level.** The starting level in every tank shall be **FTL** for the design-storm analysis. A lower starting level may be used only under a flood-cushion operating rule that meets Clause 7.8.

7.7.4 **Design maximum level.** For the 1% AEP inflow with the climate factor, routed through the cascade:

- (a) the computed maximum level shall be not higher than MWL (as defined in Clause 7.2); and
- (b) the freeboard from the computed maximum level to the lowest point of the bund (TBL) shall be not less than WRD's freeboard standard for the tank.

Where (a) or (b) fails, the tank storage above FTL shall not be counted until the surplus weir capacity is increased or the bund raised under Clause 7.7.6.

7.7.5 **Creditable volume.** The creditable design storage of a tank is the volume between the starting level (Clause 7.7.3) and the computed maximum level of Clause 7.7.4, less any volume already committed to another facility or scheme.

7.7.6 **Changes to FTL, weirs and bunds.** No surplus weir crest shall be raised or lowered, no shutters or falling boards shall be added, and no bund shall be raised, cut or breached except under a design approved by the custodian that:

- (a) routes the cascade under Clause 7.7.2;
- (b) shows the effect on flood levels in the foreshore and upstream, and on flows in the surplus course and downstream; and
- (c) checks the bund under Clause 7.14.

> **Commentary.** This Manual allows tank cascades to be used as design storage subject to three basic conditions (surveyed FTL, a documented operating rule and maintained surplus weirs). Clause 7.7.1 adds the stage–storage survey and the custodian's concurrence, because the storage a tank actually offers depends on its silt level and on who controls the sluices. The 5-year survey interval is set by this Manual.
>
> The FTL starting level follows Clause 3.12.5. In Sikkim a pokhari or reservoir may be full at any time from April to October. The Manual's season begins on 1 April because Gangtok's wet season does: its normals are 296.9 mm in April on 15.2 rainy days and 496.4 mm in May on 20.1 days, before 609.8, 626.3, 565.9 and 438.7 mm from June to September (IMD, Gangtok, 1981–2010), and its largest 24-hour falls are pre-monsoon (310.3 mm on 30 May 1975, its record; Singhik 504.2 mm on 12 May 1981, CWC FER 2(a), Table 7) (Chapter 2). Storms also follow the south-west monsoon: Gangtok recorded 201.0 mm on 3 October 1996 (IMD), and the flood of 3–4 October 2023 came in early October. Rongnichu is a run-of-river project (State affidavit, February 2026); how the pondages of the other projects are operated through the season was not found [TBC], and no record of how long any village pokhari stays at or above its outlet level in a wet spell was found. While a pokhari or reservoir is full, it stores nothing more below FTL, the jhoras that flow into it discharge against its level, and its release adds to the flow in the river below it. A tank cascade passes floods from one tank to the next, so a design that counts storage in one tank and ignores the surplus arriving from the tank above it will overstate the benefit. That is why Clause 7.7.2 requires the whole cascade to be modelled.

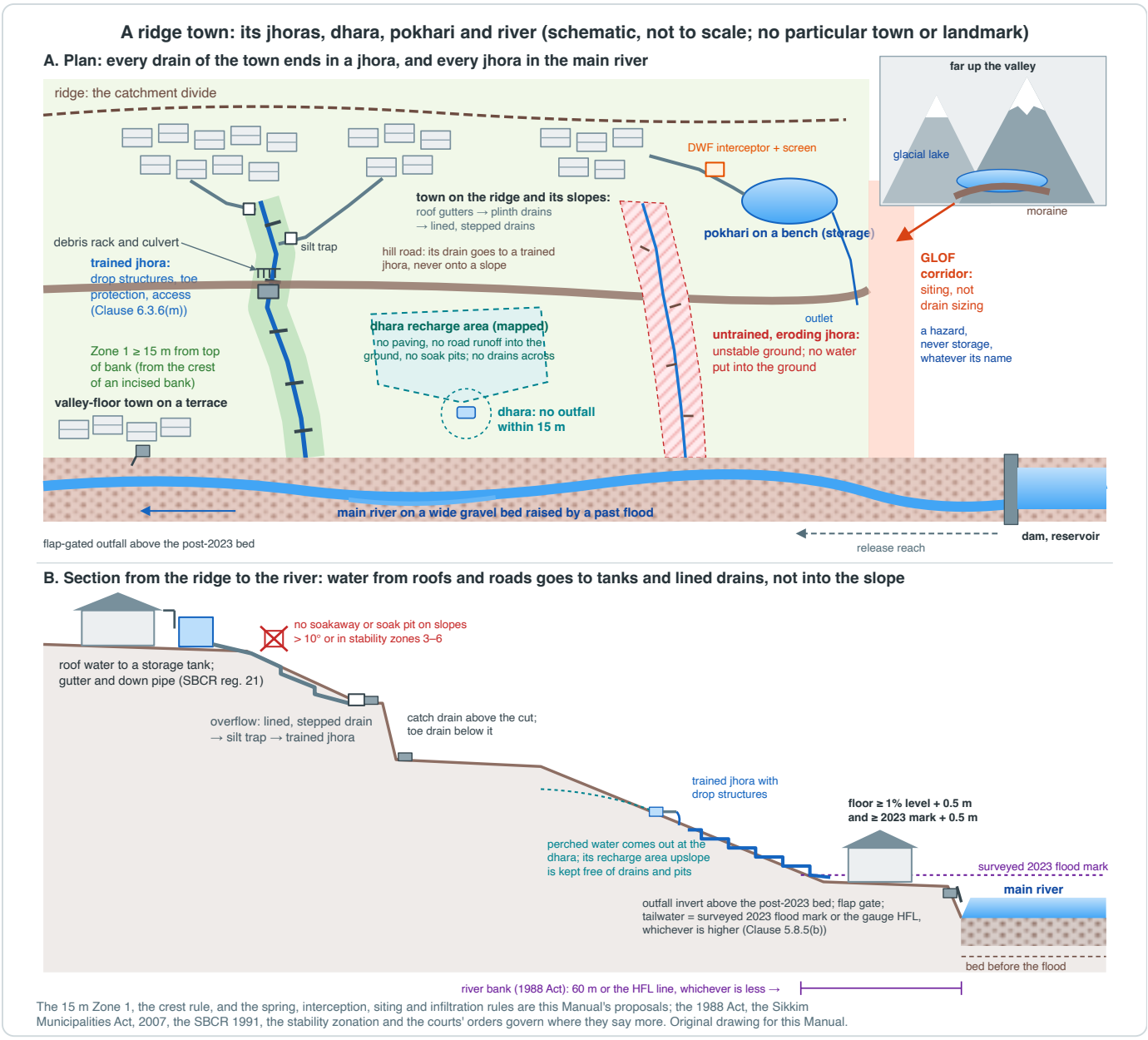


*Figure 7.3 — A ridge town: its jhoras, dhara, pokhari and river (schematic, not to scale; no particular town, lake, dam or landmark is shown). The town stands on a ridge, the catchment divide, and on the slopes below it, so every drain of the town ends in a jhora and every jhora in the main river in the valley. Roof gutters and down pipes lead to a plinth drain (SBCR 1991, regs. 21 and 25(iv)), and lined, stepped drains carry the water through silt traps, and through a debris rack at the culvert under the hill road, to a trained jhora with drop structures, toe protection and a maintenance access (Clause 6.3.6(m)). An untrained jhora that is eroding its banks is unstable ground: no water is put into the ground near it, and no soakaway is placed on a slope steeper than 10° or in stability zones 3 to 6 (Clause 4.11, hill rule). A cut slope has a catch drain above it and a toe drain below. Below the town a dhara comes out; its recharge area, as a hydrogeologist maps it, is kept free of paving, road runoff and soak pits, no drain crosses it, and no outfall lies within 15 m of the spring (Clause 8.8.1, spring rule). A pokhari on a bench is kept as storage, and the drain that reaches it carries a dry-weather-flow interceptor and a screen, because the drains carry sullage (Clause 8.9). Zone 1 along the jhora is at least 15 m from its top of bank, measured from the crest of the bank slope where the jhora is incised (Clause 7.4). At the foot of the slope the main river runs on a wide gravel bed raised by a past flood; the valley-floor town's outfall has its invert above the surveyed post-flood bed and a flap gate, with tailwater taken as the higher of the surveyed October 2023 flood mark and the gauge's highest flood level (Clause 5.8.5(b)); the river bank of a scheduled river is "sixty metres … or area within high flood level mark, whichever is less" (1988 Act, s.29(1)), and the floors stand at least 0.5 m above the 1% AEP level and the surveyed 2023 flood mark. Upstream a dam holds a reservoir, with a release reach below it (Clause 5.8.5(c)). Far up the valley a glacial lake lies behind a moraine; the band down the river marks the GLOF corridor,*

*where siting, not drain sizing, protects drainage assets (Clause 2.3.6(i); definitions after Clause 7.2). The 15 m minimum, the crest rule, the spring, interception, siting and infiltration rules are this Manual's proposals; the 1988 Act, the Municipalities Act, the SBCR 1991, the stability zonation and the orders of the courts govern where they say more. Original drawing for this Manual.*

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## 7.8 Operating rules and pre-monsoon flood cushion

7.8.1 **Operating rule content.** Every tank whose storage is counted under Clause 7.7 shall have a written operating rule, agreed by the custodian and kept with the O&M plan (Chapter 10). It shall state:

- (a) the levels and dates for filling, holding and drawdown through the year;
- (b) the sluice and regulator settings at each level;
- (c) who operates the sluices and regulators, and who may order a release;
- (d) the maximum release rate, set so that the release, added to the flow from the downstream catchment, does not cause flooding of buildings downstream;
- (e) the forecast and warning triggers (IMD district warnings, SSDMA alerts, and city forecast systems where available) and the actions taken at each trigger;
- (f) communication with downstream ULBs and residents before any release; and
- (g) the records to be kept: daily levels in the monsoon, releases, and gate settings.

7.8.2 **Flood cushion.** A tank may be operated with a flood cushion (a level below FTL during part of the monsoon), and the cushion counted under Clause 7.7.3, only where:

- (a) the tank has a gated sluice, regulator or other controllable outlet able to draw the tank down to the cushion level in the time stated in the rule;
- (b) the operating rule fixes the cushion level and the dates it applies;
- (c) continuous simulation (Clause 3.13) shows that the cushion is available at the start of a design storm in at least **90%** of monsoon seasons in the record, allowing for the rain that usually comes before the peak storm;
- (d) the custodian accepts any loss of irrigation or water-supply yield, and any agreed compensation is recorded; and
- (e) the release needed to create or restore the cushion meets Clause 7.8.1(d).

7.8.3 **No storage credit without control.** Where a tank has no controllable outlet, no flood cushion shall be assumed, whatever the past practice.

7.8.4 **Coordination.** For tanks under WRD control, the operating rule shall be WRD's rule. This Manual does not authorise any other body to operate a WRD tank.

> **Commentary.** No pokhari or lake in Sikkim was found with a written operating rule, and most pokharis have no gates to operate. No release rule, full reservoir level or maximum water level was found for any hydropower reservoir either [TBC]. The record shows why a rule matters. After a release from the Dikchu project without warning in 2017 (as reported), the High Court of Sikkim closed WP(PIL) 4/2017 on 1 March 2021 with the direction "that the hydropower projects in Sikkim shall ensure strict compliance of the safety guidelines" and that the authorities "undertake periodic inspection and review". On the night of 3–4 October 2023 the outburst flood reached Chungthang, where "discharge peaked at 5340 $m^3\ s^{-1}$ … within ~6 minutes" (Sattar et al., 2025), and destroyed the Teesta-III dam; an NDSA-constituted committee is reported to have put the inflow at about 10,000 $m^3/s$ against a spillway capacity of 7,500 $m^3/s$ (as reported; its report is unpublished). Without an agreed rule with dates, levels, release rates and a named operator, storage in a pokhari or reservoir cannot be relied on, and a release made without warning to the towns downstream is itself a flood. Clause 7.8.2 turns that principle into a rule that can be checked, with a reliability test, because a cushion that is refilled by the April and May storms gives

no protection when a June to September monsoon storm, such as those of 9 June 1997 at Gangtok and 25 September 2005 at Tadong, arrives after weeks of rain. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.

For a hydropower reservoir, the operating rule of Clause 7.8.4 is its operator's rule, and this Manual authorises no other body to operate its gates: where this chapter names WRD's rule, records or freeboard standard, for a reservoir they are the operator's, given in writing. A design takes the operator's level and release for the storm being checked (Clause 5.8.5(c)), not a drawdown the operator has not agreed to in writing; no reservoir is credited with a flood cushion against a glacial lake outburst, which no rainfall rule can size (Clause 2.3.6(i)). For a natural pokhari, Clause 7.8.3 is the governing condition: with no controllable outlet, no cushion is assumed, a design that relies on the pokhari routes the storm through it from its outlet level, and the outflow over the outlet is limited by the jhora below it, which shall be shown to carry it with the debris of Clause 6.3.6. Many pokharis and lakes are sacred or communal and are held by a community or a private owner rather than the State, which is why Clause 7.8.2(d) requires the custodian to accept any drawdown, and why no detention pond built under this Manual is called a pokhari.

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## 7.9 Restoration, desilting and deepening

7.9.1 **Pre-works survey.** Before any desilting or restoration, the proponent shall:

- (a) survey the waterspread, foreshore, bund, weirs and sluices (Clause 7.7.1(a) and (b));
- (b) find the original bed level by test pits or augering on a grid, and from historical records where available; and
- (c) where the tank receives urban runoff or sewage, test the silt for heavy metals and other contaminants before disposal is planned.

7.9.2 **Desilting limit.** Desilting shall remove accumulated sediment down to the original bed level. It shall not deepen the tank below the original bed, except under Clause 7.9.3.

7.9.3 **Deepening.** Deepening below the original bed is permitted only where a hydrogeological report shows that:

- (a) it will not cut through a clay or silt layer that holds water in the tank or protects an aquifer from polluted water;
- (b) in coastal areas, it will not draw saline water into the tank or the aquifer; and
- (c) the extra storage will be refilled and used, and will not stand stagnant below the sluice sill.

Storage created below the lowest sluice sill shall not be counted as flood storage.

7.9.4 **Safe edges.** Where the public has access to the waterbody edge:

- (a) side slopes shall be no steeper than **1V:4H** from 0.5 m above FTL down to 1.2 m below FTL, or a level safety bench at least 3 m wide shall be provided between 0.3 m and 0.5 m below FTL; and
- (b) no isolated deep pit or vertical cut shall be left in the bed.

7.9.5 **Storage not to be reduced.** Restoration shall not reduce the storage below MWL. Islands, walkways, bund widening into the waterspread, ring roads, parking, buildings and "lake-front" platforms within the waterspread or foreshore shall be counted as lost storage and shall be offset under Clause 7.6.4.

7.9.6 **Silt disposal.** Desilted material shall not be placed within the setback, on the bund (except for approved bund strengthening), or on any flood path. Silt found to be contaminated shall be disposed of as the Sikkim State Pollution Control Board (SSPCB) directs.

7.9.7 **Inlet treatment.** Every restoration of a tank that receives urban runoff shall include sediment and gross pollutant control at each inlet: a sediment forebay, a constructed wetland inlet zone, or a gross pollutant trap (Chapter 8), so that the restored storage does not silt up again.

7.9.8 **Timing.** Desilting shall be completed, and the waterbody made safe, by **31 March** each year (Chapter 10).

> Commentary. No Sikkim order fixing a date for the pre-monsoon cleaning of drains, jhoras or pokharis was found (NEER reading). In the ridge towns the material to be removed is debris, slide material and garbage as much as silt: the Gangtok Municipal Corporation's contract with its waste agency makes the agency responsible for "Clearing of Jhoras" and bars dumping "along Footpath, Roadside and Jhoras" (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024); the SBCR 1991 prohibit the "Stacking/dumping of building materials without permission and spoils on Public Street, road, drains, gullies and jhoras", with a fine of ₹500 at least (reg. 22); and on the valley floors the flood of October 2023 left the Teesta's bed raised by 7–8 m (PPR, 2026). The date of 31 March in this Manual is set by this Manual, before the Manual's season begins on 1 April, because Gangtok's April averages 296.9 mm on 15.2 rainy days and its 24-hour record fell in May (IMD), and because the State's annual notices ban "construction involving earth excavation" from early May or June to September (UD&HD Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019; UDD Notice No. T(1689)/997, 26 May 2020); the jhoras, racks and debris basins are cleared again by 30 April, after the April storms and before May, and after the season by 15 November; above about 2,500 m, where snow or frost prevents the work in March, the dates are 30 April, 31 May and 31 October (Chapter 10). Excavation to "increase capacity" is governed by Clause 7.9.3. In a pokhari fed by a spring in its bed or on its bank, deepening can cut the spring off or break the silt and clay that hold the water, and on a slope it can undercut the bench on which the pokhari stands. This Manual allows no spring-fed pokhari to be deepened below its original bed or its bed to be lined or cemented, and no pokhari on a slope steeper than 10°, on colluvium or fill, or in stability zones 3 to 6 to be deepened at all. No desilting or deepening of a glacial lake is designed under this chapter: the works the State's project report proposes there (siphoning at Shako Chho, a moraine wall at Gurudongmar "still in the concept phase", a retention structure at Dolma Sampa) are hazard-mitigation proposals outside the scope of this Manual. The 31 March deadline matches the pre-monsoon inspection date of Chapter 10. The limits on deepening are set by this Manual. Deepening tanks to "increase capacity" is common, but it can breach the silt and clay layer that holds water in the tank, it can let polluted urban water reach the aquifer, it can draw salt water toward the coast, and it creates storage below the sluice sill that never empties and gives no flood benefit. Deep pits with steep sides are also a drowning hazard. The slope and bench values in Clause 7.9.4 are adapted from common pond-safety practice; they have no Sikkim precedent.

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## 7.10 Supply channels, surplus courses, inlets and outlets

7.10.1 **Part of the major system.** Supply channels and surplus courses are part of the major drainage system (Chapter 6). They shall be protected as waterbodies, with Zone 1 and Zone 2 setbacks under Clause 7.4.

7.10.2 **No closure or covering.** No supply channel or surplus course shall be closed, filled, diverted, covered, culverted along its length, or converted into a road or a closed drain, except under a design approved by the custodian that keeps or increases its 1% AEP capacity and its access for maintenance.

7.10.3 **Crossings.** Every road, rail, utility or access crossing of a waterbody, supply channel or surplus course shall:

- (a) pass the 1% AEP flow (with the climate factor), or the surplus of the upstream tank at its MWL, whichever is greater, with the freeboard required by Chapter 9;
- (b) not reduce the waterway width at the crossing below the full channel width as recorded in Revenue records or as surveyed, whichever is greater;
- (c) keep the channel bed level and grade; and
- (d) not raise the 1% AEP water level by more than the limit in Clause 7.6.2.

7.10.4 **Capacity.** The design capacity of a surplus course shall be the greater of the surplus weir discharge at MWL and the 1% AEP flow from its own catchment, combined as the cascade model (Clause 7.7.2) shows.

7.10.5 **Protection at structures.** Outlets of surplus weirs and sluices, and drain outfalls into waterbodies, shall have energy dissipation and scour protection designed under Chapter 9, so that the flow leaving them does not erode the bund, the bank or the channel bed.

7.10.6 **Drain outfalls into waterbodies.** A storm drain outfall into a tank, channel or wetland shall:

- (a) have its invert at or above the normal water level of the receiving waterbody, unless the drain is designed for submerged outfall under Chapter 5;
- (b) be located and aligned so that it does not cut through or weaken a tank bund;
- (c) have a gross pollutant trap and first-flush treatment (Chapter 8); and
- (d) not carry sewage or dry-weather flow (Chapter 8).

> Commentary. This Manual protects supply channels and surplus courses as part of the major system. In urban areas they are often the first to be lost. Surplus courses are narrowed by culverts and compound walls, and supply channels are covered and turned into roads, which cuts the tank off from its source or leaves its surplus with nowhere to go. In Sikkim the jhoras are drains in law and natural watercourses in fact. The Sikkim Municipalities Act, 2007 counts "a jhora or water-course of natural drainage line" among drains (s.2(24)); vests a jhora on public land other than forest land within the municipal area in the Municipality (s.172(1)) and makes it protect every jhora there, public or private (s.172(2)); vests public drains "in the Municipality, or the concerned Department, or organization, of the State Government, or the agency, as the case may be" (s.189(1)); requires rain water to be led "with the natural nullahs, khola-kholsas, jhoras, or storm water drainage" in a drain separate from sewage (s.193); and makes the Municipality provide "a safe and sufficient outfall … in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187). The SBCR 1991 send every building's surface water by a "Pucca storm water/plinth protection drain … leading to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)) and refuse an occupation certificate "if the drain has not been provided to main outlet/jhora" (reg. 13(iii)). The 2021 stability zonation grades sites by their jhoras: zone 1 where "Training of jhoras/drains have been completed and done properly (with safe distance)", zone 2 where "Training jhora/drain was done but not properly maintained", zone 3 where "Jhora training is required/annual maintenance of drain is necessary", and zone 4 where there is an "Untrained jhora/ erosional potential jhora" (Notification No. 17/DMG/20-21, 19 March 2021). Outside municipal limits, and on forest land, no body is named as the owner or protector of a jhora (NEER reading); the roads' drains are the road owner's (the Roads and Bridges Department (PWD), NHIDCL or BRO, by inference); and the rivers' banks are the Forest Department's (1988 Act, s.29(9)). No rule or order dividing jhoras from municipal drains was found; Chapter 6 gives this Manual's working split and each town's drain and jhora register. Jhora training is done piecemeal by several agencies: GSCDL tendered "Construction of drainage and jhora training works" in Gangtok worth about ₹13.41 crore, and a work of "jhora training and drainage improvement" at Lingding (as reported), without a design standard that was seen, and the High Court of Sikkim is reported to have warned IRCON, building the Sevoke–Rangpo railway, to correct the damage it caused to the drainage of NH-10 (June 2025, as reported). The kulos (irrigation channels) that feed terraced fields cross the same slopes. None of these instruments keeps a jhora at its natural width once it has been lined, piped, covered, built over or filled with spoil, which is the failure Clauses 7.10.2 and 7.10.3 are written to prevent, and which the jhora-training standard of Clause 6.3.6(m) forbids: no culverting of an open jhora, no reduction of its 1% AEP capacity and no diversion without a corridor. Clause 7.10.3(b) prevents a crossing from narrowing a channel to its current, encroached width.

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## 7.11 Fee-in-lieu and regional tank storage

7.11.1 Where a basin plan has been notified, and the Authority has adopted alternative S-5 of the Policy Supplement (Clause 1.7), a development may pay a fee in lieu of on-site detention under Chapter 4. The fee shall be applied to restoring or creating storage in a tank, pond or regional facility in the same basin.

7.11.2 Tank storage funded by fee-in-lieu shall:

- (a) meet Clause 7.7.1 in full before it is counted;
- (b) be downstream of the contributing development and upstream of the flood-prone area it is meant to protect;
- (c) be created, or under construction, before the development it serves is occupied, or within a period the basin plan fixes; and
- (d) be recorded in the register of Clause 10.17 with the developments that funded it, so that the same volume is not sold twice.

7.11.3 Fee-in-lieu does not replace:

- (a) the retention requirement of Chapter 4, which is always met on site; or
- (b) the water quality requirement of Chapter 8, which is met on site or in a regional facility treating the same runoff before it reaches the tank.

> Commentary. Chapter 4 provides for fee-in-lieu toward restored pokhari or tank storage in master-planned basins. Malaysia's 2008 DID checklist allowed on-site detention only for small sites and required community ponds for larger areas (DID, 2008). In Sikkim no shared form of storage is required by any rule: the SBCR 1991 have no detention, peak-flow or design-storm clause, and the only statutory rainwater harvesting is for government buildings (Municipalities Act, s.186; Chapter 4). The drainage projects that exist convey water rather than store it: GSCDL's "Construction of drainage and jhora training works" in Gangtok (as reported) and the stormwater drains along about 60 km of roads in seven towns under the ADB-financed Sikkim Integrated Urban Development Project (ADB, 2024); the drainage and landslip works of Gangtok's City Development Plan of 2006 "were not taken up" (CAG, Report No. 3 of 2016). Every litre sent faster down a jhora arrives sooner, with more energy and more debris, on a slope that the 2021 zonation already treats as unstable where the jhora is untrained, and ends in a Teesta whose valley-floor towns receive what the ridge towns send; that is why this Manual keeps pokharis, wetlands and flat benches as storage first (Chapters 4 and 11). In the ridge towns there is little flat land on which a regional pond could be built, and none may be built on a slope where Clause 4.11 bars infiltration, in stability zones 3 to 6, or on the Teesta valley floor below the October 2023 flood and aggradation level; a regional facility there is a lined tank or a lined detention structure, never a pokhari in name, and never on a glacial lake. None of these sets a technical standard for counting storage. Clause 7.11.2(b) matters because a tank downstream of the flood-prone area protects nothing. Clause 7.11.3 keeps retention on site: it is the volume-control layer of this Manual, and a regional tank cannot recharge the aquifer under the developed site.

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## 7.12 Wetlands, marshes and estuaries

7.12.1 **Scope.** This clause applies to marshes, swamps, backwaters, estuaries, and tidal creeks and lagoons, including:

- (a) wetlands notified under the Wetlands (Conservation and Management) Rules, 2017 or listed by the State Wetland Authority that those Rules provide for (no notification constituting one for Sikkim was found [TBC]);
- (b) any wetland notified under the 2017 Rules, to its notified boundary (none was found notified in Sikkim), and Khecheopalri (Khachoedpalri) lake, reported to have been designated a Ramsar site in February 2025 (as reported), to the boundary of its designation once it is published [TBC];
- (c) the lakes in the National Wetland Conservation Programme's list (Khecheopalri, Tamze, Tembao, Phedang, Guru Dongmar and Tsomgo, as reported), the other lakes and pokharis, the hydropower reservoirs with their drawdown zones, and the marshy and seepage ground below springs, within the 1% AEP extent of Clause 7.3.4 (a river, khola or reservoir itself is a waterbody under the rest of this chapter; a glacial lake is also a hazard source under Clause 2.3.6(i), to which no drain discharges); and
- (d) any other pokhari, marsh or wetland that the Authority notifies, that the wetland authority lists, or that the High Court of Sikkim, the National Green Tribunal or the Supreme Court directs to be protected.

7.12.2 **No drainage of wetlands.** No drain, channel, cut or pump shall be designed to drain a wetland, to lower its normal water level, or to reduce the period for which it is wet, except under a plan approved by the wetland authority.

7.12.3 **Inflows.** Every drain discharging into a wetland in Clause 7.12.1 shall:

- (a) meet Clause 7.10.6;
- (b) pass through water quality treatment for the WQv of its catchment (Chapter 8) before entering the wetland; and
- (c) where practicable, spread its flow across a vegetated margin rather than discharge at one point.

7.12.4 **Hydraulic connectivity.** Roads, embankments and utility corridors across or along a wetland shall have openings that:

- (a) pass the 1% AEP flow without raising the 1% AEP water level by more than the limit in Clause 7.6.2; and
- (b) keep the wetland's normal water exchange, including tidal exchange in estuaries, with openings spread along the crossing so that no part of the wetland is cut off.

7.12.5 **Storage counted at basin scale only.** Wetland storage shall be included in basin and regional models. It shall not be counted as detention for any individual development.

7.12.6 **Tidal wetlands and estuaries.** For estuaries and tidal wetlands:

- (a) tailwater shall be taken from Chapter 5 (Clause 2.12 joint cases);
- (b) works shall also comply with the Coastal Regulation Zone Notification in force; and
- (c) mouth-opening works, training walls and dredging are outside the scope of this Manual and need their own studies.

7.12.7 **No dumping.** No solid waste, construction debris or dredged material shall be placed in a wetland or its setback.

> Commentary. No notification constituting a State Wetland Authority for Sikkim, and no wetland notified under rule 4 of the Wetlands (Conservation and Management) Rules, 2017, was found (NEER reading); a national directory lists the Secretary of the Forest and Environment Department as the contact for the State's wetland authority (as reported). The Forest and Environment Department's River Rejuvenation Committee was "notified as the Nodal Agency for all water bodies vide Order No. 205/GOS/F&ED/SECY dated 21.01.2021" (State's filings before the National Green Tribunal). Khecheopalri (Khachoedpalri) lake is reported to have become Sikkim's first Ramsar site around World Wetlands Day, February 2025 (as reported); the areas given for it conflict (17,200 ha, 11.56 ha or 29.5 ha, and 1.7 km², all as reported), the Ramsar site record was not read, and no area is used in this Manual [TBC]. Khecheopalri, Tamze, Tembao, Phedang, Guru Dongmar and Tsomgo are reported in the National Wetland Conservation Programme's list (as reported), and the State is reported to have "534 wetlands covering 7,477 ha" (as reported, from a snippet). No water-quality, level or boundary data for any of these lakes were found. Guru Dongmar, one of the listed lakes, belongs to the Gurudongmar glacial-lake complex (178 million m³; State affidavit of 28 February 2026): it is a wetland for Clause 7.12 and also a hazard source under Clause 2.3.6(i), as is any listed lake that is a glacial lake, and no drain discharges to any of them under this Manual. A drain outfall, desilting, diversion or gate operation in or next to a notified wetland or forest land therefore needs the views or permission of the Forest and Environment Department, or of the wetland authority where the Rules reach it, as well as compliance with this chapter; for the pokharis, dharas, seepage ground and marshes the Rules do not reach, this chapter is the only control on their drainage. Clause 7.12.2 targets a specific risk: drains built to relieve flooding next to a marsh can drain the marsh itself, and once it is dry it is encroached. Sewage reaches Sikkim's jhoras, kholas and rivers through the drains (Clause 8.9, Commentary). The National Green Tribunal recorded in 2024 that "treated sewage is entering in to river/ rivulets/ jhoras" and asked for the "water quality of rivers including jhoras receiving sewage", while the State replied that "No sewage is disposed off in the rivers or fast flowing water bodies" (OA 606/2018, as quoted by the State); Gangtok treated 15.22 MLD of an estimated 29.51 MLD of urban sewage in September 2025; and at Soreng septic effluent discharges "into the open storm water drains ultimately discharging into the farmland / water bodies" (ADB, 2024). Clauses 7.10.6(d) and 7.12.3

therefore cannot yet be met by many existing outfalls. In Sikkim they apply in full to every new outfall, and every existing outfall to a jhora that feeds a dhara, a pokhari or a drinking-water intake, and every outfall within a town to the Rani Khola, the Roro Chu, the Rongni Chu or the Teesta, is taken to carry dry-weather flow and comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed (Clause 6.3.6(e)). In the catchment of a pokhari or lake, every drain that enters the water also passes a silt trap and a debris trap first (Figure 7.3; Clause 6.3.6(f)), because the pokhari is the end of the slope's drainage and has no other way to lose the silt and debris; and no drain discharges to a glacial lake.

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## 7.13 Encroachment interfaces

7.13.1 **Boundary.** For design under this Manual, the boundary of a waterbody is the larger of its Revenue record boundary and its surveyed FTL (or top of bank), as in Clause 7.3.3. Setbacks are measured from that boundary.

7.13.2 **No reliance on encroached land.** No design shall:

- (a) count, as storage or conveyance, land within a waterbody boundary that is occupied by encroachment, unless its removal is ordered and funded; or
- (b) treat the encroached width of a channel as its design width.

7.13.3 **Public works in encroached reaches.** Where a public drainage work passes through an encroached reach:

- (a) it shall be designed for the full waterbody width (Clause 7.13.1);
- (b) where the full width cannot be cleared before the work is built, the design report shall state the interim capacity and the flood risk until it is cleared; and
- (c) the work shall be built so that the full width can be restored later without rebuilding it.

7.13.4 **Boundary marking.** Every development adjoining a waterbody shall, before the completion certificate:

- (a) mark the outer edge of Zone 1 on the ground with permanent survey markers at intervals of not more than 30 m and at every change of direction; and
- (b) show the setback zones on the approved layout plan and in the sale documents of every plot that includes setback land.

7.13.5 **Retaining walls.** No retaining wall, bund or embankment shall be built along the edge of a waterbody, within Zone 1, to protect or reclaim land, except to protect existing public infrastructure under the custodian's approval.

Commentary. Sikkim's controls on building and dumping along its jhoras and rivers are in its Acts and regulations, and its courts have pressed on hazard rather than on encroachment. The 1988 Act makes the unauthorised occupation of a river bank, slip reserve or road reserve an offence, with eviction (s.30; road-reserve encroachment is evicted under the Sikkim Public Premises (Eviction …) Act, 1980), and lets the Government close a river bank by notification (s.32). The SBCR 1991 count "a protective wall, fence of any type etc. in any Government or private land within the notified area or road reserve without permission" as unauthorised construction (reg. 3(1)(h)), prohibit spoil "on Public Street, road, drains, gullies and jhoras" (reg. 22), and refuse electricity, sewerage and water connections to unauthorised buildings (reg. 34); the monsoon notices add that "any building material found lying on the road setback or over drains henceforth, shall be seized and auctioned" (Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019). The Gangtok Municipal Corporation's waste contract bars dumping "along Footpath, Roadside and Jhoras" (2024). No petition before the High Court of Sikkim on the encroachment of jhoras was found. The Court dismissed WP(PIL) 3/2023 (*Mani Kumar Subba v. State*), which sought a court-monitored probe into non-compliance with the Disaster Management Act, 2005 and the Dam Safety Act, 2021 over the South Lhonak lake, as "thoroughly devoid of any merit" on 7 December 2023, after the State had constituted a committee; it closed WP(PIL) 4/2017 on the Dikchu release with a safety direction to the

hydropower projects (1 March 2021); and in September 2026 it took up a suo motu petition, WP(PIL) 11/2026, *In re Climate Justice in State of Sikkim*, in which the State is reported to have been asked to examine "land-use regulation, spatial planning, slope management, and drainage in ecologically and geologically fragile areas" and a later order urged early-warning systems for the 40 high-risk glacial lakes (all as reported; the orders were not read; next hearing 18 November 2026). Before the National Green Tribunal, OA 5/2022 and OA 38/2022 (*Dr. Bina Basnett v. State of Sikkim*) concern the height and siting of a car park in Gangtok, and OA 606/2018 the sewage reaching jhoras (Clause 8.9). This Manual adds the boundary rules of this section: the larger of the recorded and surveyed boundary governs, the crest of an incised bank is the top of bank, and Zone 1 is marked on the ground. This Manual cannot evict anyone. It can stop designs from treating encroachment as permanent (Clause 7.13.2), make public works restorable to full width (Clause 7.13.3), and make the setback visible on the ground and in property documents so that new buyers know it is there (Clause 7.13.4). The 30 m marker interval is set by this Manual.

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## 7.14 Safety of tank bunds and embankments

7.14.1 **Dam Safety Act screening.** For every tank, and every embankment built or altered under this Manual, the designer shall determine whether it is a "specified dam" under the Dam Safety Act, 2021. Under the Act, a specified dam is a dam:

- (a) more than 15 m high, measured from the lowest point of the general foundation area to the top of the dam; or
- (b) between 10 m and 15 m high, where the crest length is not less than 500 m, or the reservoir capacity is not less than one million m³, or the maximum flood discharge dealt with by the dam is not less than 2,000 m³/s, or the dam has specially difficult foundation problems, or the dam is of unusual design.

Where it is a specified dam, the Act and the requirements of the State Dam Safety Organisation govern, in addition to this Manual.

7.14.2 **Hazard class.** Every tank bund and detention embankment that is not a specified dam shall be given a hazard class:

- **High hazard:** a breach could flood a habitable building, a school, a hospital, an arterial road or critical infrastructure.
- **Low hazard:** any other case.

7.14.3 **High-hazard embankments.** For high-hazard tank bunds and embankments:

- (a) the surplus weir or spillway shall pass the 1% AEP inflow at MWL with the freeboard of Clause 7.7.4(b), and shall be checked for the 0.2% AEP (500-yr) inflow without overtopping the bund (as for detention basins in Chapter 4);
- (b) a breach analysis shall map the area flooded by a breach at MWL;
- (c) an emergency action plan shall be prepared, with the warning and evacuation arrangements for the breach area; and
- (d) the design shall be certified and independently checked under Clause 10.6.

7.14.4 **Inspection.** Every tank whose storage is counted under Clause 7.7, and every high-hazard embankment, shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Chapter 10) for seepage, slips, cracks, animal burrows, trees on the bund, and blockage of the weir and sluices.

7.14.5 **No unauthorised cutting.** No person shall cut, lower or breach a tank bund or surplus weir during a flood except under the custodian's emergency procedure.

Commentary. The definition of a specified dam is quoted from the Dam Safety Act, 2021 (Act 41 of 2021). The Act defines a "dam" as an artificial barrier constructed across rivers or tributaries to impound or divert water. It excludes flood embankments, dikes and guide bunds. No pokhari or lake in Sikkim was found to be held by a bund high enough to be a specified dam, though the bunds and outlets of the pokharis were not surveyed for this Manual [TBC]; each outlet work or bund shall be screened under Clause 7.14.1. The hydropower dams are dams across rivers under the Act; Teesta-III's "60 m high dam" (Sattar et al., 2025) was above the 15 m of Clause 7.14.1(a), and the heights of the other dams were not obtained [TBC]. A glacial lake is held by a moraine or glacier, not by an artificial barrier, so the Act's definition of a dam does not reach it (NEER reading); the retention structure of 20 to 30 m proposed at Dolma Sampa, for a catchment of more than 400 km², would be one if built (State affidavit, 2026; a proposal only). Where the storage of a pokhari or reservoir is counted under Clause 7.7, its bund, outlet works or dam is a tank bund for Clause 7.14.2 unless the Act applies. Whether a tank bund that is not across a river or tributary is a "dam" under the Act is not clear from its text. In Sikkim the embankments that matter most to the towns are the hydropower dams on the Teesta and the Rangit, and the hazards below them are the release and the breach. On 3–4 October 2023 the outburst of the South Lhonak lake sent a flood down the Teesta that destroyed the 60 m Teesta-III dam at Chungthang and buried parts of Rangpo, about 135 km downstream (Sattar et al., 2025); the cause is disputed, the State's affidavit of 5 April 2024 attributing the flood "primarily to a cloudburst" and an NDSA-constituted committee reported to have found "all scientific data and satellite images from that period points to GLOF and not a cloudburst" (as reported), and the toll is stated two ways, 55 dead and 74 missing in the SSDMA survey cited by Sattar et al. and 79 dead and 44 missing in the PDNA annexed to the State's affidavit of 28 February 2026. The release of 2017 from the Dikchu project without warning led to the High Court's direction of 2021 on safety guidelines and "periodic inspection and review". Warning is being built: SSDMA and the District Disaster Management Authorities held GLOF awareness and participatory risk assessments from 17 to 29 May 2024 and a State mock exercise on 17 November 2025, the Science and Technology Department was made nodal for GLOF studies and mitigation (Notification No. 10/Home/2025, 7 February 2025), and the Home Department constituted the Sikkim Commission on Glacial Hazards and a High-Level Steering Committee with a Multi-disciplinary Task Force (Nos. 73/Home/2024 and 72/Home/2024, 11 September 2024) (State affidavit, 2026). No breach map or emergency action plan for any dam, pokhari or lake was read for this Manual [TBC]. A failed or overtopped bund floods the land below it, a release made without warning floods it too, and a glacial lake outburst passes through every dam on the trunk, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments, why Chapter 5 treats every release reach as a flood-sensitive outfall, and why drainage assets are sited out of the GLOF corridors (definitions after Clause 7.2). The hazard classes, the breach analysis and the emergency action plan for high-hazard tanks are set by this Manual. They extend the Chapter 4 requirement for detention basins (1% AEP spillway with outlet blocked, 0.2% AEP for high-hazard basins) to tanks that are counted as design storage.

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## 7.15 Submittal requirements

Every drainage report for a development or work under Clause 7.1.2 shall include:

1. the **Waterbody Sheet (Form 7-1)** under Clause 7.3.2, with the setback zones and their basis (mapped extent, hydraulic study or fixed width);
2. the hydraulic study of the 1% AEP extent and floodway, where Clause 7.3.4 requires it;
3. the **Compensatory Storage Calculation (Form 7-3)**, by elevation band, where fill is proposed in the flood fringe;
4. for any tank storage counted: the **Tank Storage Credit Sheet (Form 7-2)**, with the survey, stage–storage curve, operating rule, cascade model results and custodian concurrence of Clause 7.7.1;
5. for any crossing, outfall or work in Zone 1: the custodian's NOC and the hydraulic analysis of Clause 7.6.2 or 7.10.3;
6. for restoration or desilting: the pre-works survey, silt tests and hydrogeological report of Clause 7.9; and
7. for any embankment: the Dam Safety Act screening and hazard class of Clause 7.14.

## 7.16 Review and update

7.16.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). The fixed-width table of Clause 7.4.6 shall also be reviewed within 2 years of the Authority adopting 1% AEP flood maps for its area.

7.16.2 Where the Authority adopts new 1% AEP flood maps, they apply to new submittals **6 months** after adoption, unless the Authority notifies otherwise.

## References (chapter)


- Government of Sikkim. *Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988* (Act 6 of 1988), as amended by Act 8 of 2000, ss. 2(j), 2(m), 29(1)–(9), 30, 32 and 42(2)(g)–(h) and the Schedule (PRS Legislative Research copy). https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf
- Government of Sikkim. *Sikkim Municipalities Act, 2007* (Act 5 of 2007), with amendments to 2026, ss. 2(24), 2(47), 163(b), 172, 173, 186, 187, 189 and 193 (PRS copy). https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf
- Government of Sikkim, Urban Development and Housing Department. *Sikkim Building Construction Regulations, 1991*, Notification No. 29(202)UD&HD/90/295 of 19 March 1991, as amended in 2000 and by No. GOS/UD&HD/6(294)2001 of 16 October 2001, regs. 3(1)(h), 13(iii), 18, 21, 22, 25, 34 and 35 (copy hosted by a third party, Sikkim Manipal University). https://smu.edu.in/img/content/dam/manipal/smu/IQAC/SDG/documents/BUILDING%20STANDARDS.pdf ; *Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985* (Act 11 of 1985), as amended to 2022 (PRS copy). https://prsindia.org/files/bills_acts/acts_states/sikkim/1985/1985SK11.pdf
- Government of Sikkim, Department of Mines and Geology. Notification No. 17/DMG/20-21 of 19 March 2021 (Gazette Extraordinary No. 86, 6 April 2021), site stability zonation parameters, read as Annexure R/2 to the State's counter-affidavit in NGT OA 5/2022 (EZ), *Dr. Bina Basnett v. State of Sikkim*, with the monsoon notices No. 613/GOS/JCTP/UD&HD of 1 May 2019 and No. T(1689)/997 of 26 May 2020 (Annexure R/5). https://www.greentribunal.gov.in/sites/default/files/news_updates/Counter%20Affidavit%20on%20behalf%20of%20R-,4,7,9%20in%20OA%205%20of%202022%20(EZ)%20(Dr.%20BINA%20BASNETT%20vs%20State%20of%20Sikkim%20&%20Ors.).pdf
- Government of Sikkim. *Sikkim Town and Country Planning Act, 2024* (Act 10 of 2024; Gazette Extraordinary No. 317, 15 June 2024), as amended by Act 24 of 2025; not commenced (PRS copy). https://prsindia.org/files/bills_acts/acts_states/sikkim/2024/Act10of2024SK.pdf
- National Green Tribunal (Eastern Zone). OA 171/2023, *In re: News item, East Mojo, 05.10.2023*: additional affidavit of the State of Sikkim of 28 February 2026, with the Home Department's notifications, the project report "GLOF Risk Mitigation in Lhonak Valley, Sikkim" (Annexure R-5) and the PDNA summary (Annexure R-6). https://www.greentribunal.gov.in/sites/default/files/news_updates/Additional%20affidavit%20on%20behalf%20of%20R-1,%20State%20of%20Sikkim,%20page%201038-1178.pdf
- National Green Tribunal (Principal Bench). OA 606/2018: six-monthly report of the Government of Sikkim (after the order of 4 July 2024), with the Gangtok Municipal Corporation's waste contract (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024). https://www.greentribunal.gov.in/sites/default/files/news_updates/SIX%20MONTHLY%20REPORT%20BY%20GOVT%20OF%20SIKKIM%20IN%20OA%20NO.%20606%20OF%202018%20FOR%20STATE%20OF%20SIKKIM%20(COMPLIANCE%20OF%20MSW%20MGT%20RULES,%202016%20AND%20OTHER%20ENVIRONMENTAL%20ISSUES).pdf
- National Green Tribunal (Principal Bench). EA 35/2023 in OA 673/2018: State affidavit of 19 December 2025, with the monthly progress report of September 2025, and the State's compliance report. https://www.greentribunal.gov.in/sites/default/files/news_updates/AFFIDAVIT%20BY%20STATE%20OF%20SIKKIM%20IN%20EA%20NO.%2035%20of%202023%20IN%20OA%20NO.%20673%20of%202018%20News%20item%20published%20in%20the%20Hindu.pdf
- National Green Tribunal (Eastern Zone). OA 38/2022: reply affidavit of GSCDL. https://www.greentribunal.gov.in/sites/default/files/news_updates/Reply%20Affidavit%20filed%20by%20R-2,%20GSCDL,%20page%20698-1006.pdf
- High Court of Sikkim. WP(PIL) 4/2017, *In re: Release of water from Dikchu Hydelpower Project*, judgment of 1 March 2021; WP(PIL) 3/2023, *Mani Kumar Subba v. State of Sikkim*, judgment of 7 December 2023 (hcs.gov.in, read from archived copies). https://hcs.gov.in/hcs/hg_orders/202600000042017_37.pdf ; https://hcs.gov.in/hcs/hg_orders/202600000032023_1.pdf
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: Drivers, causes and impacts of a multihazard cascade. *Science*. doi:10.1126/science.ads2659 (accepted manuscript).

- Comptroller and Auditor General of India. Report No. 3 of 2016 (Economic Sector, Government of Sikkim), Chapter II, Performance Audit of JNNURM, para 2.3.9.2. https://www.cag.gov.in/uploads/download_audit_report/2017/Chapter_2_Economic_Sector_Sikkim_Report_No_3_of_2016.pdf
- SANDRP. Transcriptions of CWC levels on the Teesta, Rongni Chu and Rangit, October 2023 (secondary; as reported).
- Government of India. The Dam Safety Act, 2021 (Act 41 of 2021). https://www.casemine.com/act/in/626f9167714d58ef62b50d09 ; CWC, Specified Dam. https://rrssd.cwc.gov.in/specified-dam
- MoHUA (2015). Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines, Vol I. https://web.archive.org/web/2022/https://mohua.gov.in/upload/uploadfiles/files/URDPFI%20Guidelines%20Vol%20I(2).pdf
- Mid-America Regional Council (2025). APWA Stormwater Standards Supplement (Section 5600, Version 2025.01). https://www.marc.org/document/apwa-stormwater-standards-supplement
- Kansas City Metro Chapter APWA (2006). Section 5600 Storm Drainage Systems and Facilities (§5605.3 stream buffers). https://www.kcwater.us/wp-content/uploads/2020/08/Design-Criteria-%E2%80%93-Section-5600-%E2%80%93-Storm-Drainage-Systems-and-Facilities.pdf
- Department of Irrigation and Drainage Malaysia (2008). Submission Checklist for Stormwater Management. https://www.water.gov.my/jps/resources/auto%20download%20images/5844dfbba8fc1.pdf
- Reports of Khecheopalri (Khachoedpalri) lake as Sikkim's first Ramsar site (*Sikkim Express*, February 2025; secondary; the Ramsar site record was not read), and of the lakes of the National Wetland Conservation Programme and the State's wetland count (secondary; as reported).
- Reports of RMDD's Dhara Vikas programme and the village spring atlas (India Water Portal; Scroll; The Wire; secondary).
- Reports of the High Court's suo motu WP(PIL) 11/2026, *In re Climate Justice in State of Sikkim* (LiveLaw, 17 September and November 2026; Bar & Bench; secondary; the orders were not read), of the NH-10 drainage petition against IRCON (*Sikkim Express*, June 2025), of the Dikchu release of 2017, of GSCDL's jhora-training tenders, and of the NDSA-constituted committee on the 2023 flood (ThePrint, 1 October 2024) (secondary).
- Turner, R. L. (1931). *A Comparative and Etymological Dictionary of the Nepali Language* (publication details not checked), as served by Digital Dictionaries of South Asia, University of Chicago. https://dsal.uchicago.edu/dictionaries/turner/
- Government of India. Wetlands (Conservation and Management) Rules, 2017; Coastal Regulation Zone Notification, 2019.


## Annexes and forms

| Annex / Form | Content |
|---|---|
| 7A | Statewide waterbody GIS layer and inventory fields |
| 7B | Fixed-width setback table (alternative S-3, with Annex 1C) |
| 7C | Template tank operating rule, with flood cushion |
| 7D | Desilting and restoration specification |
| 7E | Glossary of Nepali waterbody terms and regional variants |
| Form 7-1 | Waterbody Sheet |
| Form 7-2 | Tank Storage Credit Sheet |
| Form 7-3 | Compensatory Storage Calculation (by elevation band) |

CHAPTER 8

# Water Quality and Recharge

## 8.1 Purpose and scope

8.1.1 This chapter sets the requirements for the quality of stormwater leaving a site or a public drainage system, and for groundwater recharge. It covers:

- (a) the water quality volume (WQv) and the water quality design flow;
- (b) the treatment train, and the selection and design of best management practices (BMPs);
- (c) the criteria for infiltration and recharge;
- (d) the exclusion of sewage and dry-weather flow from storm drains;
- (e) gross pollutant traps, first-flush treatment and screens at outfalls to waterbodies;
- (f) how rainwater harvesting (RWH) fits with retention and detention;
- (g) erosion and sediment control during construction; and
- (h) monitoring.

8.1.2 This chapter applies to every development and public work to which Chapter 4 applies (Chapter 1). Clauses 8.9 (sewage) and 8.12 (construction erosion and sediment control) apply to every development that needs a building permit or layout approval, and to every public drainage work, whatever its size.

8.1.3 Retention under Chapter 4 is the first and preferred form of water quality control. Runoff retained on site is treated in full. The rest of this chapter applies to the part of the WQv that is not retained.

> **Commentary.** CPHEEO (2019) is the only Indian manual that covers stormwater quality in any detail. Its Chapter 9 reproduces US event mean concentrations, but cautions that "in an Indian context the values would be much higher" because drains receive night soil, urine and food waste, and it sets no Indian numeric criteria (CPHEEO 2019, Part A §9.5). Its Chapter 10 describes water-sensitive urban design, LID and SuDS treatment trains (CPHEEO 2019, Part A Ch. 10). This chapter turns that guidance into requirements. It follows the treatment approach of the MARC/APWA BMP Manual (2012), now merged into APWA 5600 (2025.01), with the Malaysian 3-month ARI water quality storm (MSMA 2, 2012) and the Georgia water quality volume (GSMM, 2016) as tropical and US benchmarks.

## 8.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Water quality volume (WQv) | The runoff volume that must be retained or treated, from the water quality rainfall depth (Clause 8.4). |
| Water quality rainfall depth (P_wq) | The greater of the retention depth (Annex 2E, Clause 2.10) and the 24-hour 3-month ARI depth (Annex 8A). |

| Term | Meaning in this Manual |
|---|---|
| 3-month ARI depth | The 24-hour rainfall depth equalled or exceeded on average four times a year, from a partial-duration series of the long-term daily record. |
| Water quality design flow (Q_wq) | The peak flow from the 3-month ARI storm, used to size flow-through devices and diversion structures (Clause 8.4.5). |
| Runoff coefficient for WQv (Rv) | The volumetric runoff coefficient for small storms, Rv = 0.05 + 0.009·I. |
| BMP | A best management practice: a structural or non-structural measure that reduces pollutant loads or runoff volume. |
| Treatment train | Two or more BMPs in series, from source to site to regional scale (Clause 8.5). |
| Pretreatment | A BMP that removes coarse sediment, litter and oil before runoff reaches a filter or infiltration BMP. |
| First flush | The early part of a runoff event, which usually carries the highest concentrations of sediment, litter and oil. |
| Gross pollutant trap (GPT) | A device that captures litter, plastics, vegetation and coarse sediment, typically above about 5 mm. |
| Dry-weather flow (DWF) | Flow in a storm drain when it has not rained for at least 72 hours. In a separate storm system, DWF is evidence of sewage, sullage, groundwater infiltration or illicit discharge. |
| Cross-connection | Any pipe, channel or opening that lets sewage or sullage (grey water from kitchens, bathrooms and laundries) enter a storm drain. |
| Infiltration facility | A facility designed to store runoff below the ground surface, or in a depression, and let it soak into the soil: infiltration trenches and basins, unlined bioretention, permeable pavement with an open base, soakaways, recharge pits and recharge wells. |
| Seasonal high groundwater table | As defined in Clause 3.10.2: the highest level in the monsoon season. |
| Hotspot | A land use with a high risk of spills or contaminated runoff (Clause 8.8.8). |
| Level of Service (LoS) / Value Rating (VR) | The scoring system of Clause 8.6, from the MARC/APWA BMP Manual (2012). |

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## 8.3 Objectives and pollutants of concern

8.3.1 Stormwater treatment under this Manual shall aim to:

- (a) remove litter, plastics and other gross pollutants before they reach a waterbody;
- (b) remove suspended sediment, and the metals, nutrients and oil carried on it;
- (c) keep sewage and sullage out of storm drains and waterbodies;
- (d) recharge groundwater where soils and groundwater depth allow, without polluting it; and
- (e) prevent erosion and sediment discharge during construction.

8.3.2 The design shall address the following pollutants for every site, and the hotspot pollutants of Clause 8.8.8 where they apply:

**Table 8.1 — Pollutants of concern, sources and primary controls**

| Pollutant | Main sources in Sikkim towns | Primary control |
|---|---|---|
| Gross pollutants (plastics, litter, vegetation) | Streets, markets, open dumping in drains | Source collection; GPTs and screens (Clause 8.10) |

| Pollutant | Main sources in Sikkim towns | Primary control |
|---|---|---|
| Suspended sediment | Construction sites, unpaved roads and verges, road wear, drain silt | Erosion and sediment control (Clause 8.12); pretreatment; filtration |
| Oil, grease and fuel | Roads, parking, fuel stations, workshops, bus depots | Oil-grit separators at hotspots; bioretention |
| Pathogens and organic load (BOD) | Sewage and sullage cross-connections, animal waste | Exclusion and DWF interception (Clause 8.9) |
| Nutrients (N, P) | Sewage, fertiliser, food waste, detergents | Exclusion; bioretention; wetlands |
| Heavy metals | Roads, roofs, industrial yards | Filtration; sedimentation |

> **Commentary.** Gross pollutants and sewage come first in Clause 8.3 because they dominate the pollution of urban waterbodies in Sikkim, and because no treatment BMP works for long if they are not removed. CPHEEO (2019) notes that Indian drains carry night soil, urine and food waste (Part A §9.5). In its WSUD procedure it lists TSS, total nitrogen, total phosphorus and gross pollutants as the key pollutants (Part A Ch. 10). AMRUT 2.0 funds the harvesting of rainwater "through storm water drains into water body (which is not receiving sewage/effluent)" (Lok Sabha unstarred question AU1419), which only works if sewage is first kept out of the drains.

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## 8.4 Water quality volume and design flow

8.4.1 **Water quality rainfall depth.** The water quality rainfall depth is:

> $P_{wq} = \max(P_{ret}, P_{3m})$

where:

- $P_{ret}$ = the retention depth for the site's zone (Annex 2E, Clause 2.10), mm; and
- $P_{3m}$ = the 24-hour 3-month ARI depth for the site's zone (Annex 8A), mm.

8.4.2 **Water quality volume.** The WQv shall be computed as:

> $WQv = (P_{wq} / 1000) \times Rv \times A$

where:

- WQv is in m³;
- A = the contributing area, m²;
- $Rv = 0.05 + 0.009 \cdot I$; and
- I = the impervious percentage of the contributing area (0–100), after the connectivity rules of Clause 3.9.

The Rv form above may be used only for sites under 0.5 ha and under the Tier B simplified method (Clause 4.14). This is the same limit as for the retention volume (Clause 4.4.2). For all other sites the WQv shall be computed with the SCS-CN method, as the retention volume is: WQv (m³) = 10 × $Q_{wq}$ × A, where $Q_{wq}$ (mm) is the SCS-CN runoff from $P_{wq}$ for each sub-area and A is in ha.

8.4.3 **Climate factor.** The climate factor of Clause 2.8 shall not be applied to P_wq. P_ret and P_3m are frequency statistics of ordinary rainfall, not AEP design depths.

8.4.4 **WQv met by retention.** The volume retained on site under Chapter 4 counts toward the WQv in full. Where the retained volume is equal to or greater than the WQv, no further treatment is required for that area, except:

- (a) pretreatment of inflows to each retention facility (Clause 8.5.3);
- (b) hotspot controls (Clause 8.8.8); and
- (c) the outfall requirements of Clause 8.10, where the site discharges to a waterbody.

8.4.5 **Water quality design flow.** Flow-through devices (swales, filter strips, oil-grit separators, GPTs) and diversion weirs for off-line BMPs shall be sized for Q_wq. Q_wq shall be computed from the 3-month ARI intensity at the time of concentration of the contributing area:

- (a) by the Rational Method, where Chapter 3 allows it (a single element draining no more than 16 ha); or
- (b) as the peak of a hydrograph method using the 3-month ARI 24-hour depth with the alternating-block pattern of Clause 2.9.1.

8.4.6 **Bypass.** Flows above Q_wq shall bypass flow-through and off-line treatment devices without washing out the material already captured. The bypass shall be part of the minor or major system (Chapter 6).

8.4.7 **Drawdown.** Where the WQv is held in an extended-detention BMP (wet pond, constructed wetland or dry extended-detention basin), it shall be released over **24–48 hours** (Chapter 4).

> Commentary. The WQv depth is the runoff from the 3-month ARI storm or the retention depth, whichever is greater. The 3-month ARI is the Malaysian water quality design storm (MSMA 2, 2012). The Malaysian 2008 checklist gave its depth as about 40 mm and said it captures 90% or more of 24-hour storm runoff volume (DID, 2008). The Sikkim value must be computed (Annex 8A). Georgia sets its WQv as the runoff from 1.2 inches (about 30 mm), the depth that covers 85% of storms in an average year, and requires 80% removal of the average annual post-development TSS load (GSMM 2016, Vol 1, Standard #4). Kansas City's water quality storm is the 1.37-inch (about 35 mm) event that produces up to 90% of the runoff from all 24-hour storms in a year (MARC BMP Manual, 2012).
>
> The Rv formula is from the MARC/APWA BMP Manual (2012), which computes WQv = P × Rv with Rv = 0.05 + 0.009·I. Rv is used instead of the SCS curve number because the CN method greatly understates runoff from small storms on pervious ground. Not applying the climate factor (Clause 8.4.3) has no direct precedent; this Manual does so because it treats P_wq like the retention depth, as a statistic of ordinary rainfall. Bypass of larger flows and the 24–48 hour drawdown follow Chapter 4; MARC (2012) required at least 40 hours of extended detention of the WQv.
>
> **Illustrative — not design values.** For a 1.0 ha site with 80% impervious cover and an assumed P_wq of 50 mm:
>
> - Rv = 0.05 + 0.009 × 80 = 0.77
> - WQv = (50 / 1000) × 0.77 × 10,000 = 385 m³

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## 8.5 Treatment train and pretreatment

8.5.1 **Treatment train.** Water quality control shall be designed as a treatment train, in the order shown in Figure 8.1:

- (a) **source controls** on the plot: roof runoff to RWH, rain gardens, permeable paving, disconnection of impervious areas, and silt traps at inlets;

- (b) **site controls**: bioretention, swales, filter strips, infiltration, oil-grit separators at hotspots, wet ponds and extended detention; and
- (c) **regional controls**, for public drainage: GPTs and DWF interceptors at outfalls, constructed wetlands at tank inlets, and regional ponds.

8.5.2 A development shall meet the WQv on site, through (a) and (b). Regional controls under (c) may count toward a development's WQv only where a regional facility treating the same runoff has been built under a notified basin plan (Clause 7.11).

8.5.3 **Pretreatment.** Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland shall have pretreatment at each concentrated inflow. Pretreatment shall be a sediment forebay, grass filter strip, silt trap or proprietary device that holds at least **10% of the WQv** of its contributing area, or that is sized for Q_wq for flow-through devices.

8.5.4 Pretreatment shall be accessible for cleaning without entering or disturbing the main BMP.

> **Commentary.** The treatment train follows CPHEEO (2019, Part A §10.2.3, SuDS treatment train) and CIRIA C753 *The SuDS Manual* (2015). It is also the order of priorities of this Manual: preserve, retain, detain, convey (Chapter 1). The 10% forebay volume has no Indian precedent; it is a common sizing rule for forebays in US manuals. In Sikkim, unpaved verges, construction sites and drain silt deliver a heavy sediment load. Bioretention and infiltration facilities without pretreatment clog, often within a year or two.

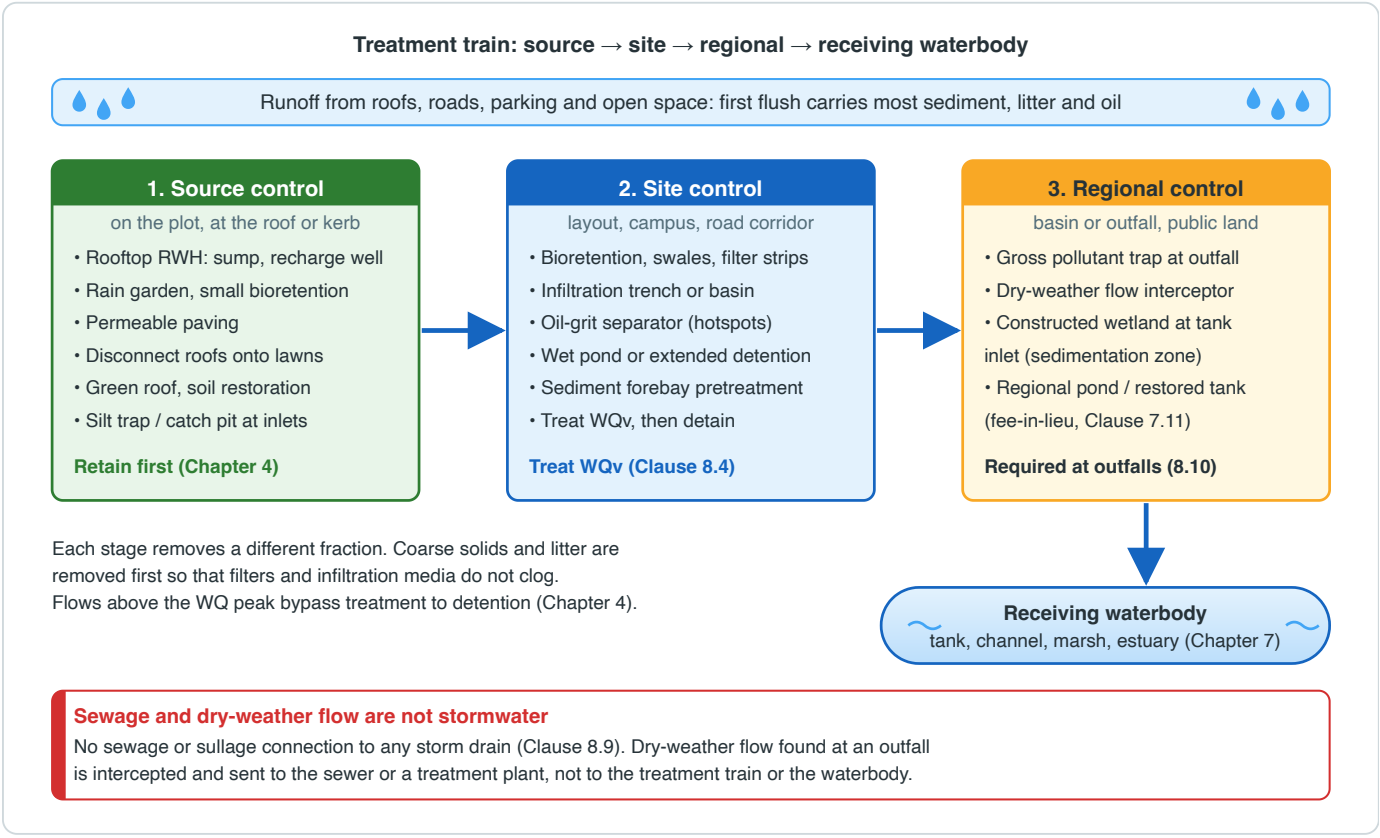


*Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012.*

## 8.6 BMP selection: Level of Service and Value Rating

8.6.1 **Method.** In Tier A areas, the BMPs for each site shall be selected by the Level of Service (LoS) method of this Clause. In Tier B areas, the simplified route of Clause 8.6.5 may be used.

8.6.2 **Required Level of Service.** For a site that is not redevelopment, the required LoS depends on the change in curve number (ΔCN) from pre- to post-development (Chapter 3):

**Table 8.2 — Required Level of Service for sites that are not redevelopment**

| ΔCN | Impact | Required LoS |
|---|---|---|
| 17 or more | High | 8 |
| 7 to 16 | Moderate | 7 |
| 4 to 6 | Low | 6 |
| 1 to 3 | Minimal | 5 |

For redevelopment (existing impervious cover of 20% or more of the site), the required LoS shall be taken from Annex 8B.

8.6.3 **Value Rating.** Each BMP treating the WQv has a Value Rating (VR) from Table 8.3. The site's composite VR is the area-weighted average of the VRs of the BMPs serving each part of the site. Treatment trains get a composite VR under Annex 8B. The composite VR shall be equal to or greater than the required LoS.

8.6.4 **Conditions for a Value Rating.** A BMP earns its VR only if:

- (a) it is sized for the WQv (or Q_wq for flow-through devices) of the area credited to it;
- (b) it meets the design requirements of Clause 8.7 and, for infiltration, Clause 8.8; and
- (c) it has pretreatment under Clause 8.5.3.

8.6.5 **Tier B simplified route.** In Tier B areas, the requirement of Clause 8.6.3 is deemed met where the whole WQv of the site is either:

- (a) retained on site under Chapter 4; or
- (b) treated by a bioretention cell, rain garden or infiltration facility designed under Clauses 8.7 and 8.8, with pretreatment.

**Table 8.3 — BMP Value Ratings and suitability in Sikkim**

| BMP | VR (MARC 2012) | Main pollutants removed | Volume reduction / recharge | River terraces of SK-A (tested) | Laterite / hard rock | Slopes over 10°, colluvium, fill, zones 3–6 / high water table | Sikkim notes |
|---|---|---|---|---|---|---|---|
| Native vegetation (preserved) | 9.25 | All | High | Suited | Suited | Suited | Counts only for preserved, undisturbed area |
| Rain garden / infiltration | 9.0 | Sediment, metals, oil, nutrients | High | Suited if 1.0 m separation met | Conditional (test) | Not suited | Mosquito control: drain within 48 h |
| Bioretention | 8.5 | Sediment, metals, oil, nutrients | Medium–high (unlined); low (lined) | Suited | Suited, with underdrain | Lined, with underdrain | Media source and phosphorus content to be specified |

| BMP | VR (MARC 2012) | Main pollutants removed | Volume reduction / recharge | River terraces of SK-A (tested) | Laterite / hard rock | Slopes over 10°, colluvium, fill, zones 3–6 / high water table | Sikkim notes |
|---|---|---|---|---|---|---|---|
| Permeable pavement | 7.5 | Sediment, metals, oil | Medium–high | Suited | Conditional | Lined only | Not where run-on carries heavy silt |
| Extended detention wetland | 7.0 | Sediment, nutrients, metals | Low | Conditional (water balance) | Suited | Suited | Good at tank inlets (Clause 7.9.7) |
| Media / sand filter | 6.0 | Sediment, metals | Low | Suited | Suited | Suited (lined) | Needs frequent cleaning |
| Extended wet detention (wet pond) | 5.0 | Sediment, metals, some nutrients | Low | Conditional (water balance) | Suited | Suited | Dry-season water balance (Clause 8.7.8) |
| Vegetated filter strip | 5.0 | Sediment | Low–medium | Suited | Suited | Suited | Mostly as pretreatment |
| Native vegetation swale | 4.0 | Sediment, oil | Low–medium | Suited | Suited | Suited | Not where Q_wq velocity is high |
| Extended dry detention | 4.0 | Coarse sediment | Low | Suited | Suited | Suited | Combine with detention (Chapter 4) |
| Proprietary / hydrodynamic devices | 3.0–5.0 | Coarse sediment, oil, litter | None | Suited | Suited | Suited | VR from verified test data only |
| Signage (public education) | +0.25 | — | — | — | — | — | Added to composite VR |

The VR column is from the MARC/APWA BMP Manual (2012), Table 4.4. The suitability columns and notes have no direct precedent and are set by this Manual.

> **Commentary.** The LoS and VR method is from the MARC/APWA Manual of Best Management Practices for Stormwater Quality (2012), Tables 4.2 and 4.4. The VRs combine a water quality score, based on effluent TSS concentrations in the International Stormwater BMP Database, with scores for volume reduction, temperature, and oils and floatables. The method suits Sikkim for two reasons. It rewards volume reduction and preservation, which also serve recharge. It can also be checked by a reviewer without water quality modelling. Its weakness is that the scores come from US data. Sikkim stormwater carries more litter and more sewage than the US runoff behind the scores (CPHEEO 2019, §9.5), so this Manual requires GPTs and DWF exclusion separately (Clauses 8.9 and 8.10) and does not let a VR stand in for them.

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## 8.7 BMP design summaries

8.7.1 **General.** Each BMP shall be designed to the requirements below and to Annex 8D (BMP design sheets). The dimensions given are **recommended starting values** where marked; the designer shall justify any departure. Every BMP shall be designed for safe passage of flows above Q_wq (Clause 8.4.6) and shall have access for maintenance (Chapter 10).

8.7.2 **Bioretention and rain gardens** (Figure 8.2).

- (a) Surface ponding depth not more than **300 mm** above the mulch, with an overflow at the maximum ponding level.
- (b) Surface ponding drained within **48 hours**.
- (c) Filter media 600–900 mm deep: an engineered sandy loam with low fines and low phosphorus content (Annex 8D), with a 50–75 mm mulch layer.
- (d) A transition (choker) layer and a gravel drainage layer below the media.
- (e) A perforated underdrain where the design infiltration rate of the native soil (Clause 8.8.4) is below the rate needed to meet (b), or where the cell is lined.
- (f) Unlined cells shall meet the infiltration criteria of Clause 8.8. Cells that cannot meet them, and cells at hotspots, shall be lined.
- (g) Plants: native or naturalised species tolerant of both waterlogging and long dry spells.

8.7.3 **Vegetated swales.**

- (a) Trapezoidal or parabolic section, with side slopes no steeper than 1V:3H.
- (b) Longitudinal slope 0.5% to 4%, with check dams where steeper.
- (c) Flow depth at Q_wq not more than the height of the grass, and velocity at Q_wq not more than 0.3 m/s.
- (d) The 1% AEP flow (or the bypass) shall not erode the swale (Chapter 9 permissible velocities).
- (e) Where longitudinal slopes are below 1% or the subsoil is poorly drained, an underdrained ("dry") swale with filter media.

8.7.4 **Vegetated filter strips.**

- (a) Receive sheet flow only, with a level spreader where flow arrives concentrated.
- (b) Length in the direction of flow at least 5 m, and slope 1% to 8%.
- (c) Used mainly as pretreatment for bioretention, infiltration and swales.

8.7.5 **Permeable pavement.**

- (a) Run-on from impervious areas not more than twice the permeable area, and no run-on from unpaved or eroding areas.
- (b) Base reservoir of clean, open-graded aggregate, sized to hold its share of the WQv in its voids.
- (c) An open base (infiltrating) only where Clause 8.8 is met; otherwise lined with an underdrain, and then counted as filtration only.
- (d) Structural design for the traffic loading by the road authority's standards.
- (e) Not at hotspots, and not where the surface will be resurfaced with impermeable material.

8.7.6 **Infiltration trenches and basins** (Figure 8.3).

- (a) Pretreatment under Clause 8.5.3 in every case.
- (b) Trenches filled with clean washed aggregate, with a void ratio confirmed by test, wrapped in geotextile on the sides and top, on a sand base.
- (c) An observation well to the base of each trench.
- (d) Storage volume = WQv (or the retention volume of Chapter 4, where greater) held in the voids; emptied within 72 hours at the design infiltration rate.
- (e) An overflow to the minor or major system at grade.
- (f) Not brought into service until the contributing area is stabilised (Chapter 10).

8.7.7 **Wet ponds (extended wet detention).**

- (a) A permanent pool of at least the WQv, plus extended detention of the WQv above the pool, released over 24–48 hours.
- (b) A sediment forebay at each inlet (Clause 8.5.3).
- (c) Length-to-width ratio of the flow path at least 3:1, with no short-circuiting.

- (d) Permanent pool depth 1.0–2.5 m, with a safety bench (Clause 7.9.4).
- (e) A dry-season water balance (Clause 8.7.8).
- (f) The detention storage of Chapter 4 may sit above the extended detention level.

8.7.8 **Water balance for permanent pools.** Wet ponds and wetlands shall be shown, by a monthly water balance using IMD rainfall and pan evaporation, to keep at least 50% of the permanent pool volume (or the minimum wetland depth) through the driest year in 10. They shall not be topped up with groundwater, potable water or sewage. Where the balance fails, a dry extended-detention basin or a constructed wetland with a smaller permanent pool shall be used instead.

8.7.9 **Constructed wetlands.**

- (a) An inlet sedimentation pond (forebay) followed by a shallow vegetated macrophyte zone.
- (b) Extended detention of the WQv above the normal water level, released over 24–48 hours, with an extended detention depth not more than 0.5 m.
- (c) A flow path length-to-width ratio of at least 3:1, with deep zones across the flow path to spread the flow.
- (d) A high-flow bypass so that floods do not scour the macrophyte zone.
- (e) Where built at a tank inlet, the wetland shall sit within the tank's setback but outside its waterspread, and its storage shall not be counted as tank storage.

8.7.10 **Gross pollutant traps.**

- (a) Sized to treat Q_wq, with all flows up to the 1% AEP passing without washing out captured material.
- (b) Capture of gross pollutants down to about 5 mm.
- (c) Head loss included in the hydraulic grade line of the drain (Chapter 9), with the screen assumed **50% blocked**.
- (d) Storage for captured material sized for the cleaning interval of the O&M plan, and not less than the 3-monthly cleaning of Chapter 10.
- (e) Vehicle access for cleaning by suction or grab.

8.7.11 **Oil-grit separators.**

- (a) Required at the hotspots of Clause 8.8.8 that involve fuel or oil: fuel stations, vehicle workshops and washing bays, bus and truck depots, and parking areas of more than 50 spaces.
- (b) Sized for Q_wq, with a high-flow bypass.
- (c) Not to be used as the only treatment: they shall be followed by a filtering BMP where the site needs a VR above 5.

8.7.12 **Silt traps and catch pits.**

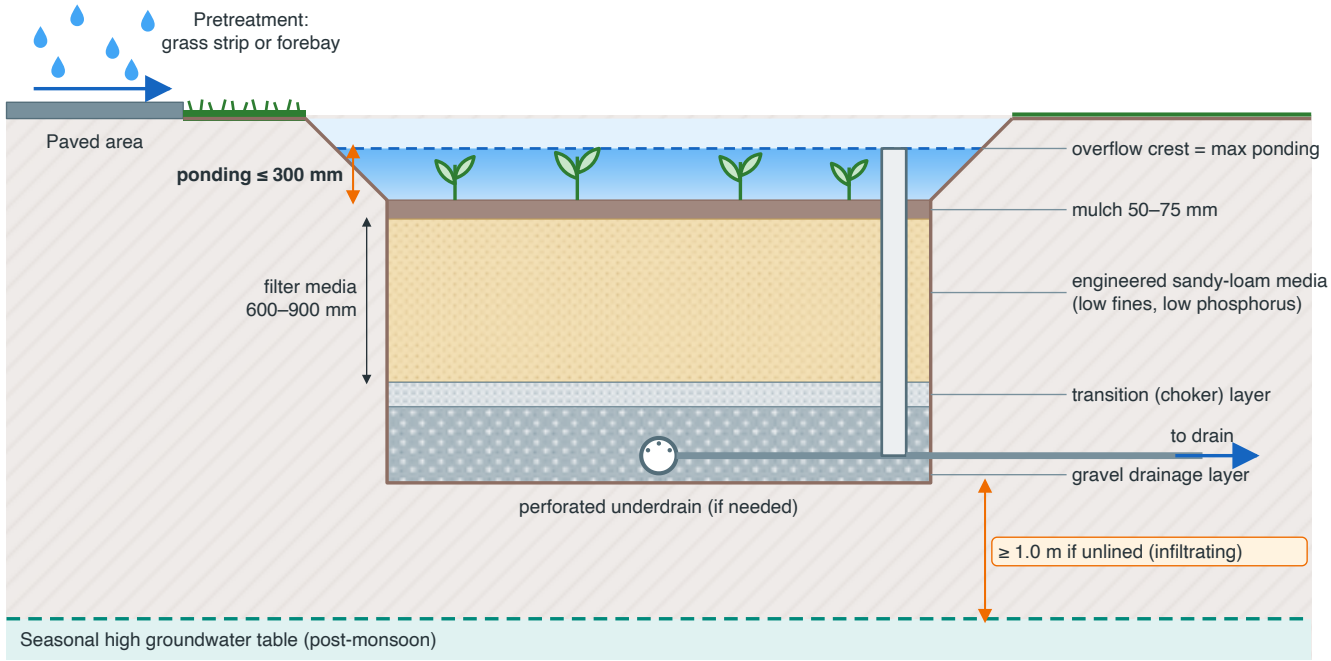
- (a) At every inlet that receives runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody.
- (b) A sump at least 300 mm below the outlet invert.
- (c) Silt traps are pretreatment only and earn no VR.

> Commentary. The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in Sikkim. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Sikkim. Surface ponding in bioretention and rain gardens must drain within 48 hours (Clause 8.7.2(b)), well inside the time mosquito larvae need to develop. This is consistent with the 24–48 hour WQv drawdown of Clause 8.4.7.
> - **Dry seasons.** Most of Sikkim's rain falls in the monsoon season of 1 April to 31 October: Gangtok's normals run from 296.9 mm in April to 173.4 mm in October, and from November to March they are 37.9, 19.5, 27.1, 72.2 and 126.4 mm (IMD, Gangtok, 1981–2010). In the dry months the pokharis (पोखरी; ponds, lakes or

tanks) fall, the jhoras (झोरा; natural watercourses or ravine streams) shrink, and the springs (dhara, धारा) weaken: "about 80%" of rural Sikkim is reported to depend on springs, and "half of the perennial springs have already dried up or have become seasonal" (as reported). In the towns the dry-weather flow of a drain or jhora is often sullage or septic effluent, because the drains carry it (Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool through the dry months on its own catchment's runoff is not to be used; in the ridge towns, where Clause 4.11 bars infiltration on slopes and in stability zones 3 to 6 and there is little flat land, the practical forms are lined bioretention with an underdrain, swales on gentle ground, storage for use, and lined extended dry detention. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage or with water taken from a spring; pokharis, dharas, lakes and wetlands are waterbodies under Chapter 7 and are not to be used as treatment for a development. Wet ponds that dry out turn into stagnant pools or are used for dumping. Clause 8.7.8 requires a water balance and bans topping up with sewage, which is a common practice for keeping urban ponds "full".

- **Litter and silt.** GPTs and silt traps are treated as essential, not optional, because Sikkim drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

The 50-space threshold for oil-grit separators, the 5 mm GPT capture size, the 0.3 m/s swale velocity and the other dimensions in this Clause have no direct precedent and are set by this Manual.




Lined version (no infiltration): impermeable liner below the gravel layer. Required at pollution hotspots and wherever the 1.0 m separation to seasonal high groundwater cannot be met.

Dimensions as set in Clause 8.7.2.

*Figure 8.2 — Bioretention cell (rain garden) in section: pretreatment, surface ponding, filter media, transition and gravel layers, underdrain, overflow, and the 1.0 m separation to seasonal high groundwater for an unlined cell. Original drawing for this Manual, adapted from MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012, and CIRIA, The SuDS Manual (C753), 2015.*

## 8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Sikkim, which has no coastal sand areas (Clause 8.8.9). For this Clause the seasonal high groundwater table is the highest level found from April to November, which covers the season of 1 April to 31 October and the month after it (Clause 3.10.2). Sikkim needs the three rules of Clause 4.11 here, with the spring rule of this Manual, and Clause 8.8.1 applies with the following. **(i) No infiltration on the hills (Clause 4.11, hill rule).** In sub-areas SK-B, SK-B1 and SK-C, and on any slope steeper than 10° in SK-A, no deliberate infiltration practice (soakaway, soak pit for storm water, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base; an unlined bioretention cell is an infiltration facility under Clause 8.2 and is treated the same way) shall be built or credited on natural ground sloping more than 10°; on colluvium, fill or slide debris, whatever its slope; in stability zones 3 to 6 of the Mines and Geology Department's notification of 2021; in any area "sinking", "landslide prone" or "having scars of old landslides" (SBCR 1991, reg. 35); or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope; and in stability zones 4 to 6 not at all, whatever certificate is offered, because the zonation already records "Dripping" or "Flowing" ground water there and judges zone 4 "Not suitable for habitation unless immediate protective measures" are taken. On such sites roof runoff goes to rainwater storage credited under Chapter 4, and its overflow and all other runoff go by a lined, stepped drain through a silt trap and an energy dissipator to a trained jhora or the road drain, never onto an unprotected slope; the exception for roof water in Clause 8.11.3(c) does not apply, and no infiltration is credited toward retention or the WQv. The hooks are regulations 21, 25(iv) and 13(iii) of the SBCR 1991, which already send roof water and surface water by "Pucca storm water/plinth protection drain" to "the road side drain or to adjoining permanent drains or jhora", and the zone-review condition of the 2021 notification: "Proper channelization of surface runoff by providing catchment drains especially during the rainy seasons and connect it to natural waterways/Jhora which also improves the stability of the area due to reduced erosions and percolation of water". Gangtok Smart City Development Ltd (GSCDL) told the National Green Tribunal that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (OA 38/2022). Regulation 25(i) of the SBCR 1991 has every building treat its sewage "in septic tanks built within the site", and regulations 6 and 13(iii) require the soak pit, which on a wet slope puts water into the ground that the hill rule protects: this Manual states the conflict and does not override the regulation; it puts no storm water into a soak pit, and recommends that no new soak pit be placed in stability zones 3 to 6 and that one on a slope steeper than 10° be sited by a geotechnical engineer, downslope of buildings and cuts (Clause 8.9). **(ii) No infiltration on the valley floors where the water stands high (Clause 4.11, valley-floor rule).** In sub-area SK-A no deliberate infiltration practice shall be built or credited on land below the 1% AEP flood level of the Teesta, the Rangit, the Rongni Chu or another river; on the river bed and terraces raised by the flood of October 2023; in Zone 1 or Zone 2 of a pokhari or reservoir (Chapter 7); or wherever the seasonal high water table is less than 2.0 m below the ground. The river terraces at Rangpo, Melli and Jorethang are gravels with a high water table in the season (NEER reading; no measured depth to water was found [TBC]). On such land roof runoff goes to storage, and detention is provided in lined storage checked for flotation. **(iii) Recharge only where it is safe (Clause 4.11, recharge rule).** Recharge is not a design objective in Sikkim, where groundwater lies "largely in disconnected localized pockets and in deeper fracture zones" and "springs are the main source" (CGWB, as quoted); no CGWB depth to water or extraction figure was read [TBC]. Deliberate recharge is allowed only on the tested river-terrace gravels of SK-A above the 1% AEP flood level and outside the zone raised in October 2023, and on benches sloping 10° or less in stability zone 1 shown safe by a geotechnical certificate, in each case with pretreatment, the field test of Clause 8.8.3, a seasonal high water table at least 2.0 m below the ground and the separation of this Clause. Springshed recharge under the Dhara Vikas programme of the Rural Management and Development Department (RMDD) (trenches and ponds on the slopes above springs) is a water-supply measure, not a stormwater credit: this Manual allows it only where the geology is mapped and the slope is stable, never above a known slide, a road cut or a building, and gives it no credit toward retention or the WQv. **(iv) Springs (dhara): the spring rule.** No storm outfall, soakaway or drain discharge lies within 15 m of a dhara; storm water is not routed into a dhara or onto the slope immediately above it; no drain, cut or fill intercepts the flow to a spring, buries its outlet or is laid across it; Zone 1 of a dhara (Clause 7.4) is measured from its outlet or the edge of its basin or chamber, and no storm drain or sewer is laid within it except a lined drain below the outlet that carries its overflow away; and the recharge area of a spring above a town's or village's intake, as a hydrogeologist maps it (the Dhara Vikas village spring atlas where it covers the site), is a

zone in which no paving is laid except for access, no road runoff is led into the ground, and no infiltration facility, soak pit or septic tank is placed. Sikkim has no statutory distance between a building, a drain or a soak pit and a water source, and no spring-protection statute or order was found; the 15 m is the Zone 1 width of this Manual. The springs are the rural water supply: the Dhara Vikas programme (from 2008, or 2010 in one source) is reported to have mapped 704 springs for rejuvenation (Scroll; The Wire), while an RMDD presentation of 2018 is reported to count "more than 2000 springs mapped on GIS platform" (both as reported; the counts are of different dates and conflict, and neither is used for design); an assessment by IISc is reported to have found a "15% enhancement in the spring discharge" under the programme (as reported). **(v) Quality.** No runoff from quarries, muck and spoil dumps, industrial yards, hydropower construction sites or roads with heavy traffic is led to any recharge structure, and a recharge well or shaft on the river terraces is used only for roof water or for runoff that has passed a filtering BMP, after a hydrogeologist's report confirming the depth to water, the receiving zone, and that no drinking-water well, spring or intake within 30 m will be harmed. The 10° trigger, the bar in stability zones 4 to 6, the distance of twice the wall height, the 2.0 m limit, the spring rule and these conditions are set by this Manual; no Sikkim rule fixes a slope or a ground on which infiltration is barred below the "around 70 (Seventy) degree" of regulation 35, and the slope bands of the stability zones (zone 1 "<15°", zone 2 16–25°, zone 3 26–35°, zone 4 36–45°, zones 5 and 6 above 45°) are site classes for building height, not infiltration rules. The seasonal high groundwater table shall be determined under Clause 3.10.2.

8.8.2 **Other separation.** The base of an infiltration facility shall also be at least 1.0 m above bedrock or any impermeable layer, unless the facility is designed to recharge a fractured or weathered rock aquifer under Clause 8.8.10.

8.8.3 **Infiltration tests.** The infiltration rate shall be measured at the proposed base level of the facility:

- (a) by a double-ring infiltrometer test (ASTM D3385) for basins, bioretention and permeable pavement;
- (b) by a falling-head borehole or trial-pit soakage test (for example BRE Digest 365) for trenches, soakaways, recharge pits and recharge wells;
- (c) with at least **2 tests per facility**, and at least 1 test per 100 m² of infiltration base area or per 50 m of trench length; and
- (d) by a person competent in geotechnical testing, with the results reported on the Infiltration Test Record (Form 8-2).

Tests made in the dry season shall be reported with the groundwater level at the time of test and the seasonal high level of Clause 8.8.1.

8.8.4 **Design infiltration rate.** The design infiltration rate is the measured rate divided by a safety factor:

- (a) **2.0** where the tests meet Clause 8.8.3(c) and the results vary by no more than a factor of 2; and
- (b) **3.0** otherwise.

8.8.5 **Minimum rates.**

- (a) Full infiltration (no underdrain) only where the design rate is at least **13 mm/h**.
- (b) Partial infiltration, with an underdrain, where the design rate is 3 mm/h to 13 mm/h. Only the volume that infiltrates within 72 hours is credited as retention.
- (c) No infiltration credit where the design rate is below 3 mm/h.

8.8.6 **Setbacks for infiltration facilities.** Infiltration facilities receiving runoff from roads, parking or other paved surfaces shall be at least:

- (a) **3 m** from building foundations, and **5 m** from a basement;
- (b) **1.5 m** from a property boundary, unless the neighbour agrees in writing;
- (c) **30 m** from a drinking-water well or borewell;
- (d) **15 m** from a septic tank or soak pit; and
- (e) **6 m** from the crest of a slope steeper than 1V:3H, unless a geotechnical report shows the slope remains stable.

Roof-only runoff to recharge structures is subject to (a) and (b) only, and to Clause 8.11.3.

8.8.7 **Drawdown and verification.** Every infiltration facility shall empty within **72 hours** at the design rate (Chapter 4), and shall be tested after construction (Clause 10.9.3).

8.8.8 **Hotspots.** Runoff from the following shall not be infiltrated without treatment, and shall not be infiltrated at all where (d) or (e) applies:

- (a) fuel stations;
- (b) vehicle workshops, washing bays, and bus and truck depots;
- (c) industrial yards and loading areas where hazardous materials are handled or stored;
- (d) solid waste transfer stations and landfill areas; and
- (e) land known or suspected to be contaminated.

Treatment for (a) to (c) shall include an oil-grit separator and a lined filtering BMP before any infiltration.

8.8.9 **Sandy coastal aquifers.** This Clause applies only to coastal sand aquifers. Sikkim has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The gravel and boulder terraces of the Teesta, the Rangit and the Rongni Chu are not coastal sand areas: Clause 8.8.1 applies there in full, with the valley-floor and recharge rules of Clause 4.11, and the reduced separation of item (d) does not. In coastal sand areas:

- (a) infiltration is the preferred means of meeting retention and the WQv wherever Clause 8.8.1 is met;
- (b) storm drains shall not be designed to lower the groundwater table: inverts below the seasonal high groundwater table shall be watertight, with no weep holes or subsoil drains that discharge groundwater to the outfall, unless a hydrogeological report shows no harm to the freshwater aquifer;
- (c) no long-term pumping of groundwater into storm drains shall be approved (for example basement dewatering); and
- (d) in notified coastal sand areas, **roof-only runoff** may be infiltrated with a separation of not less than **0.5 m** to the seasonal high groundwater table, provided a groundwater mounding check shows that the mound stays at least 0.3 m below the facility base and does not reach adjacent foundations or basements. No other runoff may use this reduced separation;
- (e) where neither the 1.0 m separation nor clause (d) can be met, the site shall use surface retention that does not infiltrate below ground (for example shallow vegetated depressions, disconnection of roofs onto lawns, and reuse), and detention under Chapter 4.

8.8.10 **Laterite and hard-rock areas.** In laterite and hard-rock terrain (for example the gneisses, schists, phyllites and quartzites of the Daling Group and the Higher Himalaya over most of the State, where groundwater is held "in fractured and jointed zones … and in weathered zones" and emerges "as seepages and springs wherever the land surface intersects local ground water body" (CGWB, East Sikkim, as quoted); on any slope in these areas the hill rule of Clause 4.11 applies first under Clause 8.8.1, so this Clause has effect only on the tested river-terrace gravels and the benches of stability zone 1 that the recharge rule of Clause 4.11 allows):

- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes shall be checked for slope stability.

8.8.11 **Delta clays and black cotton soils.** In the clayey colluvium, fill, cut-spoil and slide debris of the hills, the compacted ground of roads and building platforms, the silted beds of pokharis and the margins of reservoirs, and in expansive black cotton soils:

- (a) infiltration facilities will usually fail Clause 8.8.5 and need not be tested where the soil survey (Chapter 3) shows HSG D; and
- (b) where infiltration is used near buildings on expansive soils, the setback of Clause 8.8.6(a) shall be doubled.

Commentary. The 1.0 m groundwater separation is a core requirement of this Manual. The other values in this Clause (the 1.0 m bedrock separation, test numbers, safety factors, minimum rates and setbacks) are typical of US and UK practice and have no Sikkim precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Sikkim RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.

No map of hydrologic soil groups for Sikkim, no soil series of the State and no measured infiltration rate anywhere in the State was found [TBC]. The CGWB describes the rocks of East Sikkim as "gneiss, schists, quartzites, phyllites, limestones, sandstones, shales, meta-sedimentaries", with groundwater "in fractured and jointed zones … and in weathered zones in the phyllite, schist, gneisses and quartzites"; on steep ground it emerges "as seepages and springs wherever the land surface intersects local ground water body"; in South Sikkim the "Daling group of rocks is dominant" (the same source elsewhere names the Gorubathan Formation as dominant: the statements conflict); and statewide groundwater lies "largely in disconnected localized pockets and in deeper fracture zones", and "springs are the main source" (CGWB, all as quoted; the reports themselves were not reached). No depth to water or extraction figure was read [TBC]. Gangtok's slopes stand on "Precambrian rocks which contain foliated schists and phyllites" (as summarised from a landslide-zonation study). Water put into the ground is a hazard as well as a resource. The 2021 stability zonation records the ground water of zone 3 as "Wet", of zone 4 as "Dripping" and of zones 5 and 6 as "Flowing", and judges zone 4 "Not suitable for habitation unless immediate protective measures"; GSCDL told the National Green Tribunal that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora"; and the parent Act of the building rules opens by recording that septic tanks and water tanks built in the notified green belt were "likely to cause land slides during monsoons" (1985 Act, preamble). This Manual's interim soil groups follow from these (Chapter 3): the thin brown hill soils over phyllite, schist and gneiss C on slopes and D for design on slopes steeper than 10°, bedrock, roads and compacted ground D, colluvial debris fans B hydraulically but slide-prone and never credited with infiltration, the gravel terraces of SK-A A to B where the water table is deep and C where it is within 2 m in the season, urban fill C (D if compacted or clayey), and the alpine, moraine and frozen ground of SK-C C to D. **The State therefore needs three rules, not one** (Clause 4.11). On the hills, on colluvium and fill and in stability zones 3 to 6, no water is put into the ground on purpose, under the hill rule, and in zones 4 to 6 none at all. On the valley floors below the 1% AEP flood level, on the bed raised in October 2023 and where the water stands within 2.0 m, none is put into the ground either, under the valley-floor rule. Only on tested terrace gravels above the flood and the raised bed, and on stable benches of zone 1, is recharge allowed, with pretreatment, as a choice rather than a duty, under the recharge rule. Everywhere, runoff from roads and open land goes to surface systems and never directly to a recharge well, borewell or shaft (Clause 8.11.3(b)). Clause 8.8.9 has no effect in Sikkim, which has no coast.

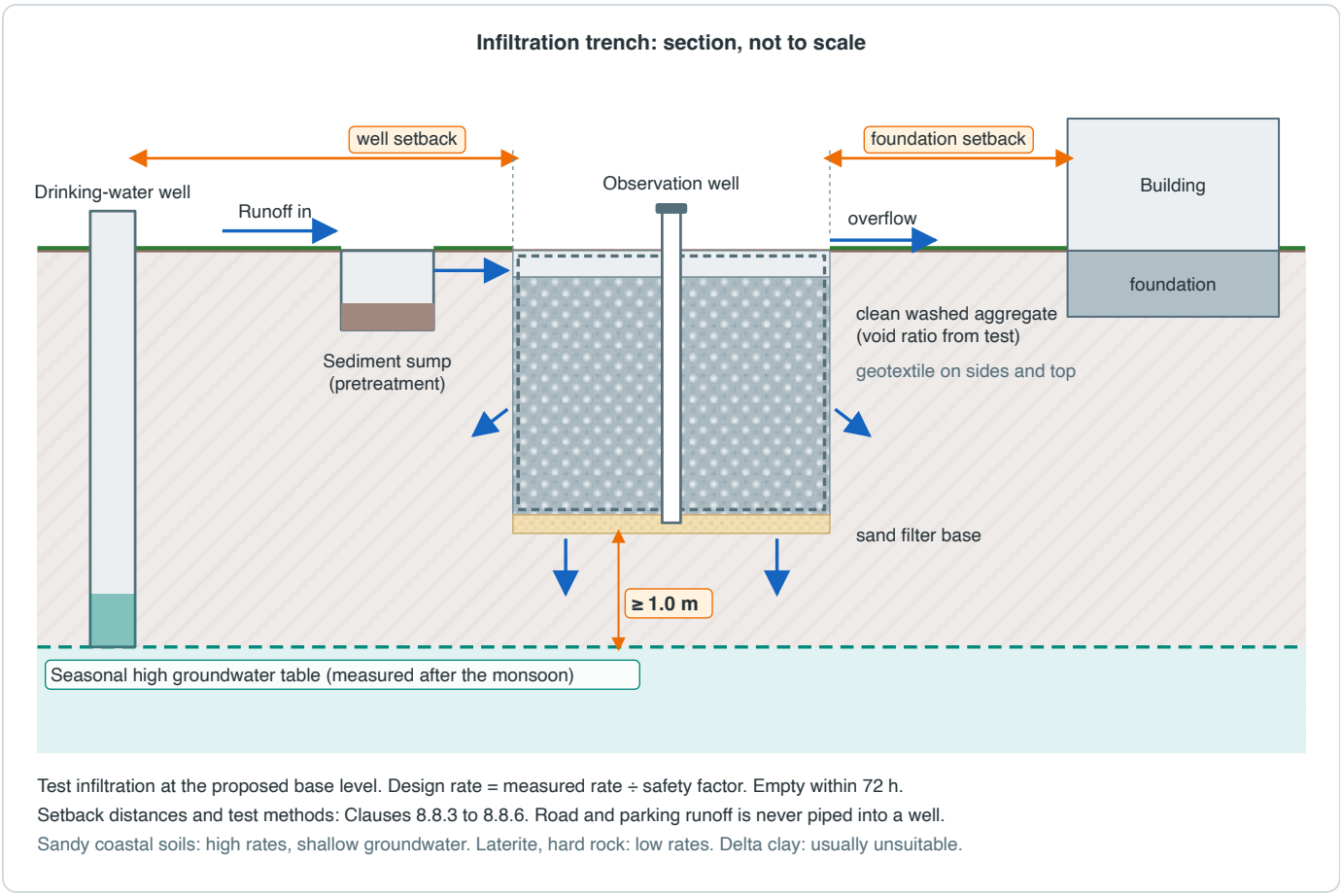



*Figure 8.3 — Infiltration trench in section: pretreatment sump, aggregate-filled trench in geotextile, observation well, overflow, the 1.0 m minimum separation to the seasonal high groundwater table, and setbacks to wells and foundations. Original drawing for this Manual, adapted from the Georgia Stormwater Management Manual, 2016 (Vol 2), and CIRIA, The SuDS Manual (C753), 2015.*

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## 8.9 Sewage cross-connections and dry-weather flow

8.9.1 **No sewage in storm drains.** No sewage or sullage (grey water from kitchens, bathrooms and laundries), septic tank effluent, or trade effluent shall be connected to, or discharged into, any storm drain, by any pipe, channel or opening.

8.9.2 **Condition of approval.** Before the completion certificate, the Applicant shall show, by a dye or smoke test witnessed by the Authority or the sewerage agency, that every sewage and sullage outlet on the site discharges to a sewer or to an approved on-site system, and that none discharges to a storm drain. Any existing cross-connection on the site shall be removed as a condition of approval, including on redevelopment and on additions to existing buildings.

8.9.3 **Where no sewer exists.** Where no sewer is available, sewage and sullage shall go to an approved on-site or decentralised treatment system. The treated effluent of such a system may be discharged to a storm drain only with the written consent of the Sikkim State Pollution Control Board (SSPCB) and the drain owner.

8.9.4 **Public drains: DWF survey.** Every ULB in a Tier A area shall survey its storm drain outfalls to waterbodies for dry-weather flow at least once a year, before the monsoon, and record:

- (a) the outfalls with DWF;
- (b) the estimated DWF rate; and
- (c) the upstream sources found by tracing, CCTV, dye or smoke testing.

The results shall be published in the register of Clause 10.17.

8.9.5 **DWF interception.** Until the sources are removed, every outfall to a waterbody that carries DWF shall have a DWF interceptor that:

- (a) diverts the DWF to a sewer or a treatment plant;
- (b) does not reduce the capacity of the storm drain for the minor or major event (Chapter 6), with its weir or diversion head losses included in the hydraulic design (Chapter 9);
- (c) has a screen ahead of the diversion; and
- (d) is not a substitute for removing the source connections.

8.9.6 **Sewage overflows.** No new sewage overflow, emergency bypass or pumping station overflow shall be designed to discharge into a storm drain or waterbody, except where the sewerage agency shows that no alternative exists, and then only with screening and with the overflow frequency stated.

> **Commentary.** The prohibition of sewage connections and the removal of existing cross-connections as a condition of approval are core requirements of this Manual, and Clause 1.10.3 allows no variance from them. Sewage in storm drains is the single largest water quality problem of urban drainage in Sikkim. It defeats every other measure in this chapter: BMPs designed for stormwater are overloaded, GPTs fill with sludge, and the receiving tanks and channels become sewage lagoons. CPHEEO (2019) notes that Indian drains carry night soil and urine (Part A §9.5). DWF interception (Clause 8.9.5) is an interim measure. It protects the waterbody while the sources are traced and removed, but it can become permanent if the source work is not done, which is why the annual survey and publication of Clause 8.9.4 are required. The annual survey frequency is set by this Manual.
>
> In Sikkim the storm drains and jhoras carry sewage outside the part of Gangtok that is sewered, and this is the normal case, not the exception. The State estimated the urban sewage generated in September 2025 at **29.51 MLD** (80% of the water supplied plus 10% for storm-water infiltration: the Gangtok Municipal Corporation 18.33 MLD, Namchi 3.35, Jorethang and Nayabazar 2.41, Rangpo 2.38, Mangan 1.14, Gyalshing 1.01 and Singtam 0.89), against **22.71 MLD installed, 17.90 MLD operational and 15.22 MLD actually treated** at Gangtok's sewage treatment plants (Adampool 8.00 and 4.69 MLD, Ranipool 1.27, Lower Sichey 3.90 and Lower Syari 1.60, with Tathangchen's 3.25 MLD not yet operating), and stated that "Sewage of towns and areas where there is no Sewage Treatment Plants is treated through anaerobic digestion in the septic tanks of individual households" (monthly progress report of September 2025, annexed to the State's affidavit of 19 December 2025 in NGT OA 673/2018). In Zone III, whose scheme is for the "Pollution abatement of Rani chu through Ro-Ro Chu", "Connections of about 500 households have so far been completed" (the same report). The State also told the Tribunal that "the establishment of sewerage systems for Namchi Town and Jorethang Town has remained stalled since the year 2013 and 2015 respectively", because of "public resentment", with completion targeted for December 2028 (affidavit of 19 December 2025, which dates the GLOF "3rd/4th September 2023" in error; the State's compliance report gives October); that the flood of October 2023 "damaged the STPs at Singtam (0.66MLD); Rangpo (1.40 MLD); Melli (0.50 MLD)", where the households "with existing septic tanks … are currently being utilized to channelize the sewage" (compliance report in EA 35/2023); and that a new plant at Singtam (₹39.03 crore) is due in December 2027. At Melli, CAG found that households "had constructed their own septic tank for disposal of sewerage and were reluctant to connect" to the plant completed in November 2013, and at Jorethang that the sewerage was incomplete "for want of land", the land chosen being "fully flooded during monsoon" (Report No. 3 of 2016). At Soreng "most of the houses have adopted the practice of onsite disposal by constructing septic tank/soak pits with effluent discharging into open surface drains", which carry "untreated wastewater into the open storm water drains ultimately discharging into the farmland / water bodies", and "In some places, sewage from septic tanks overflow/seep to roadside drains" (ADB, due-diligence report for the Sikkim Integrated Urban Development Project, December 2024). **Two statements stand side by side and are not reconciled here.** In OA 606/2018 the National Green Tribunal found, in its order of 4 July 2024 as quoted by the State, that rural sewage, "presently estimated to be 21.41MLD", "is relying on septic tanks and soak pits", and that "treated sewage is entering in to river/ rivulets/ jhoras and this is not permissible under the Water Act. Fast flowing water bodies should not be exploited for disposal of sewage or garbage", and asked for the "water quality

of rivers including jhoras receiving sewage"; the State replied that "No sewage is disposed off in the rivers or fast flowing water bodies" (six-monthly report in OA 606/2018). The State's four former Priority V stretches (the Teesta at Chungthang, the Maney Khola, the Ranichu and the Rangit at Triveni, named as cited in the State's filings) were delisted: "at present no river stretches have been identified as polluted river stretches" (Central Monitoring Committee, 12 September 2023, recorded in the affidavit of 19 December 2025), and the Maney Khola is the State's model river for bathing quality; this Manual does not describe any Sikkim river as a listed polluted stretch, and it does not read the delisting as evidence that the jhoras are clean, because the jhoras are not monitored stretches (NEER reading). The law already points the same way: section 193 of the Sikkim Municipalities Act, 2007 requires "an entirely separate drain for rain water", connected "with the natural nullahs, khola-kholsas, jhoras, or storm water drainage", and section 187 provides that, from a date to be appointed, "no sewage shall be discharged into any watercourse until it has been so treated as not to affect prejudicially the purity and the quality of the water"; regulation 25 of the SBCR 1991 sends domestic sewage to a septic tank within the site, or to the public sewer where one is available. In Sikkim, therefore: **(i)** every storm-drain or jhora outfall to a jhora that feeds a dhara, a pokhari or a drinking-water intake, and every outfall within a town to the Rani Khola, the Roro Chu, the Rongni Chu or the Teesta, is taken to carry dry-weather flow until the survey of Clause 8.9.4 shows that it does not, and has a DWF interceptor and a screen under Clause 8.9.5 before it reaches the water, and before any detention or infiltration device (Clause 6.3.6(e)); **(ii)** no septic tank overflow, soak-pit overflow or sullage pipe is connected to a storm drain or jhora on any site approved under this Manual (Clauses 8.9.1 and 8.9.2), with sections 187 and 193 of the Municipalities Act and regulation 25 of the SBCR 1991 as the local hooks; **(iii)** until sewers exist, a drain or jhora that receives the sullage of a settlement is designed as a combined channel: for the velocities that keep sludge moving in dry weather as well as for the storm flow, with access for cleaning along it, and with covers or screens where it passes homes (Clause 6.3.6(d)); and **(iv)** every new or rebuilt sewage treatment plant, interceptor and pumping station is sited above the October 2023 flood and aggradation level and outside any mapped GLOF path (Chapter 7, definitions after Clause 7.2), because the plants at Singtam, Rangpo and Melli were damaged by that flood. Every interceptor is sized from the measured dry-weather flow of its drain, does not reduce the drain's capacity for the minor and major events (Clause 8.9.5(b)), and passes the storm flow above its capacity on down the drain; on a jhora that carries boulders and debris in flood, it and its chamber are placed above the jhora's 1% AEP level or protected against the scour and debris of that flood (Chapter 9). These conditions are set by this Manual.

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## 8.10 Outfalls to waterbodies: first flush, gross pollutant traps and screens

8.10.1 **Requirement.** Every new storm drain outfall to a waterbody, and every existing outfall on a drain that is rebuilt, widened or extended, shall have:

- (a) a GPT designed under Clause 8.7.10; and
- (b) first-flush treatment: treatment of the WQv (or Q_wq) of the contributing catchment by the BMPs of Clause 8.7, either on the contributing sites or at the outfall.

8.10.2 **Where treatment at the outfall is impracticable.** Where land is not available at a public outfall, first-flush treatment may be provided by:

- (a) a proprietary first-flush or hydrodynamic device sized for Q_wq; or
- (b) a treatment wetland or forebay within the waterbody setback (Clause 7.5.1(b)), outside the waterspread.

8.10.3 **Screens and trash racks.** Screens at outfalls, culvert inlets and pump sumps shall:

- (a) be designed with **50% blockage** for hydraulic capacity;
- (b) have an overflow or bypass path so that a fully blocked screen does not flood property;
- (c) have bar spacing chosen for the hazard: closer spacing for litter capture, wider spacing where blockage would cause flooding; and

- (d) be cleanable from a safe platform, with vehicle access.

8.10.4 **Existing outfalls.** Each ULB shall prepare a programme to fit GPTs and DWF interceptors to its existing outfalls to waterbodies, starting with outfalls to tanks used for drinking water supply and to notified wetlands (Clause 7.12), and shall report progress in the register of Clause 10.17.

> Commentary. This Manual requires first-flush treatment and gross pollutant traps at outfalls to waterbodies. Gross pollutants are the most visible form of pollution in Sikkim waterbodies, and plastics also block drains and culverts, which links water quality to flooding. The 50% screen blockage matches the grate clogging factor of Chapter 6. Clause 8.10.3(c) warns against fine screens on large drains, which block in the first hour of a storm and cause the flooding they were meant to prevent.

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## 8.11 Rainwater harvesting integration

8.11.1 **RWH mandate continues.** The rainwater harvesting required by the Sikkim Building Construction Regulations, 1991 (none: the regulations require no rainwater harvesting, only that at least 25 per cent of the roof be sloped "with rain water gutter" (reg. 6) and that gutters and down pipes lead to "the storm water plinth protection drain of the building" (reg. 21); the only statutory rainwater harvesting in Sikkim is section 186 of the Sikkim Municipalities Act, 2007, which requires a "rain water harvesting structure" in "every building owned or occupied by the State Government or a statutory body or a company or an institution owned or controlled by the State Government", "in such manner as may be specified by the State Government or the Municipality from time to time", and no manner has been specified as far as found) continues to apply where it exists, that is, to the buildings that section 186 covers; for every other building rainwater harvesting is a condition of this Manual where the Manual applies, not a statutory one, and in Sikkim it is storage for use, not recharge, on every slope steeper than 10°, on colluvium and fill and in stability zones 3 to 6 (Clause 4.11, hill rule) (Chapter 1). This Clause sets how RWH structures are counted under this Manual.

8.11.2 **Three different functions.** The designer shall keep apart, on the drawings and in the calculations:

- (a) **harvesting**: storage for use (sumps and tanks);
- (b) **recharge**: recharge pits, trenches, shafts and wells that put water into the ground; and
- (c) **detention**: storage with an orifice outlet that is empty at the start of a storm (Chapter 4).

8.11.3 **Recharge structures.**

- (a) Roof runoff may be led to recharge wells, open wells, recharge pits and shafts after a filter or settling chamber.
- (b) Runoff from roads, parking and other paved areas shall not be led directly into any well, borewell or recharge shaft. It may be recharged only through an infiltration facility that meets Clause 8.8, with pretreatment.
- (c) Recharge structures shall meet the groundwater separation of Clause 8.8.1, measured from the base of the pit or the bottom of the filter media, except recharge wells that receive filtered roof water only.

8.11.4 **Credit toward retention and WQv.** A recharge structure counts toward the retention volume of Chapter 4 and the WQv only where:

- (a) its infiltration rate has been tested under Clause 8.8.3;
- (b) it empties within 72 hours at the design rate; and
- (c) it has pretreatment.

A harvesting sump counts toward retention only where its contents are used, by a demand stated in the drainage report, within 72 hours (Chapter 4).

8.11.5 **No credit as detention.** RWH storage does not count as detention unless it is a dedicated volume that is empty when a storm arrives, with an outlet. RWH sumps are assumed **full** at the start of every monsoon (April–October) design storm (Chapter 4).

8.11.6 **Overflow.** Every RWH structure shall have an overflow that discharges at grade to the site drainage, never onto a neighbouring plot or into a sewer.

8.11.7 **Surface-runoff recharge in public spaces.** Recharge trenches, shafts and percolation pits in roads, medians, parks and other public spaces shall meet Clause 8.8 in full, including the hotspot rules for roads with heavy traffic, and shall have a GPT or silt trap at each inlet.

> Commentary. The rule that RWH storage does not count as detention is set in Chapter 4. Sikkim's building rules do not require rainwater harvesting. The SBCR 1991 ask only that "minimum of 25 per cent of the roof shall be constructed in sloped gabled of traditional roofing … with rain water gutter" (reg. 6) and that gutters and down pipes be "of such design and capacity that the water will neither spill out of them nor leak through them" and lead to "the storm water plinth protection drain of the building" (reg. 21). The only statutory rainwater harvesting is section 186 of the Sikkim Municipalities Act, 2007: "In every building owned or occupied by the State Government or a statutory body or a company or an institution owned or controlled by the State Government, rain water harvesting structure shall be provided in such manner as may be specified by the State Government or the Municipality from time to time"; no manner has been specified as far as found (NEER reading). A reply in the Rajya Sabha in 2019 lists Sikkim as "NA asked to take up rain water harvesting structure for Government buildings" (as quoted in a search snippet), and GSCDL has invited expressions of interest for a rainwater-harvesting project in Gangtok (as reported; the document was not read). Rainwater harvesting in Sikkim is storage and reuse: the rural households that depend on springs face their decline (Clause 8.7, Commentary), and recharge on the slopes would move the ground. For private buildings it is a condition of this Manual where the Manual applies, not a statutory one (Clause 8.11.1). This Manual credits storage of at least 25 L per m² of roof as retention only through reuse within 72 hours (Clause 4.4.3), assumes it full at the start of every design storm of the season of 1 April to 31 October (Clause 4.11.2), and never counts it as detention. On the tested terrace gravels and the stable benches that the recharge rule of Clause 4.11 allows, recharge may be one function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); everywhere else harvesting is for storage and use only, and its overflow goes by a lined drain to a trained jhora or the road drain, never onto an unprotected slope, into a soak pit or within 15 m of a dhara. Springshed recharge under the Dhara Vikas programme is a water-supply measure and earns no stormwater credit. RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a June to September monsoon storm, such as those of 9 June 1997 at Gangtok and 25 September 2005 at Tadong, arrives after weeks of rain, which is why it cannot be counted as detention.
>
> Clause 8.11.3(b) has no direct precedent; this Manual sets it because road runoff carries oil, metals and pathogens. A recharge shaft or borewell bypasses the soil that would otherwise filter it and delivers it straight to the aquifer that supplies wells nearby. The CGWB *Manual on Artificial Recharge of Ground Water* (2007) gives recharge structure types and filter designs; this Manual adds the source-water restrictions.

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## 8.12 Construction-stage erosion and sediment control

8.12.1 **ESC plan.** Every development with land disturbance of **0.1 ha** or more, and every public drainage or road work, shall have an Erosion and Sediment Control (ESC) plan, approved with the drainage report. It shall show:

- (a) the sequence of clearing, earthworks and stabilisation;
- (b) the area exposed at each stage;
- (c) the measures of Clause 8.12.3, with their locations and sizes;
- (d) the protection of infiltration and retention areas (Chapter 10);

- (e) stockpile, concrete washout and fuel storage locations; and
- (f) the inspection and maintenance schedule.

8.12.2 **Monsoon timing.** Earthworks shall be planned so that:

- (a) the area exposed during the monsoon (April to October) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **31 March**; and
- (c) any area exposed between 1 April and 31 October has sediment controls in place before it is cleared.

8.12.3 **Measures.**

- (a) **Silt fences** along the downslope edge of disturbed areas receiving sheet flow, with the area draining to each fence limited as set in Annex 8E.
- (b) **Sediment traps** for concentrated flow from disturbed areas of up to 2 ha.
- (c) **Sediment basins** for disturbed areas of more than 2 ha. The storage volume below the outlet shall be at least the greater of the runoff from the 50% AEP (2-yr) 24-hour storm and **250 m³ per hectare** of drainage area, with a dewatering outlet that draws water from the surface.
- (d) **Inlet protection** at every existing drain inlet that receives runoff from the site.
- (e) **Stabilised construction exits**, with wheel washing where vehicles enter public roads.
- (f) **Stockpiles** outside Zone 1 of any waterbody setback (Chapter 7), at least 10 m from any drain, and covered during the monsoon.
- (g) **Dewatering** discharges passed through a sediment basin, settling tank or filter bag, never pumped directly into a drain or waterbody.
- (h) **Concrete washout** in a lined pit, never into a drain.

8.12.4 **Design storm for temporary works.** Temporary ESC measures use the rainfall of Chapter 2 with a climate factor of 1.0 (Clause 2.8.2).

8.12.5 **Inspection.** ESC measures shall be inspected weekly and within 24 hours after every heavy-rainfall event (as defined in Chapter 10), repaired within 48 hours, and cleaned when half full of sediment.

8.12.6 **Removal.** Temporary measures shall be removed only after the area draining to them is stabilised. Sediment shall be removed from any permanent facility used for sediment control before its as-built survey (Chapter 10).

> Commentary. The 0.1 ha threshold is the applicability threshold of Chapter 1. The sediment basin volume of 250 m³/ha is the US EPA Construction General Permit minimum of 3,600 ft³ per acre drained, converted to SI (US EPA, 2022 CGP); the CGP allows the alternative of the 2-year, 24-hour runoff. This Manual requires the greater of the two, because Sikkim's 2-year 24-hour depths are high and construction sites are commonly left exposed through the monsoon. The 2 ha division between traps and basins, the 31 March stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 31 March date matches the pre-monsoon deadline of Chapter 10. Construction sediment is a direct flood hazard as well as a pollutant: it fills drains, culverts and tanks, and in Sikkim spoil and slide debris travel with the sediment: on the ridges into the jhoras, and on the valley floors into a Teesta whose bed the flood of October 2023 raised by 7–8 m (PPR, 2026). The State already reaches construction sediment in three ways, without a size, an inspection or a basin. The SBCR 1991 prohibit the "Stacking/dumping of building materials without permission and spoils on Public Street, road, drains, gullies and jhoras", with a fine of ₹500 at least (reg. 22), and Form III takes a refundable security of ₹5,000 "to meet the expenses for lifting of building materials/spoils … dumped at road side including drain … and also effect repair to damages to the road including drainage system" (cl. 15). And the annual monsoon notices stop excavation: "no construction involving earth excavation works shall be permitted with effect from 6th May, 2019 till 30th September, 2019 due to the onset of the monsoon. Further, Construction Orders shall not be issued during the aforesaid period", with building material "lying on the road setback or over drains" to be seized (UD&HD Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019; UDD Notice No. T(1689)/997, 26 May 2020, for 1 June to 30 September 2020; in 2024 the ban, from 1 May, was extended by 15 days, as reported). The notices are annual, not a regulation, and they do not cover an excavation left open from before the ban;

Clause 8.12 supplies the stabilisation, the controls and the inspections. The stabilisation date of 31 March is set by this Manual, before its season begins on 1 April and before the excavation ban begins, because Gangtok's April averages 296.9 mm and its 24-hour record fell in May (Chapter 2). The reason given above for the larger basin volume, that Sikkim's 2-year 24-hour depths are high, holds in every sub-area: the 50% AEP 24-hour design depths of Clause 2.3.6(d), at 0.42 of the 2% AEP depth, are about 114 mm at Gangtok, about 118 to 151 mm on the provisional plate readings of SK-A (Rangpo to Melli), about 101 mm in SK-C and about 195 mm in SK-B1 (NEER arithmetic on the values of Chapter 2); the NIH-DHAARA reanalysis gives lower values, from about 50 mm at Lachung to about 113 mm at Rangpo (comparison values only, not design values; Chapter 2); and on bare HSG D ground under AMC III, which Chapter 3 applies from 1 May to 30 September, Gangtok's 114 mm gives about 100 mm of runoff, about 1,000 m³ per hectare, four times the 250 m³ per hectare of the CGP minimum (NEER arithmetic). The rule of Clause 8.12.3(c) is kept unchanged. In Sikkim the outlet of a sediment basin or trap under Clause 8.12 discharges to a lined drain, a trained jhora or the road drain, never onto an unprotected slope; no sediment basin or trap is designed to infiltrate where Clause 4.11 bars infiltration, which includes every slope steeper than 10° and stability zones 3 to 6; no basin or stockpile is placed on the Teesta valley floor below the October 2023 flood and aggradation level; no spoil, muck or debris from a site is placed in a jhora, khola or pokhari, within its Zone 1, on a scheduled river's bank, or on the recharge area of a dhara; and a construction site above a dhara or a drinking-water intake keeps its sediment out of every drain that reaches it.

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## 8.13 Monitoring

8.13.1 **Outfall monitoring.** Each Tier A authority shall monitor water quality at a representative set of its outfalls to waterbodies, including every outfall to a drinking-water tank or notified wetland. Monitoring shall include:

- (a) dry-weather sampling (Clause 8.9.4), at least once a year before the monsoon; and
- (b) wet-weather sampling of at least three events each monsoon at a set of index outfalls.

8.13.2 **Parameters.** At minimum: TSS, BOD, COD, faecal coliform, total nitrogen, total phosphorus, oil and grease, and, for industrial catchments, heavy metals. Results shall be compared with the CPCB water quality criteria for the designated best use of the receiving waterbody.

8.13.3 **Gross pollutant records.** The mass or volume of material removed from each GPT and screen at each cleaning shall be recorded in the O&M records (Chapter 10).

8.13.4 **BMP performance monitoring.** The State Stormwater Technical Committee shall run a BMP performance calibration programme and shall revise Table 8.3 and Annex 8C from its results.

8.13.5 **Publication.** Monitoring results shall be published in the register of Clause 10.17.

Commentary. No Sikkim programme of stormwater quality monitoring was found during research for this Manual, and CPHEEO (2019) sets no Indian targets. The monitoring in Clause 8.13 is the minimum needed to calibrate Table 8.3 and to show whether DWF interception and source removal are working. The parameter list follows the key pollutants named in CPHEEO's WSUD procedure (TSS, nitrogen, phosphorus and gross pollutants), with BOD and faecal coliform added because of sewage contamination. The monitoring frequencies are set by this Manual.

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## 8.14 Submittal requirements

Every drainage report under this chapter shall include:

1. the **Water Quality Sheet (Form 8-1)**: P_ret, P_3m and P_wq; the WQv and Q_wq for each drainage area; the volume retained under Chapter 4; and the BMP serving each area;
2. for Tier A: the LoS calculation (ΔCN, required LoS) and the composite VR (Clause 8.6);
3. the design of each BMP to Clause 8.7 and Annex 8D, with pretreatment;
4. for infiltration and recharge: the **Infiltration Test Record (Form 8-2)**, the seasonal high groundwater level and its source, the design rate, the drawdown time, and the setbacks of Clause 8.8.6;
5. the sewage and sullage connection plan and the dye or smoke test record of Clause 8.9.2;
6. the GPT and first-flush design for any outfall to a waterbody (Clause 8.10);
7. the RWH layout, separating harvesting, recharge and detention (Clause 8.11); and
8. the ESC plan (Clause 8.12).

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## 8.15 Review and update

8.15.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). Table 8.3 shall also be reviewed when the calibration programme of Clause 8.13.4 reports, and in any case within 5 years of notification.

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## References (chapter)


- MoHUA / CPHEEO (2019). Manual on Storm Water Drainage Systems, Part A: Engineering Design (§9.5, Ch. 10). https://web.archive.org/web/2024/https://mohua.gov.in/upload/uploadfiles/files/VolumeI-Part%20A-Engineering-Design.pdf
- Mid-America Regional Council and Kansas City Metro Chapter APWA (2012). Manual of Best Management Practices for Stormwater Quality (Tables 4.2–4.6). https://www.marc.org/sites/default/files/2022-05/Best_Management_Practices_for_Stormwater_Quality.pdf
- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01; MARC factsheet and Supplement. https://www.marc.org/document/apwa-5600-manual-factsheet ; https://www.marc.org/document/apwa-stormwater-standards-supplement
- Atlanta Regional Commission / Georgia EPD (2016). Georgia Stormwater Management Manual, 2016 Edition, Vols 1–2. https://documents.atlantaregional.com/gastormwater/GSMM_2016%20EDITION_FINAL_V1.pdf
- Department of Irrigation and Drainage Malaysia (2012). Urban Stormwater Management Manual for Malaysia (MSMA), 2nd Edition. https://did.sarawak.gov.my/web/attachment/show/?docid=clRsMlRycU1lNnFRcnl3eDZnNkJMdz09OjpY0au0UPvQ9zUHVWRMbCKX
- Department of Irrigation and Drainage Malaysia (2008). Submission Checklist for Stormwater Management. https://www.water.gov.my/jps/resources/auto%20download%20images/5844dfbba8fc1.pdf
- CIRIA (2015). The SuDS Manual (C753). London: CIRIA.
- PUB, Singapore's National Water Agency. Active, Beautiful, Clean Waters Design Guidelines (current edition).
- Central Ground Water Board (2007). Manual on Artificial Recharge of Ground Water. Ministry of Water Resources, Government of India.
- US Environmental Protection Agency (2022). NPDES Construction General Permit (sediment basin sizing).
- ASTM D3385. Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer.
- BRE Digest 365. Soakaway Design. Building Research Establishment, UK.
- Government of Sikkim. *Sikkim Building Construction Regulations, 1991*, as amended, regs. 6, 13(iii), 21, 22, 25 and Form III; *Sikkim Municipalities Act, 2007*, ss. 186, 187 and 193; the stability zonation of the Mines and Geology Department (Notification No. 17/DMG/20-21, 19 March 2021); and the monsoon notices of 1 May 2019 and 26 May 2020 (Chapter 7 references).
- National Green Tribunal (Principal Bench). EA 35/2023 in OA 673/2018: State affidavit of 19 December 2025 with the monthly progress report of September 2025, and the State's compliance report; OA 606/2018: six-monthly report of the Government of Sikkim after the order of 4 July 2024 (Chapter 7 references).
- Asian Development Bank (2024). *Sikkim Integrated Urban Development Project* (57230-001): resettlement and indigenous peoples due-diligence report for the Soreng sewerage subproject, December 2024. https://www.adb.org/sites/default/files/project-documents/57230/57230-001-sddr-en.pdf
- Comptroller and Auditor General of India. Report No. 3 of 2016 (Economic Sector, Government of Sikkim), Chapter II (Chapter 7 references).
- Central Ground Water Board. Aquifer mapping reports for East and South Sikkim and the State's groundwater assessment (as quoted in search results; the reports were not reached).
- National Green Tribunal (Eastern Zone). OA 38/2022: reply affidavit of GSCDL (Chapter 7 references).
- Reports of rural dependence on springs and their decline, and of the Rajya Sabha reply of 2019 on rainwater harvesting (India Water Portal; Rajya Sabha debates, as quoted; secondary).
- India Meteorological Department. *Mean monthly meteorological parameters of Gangtok, 1981–2010* (Meteorological Centre Gangtok); *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)* (Gangtok, 42299; Tadong, 22209) (Chapter 2 references).
- NIH-DHAARA (National Institute of Hydrology), IMDAA dataset, queried 14 November 2026 (tool output; comparison values only; Chapter 2 references).
- Parliament reply AU1419 on AMRUT 2.0 admissible components. https://eparlib.sansad.in/bitstream/123456789/2988692/1/AU1419_tzClvw.pdf

## Annexes and forms

| Annex / Form | Content |
|---|---|
| 8A | 3-month ARI 24-hour depth and IDF by zone |
| 8B | Redevelopment LoS table and treatment-train composite VR |
| 8C | Sikkim BMP performance calibration |
| 8D | BMP design sheets, media specification, plant lists |
| 8E | Erosion and sediment control standard details |
| Form 8-1 | Water Quality Sheet |
| Form 8-2 | Infiltration Test Record |

CHAPTER 9

# Hydraulic Design of Structures

## 9.1 Purpose and scope

9.1.1 This chapter sets the hydraulic design methods for the structures used in the minor and major systems (Chapter 6), in retention and detention facilities (Chapter 4), at outfalls (Chapter 5) and at waterbodies (Chapter 7). It covers:

- (a) pipes and box drains (Clause 9.3);
- (b) culverts (Clause 9.4);
- (c) open channels (Clause 9.5);
- (d) energy dissipators, outlet protection and drop structures (Clause 9.6);
- (e) detention outlet structures (Clause 9.7);
- (f) trash racks and screens (Clause 9.8);
- (g) pumps and sumps (Clause 9.9);
- (h) tide gates, flap gates and non-return valves (Clause 9.10);
- (i) inlets and gratings (Clause 9.11);
- (j) manholes, junction chambers and access (Clause 9.12); and
- (k) materials and durability, including coastal and saline exposure (Clause 9.13).

9.1.2 **Structural design is outside the scope of this Manual.** Structures shall be designed structurally to the applicable Indian Standards and IRC codes, for example IS 456 (plain and reinforced concrete), IS 458 (concrete pipes), IRC:SP:13 (small bridges and culverts) and the IRC bridge codes. Where this chapter refers to a structural standard, it does so only for durability (Clause 9.13) or hydraulic performance.

9.1.3 Design flows, design AEPs and level-of-service limits come from Chapters 2 to 7. This chapter does not change them.

> **Commentary.** APWA Section 5600 places most structure hydraulics in its sections on inlets and manholes (5604), enclosed pipe systems (5606), engineered channels (5607) and detention (5608). CPHEEO (2019) spreads them across Chapters 5, 6, 8 and 11. This chapter gathers them in one place and points to the US Federal Highway Administration (FHWA) hydraulic circulars for methods that Indian codes do not cover in enough detail: HDS-5 for culverts, HEC-14 for energy dissipators, HEC-22 for inlets and access holes, and HEC-24 for pump stations. The FHWA editions cited are those listed in the FHWA hydraulics library as of October 2026.

## 9.2 General requirements

9.2.1 **Tailwater.** Every structure that discharges to a river, khola (खोला; a river or large stream), jhora (झोरा; a natural watercourse or ravine stream, the word the State's statutes use), pokhari (पोखरी; pond, lake or tank) or reservoir whose level can rise above the outfall invert shall be analysed with the tailwater conditions of Chapter 5: the non-tidal tailwater of Clause 5.6 for minor- and major-system design; the riverine backwater of Clause 5.8, including the flood released from a hydropower dam upstream, among them Teesta-V at Dikchu, Teesta-VI, the Teesta Low Dam III and IV projects,

Chuzachen, Dikchu, Rongnichu, Jorethang, Tashiding and Rangit-III, and Teesta-III at Chungthang once it is restored (Clause 5.8.5(c)); and the outfall-closed check of Clause 5.10 wherever the receiving water can rise above the outfall invert, which is the case for the drains of the valley-floor towns that outfall to the Teesta at Chungthang, Dikchu, Singtam, Rangpo and Melli and along the riverside below Mangan, to the Rangit at Majitar and Jorethang and to the Rongni Chu at Ranipool and Singtam (Clause 5.8.5(b)). Most outfalls in the State, those of Gangtok, Pakyong, Namchi, Ravangla and Gyalshing among them, fall freely to a steep jhora with no river tailwater (Clause 5.8.5(a)); for them the tailwater is the level of the 1% AEP flood in the jhora at the outfall, computed with the sediment and debris allowances of Chapter 6 (Clause 6.3.6(g) and (h)) and checked against surveyed flood marks, with the outfall invert at least 0.5 m above the highest surveyed bed and the receiving jhora checked for capacity and stability to the next confluence or trained reach, the downstream duty that the Sikkim Municipalities Act, 2007 already puts on a Municipality, which must provide "a safe and sufficient outfall … in such manner as may not cause any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187). On the valley floors the design tailwater is the higher of the highest recorded CWC level at the nearest site, transferred to the outfall, and the flood mark of October 2023 surveyed at the outfall, with the outfall invert above the river bed as surveyed after that flood (set by this Manual; Clause 5.8.5(b)), because the flood of 3–4 October 2023 left the Teesta bed "risen by an average of 7-8 meters" (State affidavit to the National Green Tribunal, 28 February 2026, annexing the project proposal for GLOF risk mitigation in the Lhonak valley) and an invert set from the old bed may now be buried. The CWC levels are 298.4 m at Khanitar on the Teesta (09:00, 4 October 2023; the old high flood level was 297.7 m, 18 September 1974); at Melli on the Teesta, 225.5 m (04:00, 4 October 2023) by one transcription and 228.0 m by a CWC bulletin of 2024 as quoted, a conflict, of which the higher is used for a check level until CWC's site sheet settles it (old high flood level 225.25 m; warning and danger levels given as 226.0 m and 227.0 m, unconfirmed); 356.09 m at Singtam on the Rongni Chu (undated; danger level 355.09 m); and 279.29 m at Majitar on the Rangit (17 October 1985) (CWC levels as transcribed by SANDRP and the press, as reported; the datum of none is stated [TBC]). No CWC level was found for Rangpo [TBC], and the sites at Ranipool on the Rongni Chu and Bakcha on the Dik Chu have no published high flood level. For an outfall to a hydropower reservoir, the tailwater is its maximum water level, or its full reservoir level plus the surcharge in the design flood, as Chapter 5 sets it, and in the reach below a dam the level of the largest recorded release or, until the operator gives one in writing, of the spillway capacity (Clause 5.8.5(c)); no full reservoir level, maximum water level or release rule was found for any dam in the State [TBC], so until the operator states them on a named datum an outfall in a reservoir reach is treated as having an unknown tailwater and is sited above the surveyed flood mark of October 2023. For an outfall to a pokhari the tailwater is its surveyed spill level, with the pokhari full to its outlet (Clause 5.8.5(f)); for a river reach without a CWC site, the flood-mark profile of the reach, surveyed after October 2023; and for a drain held up by a check dam, weir, flap gate or pumping station downstream of the outfall, that control at its gate-closed level, its weir crest or the start level of its pumps; with the joint case of Clause 2.12 in every case. No rainfall-based tailwater governs on the Teesta trunk or on the Lachen Chu, the Lachung Chu or any stream below a glacial lake: these are the corridors of glacial-lake outburst floods (GLOFs), screened under Clause 2.3.6(i), and works there are sited out of the path (Clause 5.8.5(d)). The Teesta below Melli and the lower Rangit, where they form or cross the State border, run on into reaches that the West Bengal edition governs (Clause 5.8.5(e)). No document found sets a design river, reservoir, pokhari, khola or jhora level at any outfall in Sikkim, and no flood line has been notified; the only statutory river line, the river bank of the scheduled rivers under section 29(1) of the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, is a reserve of land, not a level. Until a level is published, the levels of Chapter 5 apply.

9.2.2 **Climate factor.** Design flows shall include the climate factor of Clause 2.8.

9.2.3 **Maintenance access.** Every structure shall be accessible for inspection and cleaning by the methods in Clause 9.12 and Chapter 10, without manual entry into confined spaces wherever practicable.

9.2.4 **Design life.** Structures shall be designed for a service life of at least 50 years for concrete and masonry works, and at least 25 years for mechanical and electrical equipment, unless the approving authority agrees otherwise.

9.2.5 **Blockage.** Where a structure can be blocked by debris, it shall be checked in the blocked condition set out in this chapter, and a safe overflow route shall exist for that condition (Chapter 6, Clause 6.3.2).

> **Commentary.** The design-life values in Clause 9.2.4 have no direct precedent; this Manual sets them because they are needed to decide when the climate factor applies (Clause 2.8.2 applies it to elements with a design life over 25 years).

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## 9.3 Pipes and box drains

9.3.1 **Capacity and roughness.** Pipe and box-drain capacity shall be computed by Manning's equation with the design n of Chapter 6, Table 6.6. For precast or cast-in-situ RCC box drains, the design n shall be at least 0.015.

9.3.2 **Partly full flow.** Depth, velocity and discharge in partly full circular pipes shall be computed from the hydraulic-element relationships for circular sections (for example CPHEEO 2019, Table 5.5). The minimum velocity of Clause 6.7.3 applies at the design flow.

9.3.3 **Pressure flow.** Where a pipe runs full or surcharged, the HGL shall be computed under Chapter 6, Clause 6.8, with friction and structure losses.

9.3.4 **Steep pipes.** Where the design flow in a pipe is supercritical (Froude number above 1), the designer shall:

- (a) locate any hydraulic jump and show that it occurs in a structure designed to contain it, not in a pipe run;
- (b) provide air venting where the jump can seal the pipe; and
- (c) meet the maximum velocity of Clause 6.7.3(b).

9.3.5 **Changes of size and direction.**

- (a) Pipe size shall not decrease downstream.
- (b) Pipes shall join only at manholes or junction chambers, except that inlet connections may join pipes of 1,200 mm or more through a factory-made junction.
- (c) Changes of direction greater than 90° in a single structure are not permitted.

9.3.6 **Flotation.** Pipes and box drains in high groundwater shall be checked for flotation (Chapter 6, Clause 6.7.7).

> **Commentary.** The design n of 0.015 for box drains is set by this Manual to match the "fair" concrete value in Table 6.6. Clauses 9.3.4 and 9.3.5 follow common practice in FHWA HEC-22 and other manuals. A jump inside a pipe run causes pressure surges and can blow off manhole covers.

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## 9.4 Culverts

9.4.1 **Method.** Culverts shall be designed by the methods of FHWA *Hydraulic Design of Highway Culverts*, HDS-5, 3rd edition (2012), or by software that implements them (for example FHWA HY-8). The design headwater is the **greater** of the headwater under inlet control (HWi) and the headwater under outlet control (HWo).

9.4.2 **Inlet control.** HWi shall be computed from the HDS-5 inlet-control equations or nomographs for the barrel shape, material and inlet edge condition actually built.

9.4.3 **Outlet control.** HWo shall be computed as:

$$HW_o = h_o + H - L \cdot S$$

$$H = [1 + k_e + (19.63\, n^2\, L) / R^{1.33}] \cdot V^2 / 2g \quad \text{(SI units, full barrel)}$$

$$h_o = \max(TW, (d_c + D)/2)$$

where $h_o$ is the outlet water depth used for control (m), $H$ is the total head loss through the barrel (m), $L$ is the barrel length (m), $S$ is the barrel slope (m/m), $k_e$ is the entrance loss coefficient (Table 9.1), $n$ is the barrel roughness, $R$ is the hydraulic radius (m), $V$ is the barrel velocity (m/s), $TW$ is the tailwater depth above the outlet invert (m), $d_c$ is the critical depth (m) and $D$ is the barrel rise (m). Part-full barrels under outlet control shall be analysed by backwater calculation as set out in HDS-5.

**Table 9.1 — Entrance loss coefficients $k_e$ (outlet control, full or partly full)**

| Barrel and inlet | $k_e$ |
|---|---|
| Concrete pipe, projecting from fill, socket (groove) end | 0.2 |
| Concrete pipe, projecting from fill, square-cut end | 0.5 |
| Concrete pipe, headwall or headwall with wingwalls, socket end | 0.2 |
| Concrete pipe, headwall or headwall with wingwalls, square edge | 0.5 |
| Concrete pipe, headwall, rounded entrance (radius = D/12) | 0.2 |
| Concrete pipe, mitred to conform to fill slope | 0.7 |
| Concrete pipe, bevelled edges | 0.2 |
| Corrugated metal pipe, projecting from fill | 0.9 |
| RCC box, headwall parallel to embankment, square edge on three sides | 0.5 |
| RCC box, headwall parallel to embankment, three edges rounded or bevelled | 0.2 |
| RCC box, wingwalls at 30°–75° to barrel, square-edged crown | 0.4 |
| RCC box, wingwalls at 10°–25° to barrel, square-edged crown | 0.5 |
| RCC box, wingwalls parallel (extension of sides), square-edged crown | 0.7 |

Source: FHWA HDS-5 (2012), entrance loss coefficient table (Appendix C).

9.4.4 **Tailwater.** TW shall be the higher of:

- (a) the normal or backwater depth in the downstream channel at the design flow; and
- (b) the tailwater level of Clause 9.2.1, for culverts within tidal or river backwater reach.

9.4.5 **Headwater limits.** At the design AEP of Chapter 6, Table 6.1:

- (a) HW/D shall not exceed 1.2;
- (b) the headwater shall be at least 0.3 m below the edge of the road shoulder at the upstream face; and

- (c) the headwater shall not raise water levels at any upstream building or property boundary above the limits of Chapter 6, Clause 6.12.2(d).

9.4.6 **Road overtopping.** Flow over the road in the check and 1% AEP events shall be computed with the broad-crested weir equation:

> Qr = Cd · L · h^1.5

where Qr is the overtopping flow (m³/s), L is the length of the overtopping section (m) and h is the depth of the headwater above the road crest (m). Cd shall be taken from HDS-5 for the road surface and the ratio of h to road width, and shall not exceed 1.66 (SI). The culvert and overtopping flows shall be balanced at a common headwater. The overtopping depths and hazard shall meet Chapter 6, Clause 6.12.

9.4.7 **Outlet velocity.** The outlet velocity at the design AEP and at the 1% AEP shall be computed and the outlet protected under Clause 9.6.

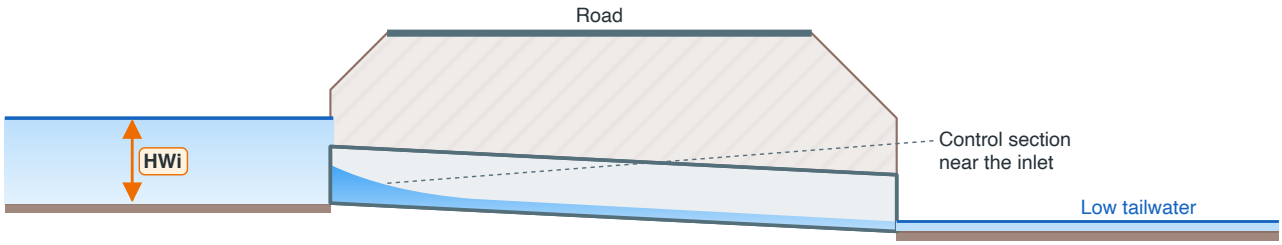
9.4.8 **Barrels and debris.**

- (a) Multi-barrel culverts shall be avoided in debris-prone urban drains. Where they are used, one barrel shall carry the dry-weather flow, and the inlet shall have a debris fin or deflector.
- (b) Culverts shall meet the minimum size and blockage checks of Chapter 6, Clauses 6.12.4 and 6.12.5.
- (c) Culvert inverts shall match the bed of the drain. They shall not be set above the bed, which traps silt and water upstream.

9.4.9 **Headwalls and cut-offs.** Inlets and outlets shall have headwalls, wingwalls and cut-off walls designed to prevent piping and undermining.

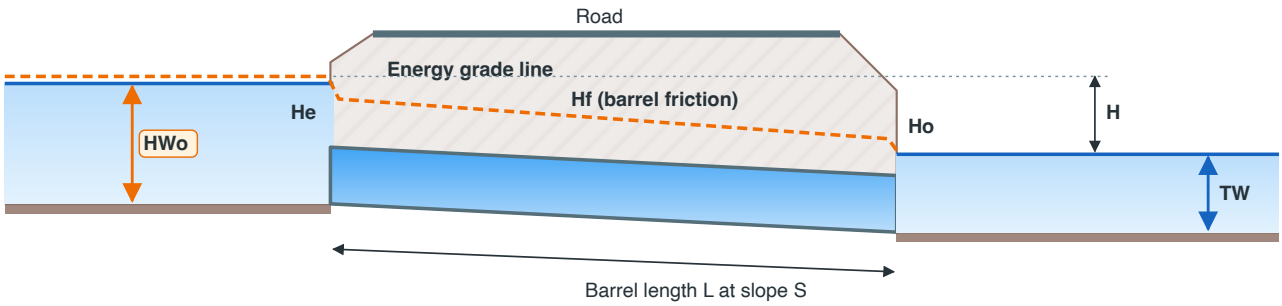
**Culvert hydraulics: inlet control and outlet control (profile, not to scale)**

**(a) Inlet control**




HWi depends only on Q and the inlet (shape, edge, skew); read from the HDS-5 inlet-control nomographs or equations. The barrel flows part full; barrel roughness, length and tailwater do not affect HWi.

**(b) Outlet control**




HWo = ho + H − L·S, with H = He + Hf + Ho and ho = max[TW, (dc + D)/2]. The barrel flows full or part full; roughness, length, slope and tailwater all matter. Design headwater = the greater of HWi and HWo (Clause 9.4).

*Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).*

> **Commentary.** HDS-5 (3rd ed., FHWA-HIF-12-026, April 2012) merged the culvert design material of HEC-5, HEC-10 and HEC-13 and is the current FHWA culvert manual. The outlet-control equation in Clause 9.4.3 is the HDS-5 energy equation in SI units: the friction coefficient 19.63 equals 2g. The ke values in Table 9.1 are reproduced from HDS-5. The weir coefficient cap of 1.66 (SI) is the conversion of the APWA 5600 (2006) limit of C ≤ 3.0 (US units) for overtopping calculations. The headwater limits of Clause 9.4.5 are set by this Manual: HW/D ≤ 1.2 keeps the inlet from operating far into submerged-orifice flow at the design event, where small increases in flow give large increases in headwater. Clause 9.4.8(c) has no direct precedent; it is included because raised culvert inverts are common in Sikkim where a road is rebuilt on top of an old culvert, and they hold standing water and silt upstream.

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## 9.5 Open channels

9.5.1 **Flow computation.** Open channels shall be designed by Manning's equation for uniform flow, with the n of Table 6.6. Water levels shall be computed by gradually varied flow (standard step) analysis where tailwater, bridges, culverts, bends or changes of section affect them, which on the drains of the valley-floor towns, Singtam, Rangpo, Melli, Majitar and Jorethang among them, whose outfalls the Teesta, the Rangit or the Rongni Chu in flood can close, on the drains that reach the hydropower reservoirs and the reaches below their dams, whose receiving levels the releases set, and on the steep drains, trained jhoras, stepped footpaths and streets of Gangtok, Namchi, Gyalshing, Mangan and the other ridge towns, stepped by drop structures and chutes and passing through critical depth at every step, is the normal case.

9.5.2 **Flow regime.** At the design flow, the Froude number shall not exceed 0.8 (CPHEEO 2019, §5.3), unless the channel is designed as a supercritical chute. Flows with a Froude number between 0.8 and 1.2 are not permitted at the design flow in any channel.

9.5.3 **Permissible velocities.** Mean velocity at the design flow shall not exceed the limits of Table 9.2.

**Table 9.2 — Maximum permissible mean velocities in channels**

| Lining or soil | Maximum velocity (m/s) | Source |
|---|---|---|
| Concrete lining | 3.0 | CPHEEO 2019 Table 5.11 |
| Riprap lining | 1.8 | CPHEEO 2019 Table 5.11 |
| Grassed lining | 1.2 | CPHEEO 2019 Table 5.11 |
| Stabilised earthen channel (modified natural channel) | 2.0, or the critical velocity if less | CPHEEO 2019 §5.10.3 |
| Unlined, fine sand | 0.46 | Fortier and Scobey (1926), clear water |
| Unlined, sandy loam | 0.53 | As above |
| Unlined, silt loam | 0.61 | As above |
| Unlined, firm loam | 0.76 | As above |
| Unlined, stiff clay | 1.14 | As above |
| Unlined, fine gravel | 0.76 | As above |
| Unlined, coarse gravel | 1.22 | As above |

Flexible linings (vegetation, riprap, geosynthetics) may instead be designed by the permissible shear stress method of FHWA HEC-15, *Design of Roadside Channels with Flexible Linings*, 3rd edition (2005).

9.5.4 **Longitudinal slope.** In engineered channels, the longitudinal slope shall not exceed 0.4% for natural linings and 0.2% for concrete linings, unless drop structures (Clause 9.6.6) or a chute are provided (CPHEEO 2019, Table 5.11).

9.5.5 **Freeboard and bends.** Freeboard shall meet Chapter 6, Table 6.7, measured above the water level that includes superelevation at bends. Bend radii shall meet Chapter 6, Clause 6.7.10.

9.5.6 **Side slopes.** Unless a structural or geotechnical design supports a steeper slope:

- (a) unlined earth channels shall have side slopes no steeper than 1V:2H; and
- (b) grassed channels that are mown shall have side slopes no steeper than 1V:3H.

9.5.7 **Low-flow channel.** Channels with a bed width of 3 m or more shall have a defined low-flow channel that carries the dry-weather flow at the self-cleansing velocity of Clause 6.7.3.

9.5.8 **Transitions.** Changes of section shall use gradual transitions. Abrupt expansions and contractions are not permitted in supercritical flow.

9.5.9 **Linings in high groundwater.** Lined channels in areas of high groundwater or tidal influence shall have weep holes with filters, or shall be designed to resist uplift with the channel empty.

9.5.10 **Natural channels.** Natural channels shall be preserved where possible (CPHEEO 2019, §5.10.3 note; Chapter 7). Where a natural channel must be modified, its capacity shall meet the design AEP of Chapter 6 and its velocities shall meet Table 9.2.

> Commentary. The lined-channel velocities and slopes are CPHEEO (2019) Table 5.11 values. The unlined-soil values are the classic Fortier and Scobey (1926) permissible velocities for clear water, as reproduced in Chow (1959). They are given for soils common in Sikkim (the thin brown hill soils and colluvium over the phyllites, schists, quartzites and gneisses of the Daling Group and the Higher Himalaya, the boulder and gravel terraces of the Teesta, Rangit and Rongni Chu valley floors, the cut-and-fill ground of the ridge towns, the debris left on the Teesta bed by the flood of October 2023, and moraine and frozen ground in the high valleys of North Sikkim, on which the boulders, gravel and slide debris a flow carries, rather than the soil itself, decide what a channel bed must withstand (this Manual's reading)). The ban on Froude numbers between 0.8 and 1.2 extends CPHEEO's advice to avoid critical flow, where the water surface "becomes unstable and wavy" (§5.3). This extension is made by this Manual. The side slopes and the low-flow channel are also set by this Manual, because many Sikkim urban channels carry sewage-mixed dry-weather flow until the cross-connections of Chapter 8 are removed. A wide flat bed then deposits sludge across its whole width, and a low-flow channel keeps the dry-weather flow concentrated.

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## 9.6 Energy dissipators, outlet protection and drop structures

9.6.1 **When required.** Outlet protection or an energy dissipator shall be provided at every pipe, culvert and channel outlet where the outlet velocity at the design AEP or the 1% AEP exceeds the permissible velocity of the receiving channel in Table 9.2, and at every outlet to an unlined channel, tank or waterbody.

9.6.2 **Method.** Energy dissipators and outlet protection shall be designed by the methods of FHWA HEC-14, *Hydraulic Design of Energy Dissipators for Culverts and Channels*, 3rd edition (2006), selecting the dissipator type by its range of application.

9.6.3 **Riprap aprons.** For a circular outlet discharging to a flat apron, the median riprap size shall be computed with the HEC-14 apron equation:

> D50 = 0.2 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D / TW)

where D50 is the median stone size (m), D is the culvert diameter or rise (m), Q is the design discharge (m³/s), g = 9.81 m/s² and TW is the tailwater depth (m). Where TW is not known, it shall be taken as 0.4D.

Apron length and thickness shall follow the HEC-14 riprap-class table (Table 9.3). The apron width at the outlet shall be at least 3D and shall flare to the downstream channel.

**Table 9.3 — Riprap classes and apron dimensions (HEC-14)**

| Class | D50 (mm) | Apron length | Apron thickness |
|---|---|---|---|
| 1 | 125 | 4D | 3.5 D50 |
| 2 | 150 | 4D | 3.3 D50 |
| 3 | 250 | 5D | 2.4 D50 |
| 4 | 350 | 6D | 2.2 D50 |
| 5 | 500 | 7D | 2.0 D50 |
| 6 | 550 | 8D | 2.0 D50 |

Source: FHWA HEC-14 (2006), §10.2 and Table 10.1, as reproduced in state-agency design worksheets. Where the computed D50 exceeds Class 6, a riprap basin or a structural stilling basin shall be used.

9.6.4 **Riprap filter and grading.** Riprap shall be placed on a granular filter or a geotextile. Stone shall be angular, durable and graded so that the D50 of Clause 9.6.3 is met.

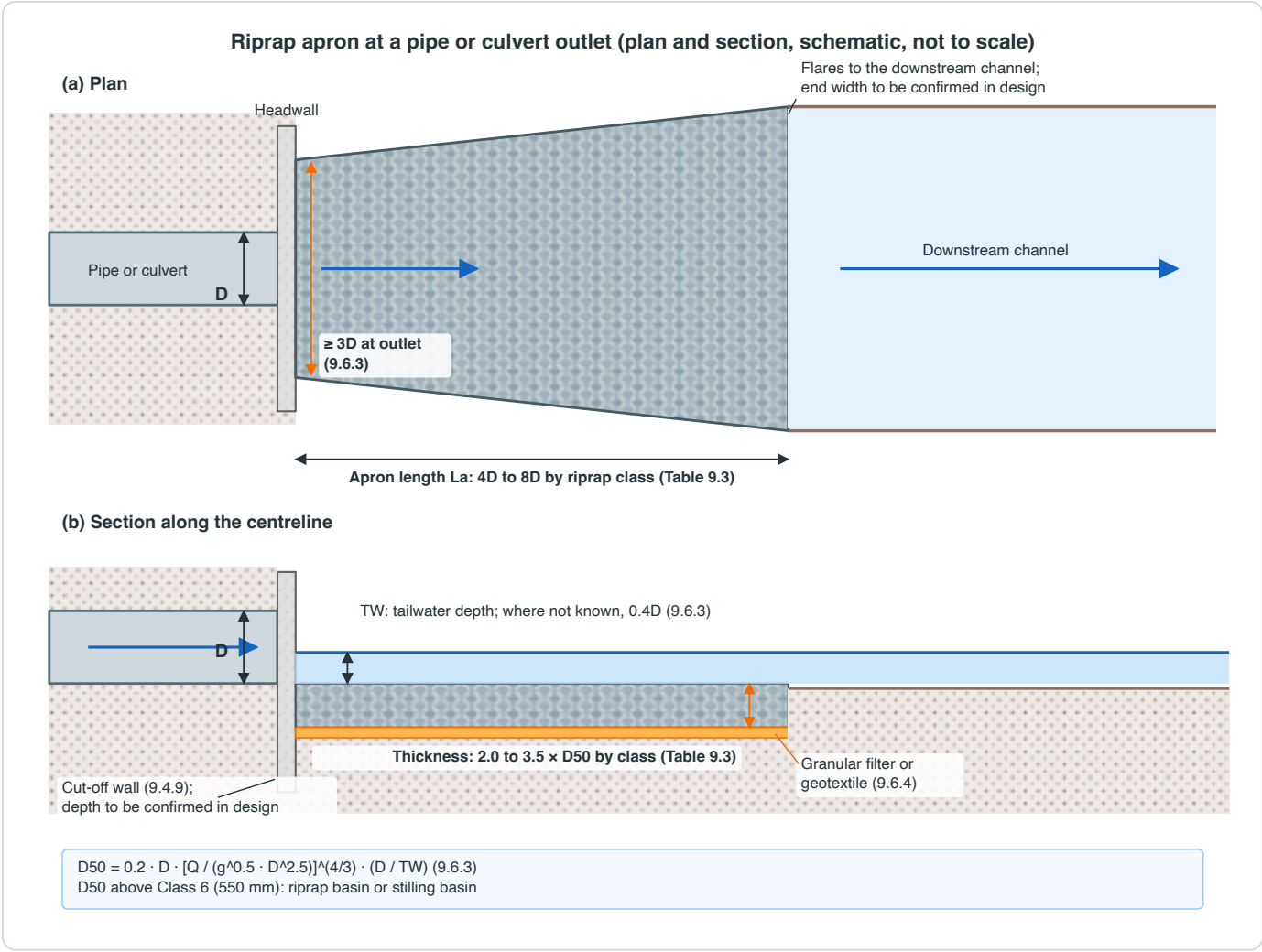


*Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC-14 (3rd ed., 2006), §10.2.*

9.6.5 **Stilling basins.** Where velocities or Froude numbers are above the range of riprap aprons and basins, a structural stilling basin or impact basin shall be designed from HEC-14 or from the US Bureau of Reclamation basin types it describes.

9.6.6 **Drop structures.** Drop structures shall be used where the channel slope would otherwise exceed Clause 9.5.4 or the velocity limit of Table 9.2.

- (a) For a straight vertical drop, the drop number $D = q^2 / (g\,h^3)$ shall be computed, where q is the unit discharge (m²/s) and h is the drop height (m). The pool geometry shall be set from the Rand (1955) relationships: drop length Ld/h = 4.30 D^0.27; pool depth Yp/h = 1.00 D^0.22; sequent depths y1/h = 0.54 D^0.425 and y2/h = 1.66 D^0.27.
- (b) Baffled chutes and stepped drops shall be designed by HEC-14 or US Bureau of Reclamation methods.
- (c) The height of a single vertical drop in a public drain shall not exceed 1.5 m. Drops shall have edge protection under Chapter 6, Clause 6.13.8.

9.6.7 **Coastal and beach outfalls.** Outfalls onto beaches or into estuaries shall be protected against wave action and scour. Where littoral sand can close the outfall, the outfall shall be designed so that it can be reopened by machine, and the drainage system shall be checked with the outfall closed under Chapter 5.

> Commentary. HEC-14 (3rd ed., FHWA-NHI-06-086, July 2006) is the current FHWA energy-dissipator manual. The apron equation and the class table are from HEC-14 §10.2 (Equation 10.4 and Table 10.1). The equation and table are given here as reproduced in secondary design documents (a Tennessee handbook and a state-agency riprap worksheet). The 3D apron width is from the same sources. A Purdue study (JTRP) found the HEC-14 apron method somewhat conservative within its range of application. The Rand (1955) drop relationships are standard and are reproduced in Chow (1959). The 1.5 m limit on a single vertical drop has no direct precedent; this Manual sets it for public safety in urban drains.

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## 9.7 Detention outlet structures

9.7.1 **Primary outlet.** The primary outlet of a detention facility shall:

- (a) produce the release rates and drawdown times of Chapter 4;
- (b) work without mechanical parts or operator action, except in pumped facilities (Clause 9.9);
- (c) have no orifice smaller than **50 mm**, and every orifice shall be protected by a trash screen (Clause 9.8.5); and
- (d) be accessible for cleaning from the surface.

9.7.2 **Orifices.** Orifice flow shall be computed as:

> $Q = C_d \cdot A \cdot (2 g h)^{0.5}$

where $A$ is the orifice area (m²) and $h$ is the head (m) on the centroid of the orifice, or the difference between the upstream and downstream water levels where the orifice is submerged. $C_d$ shall be 0.60 for a sharp-edged orifice in a thin plate. Other edge conditions shall use published tested values.

9.7.3 **Weirs.** Weir flow shall be computed as $Q = C_w \cdot L \cdot H^{1.5}$, with:

- (a) sharp-crested rectangular weirs: $C_w = 1.84$ (SI), with the effective length reduced by 0.1 $H$ for each end contraction;
- (b) V-notch weirs: $Q = 1.38 \cdot \tan(\theta/2) \cdot H^{2.5}$ (SI), where $\theta$ is the notch angle; and
- (c) broad-crested weirs and spillway crests: $C_w = 1.44$ to $1.70$ (SI), selected from published tables for the crest shape and head.

Submerged weirs shall be corrected for submergence from published relationships.

9.7.4 **Stage–discharge rating.** For multi-stage outlets (orifices and weirs in a riser, with an outlet pipe), the designer shall compute, at each stage, the discharge under every possible control (each orifice, each weir, riser crest, and the outlet pipe under inlet and outlet control) and use the **smallest** combined value. The rating shall be tabulated from the outlet invert to the emergency spillway crest plus the design head.

9.7.5 **Tailwater.** Ratings shall be computed with the tailwater of Clause 9.2.1. Where the receiving water can rise above the outlet, the outlet shall have a flap gate or non-return valve under Clause 9.10, and the storage shall meet the outfall-closed check of Chapter 5.

9.7.6 **Emergency spillway.** The emergency spillway shall pass the 1% AEP inflow with the primary outlet assumed blocked and the basin full at the start, with **0.3 m** freeboard to the embankment crest. High-hazard basins shall also be checked for the 0.2% AEP inflow (Chapter 4).

9.7.7 **Outlet pipes through embankments.** Outlet pipes through embankments shall have a filter diaphragm or seepage collars to prevent piping along the pipe, and a flared or headwalled inlet.

9.7.8 **Anti-vortex.** Riser outlets with a design head above the riser crest greater than the riser diameter shall have an anti-vortex plate.

> **Commentary.** The 50 mm minimum orifice with a trash screen, the emergency-spillway criterion and the drawdown times are core criteria of this Manual (Chapter 4). The minimum orifice is smaller than the APWA 5600 (2006, 5608.4) minimum of 3 in (about 75 mm). It allows the low release rates of the Chapter 4 mixed-frequency rule on small sites, and it relies on a good screen (Clause 9.8.5). The "no mechanical parts" rule follows APWA 5600 (2006, 5608.4), which requires the primary outlet to function unattended. The orifice and weir coefficients are standard textbook values (for example Brater and King, *Handbook of Hydraulics*; Chow 1959). The 1.84 sharp-crested coefficient and the 0.1H end-contraction correction are the Francis formula in SI units. The broad-crested range 1.44–1.70 is the SI equivalent of the US range 2.6–3.1 commonly tabulated. Clauses 9.7.7 and 9.7.8 follow common dam and detention practice.

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## 9.8 Trash racks and screens

9.8.1 **Where required.** Trash racks or screens shall be provided:

- (a) where an open drain enters a pipe, covered drain or culvert longer than 30 m (Chapter 6, Clause 6.13.4);
- (b) at every detention outlet orifice (Clause 9.7.1);
- (c) at the inlet of every pump sump (Clause 9.9); and
- (d) at outfalls to waterbodies, as part of the gross pollutant trap of Chapter 8.

9.8.2 **Conduit-entrance racks.** Racks at the entrance to conduits and culverts shall have:

- (a) clear bar spacing not less than 75 mm and not more than half the smallest internal dimension of the conduit;
- (b) a gross area at least 4 times the conduit's cross-sectional area;
- (c) a mean velocity through the rack at the design flow, with 50% of the rack blocked, of not more than 1.0 m/s; and
- (d) an inclination no steeper than 1V:2H where the rack is to be raked by hand, with a working platform and handrail.

9.8.3 **Head loss.** Head loss through a clean rack shall be computed with the Kirschmer equation:

$$h_r = \beta \cdot (t / b)^{4/3} \cdot (V^2 / 2g) \cdot \sin\theta$$

where $t$ is the bar thickness, $b$ is the clear bar spacing, $V$ is the approach velocity, $\theta$ is the angle of the rack from the horizontal, and $\beta$ is the bar shape factor (2.42 for sharp-edged rectangular bars; 1.79 for circular bars). The HGL and headwater shall be checked with the rack **50% blocked** (head loss computed with half the open area).

9.8.4 **Overflow when blocked.** Every rack shall have an overflow route so that a fully blocked rack does not flood buildings or exceed the limits of Chapter 6.

9.8.5 **Detention outlet screens.** Screens over detention orifices shall have openings smaller than the orifice they protect, and an open area at least 10 times the orifice area.

9.8.6 **Pump sump screens.** Bar screens at pump-station inlets shall have a clear spacing smaller than the largest solid the pumps can pass, as stated by the pump manufacturer. Screens shall be built in removable modules, and a mechanically raked screen shall be used where the design inflow exceeds 1 $m^3/s$.

9.8.7 **Safety.** Racks at the entrance to long conduits shall prevent people from being drawn in. They shall be designed for the hydrostatic load of a fully blocked rack.

> Commentary. CPHEEO (2019, §8.3.1.3) describes pump-station bar screens with a spacing of "approximately 58 mm", built in modules, with an emergency overflow in case of clogging. Clause 9.8.6 follows that approach but links the spacing to the pump's solids-passing size, which varies by pump. The 50% blockage check matches the grate clogging factor of Chapter 6. The Kirschmer equation and its shape factors are standard (Kirschmer 1926, as reproduced in hydraulic handbooks). The rack spacing, area ratio, through-velocity, the 30 m conduit length trigger, the 10× screen area for orifices and the 1 m³/s trigger for mechanical raking have no direct precedent and are set by this Manual.

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## 9.9 Pumps and sumps

9.9.1 **When pumping is used.** Pumping shall be used only where gravity drainage cannot meet the requirements of Chapters 5 and 6, for example at road underpasses (Chapter 6, Clause 6.10.5), basements, low-lying areas and outfalls that are tide-locked under the outfall-closed check of Chapter 5.

9.9.2 **Design inflow and storage.** The station shall be designed with the inflow hydrograph routed through the catchment and any upstream storage. Pump capacity and storage shall be chosen together:

- (a) the station shall meet the design AEP of the element it serves (for underpasses, the 2% AEP with a 1% AEP check);
- (b) where the station serves a tidal outfall, storage plus pumps shall hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default: two consecutive high tides of 6 h each), as required by Chapter 5; and
- (c) the pumps shall be selected for the full range of static head between the lowest sump level against the lowest tailwater, and the highest tailwater (HAT plus surge plus 0.3 m).

9.9.3 **Wet-well volume.** The effective wet-well volume (between the pump-stop and the lowest pump-start level) shall be the greatest of:

- (a) where variable-speed drives and automatic controls are installed, 5 minutes of the minimum inflow (CPHEEO 2019, §8.3.3);
- (b) otherwise, 10 to 15 minutes of the peak inflow, or the volume needed for the pump manufacturer's minimum cycle time, from $V = Q \cdot t$ (CPHEEO 2019, Eq. 8.1); and
- (c) for constant-speed pumps, the volume $V = \Theta \cdot q / 4$ for each pump, where $\Theta$ is the minimum cycle time recommended by the motor manufacturer and $q$ is the pump capacity (FHWA HEC-24, 2001).

9.9.4 **Duty and standby.**

- (a) Duty pumps shall be of the same size where practicable (CPHEEO 2019, §8.3.3).
- (b) Standby capacity shall be at least equal to the largest duty pump, and not less than 50% of the number of duty pumps.
- (c) Duty and standby roles shall alternate automatically.

9.9.5 **Pump type.** Pumps shall be solids-handling (non-clog) types suited to stormwater with sand and debris. Axial-flow pumps shall be used only behind a screen that meets Clause 9.8.6, because they cannot handle debris (CPHEEO 2019, §8.3.2).

9.9.6 **Sump and intake design.** Sump geometry, pump spacing, minimum submergence and approach flow conditions shall follow the pump manufacturer's requirements and ANSI/HI 9.8 (Rotodynamic Pumps for Pump Intake Design). A physical hydraulic model study shall be carried out where any pump exceeds 1 m³/s, or where the sump does not follow

standard ANSI/HI 9.8 geometry. The minimum clear space between adjacent pumps or motors is 0.6 m for small and medium units and 1.0 m for large units (CPHEEO 2019, §8.2.5).

9.9.7 **Silt and screens.** A silt trap and a bar screen shall be provided upstream of the wet well (Clause 9.8.6; Chapter 6, Clause 6.13.3).

9.9.8 **Controls and monitoring.**

- (a) Pumps shall be controlled by a primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up.
- (b) High-level and pump-fault alarms shall be sent by telemetry to the local body's control room.
- (c) Sump levels, pump run hours and power status shall be logged and kept for at least 5 years.

9.9.9 **Power supply.**

- (a) The station shall have two independent power sources: the grid supply and a standby generator (or a second independent grid feeder) able to run all duty pumps at once (CPHEEO 2019, §2.4.2.3(j)).
- (b) Fuel for at least **72 hours** of continuous operation of all duty pumps shall be stored on site, above the flood level of Clause 9.9.10.
- (c) Changeover to standby power shall be automatic.

9.9.10 **Flood protection of the station.** The floor of the electrical and control room, the generator and the transformer shall be at least 0.5 m above the 1% AEP flood level at the station (Chapter 6, Clause 6.11). Access to the station for maintenance vehicles shall remain usable in the 1% AEP event.

9.9.11 **Discharge.** Each pump shall have its own rising main, or a non-return valve and an isolating valve where mains combine. Rising mains shall discharge into a delivery chamber or outfall fitted with a flap gate or non-return valve under Clause 9.10. Discharge piping shall be sized by a recognised friction formula (CPHEEO 2019, §8.3.9).

9.9.12 **Emergency connections.** Every station shall have a hard-standing area and a quick-coupling connection for mobile pumps to discharge into the delivery chamber.

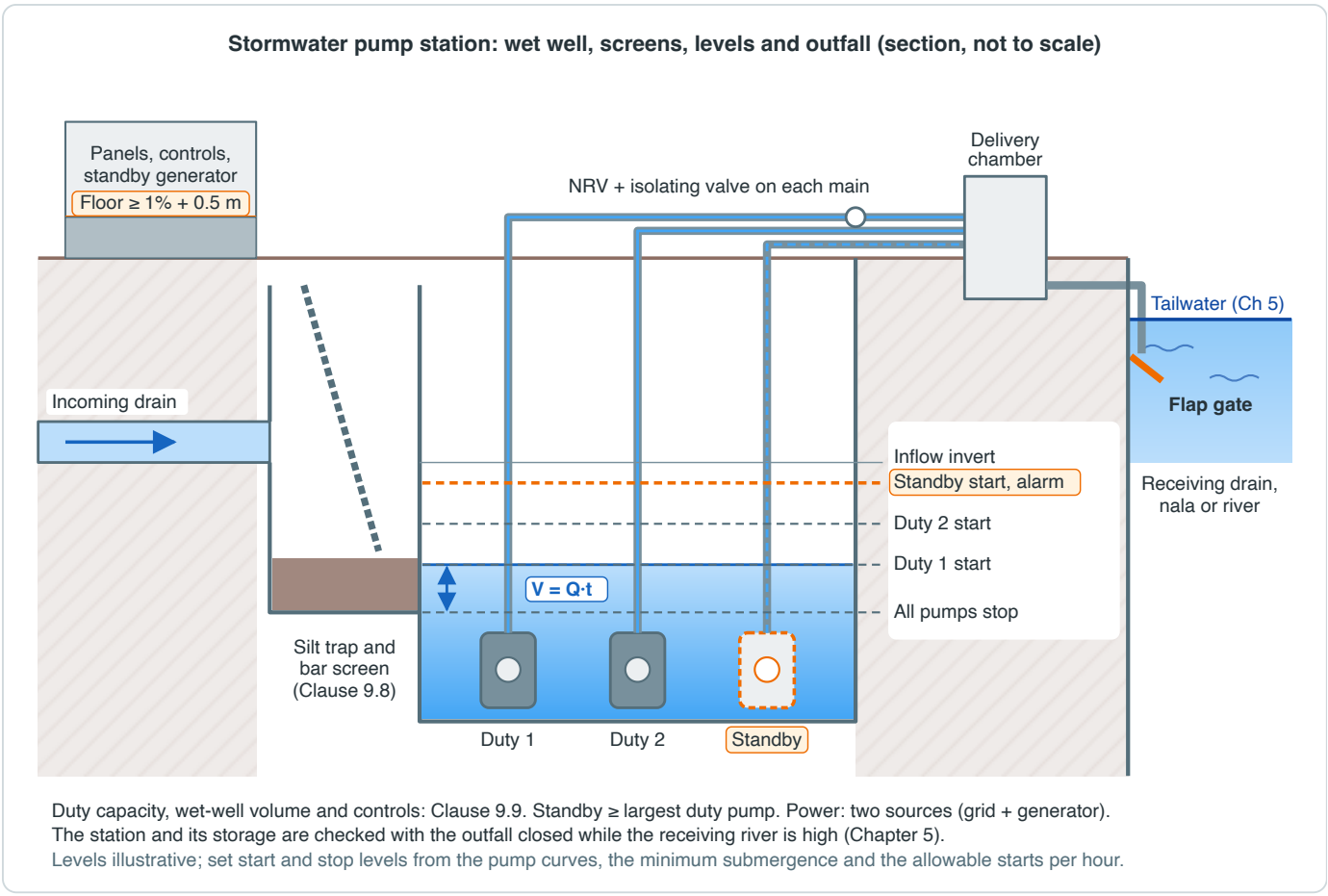


*Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).*

> **Commentary.** CPHEEO (2019) Chapter 8 covers stormwater pumping: wet-well sizing (§8.3.3), pump types (§8.3.2), trash screens (§8.3.1.3), space requirements (§8.2.5) and the need for generator sets "as standby for emergency operation during failure of electricity" (§2.4.2.3). It recommends standby units of "minimum 50% of the duty pump units". Clause 9.9.4(b) is stricter: the standby must at least equal the largest duty pump, so the station still meets its design duty with its largest pump out of service. This stricter rule is set by this Manual. FHWA HEC-24 (*Highway Stormwater Pump Station Design*, FHWA-NHI-01-007, 2001) is the FHWA pump-station manual. The 72 h fuel storage is set by this Manual to match the 72 h design storm of Chapter 2. The model-study trigger, the telemetry and data-retention requirements, and the emergency connection have no direct precedent and are set by this Manual.

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## 9.10 Tide gates, flap gates and non-return valves

9.10.1 **Where required.** Flap gates, tide gates or non-return valves shall be provided on every outfall whose invert is below the 1% AEP still-water level of the receiving water (Chapter 5).

9.10.2 **Types.** Acceptable devices are:

- (a) hinged flap gates (cast iron, ductile iron, stainless steel, HDPE or composite);
- (b) elastomeric in-line or end-of-pipe check valves (duckbill type); and
- (c) penstocks or sluice gates, manual or motorised, as a secondary closure.

9.10.3 **Secondary closure.** Outfalls of 900 mm or more, and every outfall serving a pumped or storage system, shall have a penstock or stop-log slot upstream of the flap gate so that the gate can be maintained, and as a back-up if the gate jams open.

9.10.4 **Hydraulics.** The head loss through the device in the open position shall be taken from the manufacturer's tested data and included in the HGL (Chapter 6, Clause 6.8.7). Flap gates shall open at a small head difference (CPHEEO 2019, §6.3.10.1).

9.10.5 **Sand and debris.** At beach, estuary and creek outfalls where sand or debris can hold a gate open or shut:

- (a) the gate shall be housed in a chamber with surface access, or elastomeric check valves shall be used; and
- (b) the gate shall be inspected after every high-tide or surge event during the monsoon season (Chapter 10).

9.10.6 **Materials.** Hinges, pins, links and fixings shall be of corrosion-resistant material (CPHEEO 2019, §6.3.10.1). In coastal and tidal locations this means stainless steel grade 316, bronze or a non-metallic material (Clause 9.13).

9.10.7 **Storage behind gates.** Where gates close during a storm, the storage or pumping behind them shall meet the outfall-closed check of Chapter 5.

> Commentary. CPHEEO (2019, §6.3.10.1) describes flap gates and flood gates at outfalls to tidal waters. It notes that "adequate storage may be necessary if pumping is to be avoided during the closure of the gate" and that hinge pins and links "should be of corrosion-resistant materials". Sikkim has no coast, so no outfall in the State is closed by the tide, and the beach, estuary, tidal and coastal provisions of Clauses 9.6.7, 9.9.2(b), 9.10.5 and 9.13.6, and the coastal and tidal rows of Table 9.5, do not arise; in Clause 9.9.2(c) the highest tailwater is the highest river, khola, jhora, reservoir or pokhari level of Chapter 5. No pumping station on a storm drain was found anywhere in the State, and most outfalls, those of Gangtok and the other ridge towns among them, fall freely to a steep jhora with no river tailwater (Clause 5.8.5(a)), so pumps and sumps under Clause 9.9 are needed only where the outfall-closed check of Chapter 5 shows that gravity cannot drain a site on valley-floor land: at Singtam, Rangpo and Melli on the Teesta, at Majitar and Jorethang on the Rangit, at Ranipool and Singtam on the Rongni Chu, and at Dikchu and Chungthang and along the riverside below Mangan (Clause 5.8.5(b)). There the flood of 3–4 October 2023 left the Teesta bed "risen by an average of 7-8 meters", "a flattened, more expansive river profile than the typical V-shaped valley", NHPC estimated a rise of about 7.44 m at the Teesta Low Dam IV project, 7.29 m at Low Dam III, 6.00 m at Teesta-V and 2.00 m at Teesta-VI, NH-10 along the river "has become prone to submergence and subsidence", and 155 households at Toong Naga "have been mandated for relocation" (project proposal for GLOF risk mitigation in the Lhonak valley, annexed to the State's affidavit to the National Green Tribunal of 28 February 2026). Gates are required below the 1% still-water level there, because those outfalls end in a river that can rise above them, and the storage or pumps behind them are sized for an outfall closed for not less than 72 hours (Clause 5.8.5(b)), with every invert set above the river bed surveyed after October 2023, since one set from the old bed may now be buried. No CWC site in the State has a published datum, and the levels conflict: at Melli the peak of 4 October 2023 is 225.5 m in one transcription and 228.0 m in a CWC bulletin of 2024 as quoted, against an old high flood level of 225.25 m (as reported), so a gate sill and a pump start level on a valley floor are set from surveyed flood marks on a named datum, with the higher CWC value used only as a check. The outfalls in the reaches of the hydropower dams are checked against the largest recorded release or, until the operator gives one in writing, the spillway capacity (Clause 5.8.5(c)), and no full reservoir level, maximum water level or release rule was found for any of them [TBC]: Teesta-III (1,200 MW) at Chungthang, whose 60 m dam was destroyed in October 2023, is "Under restoration & first phase of wet commissioning is expected by 31st MAY 2026 through coffer dam", with no live storage in that phase (State affidavit, February 2026; its present state is not known [TBC]), and the committee constituted by NDSA is reported to have put the inflow at Teesta-III at about 10,000 m³/s against a spillway capacity of 7,500 m³/s (as reported). These dams are works of NHPC and the other operators, designed to dam-safety standards and not to this chapter, but their reservoir levels and releases are this chapter's boundary conditions. No structure of this chapter is designed to pass a glacial-lake outburst flood, a debris flow or a landslide. At the South Lhonak lake the outflow of 3–4 October 2023 "peaked at $4.85 \times 10^4$ m³ s⁻¹" of water with $1.03 \times 10^4$ m³ s⁻¹ of sediment; at Chungthang the "discharge peaked at 5340 m³

s⁻¹ … within ~6 minutes", with depths of 9 m and velocities of 9 m/s; and Rangpo, about 135 km downstream, was "severely impacted by the debris, burying buildings and automobiles" (Sattar et al., 2025, whose account of the cause, a moraine collapse with modest rain, differs from the State's affidavit of 5 April 2024, which attributed the flood "primarily to a cloudburst"; this Manual takes no side), so on the Teesta trunk, on the Lachen Chu and the Lachung Chu, below any glacial lake, debris-flow fan, slide scar or sinking area, and in the release reach of a dam, the screening of Clause 2.3.6(i) comes first, and a structure is sited out of the hazard, above the flood and aggradation level of October 2023 (Clause 5.8.5(d)). Most of the State drains steeply. The stability zones that set building heights run from slopes of "<15°" in zone 1 through 16–25°, 26–35° and 36–45° to more than 45° in zones 5 and 6 (Mines and Geology Department, Notification No. 17/DMG/20-21, 19 March 2021), and the Sikkim Building Construction Regulations, 1991 bar allotment only on slopes "exceeding or around 70 (Seventy) degree" (reg. 35), far beyond the 0.4% and 0.2% of Clause 9.5.4, so drop structures (Clause 9.6.6), stepped channels, baffled chutes and stilling basins (Clauses 9.6.5 and 9.6.6(b)) and supercritical chutes designed under Clause 9.5.2 are the normal case, not the exception, as IRC:SP:42-2014 (§8.5.1) already asks for lined, stepped or baffled drains on hill roads. In Sikkim the following are set by this Manual, as in the mountain editions of this series, for a structure on a drain whose catchment includes an undeveloped hill slope, a cut slope, a jhora or a khola: (a) a drop, chute or stepped channel shall end in an energy dissipator and discharge to a lined drain, a trained jhora or a stable natural channel, never onto an unprotected slope, a fill or a cut face; every pool of a stepped channel shall be shaped to drain dry and be reachable for cleaning; and no single vertical drop shall exceed the 1.5 m of Clause 9.6.6(c); (b) where such a drain enters a pipe, covered drain or culvert, at the catchment size and with the sediment bulking and blockage factors that Chapter 6 sets (Clause 6.3.6(f)–(h)), a debris rack, inclined so that the flow lifts debris onto it, shall stand upstream of the inlet, with a clear bar spacing chosen from a survey of the boulders and the garbage in the bed and not less than that of Clause 9.8.2(a), and a debris basin or sediment trap upstream of the rack; the basin volume shall be estimated from the debris and spoil deposited at the site in past floods and a stated debris-yield method, counting every slide scar, road cut, spoil dump and garbage dump in the catchment as a source, because no Indian or Sikkim guidance on sizing debris basins was found [TBC]; its spillway shall pass the 1% AEP inflow with the basin full of debris, as for Clause 9.7.6, and it shall have a ramp for the machines that empty it; (c) a culvert on a jhora shall have a single barrel where possible (Clause 9.4.8(a)), an armoured headwall and apron at the inlet with a deflector against boulders, an invert that follows the bed (Clause 9.4.8(c)), and an outlet protected under Clause 9.6 and led to a stable natural channel, never onto an unprotected slope, and it shall also pass the 72-hour storm of Clause 2.3.6(e), because the State's slides follow days of rain; (d) the drop structures and check dams of a trained jhora (Clause 6.3.6(m)) shall each have an energy dissipator below the fall, bed and toe protection against scour to below the depth of scour, a crest notched to keep the low flow in the middle of the channel and a maintenance access, and shall not reduce the jhora's 1% AEP capacity; no open jhora shall be culverted and none diverted without a corridor (Chapter 7); this is the structural content of the training that the zones of 2021 require "done properly (with safe distance)"; (e) every retaining wall that holds back a slope or a fill shall have weep holes and a subsurface drain behind it, with a filter against the fines of the backfill, discharging to a lined drain or a trained jhora and never onto the slope below, inspected and cleared by 31 March each year (Chapter 10), and groundwater met in an excavation shall be led away in lined drains, as the geotechnical advice in Gangtok put it, by "multiple drains connecting to nearby Jhoras" (reply affidavit of Gangtok Smart City Development Ltd (GSCDL) in O.A. No. 38 of 2022 before the National Green Tribunal); (f) every lined drain that receives runoff from unpaved slopes, hill roads or building sites shall have a sediment trap before it joins a public drain, a jhora or a pokhari, and every drain outfall to a jhora that feeds a dhara (धारा; a spring or spring spout), a pokhari or a drinking-water intake, and to the Rani Khola, the Roro Chu, the Rongni Chu and the Teesta within a town, a screen and the interception of dry-weather flow (Clause 6.3.6(e); Chapter 8, Clause 8.9); and (g) a lining in a steep drain shall be designed for the abrasion of the gravel and boulders it carries as well as for the velocity of Table 9.2. In sub-area SK-C, and at any site above about 2,500 m, every inlet shall have a side or kerb opening as well as a grating, so that it still takes water when snow or ice lies on the grating, every culvert, drain and debris rack shall be reachable for clearing after snowfall (Chapter 10 has them cleared of snow and ice after every snowfall from December to March), frozen or snow-covered ground is taken as hydrologic soil group D, and rain on snow is screened under Clause 2.3.6(i) (set by this Manual; no snow-day statistics or snow lines by valley were found [TBC]). On hill ground no structure of this chapter shall be built to exfiltrate: no soakaway, soak pit for storm water, exfiltrating chamber, perforated pipe or open-jointed drain on natural ground sloping more

than 10°, on colluvium, fill or slide debris, in stability zones 3 to 6, in an area that is sinking, landslide prone or has scars of old landslides (reg. 35), or upslope of a cut slope or retaining wall within twice its height, unless a geotechnical certificate allows it, and in stability zones 4 to 6 not at all (Clause 4.11, hill rule); pipes, chambers and channels there are watertight, because the zones of 2021 record the ground water of zones 3 to 6 as "Wet", "Dripping" and "Flowing", and GSCDL's affidavit says that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora". The need is shown by the record. The stability zones already grade a site by its jhora: zone 1 where "Training of jhoras/drains have been completed and done properly (with safe distance)", zone 2 where "Training jhora/drain was done but not properly maintained", zone 3 where "Jhora training is required/annual maintenance of drain is necessary", and zone 4 at an "Untrained jhora/ erosional potential jhora", with "Gully erosion & collapse of jhora facing slope" (the same notification). The regulations forbid dumping spoil on "drains, gullies and jhoras" (reg. 22), and the Gangtok Municipal Corporation (GMC) pays its waste agency for the "Clearing of Jhoras" (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024). GSCDL has tendered "Construction of drainage and jhora training works" for about ₹13.41 crore (as reported), while the drainage and landslip protection works of Gangtok's City Development Plan of 2006 "were not taken up" (CAG, Report No. 3 of 2016). The Gangtok landslides of June 1997, in a month of 1,281.3 mm with 223.8 mm on 9 June (IMD), are given by a single unofficial source as 38 deaths (as reported). The roads show the same failures: the High Court warned IRCON to correct the damage it had done to the drainage of NH-10 (June 2025), the Teesta submerged NH-10 in July 2025, the rain and slides of 12–13 June 2024 in Mangan district brought down the Sangkalang bridge, and a slide hit the army camp at Chaten near Lachen at about 19:00 on 1 June 2025, with 3 dead and 6 missing (all as reported), so a road drain or culvert of the Roads and Bridges Department (PWD), NHIDCL or BRO never discharges onto an unprotected slope (Clause 6.3.6(k)). Screens matter as much as gates, because the drains also carry sewage: the State's towns generate an estimated 29.51 MLD, against 15.22 MLD treated at Gangtok's plants, and outside Gangtok's network sewage is treated "through anaerobic digestion in the septic tanks of individual households" (monthly progress report of September 2025, annexed to the State's affidavit to the National Green Tribunal of 19 December 2025); the Tribunal recorded that "treated sewage is entering in to river/ rivulets/ jhoras and this is not permissible under the Water Act" (O.A. No. 606 of 2018, order of 4 July 2024, as quoted by the State), while the State replied that "No sewage is disposed off in the rivers or fast flowing water bodies"; and at Soreng septic effluent discharges "into open surface drains" (ADB, due-diligence report, December 2024). So a rack on a jhora below a settlement is checked in the blocked case of Clause 9.8.4. No inventory of the flap gates, debris racks, debris basins, sediment traps, check dams and pumping stations on the drains and jhoras of any Sikkim town, with their capacities and operating rules, no operating rule for the gates of any dam in the State linked to the reaches below it, and no design river, reservoir, pokhari, khola or jhora level at any outfall was found in the public domain. Clauses 9.10.3 and 9.10.5 are set by this Manual because a flap gate or penstock that fails, or is jammed open by silt, gravel, boulders, slide debris, construction spoil, garbage or woody debris, lets a river in flood back into the drain network of a valley floor, and one jammed shut blocks it. The jhoras and drains of Sikkim carry boulders, slide debris, spoil and garbage as well as silt: the Sikkim Building Construction Regulations, 1991 forbid dumping spoil on "drains, gullies and jhoras", with a fine of ₹500 at least (reg. 22), and hold a security of ₹5,000 against spoil and damage to the drainage (Form III, cl. 15); the GMC makes its waste agency responsible for the "Clearing of Jhoras" and bars dumping "along Footpath, Roadside and Jhoras" (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024); the flood of October 2023 left Rangpo "severely impacted by the debris, burying buildings and automobiles" (Sattar et al., 2025); and outside Gangtok's partial sewer network the drains carry septic effluent and sullage (Chapter 8, Clause 8.9), so a gate, its screen and the debris rack above it are exposed to the same load and must be kept clear together; and because no release rule, warning rule or reservoir level was found for any hydropower dam in the State [TBC], and the High Court closed its case on a release from the Dikchu project in 2017, reported to have come without warning, only with a direction that the projects "shall ensure strict compliance of the safety guidelines" (WP(PIL) 4/2017, 1 March 2021), a gate on an outfall to a reservoir or to a reach below a dam must be taken as exposed for the whole of a flood.

## 9.11 Inlets and gratings

9.11.1 **Hydraulics.** Inlet capacity, spacing and clogging shall follow Chapter 6, Clause 6.6.

9.11.2 **Load class.** Gratings, covers and frames shall be rated for the traffic at their location. Load classes shall be those of IS 1726 (cast iron manhole covers and frames) or EN 124 (gully tops and manhole tops), at least:

- (a) carriageways and medians: EN 124 class D400 or the equivalent heavy-duty IS class;
- (b) kerb-side channel inlets within 0.5 m of the kerb: class C250 or equivalent; and
- (c) footpaths and cycle tracks: class B125 or equivalent.

9.11.3 **Grate pattern.**

- (a) Grates in carriageways, cycle tracks and footpaths shall not have openings parallel to the direction of travel wider than 25 mm.
- (b) Grate types without tested capacity data shall be rated by the weir and orifice methods of FHWA HEC-22 (2024), with the clogging factors of Chapter 6.

9.11.4 **Kerb openings.** Kerb-opening inlets shall have a clear opening height of at least 100 mm and a length of at least 1.0 m. Where a kerb inlet discharges through the wall of a covered drain (Chapter 6, Clause 6.13.1), the opening shall be at road level.

9.11.5 **Security.** Gratings and covers on public land shall be hinged or locked to their frames, so that they cannot be removed without a tool.

9.11.6 **Inlet chambers.** Inlet chambers shall have the silt sump of Chapter 6, Clause 6.6.7, and shall be sized so that the sump can be emptied by a suction or grab machine.

> Commentary. NDMA (2010, §4.13) cites IS 5961 for cast-iron gratings for drainage inlets. The load classes are based on the EN 124 classes used internationally. The 25 mm limit on parallel openings is set for cyclist and pedestrian safety. APWA 5600 (2006, 5604.2) requires kerb openings of at least 4 ft (about 1.2 m) long and 6 in (about 150 mm) clear height. Clause 9.11.4 sets smaller minimums suited to the narrower roads and lower kerbs common in Sikkim towns.

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## 9.12 Manholes, junction chambers and access

9.12.1 **Location and spacing.** Manholes shall be provided at the locations and spacings of Chapter 6, Clause 6.7.11 and Table 6.8. Where pipes are too large for a standard manhole, a junction chamber with a riser to the surface shall be used (CPHEEO 2019, §11.3.7.3).

9.12.2 **Minimum internal size.** Manholes shall have at least the internal dimensions of Table 9.4 (CPHEEO 2019, §11.3.7.6):

**Table 9.4 — Minimum internal size of manholes**

| Shape and depth | Minimum internal size |
|---|---|
| Rectangular, depth below 0.9 m | 900 mm × 800 mm |
| Rectangular, depth 0.9–2.5 m | 1,200 mm × 900 mm |
| Circular, depth above 0.9 m and up to 1.65 m | 900 mm diameter |

| Shape and depth | Minimum internal size |
|---|---|
| Circular, depth above 1.65 m and up to 2.30 m | 1,200 mm diameter |
| Circular, depth above 2.30 m and up to 6.0 m | 1,500 mm diameter |
| Circular, depth above 6.0 m and up to 9.0 m | 1,800 mm diameter |

The manhole shall also be large enough to fit the largest pipe connected plus the benching on each side.

9.12.3 **Access openings.** The clear access opening of manholes and access chambers on public drains shall be at least 600 mm, so that cleaning equipment can be lowered.

9.12.4 **Drops.** Where the difference between incoming and outgoing inverts exceeds 0.6 m, a drop connection shall be provided. Below 0.6 m, the difference shall be taken up by adjusting the slope of the incoming pipe or the benching (CPHEEO 2019, §11.3.7.5). The invert drop across a manhole where pipe size changes shall be at least the following fraction of the difference in diameters (CPHEEO 2019, Table 11.6):

- conduits below 400 mm: one-half;
- 400 mm to 900 mm: two-thirds;
- above 900 mm: four-fifths.

9.12.5 **Benching.** Manhole floors shall be benched to at least the crown of the outgoing pipe, with channels shaped to guide flow from each incoming pipe.

9.12.6 **Surcharge.** Manholes on mains where the 1% AEP HGL can rise above the cover (Chapter 6, Clause 6.8.4) shall have bolted, locked or hinged covers designed for that pressure.

9.12.7 **Mechanical cleaning.** Manholes, chambers and covered drains shall be designed for cleaning by machine (suction, jetting, grab or robotic equipment) from the surface. Fixed ladders shall be of corrosion-resistant, encapsulated material where provided.

> **Commentary.** The size and drop requirements are from CPHEEO (2019) Chapter 11. The 600 mm access opening, the benching rule and the bolted covers are set by this Manual. Designing for mechanical cleaning supports the prohibition on hazardous manual cleaning under *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.

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## 9.13 Materials and durability

9.13.1 **Exposure classes.** Concrete structures shall be designed for the exposure class of IS 456: 2000, Table 3. In Sikkim the minimum classes of Table 9.5 apply unless a site investigation shows a more severe condition:

**Table 9.5 — Minimum IS 456 exposure classes for Sikkim locations**

| Location | Minimum IS 456 exposure class |
|---|---|
| Inland drains and structures | Moderate |
| Drains and structures in the coastal environment, and any drain that carries or may carry sewage-mixed flow | Severe |
| Structures exposed to sea-water spray, or in contact with saline or aggressive groundwater | Very severe |
| Structures in the tidal zone | Extreme |

9.13.2 **Concrete.** Minimum concrete grade, maximum water–cement ratio, minimum cement content and nominal cover to reinforcement shall be those of IS 456 for the exposure class. For the reader's convenience, IS 456 sets the minimum reinforced-concrete grades as M25 (moderate), M30 (severe), M35 (very severe) and M40 (extreme), and the nominal covers as 30, 45, 50 and 75 mm respectively.

9.13.3 **Aggressive ground.** Groundwater and soil at every structure in coastal and delta areas shall be tested for chlorides and sulphates. Cement type and concrete mix shall be chosen to suit the results under IS 456.

9.13.4 **Sewage-mixed flow.** Pipes and covered drains that carry, or may carry, sewage-mixed flow shall be protected against sulphide (crown) corrosion, by a sacrificial concrete thickness, a corrosion-resistant lining or a non-concrete pipe material.

9.13.5 **Pipes.** Concrete pipes shall comply with IS 458, with the class selected by structural design. Other pipe materials (for example ductile iron, HDPE or structured-wall plastic pipes) shall comply with the applicable Indian Standard and be approved by the approving authority.

9.13.6 **Metalwork.** Within 5 km of the coast, and in all tidal and saline locations:

- (a) fixings, hinges, ladders, handrails and screen frames shall be stainless steel grade 316, or hot-dip galvanised steel with a protective coating, or a non-metallic material; and
- (b) dissimilar metals shall be isolated from each other.

9.13.7 **Masonry.** New public drains in Tier A bodies shall be in reinforced or plain concrete. Brick or stone masonry may be used for drains in Tier B bodies only if it is plastered on the wetted face and meets the n value of Table 6.6.

> Commentary. The IS 456 exposure classes and the grade and cover values are quoted from IS 456: 2000 (Tables 3, 5 and 16) for convenience. The standard governs, and designers shall use its current amendment. Assigning Sikkim locations to exposure classes, the sulphide-corrosion requirement and the ban on new masonry drains in Tier A bodies have no direct precedent and are set by this Manual. Drains that receive sewage cross-connections (a common condition, Chapter 8) generate hydrogen sulphide, which attacks unprotected concrete above the water line.

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## 9.14 Submittal requirements

Every structure design shall be submitted with a **Hydraulic Structures Report** (Form 9-1) containing, as applicable:

1. culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check;
2. channel water-surface profiles, velocities, Froude numbers and freeboard;
3. outlet protection and dissipator design, with riprap sizing;
4. detention outlet stage–discharge tables and the emergency spillway check;
5. screen and rack design with the 50% blocked check;
6. a pump station design report: inflow hydrograph, storage, pump curves and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check;
7. gate and valve selection with head-loss data;
8. inlet, grate and cover load classes; and
9. an exposure class and materials statement (Clause 9.13).

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## References (chapter)


- Federal Highway Administration (2012). *Hydraulic Design of Highway Culverts*, Hydraulic Design Series No. 5, 3rd edition, FHWA-HIF-12-026.
- Federal Highway Administration (2006). *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14, 3rd edition, FHWA-NHI-06-086.
- Federal Highway Administration (2005). *Design of Roadside Channels with Flexible Linings*, Hydraulic Engineering Circular No. 15, 3rd edition, FHWA-IF-05-114.
- Federal Highway Administration (2024). *Urban Drainage Design Manual*, Hydraulic Engineering Circular No. 22, 4th edition, FHWA-HIF-24-006.
- Federal Highway Administration (2001). *Highway Stormwater Pump Station Design*, Hydraulic Engineering Circular No. 24, FHWA-NHI-01-007.
- FHWA Hydraulics Engineering publications listing. https://www.fhwa.dot.gov/Engineering/hydraulics/library_listing.cfm
- MoHUA / CPHEEO (2019). *Manual on Storm Water Drainage Systems*, Volume I, Part A: Engineering Design. §2.4.2.3, §5.3, Tables 5.5, 5.11, 5.12, §6.3.10.1, Chapter 8, Chapter 11. https://www.mohua.gov.in/static/uploads/2025/10/8a2456c722036d78c72a698898ef846d.pdf
- Kansas City Metro Chapter APWA (2006). *Section 5600 Storm Drainage Systems and Facilities* (5604.2, 5608.4); and Version 2025.01 (Dec 2025).
- Bureau of Indian Standards. IS 456: 2000, *Plain and Reinforced Concrete — Code of Practice* (Tables 3, 5 and 16).
- Bureau of Indian Standards. IS 458, *Precast Concrete Pipes (with and without Reinforcement) — Specification* (current revision).
- Bureau of Indian Standards. IS 1726, *Cast Iron Manhole Covers and Frames*; IS 5961, *Cast Iron Gratings for Drainage Purposes*; IS 12592, *Precast Concrete Manhole Covers and Frames* (current revisions).
- European Committee for Standardization. EN 124, *Gully tops and manhole tops for vehicular and pedestrian areas*.
- Hydraulic Institute. ANSI/HI 9.8, *Rotodynamic Pumps for Pump Intake Design* (current edition).
- Indian Roads Congress. IRC:SP:13, *Guidelines for the Design of Small Bridges and Culverts* (current revision).
- Chow, V.T. (1959). *Open-Channel Hydraulics*. McGraw-Hill. (Fortier and Scobey 1926 permissible velocities; Rand 1955 drop relationships.)
- Fortier, S. and Scobey, F.C. (1926). Permissible canal velocities. *Transactions of the ASCE* 89.
- Rand, W. (1955). Flow geometry at straight drop spillways. *Proceedings of the ASCE* 81.
- Brater, E.F. and King, H.W. *Handbook of Hydraulics*. McGraw-Hill.
- Tennessee Department of Environment and Conservation (2026). *Erosion Prevention and Sediment Control Handbook*, §4.3.6 Riprap Apron (reproduces the HEC-14 apron equation and table). https://www.tn.gov/content/dam/tn/environment/water/stormwater/epsc-handbook/dwr-npdes-sop-g-16-erosion-prevention-sediment-control-handbook-01092026-4.3.6%20-riprap-apron.pdf
- Purdue University Joint Transportation Research Program. Study of riprap apron design at culvert outlets. https://docs.lib.purdue.edu/jtrp/1704
- CIRIA (2019). *Culvert, screen and outfall manual*, C786. London: CIRIA.
- National Disaster Management Authority (2010). *National Guidelines: Management of Urban Flooding*, §4.13.
- Government of India. *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.


## Annexes and forms

| Annex / Form | Content |
|---|---|
| 9A | HDS-5 inlet-control coefficients and worked culvert example in SI units |
| 9B | Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers |
| 9C | Pump station design checklist and standard control philosophy |

| Annex / Form | Content |
| --- | --- |
| Form 9-1 | Hydraulic Structures Report checklist |

CHAPTER 10

# Submittals, Review, Operation & Maintenance and Enforcement

## 10.1 Purpose and scope

10.1.1 This chapter sets out how compliance with this Manual is shown, checked, built, kept working and enforced. It covers:

- (a) the submittal stages and their contents (Clauses 10.3–10.4);
- (b) the compliance calculator (Clause 10.5);
- (c) professional certification and review (Clauses 10.6–10.7);
- (d) construction inspection and as-built certification (Clauses 10.8–10.9);
- (e) maintenance declarations, O&M plans, inspection and access (Clauses 10.10–10.13);
- (f) handover of public assets (Clause 10.14);
- (g) enforcement (Clause 10.15); and
- (h) monitoring, post-event review and data publication (Clauses 10.16–10.17).

10.1.2 This chapter applies to every development and public work to which Chapters 4 and 5 apply under Clause 1.5.2. Clauses 10.3.1 (Stage 0), 10.15 and 10.17 also apply to development that is subject only to Clause 1.5.4.

> Commentary. A criterion that is not checked at approval, built as approved, and maintained afterwards has no effect. In Sikkim the failure is one of missing criteria, of one old building rule whose drainage clauses carry no numbers, and of land that no building rule reaches. No document of the Urban Development Department (UDD; the Urban Development and Housing Department, UD&HD, until about 2020), the Gangtok Municipal Corporation (GMC), any other urban local body, Gangtok Smart City Development Ltd (GSCDL), the Water Resources Department (WRD) or the Roads and Bridges Department (PWD) stating a design return period, intensity, runoff coefficient or drain standard for the storm drains of any town, or a standard for training a jhora (झोरा; a natural watercourse or ravine stream), was found. The building rule is the Sikkim Building Construction Regulations, 1991 (UD&HD Notification No. 29(202)UD&HD/90/295, 19 March 1991, made under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985), as amended in 2000 and 2001 (No. GOS/UD&HD/6(294)2001, 16 October 2001); a Sikkim Building Construction (Amendment) Regulation, 2022 is reported to have been published on 12 April 2023 (as reported), was not read, and may change what follows [TBC]. The regulations "extend to all the notified areas in Sikkim" (reg. 1(2)), and the 1985 Act requires prior permission for any construction in a notified area (s.7(1)); the list of notified areas was not found [TBC], and land outside them has no building permission under the regulations. Inside Gangtok, building-plan approval passed from UD&HD to the GMC's Town Planning Cell in 2017, still under the 1991 Regulations (GMC's counter-affidavit in O.A. No. 5 of 2022 before the National Green Tribunal; the transfer notification was not seen [TBC]); how approval is shared between UDD and the other urban local bodies, seven or nine of them as the sources differ, was not found [TBC]. The regulations already contain the steps a drainage submittal needs, and this chapter hooks into them. The application goes in Forms I and II (reg. 4), with a site plan showing the "position of sewer line, water main pipe line, electricity line" (reg. 5(f)) and a blue-print plan showing the "drainage including connection to main outlet and the slopes of the roof" and the "sanitary/plumbing layout … drainage system … sewerage disposal system/septic tank and soak pit" (reg. 6): the drainage sheets of Stages 1 and 2 go with them.

The decision is given in Form III or IV within 120 days of the application (reg. 9(i)), which is the overall time limit within which the review periods of Clause 10.7 run (Clause 10.7.6). The Construction Order is "the permission to start the building after approval of Blue Print Plan and demarcation" (reg. 3(1)(g)), and the State's notices stop Construction Orders and earth excavation in each monsoon (6 May to 30 September in 2019; 1 June to 30 September in 2020), so the earthworks of Stage 3, and the drainage that protects them, must be programmed outside the ban. Form III holds a refundable security of ₹5,000 "to meet the expenses for lifting of building materials/spoils … dumped at road side including drain … and also effect repair to damages to the road including drainage system" (cl. 15), which Clause 10.15.4 extends to the works of this Manual. No occupation certificate may be issued "if the drain has not been provided to main outlet/jhora or if the septic tank/soak pit has not been properly built/connected/ventilated" (reg. 13(iii)): the as-built certificate of Stage 4 is the measured form of that test. Height is set by the stability zone of the site (reg. 17(i)), and the Mines and Geology Department's zones of 2021 (Notification No. 17/DMG/20-21, 19 March 2021) are reviewed on conditions that include "Training of untrained Jhora and maintenance at regular intervals which is located adjacent to the plot" and "Proper channelization of surface runoff by providing catchment drains especially during the rainy seasons and connect it to natural waterways/Jhora", so the jhora training of Clause 6.3.6(m) and the catchment drains of this Manual are what a zone review checks. The Government may relax any provision for a building of the Government or a registered organisation (reg. 39, 2001), and has done so on "the merit of the case to engineered structures", as for the GSCDL car park at Gangtok, approved for "a 4+7 storeys building subject to confirmation of a Geotechnical investigation and Report" (GMC's counter-affidavit); a relaxation in a stability zone of 3 or more travels with the geotechnical certificate of Clause 4.11. The Sikkim Municipalities Act, 2007 sets up a second route, a permit system run by the Municipality (Chapter XXXII: "No person shall undertake any building activity without obtaining" a permit, s.271), with Advocates, Architects, Construction Engineers and Structural Engineers on Record registered "in the books of the Municipality" in a manner to be prescribed (ss.266–267) and rules that may cover "infrastructure in relation to building activity" (s.287); no rules under it were found, and whether any Municipality applies it in place of the 1991 Regulations is not clear [TBC], so where it is applied the same drainage sheets go with the permit. Where a drain or outfall serves a sewage treatment plant or carries effluent, the consent of the Sikkim State Pollution Control Board (SSPCB) is needed, as for the plant at Tathangchen (consent-to-operate application 548294, 20 September 2025). The regulations ask for a plinth drain "leading to the road side drain or to adjoining permanent drains or jhora" (reg. 25(iv)) and roof gutters and down pipes of a "design and capacity that the water will neither spill out of them nor leak through them" (reg. 21), but none asks for a drainage report, limits peak runoff, requires on-site detention or rainwater harvesting, sets a design storm or draws a line from a jhora, a khola (खोला; a river or large stream), a dhara (धारा; a spring or spring spout) or a pokhari (पोखरी; pond, lake or tank). Two fields of the forms read differently here. The "SBCR 1991 registration number" of Form 10-3, the "SBCR 1991 registration" of Clause 10.6.1's commentary and the registration "under the Sikkim Building Construction Regulations, 1991" in the model criteria of Annex 10E refer to a register the regulations do not set up: the 1991 Regulations, as read, register no professionals, and the only register found is the Municipality's register of persons on record under the Municipalities Act (ss.266–287), with no rules made [TBC], so the registration or licence under which the Authority accepts the signatory (the Council of Architecture for an architect, or the Municipality's register where one is kept) is entered there. And the "survey numbers, village, sub-division, district" of Form 10-6 are entered as the land records of the Land Revenue and Disaster Management Department give them, in which the unit that the form calls a village is the revenue block (this Manual's reading [TBC]). Land is the last hook. A jhora on public land other than forest land within a municipal area already vests in the Municipality, which "shall protect any jhora, whether on a public land or on a private land" (Municipalities Act, s.172), and the river bank of a scheduled river is under the Forest Department "as if it were a forest" (Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, s.29(9)); private land that a drain, corridor, storage or outfall needs is secured by agreement with the owner or by donation, or reserved in a development plan once the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced) is brought into force, and never taken by this Manual. On land outside every notified and municipal area this chapter is guidance, except for public works and for any body that applies the Manual. Every stormwater item in this chapter is therefore written so that the architect or engineer who signs the plans can certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the competent authority for the area (the GMC in Gangtok; UDD or the urban local body that approves plans in another notified area [TBC]; the Forest Department for the river bank

of a scheduled river; the department or agency that executes a public work) can check it with the site plan and blue-print plan of regs. 5 and 6, in the time of reg. 9(i), against the stability zone of the site, and at the occupation certificate of reg. 13(iii). This chapter is the process.

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## 10.2 Definitions

| Term | Meaning in this chapter |
|---|---|
| Submittal | A set of documents lodged with the Authority at one of the stages of Clause 10.3. |
| Drainage report | The preliminary (Stage 1) or final (Stage 2) report required by Clause 10.4. |
| Stormwater facility | Any retention, detention, water quality, conveyance, pumping, gate or outfall element required by this Manual, public or private. |
| Hold point | A construction stage at which work shall not proceed until the Authority or the certifying professional has inspected it (Clause 10.8). |
| As-built certificate | The certificate of Clause 10.9 that the facility was built as approved and performs as designed. |
| Owner | The person or body responsible for a facility under its maintenance declaration, or the ULB for a handed-over asset. |
| O&M plan | The operation and maintenance plan of Clause 10.11. |
| Facility register | The public register of facilities of Clause 10.17. |

Other terms are defined in Clause 1.4.

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## 10.3 Submittal stages

10.3.1 Submittals shall be made in the following stages, linked to the approval steps of the Sikkim Building Construction Regulations, 1991 (Table 10.1):

**Table 10.1 — Submittal stages and linked approvals**

| Stage | Submittal | When | Linked approval |
|---|---|---|---|
| 0 | **Pre-application** meeting and **Form 1-1** (Applicability Determination) | Before the planning permission or layout application | None (advisory record) |
| 1 | **Preliminary drainage report** | With the planning permission or layout application | Planning permission / layout approval |
| 2 | **Final drainage design** | Before building permit, or before commencement where the permit is issued with the planning permission | Building permit / commencement |
| 3 | **Construction inspections** at hold points | During construction | None (records filed) |
| 4 | **As-built certificate** and verification tests | Before the completion certificate | Completion / occupancy certificate |
| 5 | **Maintenance declaration** registered, or **handover** of public assets | Before or with the completion certificate | Completion certificate; asset acceptance |

| Stage | Submittal | When | Linked approval |
|---|---|---|---|
| 6 | **Annual declarations** and inspection reports | Every year after completion | Continuing compliance |

10.3.2 **Stage 0 is mandatory** for:

- (a) sites of 2 ha or more;
- (b) sites in a flood-sensitive catchment;
- (c) sites proposing a variance, waiver, regional facility or fee-in-lieu; and
- (d) sites draining to a tidal outfall or adjoining a waterbody.

For other sites, Stage 0 is optional, and Form 1-1 is lodged with Stage 1.

10.3.3 **Combined stages.** For sites of less than 1 ha outside flood-sensitive catchments, the Authority may accept Stages 1 and 2 as one submittal.

10.3.4 **Public works.** For a public work, Stage 1 is the drainage section of the DPR and Stage 2 is the drainage section of the tender drawings. The sanctioning authority shall not sanction or tender the work until the relevant stage has been reviewed under Clause 10.7.

10.3.5 **Changes after approval.** Any change that alters impervious area, levels, storage, outlet or outfall after Stage 2 shall be resubmitted, with the compliance calculator re-run, before the change is built.

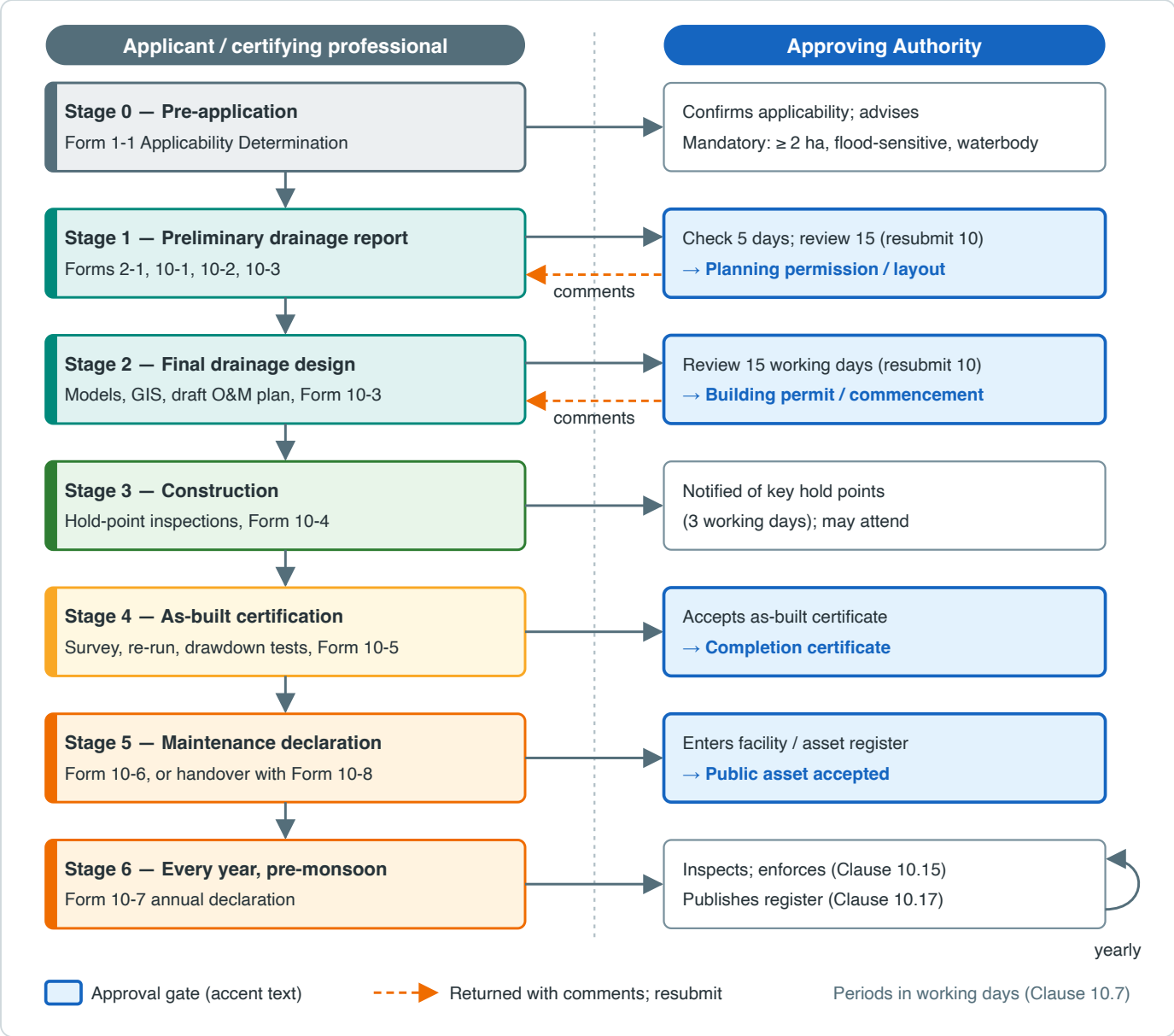


*Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.*

> **Commentary.** The stages follow the APWA 5600 sequence of preliminary and final stormwater studies, construction inspection and maintenance agreements (APWA 5600, 2006, §5608 and §5609), mapped onto the SBCR 1991 steps a Sikkim applicant already follows. Linking Stage 4 to the completion certificate copies the MBBL 2016 RWH model, which requires inspection before the completion certificate (MBBL 2016, §9.6). The 2 ha and 1 ha limits in Clauses 10.3.2 and 10.3.3 have no direct precedent and are set by this Manual.

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## 10.4 Required contents and checklists

10.4.1 **Preliminary drainage report (Stage 1).** The report shall contain at least:

- (a) Form 1-1 and, where applicable, Form 1-2 (Variance / Waiver Request);
- (b) a site plan with existing and proposed levels, impervious areas, and the catchment boundaries draining to and through the site;
- (c) soils (HSG), the seasonal high groundwater table, and infiltration test results or a test plan (Chapter 3);

- (d) the **Design Rainfall Sheet (Form 2-1)**, completed as Clause 2.13 requires;
- (e) the pre-development condition and hydrologic method (Chapter 3);
- (f) how the hierarchy of Clause 1.2 has been applied: areas preserved, retention method, detention concept and conveyance;
- (g) preliminary retention, water quality and detention volumes, and release rates, from the compliance calculator (Clause 10.5);
- (h) the downstream extent and tailwater case (Chapter 5);
- (i) waterbodies, setbacks and the 1% AEP level (Chapters 6 and 7); and
- (j) the land reserved for facilities and maintenance access (Clause 10.13).

10.4.2 **Final drainage design (Stage 2).** The final design shall contain, in addition to updated Stage 1 contents:

- (a) the final calculations for every storage duration of Clause 2.5.2 and every AEP required by Chapter 4, including the outfall-closed check of Chapter 5;
- (b) stage–storage–discharge tables for each facility, and the emergency spillway design (Chapter 4);
- (c) hydraulic design of conveyance elements, inlets and structures (Chapters 6 and 9);
- (d) the water quality design and the first-flush or gross pollutant trap where required (Chapter 8);
- (e) construction drawings, details and specifications of every facility;
- (f) the construction sequence, including protection of retention and infiltration areas from sediment and compaction (Clause 10.8.3);
- (g) the hold-point schedule (Clause 10.8);
- (h) the draft O&M plan (Clause 10.11) and draft maintenance declaration (Clause 10.10);
- (i) the model input files and the GIS data of Clause 10.4.4; and
- (j) the certificates of Clause 10.6.

10.4.3 **Checklist.** Each submittal shall include the **Drainage Report Checklist (Form 10-1)**, showing for each item of Clauses 10.4.1–10.4.2 the page or sheet where it is addressed, or the reason it does not apply. The Authority shall not start technical review of a submittal without a completed Form 10-1.

10.4.4 **Digital submittal.**

- (a) Reports and drawings shall be submitted as searchable PDF.
- (b) Hydrologic and hydraulic models shall be submitted in their native, runnable format (for example SWMM .inp, HEC-HMS or HEC-RAS project files), with the version of the software used.
- (c) Facilities, outfalls, flow paths and catchment boundaries shall be submitted as GIS data (GeoPackage or shapefile) in WGS 84 (EPSG:4326) or the applicable UTM zone (45N for the whole State, which spans roughly 88.0°–88.9° E, inside zone 45N (84°–90° E), so that no project needs another zone (this Manual's reading; the State's extreme longitudes are to be confirmed against Survey of India [TBC])), with attributes as listed in Annex 10B.
- (d) Levels shall be stated relative to a named vertical datum. The relationship to the river datums of the CWC level-monitoring sites on the Teesta, the Rangit and the Rongni Chu, Khanitar, Melli, Singtam and Majitar among them (not stated in any source found [TBC]), of the reservoir levels of NHPC and the other hydropower operators (not found [TBC]), and of the flood marks of October 2023 and the post-2023 river beds surveyed at the outfalls and on ungauged kholas, jhoras and pokharis used in Chapter 5 shall be stated.

10.4.5 **Summary of forms used in submittals** (Table 10.2):

**Table 10.2 — Forms used in submittals**

| Form | Title | Stage |
|---|---|---|
| 1-1 | Applicability Determination | 0 or 1 |
| 1-2 | Variance / Waiver Request | 1 |
| 2-1 | Design Rainfall Sheet | 1, 2 |

| Form | Title | Stage |
|---|---|---|
| 10-1 | Drainage Report Checklist | 1, 2 |
| 10-2 | Compliance Calculator Summary | 1, 2, 4 |
| 10-3 | Professional Design Certificate | 1, 2 |
| 10-4 | Hold-Point Inspection Record | 3 |
| 10-5 | As-built Certificate | 4 |
| 10-6 | Maintenance Declaration | 5 |
| 10-7 | Annual Maintenance Declaration and Inspection Report | 6 |
| 10-8 | Asset Handover Certificate | 5 |

**Commentary.** Runnable models and GIS data cost the applicant little and let the Authority check the work, and later build a city-wide picture of private storage. Sikkim has no notified design return period or design storm for its urban drains, and no document of UDD, the GMC, any other urban local body, GSCDL, WRD or the Roads and Bridges Department stating a return period, a runoff coefficient, a time-of-concentration rule or a standard for drains or jhora training was found; the 1991 Regulations' drainage clauses (regs. 6, 13(iii), 21 and 25(iv)) carry no numbers. The works that exist convey: GSCDL's "Construction of drainage and jhora training works" in several Gangtok constituencies, put at about ₹13.41 crore (as reported), and the stormwater drains of about 60 km of roads in seven towns under the ADB-funded Sikkim Integrated Urban Development Project (SIUDP, 57230-001; ADB, due-diligence report, December 2024); no design storm was seen for either. A Lok Sabha reply gives the national fallback that where records are lacking "rainfall intensity is usually taken in the range of 12 to 20 mm/hr" (as quoted), far below every Sikkim value, and it is not used; road drains follow IRC:SP:42-2014 and IRC:SP:48. The rainfall studies do not supply a design basis either. No intensity–duration–frequency relation with constants and no recording-gauge ratio was found for any Sikkim station; the only Gangtok "IDF" (Wangsu, Isaac and Tirkey, 2022, for the Ranikhola watershed) disaggregates daily data and reports a July "peak intensity" of 259.785 mm/h, which is not usable; IMD's national study (Das et al., 2022) has no Sikkim panel; and the plates of the CWC Flood Estimation Report for subzone 2(a) draw no contour north of Gangtok, while the State's own records exceed them: 310.3 mm in 24 hours at Gangtok on 30 May 1975 (IMD, *Extremes*), against a 100-year plate band of 240–320 mm there, and 504.2 mm at Singhik on 12 May 1981 and 400.8 mm at Dikchu on 25 August 1969 (the same report, Table 7), where the plate implies 200–240 mm at 50 years. NIH-DHAARA is lower still in the north, 121–183 mm at 50 years in the cells of Lachung, Lachen, Chungthang and Mangan (tool output, 14 November 2026). The State's design values are therefore those of Chapter 2: the 2(a) plates in sub-areas SK-A and SK-B (Clause 2.3.6(c)(i)), the Gangtok record within 25 km east of the Teesta (Clause 2.3.6(h)), the Singhik record floor in sub-area SK-B1 (Clause 2.3.6(c)(ii)) and the plate's last values carried north in sub-area SK-C (Clause 2.3.6(c)(iii)), with the hazard screening of Clause 2.3.6(i) on the Teesta valley floor and in the GLOF corridors, and each submission must state its own design basis on Form 2-1. Form 2-1 and Form 10-2 ensure that every design states its inputs.

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## 10.5 Compliance calculator

10.5.1 The State Stormwater Technical Committee shall issue and maintain a **compliance calculator**: a version-controlled spreadsheet or web tool that, for a given site:

- (a) applies the applicability tests of Clause 1.5;
- (b) computes the retention volume from the Annex 2E depth, and the water quality volume (Chapter 8);
- (c) applies the credits for preserved areas and retained volume against detention (Chapter 4);
- (d) on the design-aid route (Clause 1.7, S-1), gives retention and detention volumes from the unit-storage tables;

- (e) on alternative S-2, gives the permissible site discharge for each AEP; and
- (f) produces the **Compliance Calculator Summary (Form 10-2)**.

10.5.2 **Use.**

- (a) Every Stage 1, 2 and 4 submittal shall include Form 10-2 from the current version of the calculator.
- (b) On the design-aid route, the calculator may be the only storage calculation.
- (c) Outside the design-aid route, the calculator is a summary and a screening check. It does not replace the hydrograph analysis of Chapter 3. Where a model result differs from the calculator screen by more than the tolerance stated in the calculator guide, the report shall explain why.

10.5.3 **Version control.** The calculator shall record its version in every output. A new version applies to new submittals 6 months after release, in line with Clause 2.14.2. A submittal shall use one version throughout Stages 1 to 4, unless the Applicant elects a later one.

10.5.4 **Openness.** The calculator, its user guide, and the source of every table in it shall be published free of charge.

> Commentary. The Mid-America Regional Council issued a Compliance Calculator (.xlsm) and a Calculator Start-Up Guide with APWA 5600 Version 2025.01, together with a site activity plan template and the Policy Supplement (MARC stormwater management page, 2025). The calculator turns a layered standard with credits into one consistent set of numbers that a reviewer can check quickly. Singapore achieves a similar effect with a much simpler rule: a single allowable C value of 0.55 for 10-yr storms up to 4 h, applied by formula (PUB Code of Practice, cl. 7.1.5). A Sikkim calculator serves Tier B authorities in particular, where it may be the whole calculation.

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## 10.6 Professional certification

10.6.1 **Who may sign.** Drainage reports and designs shall be prepared and signed by a registered professional (Clause 1.4) competent in hydrology and hydraulics. For any of the following, the signatory shall be a civil engineer **empanelled as a Stormwater Design Professional** by the Authority or UDD:

- (a) Tier A sites of 1 ha or more;
- (b) any site in a flood-sensitive catchment;
- (c) any facility with an embankment, or a high-hazard basin checked for the 0.2% AEP (Chapter 4); and
- (d) any pumped facility, tide gate or regional facility.

10.6.2 **Empanelment criteria** shall be issued by UDD and shall include a civil engineering degree, relevant experience in drainage design, and completion of a training course on this Manual.

10.6.3 **Certificate.** The signatory shall complete the **Professional Design Certificate (Form 10-3)**, certifying that:

- (a) the design complies with this Manual, except for variances listed and approved;
- (b) the rainfall, soils and tailwater inputs are as recorded in Forms 2-1 and 10-2; and
- (c) the models submitted reproduce the results reported.

10.6.4 **Independent check.** Facilities under Clause 10.6.1(c) and (d) shall be checked by a second empanelled professional who is independent of the designer. That professional shall sign Form 10-3 as checker.

10.6.5 **False certification.** A false or negligent certificate is an offence under Clause 10.15.

> Commentary. Singapore requires that its ABC Waters design features used for peak control be endorsed by an ABC Waters Professional who is also a Professional Engineer (Civil) (PUB Detention Tank Guide, 2024). India has no statutory register of professional engineers comparable to Singapore's, so this clause uses the SBCR 1991 registration and adds empanelment for the higher-risk cases. The 1 ha limit is set by this Manual.

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## 10.7 Review procedure and timelines

10.7.1 **Completeness check.** The Authority shall check each submittal against Form 10-1 within **5 working days** and either accept it for review or return it with a list of missing items.

10.7.2 **Technical review.** The Authority shall complete technical review and issue approval, conditional approval or a single consolidated list of comments within:

- (a) **15 working days** of acceptance for a first submittal; and
- (b) **10 working days** of acceptance for a resubmittal.

10.7.3 **No new comments.** On resubmittal, the Authority shall not raise new comments on matters that were unchanged and not commented on in the earlier review, unless the matter affects safety.

10.7.4 **Review capacity.** A Tier B authority, or a Tier A authority for overflow work, may use an empanelled reviewer from the UDD list. The empanelled reviewer shall not have worked on the same site. The Authority remains the decision-maker.

10.7.5 **Concurrent clearances.** Where the approval of the Water Resources Department (WRD) for a work on, or a discharge to, a river or a river or jhora work in its charge, the permission of the Forest Department for a work in the river bank of a scheduled river, which is under its administrative control "as if it were a forest", or in a slip reserve or road reserve (Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, s.29), the consent of the Municipality for a work on, or a discharge to, a municipal drain or a jhora that vests in it or that it must protect (Sikkim Municipalities Act, 2007, ss.172, 187 and 189), the consent of the Roads and Bridges Department (PWD), NHIDCL or BRO for a discharge to a side drain, catch-water drain or culvert of one of their roads, the reservoir levels and release records, in writing, of NHPC or the other operator for a work that drains to its reservoir or to the reach below its dam (operator data, not an approval; Clause 5.8.5(g)), the consent of the Sikkim State Pollution Control Board (SSPCB) for a discharge that carries effluent, the views of the Mines and Geology Department where a work forms part of the review of a site's stability zone (Notification No. 17/DMG/20-21, 19 March 2021), and the consent of the body that owns or runs the receiving drain where that body is not the Authority (for example Gangtok Smart City Development Ltd (GSCDL) or PHED for a drain or sewer it has built and not yet handed over), or another agency's concurrence is required (Chapter 7), the Authority shall forward the submittal on the day it is accepted for review, and the review periods shall run concurrently.

10.7.6 **Fit with permit timelines.** The periods in Clauses 10.7.1–10.7.2 run within, and do not extend, the overall time limits for planning permission and building permits set by the Government.

10.7.7 **Reasons.** Every refusal or condition shall state the clause of this Manual on which it is based.

> Commentary. The review periods have no direct precedent and are set by this Manual. A single consolidated comment list and the "no new comments" rule follow common good practice for engineering review.

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## 10.8 Construction inspection

10.8.1 **Hold points.** The approved hold-point schedule (Form 10-4) shall include at least:

- (a) the excavated base of each retention, infiltration and detention facility, before any media, liner or structure is placed;
- (b) the outlet structure, orifice and trash screen, before backfill or before the facility is first allowed to fill;
- (c) the infiltration tests of Clause 10.9.3;
- (d) the outfall, flap or tide gate and non-return valve, before the downstream connection is made; and
- (e) pumps and controls, at commissioning.

10.8.2 Each hold point shall be inspected by the certifying professional and recorded on Form 10-4 with dated, geotagged photographs. For sites under Clause 10.6.1, the Authority shall be given at least 3 working days' notice of hold points (a) and (b), and may attend.

10.8.3 **Protection during construction.**

- (a) Retention and infiltration areas shall be fenced off from construction traffic and stockpiles.
- (b) Infiltration facilities shall not be brought into service until the area draining to them is stabilised.
- (c) Sediment shall be removed from any facility used for temporary sediment control before the as-built survey.

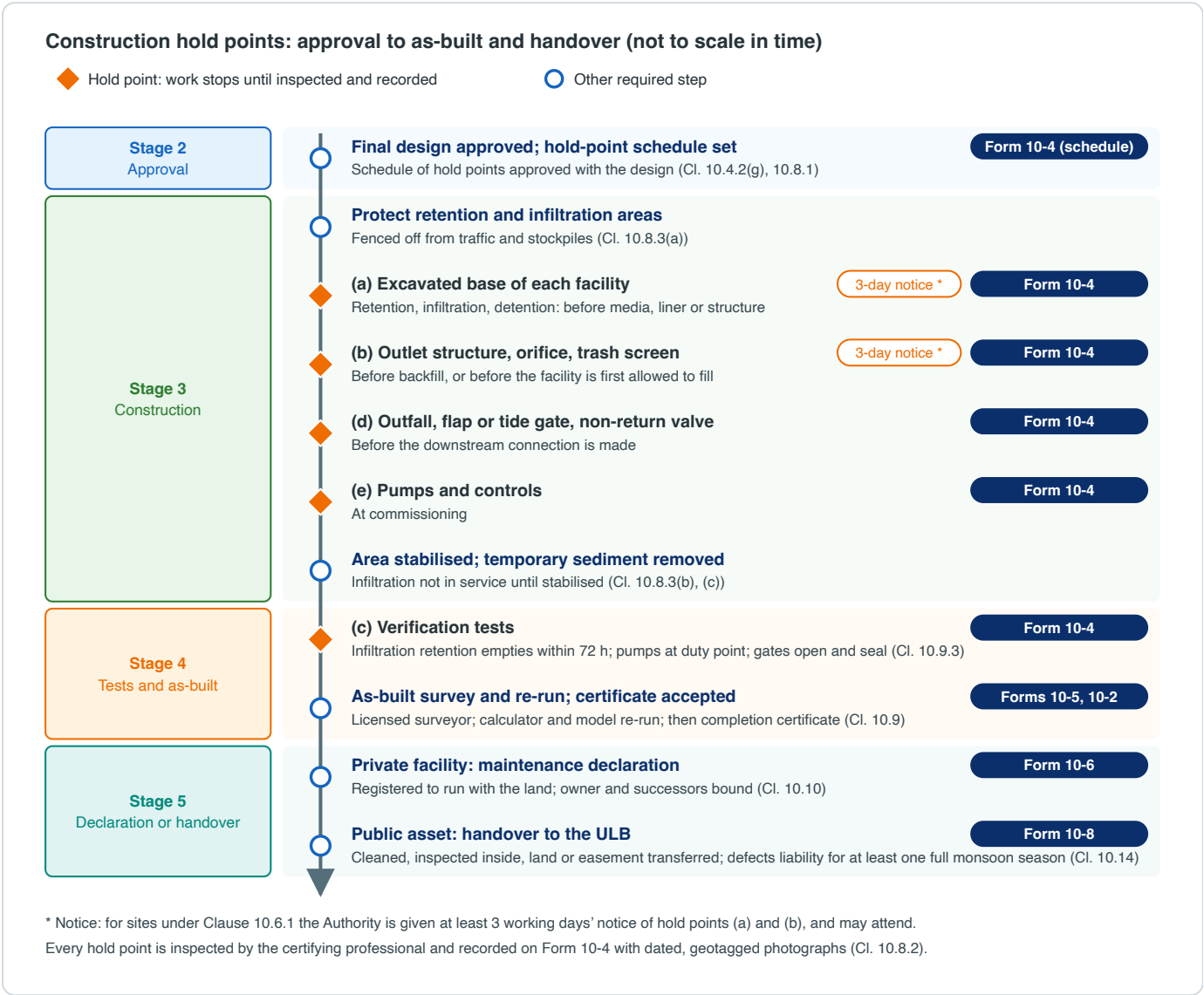

*Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement sequence of APWA Section 5600 (2006), §5608.*

> Commentary. Infiltration facilities fail most often in construction, when they are compacted or filled with silt before they ever operate. Hold points (a) and (c) target that failure. The 3-day notice is set by this Manual.

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## 10.9 As-built certification

10.9.1 Before the completion certificate is issued, the certifying professional shall submit the **As-built Certificate (Form 10-5)** with:

- (a) an as-built survey by a licensed surveyor of each facility's levels, storage volume, outlet dimensions and inverts, and the outfall;
- (b) a re-run of the compliance calculator, and of the model where one was used, with as-built values;
- (c) the completed hold-point records (Form 10-4); and
- (d) the final O&M plan and the executed maintenance declaration or handover documents (Clauses 10.10 and 10.14).

10.9.2 **Acceptance.** The as-built facility is accepted where:

- (a) the as-built storage volume at each design level is not less than the volume required by Chapter 4;
- (b) the outlet dimensions and inverts match the approved design; and
- (c) the re-run shows compliance with every criterion of Chapters 4 and 5.

Any deviation shall be corrected, or re-certified as compliant under Clause 10.3.5.

10.9.3 **Verification tests.** Every retention facility that relies on infiltration shall be tested after construction to show that it empties within **72 hours**, as Chapter 4 requires. Pumped facilities shall be tested at their design duty point. Tide gates and non-return valves shall be shown to open and seal.

10.9.4 The Authority shall not issue the completion certificate until Form 10-5 is accepted.

> Commentary. The 72-hour retention drawdown is the criterion of Chapter 4. This Manual requires it to be tested after construction, rather than relying on pre-construction tests alone, because compaction during construction can cut infiltration rates far below the design values.

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## 10.10 Maintenance declarations and covenants

10.10.1 **Declaration.** The owner of every private stormwater facility shall execute a **Maintenance Declaration (Form 10-6)** before the completion certificate is issued. The declaration shall:

- (a) identify each facility, its location and the approved O&M plan;
- (b) bind the owner and successors in title to operate, inspect and maintain the facility under the O&M plan;
- (c) grant the Authority a right of entry to inspect, and to carry out works in default under Clause 10.15;
- (d) prohibit removal, filling, covering, reduction or change of use of the facility without the Authority's approval; and

- (e) be registered so that it runs with the land and is disclosed to purchasers.

10.10.2 **Multi-owner developments.** For apartments, layouts and gated communities, the declaration shall name the association or body responsible after handover by the developer. The developer remains responsible until that body is legally constituted and has accepted the declaration in writing.

10.10.3 **Annual declaration.** Every owner of a facility in a Tier A area, and of any pumped facility, tide gate or regional facility anywhere, shall submit an **Annual Maintenance Declaration and Inspection Report (Form 10-7)** by **31 March** each year. The report shall be signed by the owner and, for facilities under Clause 10.6.1(c) and (d), by an empanelled professional. It shall state that the pre-monsoon inspection of Clause 10.12 has been done and any defects corrected.

10.10.4 **Transfer.** On sale or transfer, the seller shall disclose the declaration and the latest Form 10-7. The purchaser takes on the obligations from the date of transfer.

> Commentary. Singapore requires owners of pumped detention systems to file yearly declarations and documents with PUB (PUB Detention Tank Guide, citing Code of Practice §13.2). Addendum No. 3 to the Code of Practice (16 Apr 2025) introduced annual maintenance declarations for flood barriers and pumped detention tanks, following amendments to the Sewerage and Drainage Act. APWA 5600 (2006, §5608) required easements and maintenance provisions for detention facilities. A registered declaration matters in Sikkim because detention tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 31 March date is set by this Manual to fall before the monsoon season (April–October), when most Sikkim extreme rainfall occurs.

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## 10.11 O&M plans

10.11.1 Every stormwater facility shall have an O&M plan, approved at Stage 2 and finalised at Stage 4. The plan shall include:

- (a) an inventory and a plan drawing of each facility, with design levels, volumes and outlet details;
- (b) routine tasks and their frequency: inspection, debris and sediment removal, vegetation care, screen cleaning;
- (c) the trigger for sediment removal, stated as a depth or a percentage of design volume;
- (d) inspection checklists matching Form 10-7;
- (e) for pumped systems, gates and valves: the operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning;
- (f) actions to prevent standing water and mosquito breeding, consistent with the drawdown times of Chapter 4;
- (g) safety measures for confined spaces, deep water and public access;
- (h) access routes and equipment needed (Clause 10.13);
- (i) an annual cost estimate and who pays it; and
- (j) the records to be kept, and for how long.

10.11.2 **Public facilities.** For facilities owned by a ULB or department, the O&M plan shall be included in the asset register (Clause 10.14.3) and funded in the annual maintenance budget.

> Commentary. Sikkim has no dated State or municipal order fixing a date for desilting drains or clearing jhoras; the only fixed dates are those of the monsoon excavation ban, which UDD issues as an annual notice (UD&HD Notice No. 613/GOS/JCTP/UD&HD of 1 May 2019; UDD Notice No. T(1689)/997 of 26 May 2020), not as a regulation. The drains are run by several hands, and no notification divides them (Chapter 6): the Municipality for its drains and for the jhoras on public land other than forest land within its area, which vest in it, and for the protection of every jhora in that area, public or private (Sikkim Municipalities Act, 2007, ss.172 and 189); the Forest Department for the river banks of the 103 scheduled rivers (1988 Act, s.29(9)); the Roads and Bridges Department (PWD) for

the drains of State roads, and NHIDCL and BRO for those of the national highways (this Manual's reading); GSCDL, WRD and the Rural Management and Development Department (RMDD) for the jhoras they train (as reported); PHED for the sewers and treatment plants ("the concern department for sewage management in the State"); and no one for the jhoras outside municipal limits or on forest land, which have no named owner. Maintenance is let by contract: the GMC's waste agency is responsible for the "Clearing of Jhoras" and barred from dumping "along Footpath, Roadside and Jhoras" (Memo No. GMC/6727/III/2024/OL/01, 8 October 2024), and GSCDL's jhora-training works (as reported) will need their own maintenance once handed over. The gates that matter most are run by rules made for other purposes: the hydropower reservoirs are operated for power, no release rule, full reservoir level or maximum water level was found for any of them [TBC], and the High Court closed its case on a release from the Dikchu project in 2017, reported to have come without warning, with a direction that the projects "shall ensure strict compliance of the safety guidelines" and that the authorities "undertake periodic inspection and review" (WP(PIL) 4/2017, 1 March 2021). Warning of the largest hazard rests with other bodies: the Science and Technology Department is the nodal department for GLOF studies and mitigation (Notification No. 10/Home/2025, 7 February 2025), SSDMA and the District Disaster Management Authorities ran participatory risk assessments with GLOF evacuation maps in May 2024 and a State mock exercise on 17 November 2025 (State affidavit to the National Green Tribunal, 28 February 2026), and no operating procedure for urban floods was read [TBC]. No operating rule for any flap gate, sluice or pumping station in a Sikkim town, linking it to a river level, a dam release or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

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## 10.12 Inspection frequencies

10.12.1 **Owner inspections.** Owners shall inspect facilities at least as set out in Table 10.3:

**Table 10.3 — Minimum owner inspection frequencies**

| Facility type | Routine | Pre-monsoon (by 31 March) | After a heavy-rainfall event |
|---|---|---|---|
| Retention / infiltration (soakaways, trenches, bioretention, permeable paving) | Every 6 months | Yes | Yes |
| Surface detention basin or multi-use open space area | Every 6 months | Yes | Yes |
| Underground or podium detention tank, gravity outlet | Every 6 months | Yes | Yes |
| Pumped detention, pumps and controls | Monthly test run | Yes, with full duty test | Yes |
| Flap / tide gate, non-return valve | Every 3 months | Yes, with seal test | Yes |
| Gross pollutant trap / first-flush device | Every 3 months | Yes | Yes |
| Private drains and inlets | Every 6 months | Yes | — |

A heavy-rainfall event, for this Clause, is a day on which the nearest approved gauge records rainfall at or above the IMD "heavy rainfall" category, or a day for which a red alert is issued for the district. In Sikkim, the pre-monsoon inspection of flap gates, penstocks, non-return valves, debris racks, debris basins, silt traps, culvert inlets and any pumped facility, including the gates, where any exist, on the outfalls of the valley-floor towns that the Teesta, the Rangit or the Rongni Chu can close and on outfalls to a hydropower reservoir or its release reach, with the desilting of every drain and jhora

channel, the clearance of inlets, culverts, racks, debris basins, silt traps and slide debris, the clearance of plinth drains and catchment drains, the inspection and clearance of the weep holes and subsurface drains of retaining walls, and the pump duty and gate seal tests, shall be completed by **31 March**, with completed earthworks and cut slopes stabilised by the same date; flap gates and any pumped facilities, with their standby power, shall be certified ready on the same date, with every gate on an outfall to a river or reservoir operated through its full travel, because the season of this Manual begins on 1 April and the storms of April and May are among the State's largest. Flap gates, racks and any pumps shall then be kept on standby, with the monthly test run, from **1 April to 31 October**, and at an outfall to a hydropower reservoir or to a reach below a dam until the operator's releases have ended, if that is later. Drains, jhora channels, racks, culvert inlets and debris basins shall be cleared again by **30 April**, of the silt, debris and slide material of the April storms, before May, the month of the State's largest recorded 24-hour falls, and every public drain, jhora channel, inlet, rack, trap, basin and culvert in every town shall be cleared of the silt, debris and slide material of the season by **15 November**, with a survey of the cut slopes, retaining walls and trained jhoras above them. In sub-area SK-C, and at any site above about 2,500 m, where snow or frost prevents the works in March, the pre-season works shall be completed by **30 April** and the mid-season clearance by **31 May**, with the reason recorded on Form 10-7; inlets, gratings, culverts and drains shall be cleared of snow and ice after every snowfall from **December to March**; and the post-season clearance shall be completed by **31 October**, before the first snow. WRD's own works on rivers keep WRD's calendar.

10.12.2 **Authority inspections.** The Authority shall inspect:

- (a) every facility on a site of 1,000 m² or more, or under Clause 10.6.1(c) or (d), at least once every 2 years, and every year in a flood-sensitive catchment; and
- (b) a random sample of at least 10% of other facilities each year.

10.12.3 The results of Authority inspections shall be entered in the facility register (Clause 10.17).

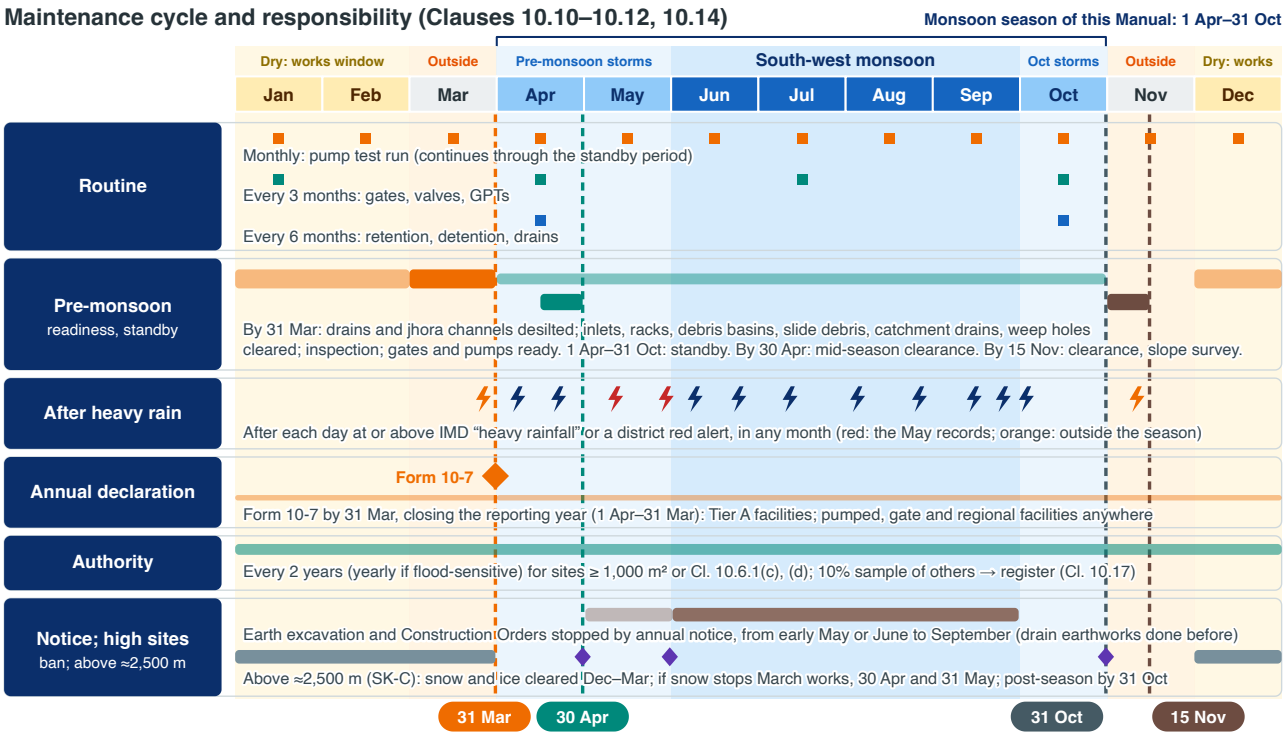


*Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 March) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the monsoon season (April–October); tick positions within the year are illustrative.*

**Commentary.** The split in Clause 10.12.2 follows the MBBL 2016 inspection regime for RWH, which requires 100% monitoring of buildings over 1,000 m² and a 10% random check below that (MBBL 2016, §9.6). The inspection intervals in Table 10.3 are set by this Manual. The 31 March deadline is set by this Manual for a wet season that begins in April. In this Manual the monsoon season runs from 1 April to 31 October: the pre-monsoon storms of April and May and the south-west monsoon. IMD's normal dates of onset and withdrawal for Sikkim were not found [TBC], and the monsoon in IMD's sense is not said here to begin in April; the season of this Manual does, for four reasons. Gangtok's rain rises steeply from April: its normals for 1981–2010 are 126.4 mm in March, 296.9 mm in April on 15.2 rainy days, with 10.7 days of thunder, 496.4 mm in May on 20.1 rainy days, 609.8 mm in June, 626.3 mm in July, 565.9 mm in August, 438.7 mm in September and 173.4 mm in October (IMD, M.O. Gangtok), and March to May bring 919.7 mm, 26% of the year (sum computed for this Manual); its highest April total is 687.8 mm (1974) and its highest May total 951.7 mm (1996) (IMD, *Extremes*). The largest 24-hour falls on record are pre-monsoon: Gangtok's 310.3 mm on 30 May 1975, its record for 1958–2012 (IMD), and Singhik's 504.2 mm on 12 May 1981 (CWC Flood Estimation Report for subzone 2(a), Table 7). The State already treats May as the

start of the season for earthworks: its notices ban "construction involving earth excavation" and stop Construction Orders each monsoon, from 6 May to 30 September in 2019 and from 1 June to 30 September in 2020 (UD&HD Notice No. 613/GOS/JCTP/UD&HD; UDD Notice No. T(1689)/997), in 2024 from 1 May, extended by 15 days (as reported), and the State told the National Green Tribunal that the monsoon "starts around the month of May or June and continues till September" (counter-affidavit in O.A. No. 5 of 2022); drainage earthworks must therefore be finished before the ban, and the April storms argue for March. And NDMA (2010) sets 31 March for pre-monsoon desilting nationally; this Manual keeps that date, as the other North-East editions of this series do, while the CWC Flood Estimation Report for subzone 2(a) finds that "The south-west monsoon and cyclonic storm causes the rainfall in the subzone from May to October". No Sikkim order fixing a date for clearing drains or jhoras was found. The research's own suggestion, desilting complete by 30 April, is not used as the deadline, because it would put the desilting into April's 297 mm on 15 rainy days; the 31 May and 15 June dates of the mountain editions of this series, set for a monsoon that begins in late June, are not used either, because Sikkim's wet season and records begin in April and May. December to February is the works window, and in North Sikkim above about 2,500 m snow and frost limit it. This Manual therefore takes 31 March for the desilting of drains and jhora channels, the clearance of inlets, culverts, racks, debris basins, silt traps and slide debris, the clearance of plinth drains and catchment drains, the inspection and clearance of the weep holes and subsurface drains of retaining walls, the pre-monsoon inspection, the annual declaration, the BSMP annual report, the stabilisation of completed earthworks and cut slopes, and the readiness of flap gates and any pumps, with no later readiness date; WRD's own works on rivers keep WRD's calendar. The research's 30 April becomes instead the date of the mid-season clearance. Drains, jhora channels, racks, culvert inlets and debris basins are cleared again by 30 April, after the April storms and before May, the month of both the Gangtok and the Singhik records. One other North-East edition of this series uses the same date; the rest clear a second time by 31 May or by 15 May, but here the largest falls on record come in May, on 12 May at Singhik and 30 May at Gangtok, so a clearance due by 15 May or 31 May could come after them. Storms continue into October: Gangtok recorded 201.0 mm on 3 October 1996 (IMD), the regional storm of 2–5 October 1968 brought hundreds of landslides in Darjeeling and Sikkim (as reported), and the flood of 3–4 October 2023 came down the Teesta, so flap gates, racks and any pumps are kept on standby to 31 October (Figure 10.3). Storms also come outside the season, 96.0 mm at Gangtok on 11 November 1995 and 72.0 mm on 27 March 2008 (IMD); design statistics use annual maxima from all months, the drains and jhoras fill with silt, debris and slide material during the season, and every town clears its drains a second time, and surveys its cut slopes, retaining walls and trained jhoras, by 15 November. In sub-area SK-C and at any site above about 2,500 m, where snow or frost prevents the works in March, the pre-season works are due by 30 April and the mid-season clearance by 31 May, with the reason recorded on Form 10-7, snow and ice are cleared from inlets, culverts and drains after every snowfall from December to March, and the post-season clearance is due by 31 October, before the first snow, as the mountain editions of this series do for their high towns (set by this Manual; no snow-day statistics or snow lines by valley were found [TBC]; Gangtok itself has occasional snow, with a January minimum of −2.2 °C in 1956, IMD). The post-event inspections of Table 10.3 cover storms at any time of year. The reporting year runs from 1 April to 31 March, so that the annual declaration of 31 March closes it.

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## 10.13 Maintenance access

10.13.1 Every facility shall have permanent access for inspection and maintenance, shown on the approved drawings and protected by the maintenance declaration or, for public facilities, by an easement or land transfer.

10.13.2 **Surface facilities.** Basins, ponds and open channels shall have a vehicle access route to the inlet, the outlet and the base, and a maintenance strip along at least one side. Ramps into basins shall be suitable for the plant needed to remove sediment.

10.13.3 **Underground facilities.** Tanks shall have:

- (a) an access opening over the inlet, the outlet and each chamber;

- (b) fixed ladders or steps, and ventilation for confined-space entry;
- (c) a sump or low point for sediment removal; and
- (d) headroom sufficient for manual cleaning.

10.13.4 **Outlets.** Orifices and screens shall be reachable for cleaning without entering a full facility.

10.13.5 Access routes shall not be built over, fenced off or used for parking in a way that prevents access.

> Commentary. APWA 5600 (2006, §5608) required a 15-ft (about 4.5 m) maintenance access strip for detention facilities. Plot sizes in Sikkim towns make a fixed width hard to apply to every site, so this Manual sets functional requirements. Annex 10C covers maintenance access dimensions.

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## 10.14 Handover of public assets to the ULB

10.14.1 Drains, roads, open space facilities, regional facilities and other stormwater assets that a developer builds for transfer to a ULB shall be handed over only when:

- (a) the as-built certificate (Clause 10.9) has been accepted;
- (b) the facility has been cleaned, and pipes and culverts have been inspected internally (for example by CCTV or manual entry), with the record handed over;
- (c) the land, or an easement over it, has been transferred to the ULB;
- (d) the O&M plan, drawings, GIS data and warranties have been handed over; and
- (e) the **Asset Handover Certificate (Form 10-8)** has been signed by both parties.

10.14.2 **Defects liability.** The developer shall remain responsible for defects and for routine maintenance for a defects liability period that includes at least **one full monsoon season, from 1 April to 31 October,** after handover. The ULB may hold a security deposit for this period.

10.14.3 **Asset register.** On acceptance, the ULB shall enter the asset in its GIS drainage asset register and in the facility register of Clause 10.17.

10.14.4 **Private facilities.** A private facility remains the owner's responsibility under its maintenance declaration unless the ULB formally accepts it under this Clause.

> Commentary. NDMA (2010) calls for a GIS inventory of drains. Requiring the developer's GIS data at handover builds that inventory as the city grows, at no cost to the ULB. The defects period spans one monsoon because many defects in Sikkim drainage show up only in the first monsoon.

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## 10.15 Enforcement

10.15.1 **Offences.** The following are contraventions of this Manual:

- (a) building without an approved drainage design where one is required;
- (b) building a facility other than as approved;
- (c) removing, filling, covering, reducing or changing the use of a facility without approval;
- (d) failing to maintain a facility, or to submit Form 10-7;
- (e) a sewage connection to a storm drain;
- (f) building or filling in a waterbody setback or no-fill zone (Chapter 7);

- (g) obstructing a natural drainage path or major-system flow path; and
- (h) false or negligent certification.

10.15.2 **Graduated response.** The Authority shall respond in the following order, moving to a later step where an earlier one fails or where the contravention is serious (Table 10.4):

**Table 10.4 — Graduated enforcement response**

| Step | Action |
|---|---|
| 1 | Written notice stating the contravention, the clause breached, the remedy and a compliance period. |
| 2 | Stop-work order, or withholding of the completion certificate, for development not yet complete. |
| 3 | Penalty under the applicable Act or rules. |
| 4 | Works in default by the Authority, with the cost recovered from the owner. |
| 5 | Disconnection of the private drain connection to the public system, where this causes no hazard to others. |
| 6 | Report of the certifying professional to the registering authority, and suspension from the empanelled list. |

10.15.3 **Immediate action.** Where a contravention puts life or property at risk during a monsoon, the Authority may carry out works in default at once and recover the cost later.

10.15.4 **Security deposits.** For sites under Clause 10.6.1, the Authority may require a security deposit or bank guarantee, released after the as-built certificate is accepted, to cover works in default.

10.15.5 **Record.** Every notice and action under this Clause shall be entered in the facility register.

> Commentary. Penalties are referred to generically. This Manual cannot itself create offences or fines, and the powers come from the Acts under which the Sikkim Building Construction Regulations, 1991 were made and from the municipal Acts. The graduated steps are set by this Manual. In Sikkim the statutes give the building authority strong powers over unauthorised works and weak, unstated penalties, and the High Court and the National Green Tribunal have begun to act where the rules do not. The Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 lets the Government demolish works built without permission in a notified area (s.8) and act against unsafe structures (s.9); since its amendment of 2022 (Act 24 of 2022) its penalty is "such fine as may be notified from time to time" (s.11) and its offences are "triable by the District Magistrate" (s.12), and no notified fine was found [TBC]. The Sikkim Building Construction Regulations, 1991 count as "Unauthorized Construction" even "a protective wall, fence of any type etc." built without permission in the notified area or a road reserve (reg. 3(1)(h)), fine the dumping of spoil on "drains, gullies and jhoras" ₹500 at least (reg. 22), refuse an electricity, sewerage or water connection or a trade licence to an unauthorised building (reg. 34), and hold Form III's security of ₹5,000 against spoil and damage to the drainage (cl. 15); the monsoon notices add that building material "lying on the road setback or over drains" will be "seized and auctioned" and that a violator is "solely responsible for any loss of life and property" (UD&HD Notice No. 613/GOS/JCTP/UD&HD, 1 May 2019). The Sikkim Municipalities Act, 2007 puts the duty on the Municipality, which must provide "a safe and sufficient outfall" that does not cause "any nuisance, either by flooding any part of the municipal area or any area surrounding the outfall" (s.187), must protect every jhora in its area, public or private (s.172(2)), and must keep sewage and rain water in separate drains, the rain water "connected with the natural nullahs, khola-kholsas, jhoras, or storm water drainage" (s.193); the State may notify the limits of a jhora (s.173), and none has been notified as far as found. The Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 makes the unauthorised occupation of a river bank, slip reserve or road reserve an offence (s.30) and lets the Government close one by notification (s.32). The audits show how works fail without a design basis or follow-through: of the ₹2,217 crore proposed in Gangtok's City Development Plan of 2006, project reports for only seven projects (₹153.02 crore) were approved, and "Projects under Drainage, Landslip Protection, Traffic, Street Lighting, Tourism and Environment were not taken up"; at Melli the households "had constructed their own septic tank …

> and were reluctant to connect" to the new treatment plant; and Jorethang's sewerage was incomplete "for want of land", the land chosen being "fully flooded during monsoon" (CAG, Report No. 3 of 2016, performance audit of JNNURM); no audit of storm drainage, flood works, GSCDL or the response to the flood of 2023 was found. The courts and the Tribunal supervise what the rules leave open. Before the National Green Tribunal the State reported that "the establishment of sewerage systems for Namchi Town and Jorethang Town has remained stalled since the year 2013 and 2015 respectively" (affidavit of 19 December 2025 in O.A. No. 673 of 2018), and the Tribunal recorded that treated sewage entering "river/ rivulets/ jhoras" is "not permissible under the Water Act" (O.A. No. 606 of 2018, order of 4 July 2024, as quoted by the State), which the State disputes; it has also sought data on all the Teesta dams after the breach at Chungthang (O.A. No. 171 of 2023, order of 13 January 2026). The High Court directed the hydropower projects to "ensure strict compliance of the safety guidelines" (WP(PIL) 4/2017, 1 March 2021), warned IRCON to correct its damage to the drainage of NH-10 (June 2025, as reported), and in its suo motu case *In re Climate Justice in State of Sikkim* (WP(PIL) 11/2026) is reported to have asked the State to examine "land-use regulation, spatial planning, slope management, and drainage in ecologically and geologically fragile areas" and urged early-warning systems for the 40 high-risk glacial lakes, with a hearing listed for 18 November 2026 (as reported; the orders were not read). This shows that a rule without routine enforcement does little, and that where no rule draws a line beside a jhora or a river, the courts have begun to ask the State to look at drainage and slopes. Professional accountability (step 6) is often more effective than fines on owners, because it acts on the person who signs the design.

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## 10.16 Monitoring and post-event review

10.16.1 **Monitoring network.** Tier A authorities shall maintain, or have access to, recording rain gauges and water-level gauges at their main outfalls and regional facilities. Data shall be archived at intervals of 15 minutes or less.

10.16.2 **Event reports.** After any event that floods buildings within a ULB area, the ULB shall prepare a short event report within **3 months**, recording:

- (a) rainfall at the nearest approved gauges, by duration, compared with the design depths of Chapter 2;
- (b) the level of the receiving river at the nearest CWC level-monitoring site, where there is one (Khanitar or Melli on the Teesta, Singtam on the Rongni Chu or Majitar on the Rangit; none was found for Rangpo), each on a named datum, with any reading of a local gauge or a press report kept apart from the CWC levels, and the flood marks surveyed at the outfall and compared with the flood mark of October 2023 and with the river bed surveyed after it; for an ungauged khola or jhora, the Rani Khola and the Roro Chu in Gangtok among them, the flood marks surveyed after the event and the boulders, spoil, slide debris and garbage deposited at crossings, racks and culverts; the state of every flap gate, debris rack, debris basin, silt trap, check dam and pumping station on the outfall and on the drain upstream of it, with the volume of debris and garbage removed from each and the hours any pump ran; the slides, slope failures and blocked catchment drains, jhoras and weep holes in the catchment of the outfall, located on the stability zones of the Mines and Geology Department; and the gate openings and releases of any hydropower dam that sets the receiving level, with the times of any warning its operator gave;
- (c) flooded locations, depths and durations, with flood marks surveyed where possible;
- (d) the performance of public and inspected private facilities, including any blocked outlets, failed pumps or closed gates; and
- (e) recommended actions.

10.16.3 **Post-event review.** Where an event exceeds the 1% AEP 24-hour or 72-hour design depth at two or more approved gauges in the State (Clause 2.14.1), SSDMA, with the State Stormwater Technical Committee, shall lead a post-event review within **12 months**. It shall assess whether the criteria of this Manual were adequate, and shall feed into the review of Clause 1.12.

10.16.4 **Facility performance sampling.** The Authority shall, at least every 5 years, monitor a sample of private retention and detention facilities through a monsoon, to test whether they perform as designed.

Commentary. The post-event trigger is the review trigger already set in Clause 2.14.1. Sikkim's floods and landslides have been counted more often than they have been reviewed, and the counts conflict. For the South Lhonak lake outburst and Teesta flood of 3–4 October 2023 the post-disaster needs assessment of SSDMA with NDMA (field assessment 7–11 December 2023) gives 79 dead and 44 missing, 2,004 houses damaged, 33 bridges damaged, 13 of them major, and damage and loss of ₹1,480.07 crore, with a recovery need of ₹2,192.59 crore (summary annexed to the State's affidavit to the National Green Tribunal of 28 February 2026), while the SSDMA survey cited by Sattar et al. (2025) gives 55 dead and 74 missing, and the press other figures (as reported); its cause is disputed too, the State's affidavit of 5 April 2024 attributing it "primarily to a cloudburst" and the committee constituted by NDSA finding, as reported, that "all scientific data and satellite images from that period points to GLOF and not a cloudburst", while Sattar et al. found a moraine collapse into the lake with modest rain, 29–39 mm over eight days in ERA5. This Manual takes no side. The Gangtok landslides of June 1997 are given as 38 deaths by a single unofficial source (as reported); the rain and landslides of 12–13 June 2024 in Mangan district killed 6 by early reports and 9 by a later account (as reported); the slide at the army camp at Chaten near Lachen on 1 June 2025 left 3 dead and 6 missing (as reported); and the earthquake of 18 September 2011 is given as 92 deaths by the count of 23 September and 97 to 116 in later totals (as reported). No official account of the regional storm of 2–5 October 1968 in Sikkim, of June 1997, or of SSDMA's final tolls for 2024 and 2025 was found [TBC], and for none of these events was an IMD station rainfall found except Gangtok's 223.8 mm on 9 June 1997. No review of any flood in a Sikkim town, and no record of flood extents, depths or durations kept by any urban local body or SSDMA, was found; the State's own reconstruction of the flood of 2023 rests on the needs assessment and the project proposal for the Lhonak valley, not on a drainage review. NDMA (2010) called for automatic rain gauges at "1 in every 4 sq km" in Class I, II and III cities. Clause 10.16.1 asks only for gauges where they serve design and review. The report and sampling intervals are set by this Manual.

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## 10.17 Data publication

10.17.1 Each Authority shall publish, on a public website, and update at least quarterly:

- (a) a **facility register**: location, type, design volume, release rate, owner, date of as-built acceptance, and the latest inspection result for every facility approved under this Manual;
- (b) a summary of each approved drainage report, with Forms 2-1 and 10-2;
- (c) the register of variances and waivers (Clause 1.10);
- (d) the alternatives adopted under the Policy Supplement (Clause 1.7);
- (e) enforcement actions (Clause 10.15.5); and
- (f) event reports and post-event reviews (Clause 10.16).

10.17.2 The State Stormwater Technical Committee shall publish the compliance calculator, all Annexes, the flood-sensitive catchment maps and the State-level summary of facility registers as open data.

10.17.3 Personal data other than the name of a corporate owner or association shall not be published. Security-sensitive details of critical infrastructure may be withheld, with the reason recorded.

10.17.4 Published data shall be machine-readable (for example CSV and GeoPackage) and released under the Government Open Data Licence – India or an equivalent open licence.

Commentary. Transparency is a design criterion in its own right here. Much of Sikkim's drainage record is public: the Sikkim Building Construction Regulations, 1991 with their amendments of 2000 and 2001 (in a copy held by a third-party host); the Acts of 1985, 1988 and 2007 and the Sikkim Town and Country Planning Act, 2024 as consolidated by PRS; the stability-zone notification of 2021 and the monsoon notices of 2019 and 2020, annexed to the State's affidavits before the National Green Tribunal; the Gazette notifications of 2026 on the urban local

bodies; the State's affidavits of 2024 to 2026 on the flood of 2023, with the project proposal for the Lhonak valley and the summary of the post-disaster needs assessment, and on sewage and the rivers, with the monthly progress report of September 2025; the High Court's judgments on the Dikchu release and on the petitions after the flood; the CAG's audit of JNNURM in Gangtok; the ADB due-diligence report for Soreng; IMD's station extremes and Gangtok normals; and Sattar et al. (2025) on the cascade of 2023. Much else could not be found in the public domain: the text of the Sikkim Building Construction (Amendment) Regulation, 2022; the list of notified areas; the notification of 2017 that gave building-plan approval in Gangtok to the GMC, and any rules under Chapter XXXII of the Municipalities Act; any notification of jhora limits under section 173; the commencement of the 2024 Act, its rules and its Board; the design basis of any storm drain or jhora-training work, including GSCDL's works and the road drains of SIUDP; any drainage master plan or notified master plan for Gangtok; CWC's site sheets and gauge datums, and any level at Rangpo; the full reservoir levels, maximum water levels and release rules of every hydropower dam; the report of the committee constituted by NDSA on the flood of 2023; SSDMA's official tolls for 2024 and 2025 and its procedures for urban floods; the High Court's orders in its climate-justice case of 2026; and an inventory of the gates, racks, debris basins and traps of any town. Publishing inputs and facility records lets the public, researchers and other agencies check that the city's growing stock of private storage actually exists. The open-format requirement is set by this Manual.

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## 10.18 Review of this chapter

10.18.1 This chapter shall be reviewed with the Manual under Clause 1.12. The forms and the compliance calculator may be revised by the State Stormwater Technical Committee between reviews, under Clause 10.5.3.

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## References (chapter)


- Government of Sikkim, Urban Development and Housing Department. *Sikkim Building Construction Regulations, 1991*, Notification No. 29(202)UD&HD/90/295 of 19 March 1991, under s.7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985, as amended by the Sikkim Building Construction (Amendment) Regulations, 2000 and 2001 (No. GOS/UD&HD/6(294)2001 of 16 October 2001): regs. 1(2), 3(1)(g)–(h), 4–6, 9(i), 13(iii), 17, 18, 21, 22, 25, 34, 35 and 39; Forms I–III. Copy held by a third-party host (Sikkim Manipal University). https://smu.edu.in/img/content/dam/manipal/smu/IQAC/SDG/documents/BUILDING%20STANDARDS.pdf. The Sikkim Building Construction (Amendment) Regulation, 2022, reported as published on 12 April 2023, was not read.
- *Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985* (Act 11 of 1985), as amended by Acts 16 of 2000, 8 of 2001, 6 of 2007 and 24 of 2022: ss.7, 8, 9, 11 and 12. https://prsindia.org/files/bills_acts/acts_states/sikkim/1985/1985SK11.pdf
- Government of Sikkim, Department of Mines and Geology. Notification No. 17/DMG/20-21 of 19 March 2021 (Sikkim Government Gazette Extraordinary No. 86, 6 April 2021): site stability zonation parameters and conditions for review; read as Annexure R/2 to the State's counter-affidavit in O.A. No. 5 of 2022 (EZ) before the National Green Tribunal.
- *Sikkim Municipalities Act, 2007* (Act 5 of 2007), as amended to Act 3 of 2026: ss.2(24), 163(b), 172, 173, 186, 187, 189, 193, 266–287 (Chapter XXXII). https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf
- *Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988* (Act 6 of 1988), as amended by Act 8 of 2000: ss.2(m), 29, 30 and 32. https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf
- *Sikkim Town and Country Planning Act, 2024* (Act 10 of 2024), as amended by Act 24 of 2025; not yet commenced (s.1(3)). https://prsindia.org/files/bills_acts/acts_states/sikkim/2024/Act10of2024SK.pdf
- Government of Sikkim, Urban Development and Housing Department. Notice No. 613/GOS/JCTP/UD&HD of 1 May 2019; Urban Development Department, Notice No. T(1689)/997 of 26 May 2020 (monsoon bans on earth excavation and Construction Orders); Annexure R/5 to the State's counter-affidavit in O.A. No. 5 of 2022 (EZ).
- National Green Tribunal (Eastern Zone). O.A. No. 5 of 2022, *Dr. Bina Basnett v. State of Sikkim and Others*: counter-affidavits of the State and of the Gangtok Municipal Corporation (2022); and O.A. No. 38 of 2022, reply affidavit of GSCDL. https://www.greentribunal.gov.in/
- Government of Sikkim. Additional affidavit of 28 February 2026 in O.A. No. 171 of 2023 (EZ) before the National Green Tribunal, with the Home Department's notifications, the project proposal *GLOF Risk Mitigation in Lhonak Valley, Sikkim* and the summary of the post-disaster needs assessment of 2023. https://www.greentribunal.gov.in/
- Government of Sikkim. Affidavit of 19 December 2025 in E.A. No. 35 of 2023 in O.A. No. 673 of 2018, with the monthly progress report of September 2025; and six-monthly report in O.A. No. 606 of 2018 (sewage; the Tribunal's order of 4 July 2024 as quoted; the GMC's waste-agency contract). https://www.greentribunal.gov.in/
- Comptroller and Auditor General of India. *Report No. 3 of 2016* (Economic Sector, Government of Sikkim), Chapter II, performance audit of JNNURM, para 2.3.9.2. https://www.cag.gov.in/uploads/download_audit_report/2017/Chapter_2_Economic_Sector_Sikkim_Report_No_3_of_2016.pdf
- India Meteorological Department. *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)*: Gangtok (42299) and Tadong (22209); and *Mean monthly meteorological parameters of Gangtok, 1981–2010*. https://mausam.imd.gov.in/gangtok/mcdata/climatology_gangtok.pdf
- Central Water Commission (1991). *Flood Estimation Report for North Brahmaputra Subzone 2(a)*, Report No. NB/18/1991 (Table 7; Plates 8–10; rainfall season).
- Kansas City Metro Chapter APWA (2006). Section 5600 Storm Drainage Systems and Facilities, §5608 (easements, maintenance, submittals) and §5609 (plan requirements). https://www.kcwater.us/wp-content/uploads/2020/08/Design-Criteria-%E2%80%93-Section-5600-%E2%80%93-Storm-Drainage-Systems-and-Facilities.pdf

- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01.
- Mid-America Regional Council (2025). Stormwater management page: 2025 Stormwater Standards Manual, Compliance Calculator, Calculator Start-Up Guide, Policy Supplement. https://www.marc.org/environment/environment-plans/stormwater-management
- PUB Singapore (2018, with Addendum No. 3 of 16 Apr 2025). Code of Practice on Surface Water Drainage, 7th ed. https://info.corenet.gov.sg/docs/default-source/pub-circulars/pub-circular_cop-7th-ed-addendum-no-3_16-apr-2025.pdf?sfvrsn=5a2c1e1a_2
- PUB Singapore (2024). On-site Stormwater Detention Tank Technical Guide. https://www.pub.gov.sg/-/media/PUB/PDF/detentionTank.pdf
- PUB Singapore (11 Nov 2024). Amendments to Sewerage and Drainage Act (press release). https://www.pub.gov.sg/Resources/News-Room/PressReleases/2024/11/Amendments-to-Sewerage-and-Drainage-Act
- MoHUA (2016). Model Building Bye-Laws, Chapter 9, §9.6. https://web.archive.org/web/2022/https://mohua.gov.in/upload/uploadfiles/files/MBBL.pdf
- National Disaster Management Authority (2010). National Guidelines on Management of Urban Flooding. https://sdma.goa.gov.in/sites/default/files/2022-05/management_urban_flooding.pdf
- High Court of Sikkim. *In re: Release of water from Dikchu Hydelpower Project*, WP(PIL) No. 4 of 2017, judgment of 1 March 2021; *Mani Kumar Subba v. State of Sikkim*, WP(PIL) No. 3 of 2023, judgment of 7 December 2023. https://hcs.gov.in/
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: drivers, causes and impacts of a multihazard cascade. *Science*, doi:10.1126/science.ads2659 (accepted manuscript).
- Asian Development Bank. *Sikkim Integrated Urban Development Project* (57230-001), resettlement and indigenous peoples due-diligence report for Soreng sewerage, December 2024, prepared by the Urban Development Department. https://www.adb.org/sites/default/files/project-documents/57230/57230-001-sddr-en.pdf
- Wangsu, M., Isaac, R.K. and Tirkey, N. (2022). Development of rainfall-intensity-duration-frequency (IDF) curves for Ranikhola watershed, Gangtok, India. *Journal of Soil and Water Conservation* (abstract only; cited to show that no gauge-based Gangtok IDF exists).
- Das, S.K. et al. (2022). Isopluvial analysis and intensity–duration–frequency curves for different cities in India. *MAUSAM* 73(4), 887–898 (no Sikkim panel).
- Indian Roads Congress (2014). IRC:SP:42-2014, *Guidelines on Road Drainage*; and IRC:SP:48, *Hill Road Manual*.
- South Asia Network on Dams, Rivers and People. Transcriptions of CWC site data for the Teesta basin, including the levels of 4 October 2023 (secondary source).
- Sikkim Express, LiveLaw, Bar & Bench, ThePrint, EastMojo, Scroll, Business Standard, Republic World and other news sources (2017–2026). Reports of the Dikchu release of 2017, GSCDL's jhora-training tenders, the extension of the excavation ban in 2024, the NH-10 drainage case, the High Court's climate-justice case, the NDSA committee's findings, and the events of 1997, 2024 and 2025 (secondary sources).


## Annexes and forms

| Annex / Form | Content |
|---|---|
| 10A | Compliance calculator and user guide |
| 10B | GIS data specification and attribute schema |
| 10C | Maintenance access dimensions |
| 10D | Model O&M plans by facility type |
| 10E | Empanelment criteria for Stormwater Design Professionals and reviewers |
| Form 10-1 | Drainage Report Checklist |
| Form 10-2 | Compliance Calculator Summary |

| Annex / Form | Content |
|---|---|
| Form 10-3 | Professional Design Certificate |
| Form 10-4 | Hold-Point Inspection Record |
| Form 10-5 | As-built Certificate |
| Form 10-6 | Maintenance Declaration |
| Form 10-7 | Annual Maintenance Declaration and Inspection Report |
| Form 10-8 | Asset Handover Certificate |
| Form 2-1 | Design Rainfall Sheet (Chapter 2) |

CHAPTER 11

# Basin and City Stormwater Master Plans

## 11.1 Purpose and scope

11.1.1 Chapters 2 to 10 control one project at a time. This chapter sets the requirements for the plan that ties those projects together: the **Basin Stormwater Master Plan (BSMP)**. A BSMP is prepared for each drainage basin of a city or urban area. A city's set of BSMPs makes up its **City Stormwater Master Plan**.

11.1.2 A BSMP shall:

- (a) map flood hazard for the basin under existing and future conditions;
- (b) set the level of service each part of the drainage system must achieve (Clause 11.6);
- (c) identify the works, storage and land needed to reach that level of service, and rank them (Clauses 11.7 and 11.8);
- (d) reserve land for regional storage, pokhari and tank restoration, and major flow paths in the statutory land-use plan (Clause 11.9);
- (e) set the basin-specific inputs that site designs under Chapter 4 depend on: regional facilities, the fee-in-lieu unit rate, and any basin release rate stricter than Chapter 4 (Clause 11.8.3); and
- (f) recommend catchments for notification as flood-sensitive (Clause 4.5.4).

11.1.3 **Relationship to site design.** Site criteria (Chapters 4 to 8) apply whether or not a BSMP exists. A BSMP may make the site criteria **stricter** for its basin. It shall not relax them, except through the regional detention and fee-in-lieu routes of Clauses 4.13 and 4.5.6.

> Commentary. Sikkim's towns have project plans and hazard studies, but no storm-drainage master plan with a design storm, and no notified master plan or drainage master plan for Gangtok was found. Gangtok's City Development Plan of 2006 proposed ₹2,217 crore of works, among them "Drainage and Landslip Protection", but project reports for only seven projects (₹153.02 crore) were approved, and the drainage and landslip works "were not taken up" (CAG, Report No. 3 of 2016, para 2.3.9.2); the Sikkim Strategic Plan of 2008, with its "Long-Term Strategies: 2040", is listed by the Urban Development Department (UDD) (as reported; not read). The ADB-funded Sikkim Integrated Urban Development Project (SIUDP, 57230-001) includes stormwater drains on about 60 km of roads in seven towns, Gangtok (Ranipool and Tadong), Singtam, Pakyong, Rangpo, Mangan, Gyalshing and Soreng, the "preparation of urban infrastructure master plan for four towns" other than Gangtok, and the strengthening of the State climate change cell (ADB, due-diligence report, December 2024), and UDD has sought proposals for a "GIS based Master Plan for Namchi Planning Area"; none of these sets a design storm that was seen. The Sikkim Town and Country Planning Act, 2024 (Act 10 of 2024, amended by Act 24 of 2025; enacted in 2024 and amended in 2025, not yet commenced) would require development plans with "proposals for water supply, drainage, sewage and solid waste disposal" and "proposals for flood control, land stability and sloped linked controls", and regional plans that map the "natural disaster-prone area", but no commencement notification, rules, Board or development authority under it was found. The hazard studies are led by the flood of 2023: the project proposal for the mitigation of glacial-lake outburst flood (GLOF) risk in the Lhonak valley (Science and Technology Department, annexed to the State's affidavit to the National Green Tribunal of 28 February 2026) counts 320 glacial lakes in the State, of which NDMA identifies 40 as high-risk and 16 as very high-risk, and proposes works such as a retention structure at Dolma Sampa and the siphoning of Shako Chho, as proposals.

Drainage work in the towns has been led by the training of jhoras (झोरा; natural watercourses or ravine streams) and by sewage rather than by a basin plan: Gangtok Smart City Development Ltd's (GSCDL's) "Construction of drainage and jhora training works" (as reported), and the sewer zones of Gangtok, one of which is described as "Pollution abatement of Rani chu through Ro-Ro Chu" (monthly progress report of September 2025). The receiving waters are kholas (खोला; rivers or large streams), jhoras, dharas (धारा; springs or spring spouts) and pokharis (पोखरी; ponds, lakes or tanks), with the Teesta, the Rangit and the Rongni Chu below them. No published document sets a design return period for the storm-drain network of any Sikkim town. This chapter supplies the design storm, levels of service, storage and buffer criteria that such a plan needs, with the design storms of Chapter 2 and the levels of service of Clause 11.6; it has not been adopted by UDD, the Gangtok Municipal Corporation (GMC), the Namchi Municipal Council, any Nagar Panchayat, GSCDL, WRD, SSDMA, the Science and Technology Department or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, jhoras narrowed, culverted or loaded with construction spoil, garbage and slide debris on the ridges of Gangtok and the other towns, slopes that water from drains, soak pits and springs destabilises, so that the State's own stability zones grade a site by the training of the jhora beside it, drains and jhoras that carry septic effluent and sullage to the Rani Khola, the Roro Chu and the Teesta, valley-floor towns on a Teesta whose bed the flood of October 2023 raised by metres, outfalls in the reaches of hydropower reservoirs whose levels and releases are not published, and single jhoras split between a Municipality, the Forest Department, a road owner and private land on their way to a river, and drains that are adequate on their own but overload the next reach. Comparable manuals pair site criteria with basin planning:

- Denver's Mile High Flood District prepares major drainageway master plans that set regional facilities and release rates.
- The Kansas City APWA criteria rest on regional watershed studies (MARC).
- England's Surface Water Management Plans (Defra, Surface Water Management Plan Technical Guidance, 2010) set a phased method of preparation, risk assessment, options and implementation.
- Malaysia's MSMA requires drainage master plans for urban areas.

This chapter adapts that method to Sikkim, the series' last North-East edition, its third mountain State and its first in the Eastern Himalaya: to towns in two settings, the ridge towns, Gangtok, Pakyong, Namchi, Ravangla and Gyalshing among them, built on phyllite, schist and colluvium where water put into the slope moves the ground and whose drains fall freely to steep jhoras, and the valley-floor towns, Singtam, Rangpo, Melli, Majitar and Jorethang, on a Teesta whose bed the flood of October 2023 raised by metres; to one CWC subzone whose plates draw no contour north of the capital, and records up to twice the plate, 504.2 mm in 24 hours at Singhik and 310.3 mm at Gangtok, both in May; to a building rule of 1991 that already grades a site by the training of the jhora beside it but sets no setback, detention, rainwater harvesting or design storm; to jhoras that the Municipalities Act calls drains and makes the Municipality protect, and a statutory river bank of "sixty metres … or area within high flood level mark, whichever is less" on the scheduled rivers only; to drains that carry septic effluent and sullage to the jhoras and rivers outside Gangtok's partial sewer network; to hydropower reservoirs whose levels and releases are not published; to springs on which most rural households depend; and to a valley whose largest flood was a glacial-lake outburst, not a rainfall flood, so that in North Sikkim and on the Teesta trunk a BSMP begins with the hazard, not the storm (Clause 11.3.3).

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## 11.2 Definitions

| Term | Meaning in this Manual |
|---|---|
| Basin | The land draining to one outfall to the sea, a river, or a major waterbody, as delineated under Clause 11.3. |
| Basin Stormwater Master Plan (BSMP) | The plan for one basin prepared under this chapter. |

| Term | Meaning in this Manual |
|---|---|
| Lead Authority | The body responsible for preparing a BSMP (Clause 11.4). |
| Level of service (LoS) | The flood performance a part of the drainage system must achieve, expressed as an AEP and an outcome (Clause 11.6). |
| Flood hazard map | A map of flood extent, depth, velocity and hazard class (H1–H6, Chapter 6) for a stated AEP and scenario. |
| Regional facility | A storage, conveyance or outfall work serving more than one development, identified in a BSMP. |
| Capital Improvement Programme (CIP) | The ranked, costed list of works in a BSMP (Clause 11.8.4). |

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## 11.3 Planning unit: the basin, not the ward

11.3.1 BSMPs shall be prepared **by hydrological basin**, not by ward, zone or local-body boundary. Where a basin crosses local-body boundaries, one BSMP shall cover the whole basin.

11.3.2 Basin boundaries shall be delineated from the digital elevation model of Clause 11.5.2, checked against the drain network, road embankments, canals and tank supply channels. Diversions between basins, whether by canal, drain or surplus course, shall be mapped and represented in the model.

11.3.3 No basin delineation has been published for any Sikkim town. For the urban areas where the evidence identifies them, the basins are at least the following, in the order of the flood-sensitive catchments of Clause 4.5.3.2:

- **Gangtok, Rani Khola and Roro Chu:** the catchments of the jhoras of Gangtok, with Tadong and Ranipool, that drain west and south to the **Rani Khola** and east to the **Roro Chu**, delineated jhora by jhora and not by ward, with the jhoras named in ICLEI's documents for the city, Goshkhan and the Hospital jhora among them (as cited), the stability zones of the Mines and Geology Department and the slide areas of June 1997 shown where they can be located, the sewer zones and the outfalls of the treatment plants at Adampool, Ranipool, Lower Sichey, Lower Syari and Tathangchen in the 1D network, free outfalls to the jhoras checked to the next confluence or trained reach (Clause 5.8.5(a)), and surveyed flood marks and the 1% AEP level with its sediment and debris as the boundary condition, since neither stream has a gauge (whether the Rani Khola is the scheduled "Rongni chu" of the 1988 Act is this Manual's reading, to be confirmed [TBC]);
- **Teesta valley floor, Chungthang to Melli:** the catchments of Chungthang, Dikchu, Singtam, Rangpo and Melli, with Toong Naga, that drain to the **Teesta** in the corridor of the flood of October 2023, with the river bed surveyed after that flood, the surveyed flood mark of October 2023 and the CWC levels at Khanitar and Melli as boundary conditions (Clause 5.8.5(b)), the outfall-closed case a design case for at least the 72-hour storm, and the GLOF corridor mapped as its own layer under the hazard-first rule below;
- **Jorethang and Majitar, Rangit:** the catchments of Jorethang (Nayabazar-Jorethang) and Majitar that drain to the **Rangit**, with the high flood level at CWC's Majitar site (279.29 m, 17 October 1985; datum not stated) re-surveyed and the release reaches of the Jorethang, Tashiding and Rangit-III projects as boundary conditions;
- **Ranipool and Singtam, Rongni Chu:** the catchments that drain to the **Rongni Chu** at Ranipool and Singtam, with the high flood level at CWC's Singtam site (356.09 m, undated) and the Teesta's level at the confluence below Singtam as boundary conditions;
- **Mangan:** the catchments of Mangan town and of the slopes of the North Sikkim road that drain to the Teesta, with the slides of June 2024 mapped and the debris-flow and jhora gullies above the town treated as hazards, not drains;
- **Lachen, Chaten and the catchments below high-risk glacial lakes:** the catchments of the settlements and camps of the Lachen Chu and Lachung Chu valleys in sub-area SK-C, under the hazard-first rule below, with the slide of 1 June 2025 at Chaten mapped;

- Hydropower reservoirs and release reaches: the catchments that drain to the reservoirs of Teesta-III to Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III and to the reaches below their dams, with the reservoir levels and the largest recorded releases, once the operators state them on a named datum [TBC], as boundary conditions (Clause 5.8.5(c));
- NH-10 corridor: the catchments of the road and its settlements along the Teesta, with the reaches where the road is "prone to submergence and subsidence" and the drainage damage before the High Court mapped;
- Namchi: the catchments of the ridge town and its jhoras, free outfalls to the jhoras checked downstream (Clause 5.8.5(a)), with the sewage that the stalled sewerage leaves in the drains in the 1D network; and
- Soreng: the catchments of the town, whose septic effluent discharges into open storm drains, with the same boundary conditions.

Hazard first in North Sikkim and on the Teesta trunk (set by this Manual). In sub-areas SK-B1, Middle Teesta valley (Dikchu–Mangan–Singhik–Chungthang), and SK-C, High valleys (Lachen–Lachung–Thangu), of Annex 2A, on the Teesta valley floor, and in any basin with a glacier, a glacial lake, a mapped debris-flow fan, a slide scar or a sinking area above it or a dam release upstream, the BSMP begins with a hazard screening for glacial-lake outbursts, debris flows, landslide dams and releases, made with the GLOF evacuation maps of SSDMA and the District Disaster Management Authorities where they exist [TBC], the State's glacial-lake studies and the stability zones, and uses site-specific hydrology in sub-area SK-C (Clause 2.3.6(i)). The GLOF corridors and the Teesta valley floor at or below the flood and aggradation level of October 2023 are mapped as their own layer, not as a rainfall flood extent: the flood of 3–4 October 2023 peaked at 5,340 m³/s at Chungthang within about six minutes (Sattar et al., 2025), so the 1% AEP rainfall flood is not the design flood for the trunk, and no rainfall-based setback or level protects against the cascade. The hazard zones are shown on the 1% AEP map, no drain, storage, pumping station or treatment work is sited in them, and no work in the CIP is sized to carry a GLOF, a debris flow or a landslide. Other Tier A bodies and the other urban local bodies define their basins in the first BSMP that covers them.

Stress tests (set by this Manual). Besides the calibration events of Clause 11.7.5, each BSMP is run against two stress tests, neither of which calibrates a model. The first is the regional storm of 2–5 October 1968, with its "hundreds of landslides" and about 1,000 dead in Darjeeling and Sikkim, and Kalimpong's 419.2 mm on 5 October (IMD) across the Teesta (as reported; the "1,000 mm of rainfall in 52 hours" quoted in the press is not a measurement, and no Sikkim gauge record of the storm was found [TBC]): it is run as the 72-hour design storm of Clause 2.3.6(e) with every outfall to the Teesta closed, to show where the drains and jhoras of a basin fail when the river and the slopes fail together. The second is the South Lhonak lake outburst and Teesta flood of 3–4 October 2023, used as a siting test, not a calibration event, because the rain over the lake was modest (29–39 mm over eight days in ERA5) and the flood came from the lake and the sediment it carried, not from the rain on the basin, so a rainfall-runoff model cannot reproduce it: the BSMP maps its flood and aggradation line and shows that every asset of the plan stands above it and outside the mapped GLOF path (its cause is disputed, the State's affidavit of 5 April 2024 attributing it "primarily to a cloudburst"; this Manual takes no side). The slide of 1 June 2025 at Chaten is a siting case of the same kind for slides and debris flows, and the rain and slides of 12–13 June 2024 in Mangan district serve both as a calibration event, where rainfall and flood marks can be found, and as such a siting case. Where CWC, a hydropower operator, a development plan or a court has a high flood level, a reservoir level, a flood line or an operating rule for a dam, gate or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

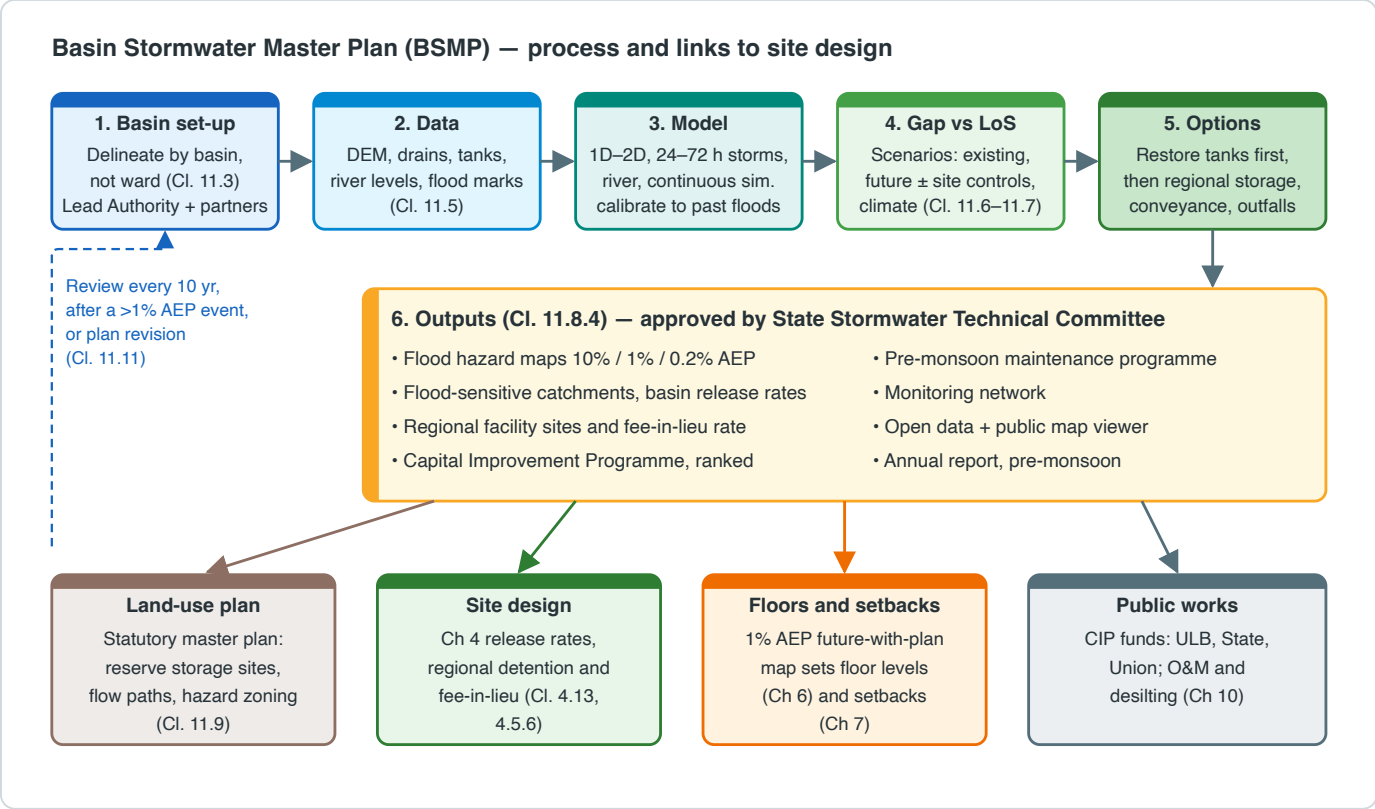


*Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.*

Commentary. Water does not follow ward boundaries. A ward-by-ward drain plan can pass the problem to the next ward, and to the next local body. In Sikkim a single jhora passes through many hands on its way from a ridge to a river. In Gangtok the jhoras are at once storm drains, the receivers of septic effluent and sullage, and the feeders of the Rani Khola and the Roro Chu, and the treatment plants of the city's sewer zones discharge to the same streams; the Tribunal recorded that treated sewage "is entering in to river/ rivulets/ jhoras" (O.A. No. 606 of 2018, order of 4 July 2024, as quoted by the State), which the State disputes. Within a municipal area the jhoras on public land other than forest land vest in the Municipality, which must protect every jhora in that area, public or private (Sikkim Municipalities Act, 2007, s.172), and the drains vest "in the Municipality, or the concerned Department, or organization, of the State Government, or the agency, as the case may be" (s.189(1)); the river bank of each of the 103 scheduled rivers, up to sixty metres or the high flood level line, whichever is less, is under the Forest Department (Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, s.29); the road drains are the road owner's; the jhoras that GSCDL, WRD or RMDD train are worked on by that agency (as reported); and the jhoras outside municipal limits or on forest land have no named owner, because section 172 excludes forest land (this Manual's reading). No notification divides the jhoras from the municipal drains or the drains from the rivers, and no limits of any jhora have been notified under section 173. Below the towns the jhoras reach the Teesta, whose valley floor receives everything the ridge towns send, and whose lower reaches run on into the area that the West Bengal edition governs. This clause makes the basin the planning unit, so that one model carries each jhora from its head on the ridge to the river or reservoir whoever owns each reach, and so that the drain and jhora register of each town (Chapter 6) gives every reach an owner, its land status (municipal, Forest Department, private or road reserve) and its outfall, and so that the sewage it carries is separated before it reaches a dhara, a pokhari, an intake or the river (Chapter 8, Clause 8.9).

## 11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of Gangtok: the **Gangtok Municipal Corporation (GMC)**, in which the municipal drains and the jhoras on public land other than forest land within its area vest and which must protect every jhora in that area (Sikkim Municipalities Act, 2007, ss.172 and 189) and which has approved building plans in Gangtok since 2017, jointly with the **Urban Development Department (UDD)**, the department for planning and development in the notified areas, into whose plans, and once the Sikkim Town and Country Planning Act, 2024 commences into whose development plan, the BSMP is taken (Clause 11.9). For the basins of Namchi: the **Namchi Municipal Council**, with UDD, which has sought proposals for a GIS-based master plan for the Namchi Planning Area. Each role is the one the body would have if the Manual were adopted; none has adopted it. Where a basin extends beyond the municipal limits, the other urban local bodies and the Gram Panchayats in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the jhoras from the municipal drains, or the drains of the local bodies from the rivers and reservoirs, was found; until one is made, this Manual assigns the reaches within each BSMP as follows, each body being Lead Authority for the reaches and works it owns or runs and for the parts of the CIP on them: **WRD** for the rivers and their beds, banks and river works, and for the jhora works in its charge; the **urban local body** for its drains and the jhoras that vest in it; the **Forest Department** for the river banks of the scheduled rivers, which are under its control "as if it were a forest" (1988 Act, s.29(9)); **GSCDL** for the drains and jhora-training works it builds, until handed over in writing; the **Roads and Bridges Department (PWD)** for the side drains, catch-water drains and culverts of the State roads, and **NHIDCL** and **BRO** for those of the national highways, NH-10 among them, with the spoil of their works; **PHED** for the sewers and treatment plants, and **RMDD** for rural and peri-urban sewage and the Dhara Vikas springshed works; **NHPC** and the other hydropower operators for their reservoirs, levels and releases, as providers of data, not as approving authorities; and **SSDMA**, with the **Science and Technology Department** (the nodal department for GLOF studies and mitigation since 7 February 2025) and the **Mines and Geology Department** (the stability zones), for the mapping of glacial-lake, landslide, sinking and debris hazards that a BSMP must show.
- In the Nagar Panchayats (Rangpo, Singtam, Mangan, Gyalshing, Nayabazar-Jorethang, Soreng and Pakyong, as UDD's notification No. 06/UDD/2026 lists them) and in other Tier B bodies: the Lead Authority would be named by UDD. Basins draining to a common river reach or reservoir, such as the Teesta valley floor from Singtam to Melli, may be grouped into one district-level plan.

SSDMA and the District Collector shall be consulted on every BSMP; the hydropower operator on every BSMP whose basin drains to a reservoir or to a reach below a dam; the Forest Department on every BSMP whose works touch the river bank of a scheduled river, a slip reserve or a road reserve; the Science and Technology Department on every BSMP in sub-area SK-B1 or SK-C or on the Teesta trunk; the Sikkim State Pollution Control Board (SSPCB) on every BSMP that proposes works on a drain or jhora that carries sewage; the landowners on every BSMP that needs private land for a corridor or storage, which is secured by agreement or donation, or reserved in a development plan once the 2024 Act commences, and never taken; and, for a basin whose outfall lies on the Teesta or the Rangit where they run on across the State border, the water resources department of the adjoining State, through WRD.

The Water Resources Department (WRD) shall be a partner in every BSMP that includes a river, canal or tank under its control.

11.4.2 **When a BSMP is required.**

- (a) Every Tier A body shall approve BSMPs covering its whole area within **3 years** of this Manual taking effect.
- (b) A BSMP is required before:
  - any regional detention or fee-in-lieu is accepted under Clause 4.13;
  - a fee held under Clause 4.5.6.3 is spent; and
  - a basin-specific release rate is applied under Clause 11.8.3.
- (c) A Tier B body shall prepare a BSMP where its Lead Authority, or the State Stormwater Technical Committee, finds recurrent flooding of buildings or arterial roads.

11.4.3 **Preparation.** BSMPs shall be prepared by, or under the direction of, an engineer empanelled as a Stormwater Design Professional (Chapter 10) with experience in basin-scale modelling.

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## 11.5 Data and surveys

11.5.1 Each BSMP shall assemble and publish (Clause 11.10) the data in Table 11.1:

**Table 11.1 — Minimum data and surveys for a BSMP**

| Data | Minimum requirement |
|---|---|
| Terrain | Digital elevation model from LiDAR or photogrammetry, with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum |
| Drain network | Inventory of all public drains, culverts and outfalls with invert levels, sizes, condition and silt depth; private drains above 600 mm |
| Waterbodies | Survey of every tank, pokhari, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels, encroachment |
| Rivers and canals | Cross-sections at no more than 200 m spacing and at every structure |
| Outfalls, rivers, kholas, jhoras, reservoirs and pokharis | The datum of every level named; outfall invert levels against the river bed surveyed after October 2023 and against the high flood level of the receiving river at the nearest CWC level-monitoring site, where there is one (298.4 m on the Teesta at Khanitar, 4 October 2023; 225.5 m or 228.0 m on the Teesta at Melli, 4 October 2023, a conflict between two transcriptions, of which the higher is used for checks; 356.09 m on the Rongni Chu at Singtam; 279.29 m on the Rangit at Majitar, 17 October 1985; none found for Rangpo; CWC levels as transcribed by SANDRP and the press, as reported, with the datum not stated), with the flood mark of October 2023 surveyed at every valley-floor outfall; for the Rani Khola, the Roro Chu and the other ungauged kholas and jhoras, surveyed flood marks, the debris lines of past floods and the 1% AEP flood level with its sediment and debris; for outfalls to hydropower reservoirs and their release reaches, the maximum water level, full reservoir level, spillway capacity and release records from NHPC and the other operators, none of which was found [TBC], naming which is used; pokharis at their surveyed spill levels; the GLOF corridors of the Teesta, the Lachen Chu, the Lachung Chu and the streams below the high-risk glacial lakes, from the evacuation maps of SSDMA and the District Disaster Management Authorities and the State's glacial-lake studies where they exist; the stability zones of the Mines and Geology Department and the landslide, sinking and debris-flow areas above the basin; and the flap gates, debris racks, debris basins, silt traps, check dams and any pumping stations on the outfalls, with their capacities and operating rules |
| Rainfall and levels | All available rain gauges (IMD, including its observatories at Gangtok (42299; rainfall from 1958) and Tadong (22209; 1978–2007 in its *Extremes*) and the district gauges reported by the Meteorological Centre Gangtok (types and record lengths [TBC]); the ordinary gauges at Singhik and Dikchu used for the CWC Flood Estimation Report for subzone 2(a), whose record lengths are not confirmed [TBC]; the automatic weather station at Lachen used by Sattar et al. (2025) and the India-WRIS rainfall station at Lachen; the river gauges of CWC on the Teesta, the Rangit, the Rongni Chu and the Dik Chu; the hydro-meteorological gauges of NHPC and the other hydropower operators, at Teesta-V, Dikchu and Chuzachen among them [TBC]; and any gauges or sensors kept by the Gangtok Municipal Corporation, GSCDL, SSDMA or WRD [TBC]) and water-level records, including those for the 9 June 1997 (Gangtok's 223.8 mm in 24 hours, in a June whose 1,281.3 mm is the station's highest monthly total, IMD, with the Gangtok landslides of that month, for which a single unofficial source gives 38 deaths, as reported), 25 September 2005 (212.5 mm at Tadong, its record, and 141.0 mm at Gangtok on the same day, IMD, at stations 4–5 km apart; no flood record of the day was found [TBC]) and 12–13 June 2024 (the rain and landslides of Mangan district, with 6 deaths reported at first and 9 in a later account, the Sangkalang bridge lost and tourists stranded at Lachung, and about 250 mm over the State in 1–13 June, all as reported; no IMD station rainfall for the event was found [TBC]) events |
| Flood evidence | Surveyed flood marks and mapped flood extents from past events, including public reports |
| Land use | Existing land use and imperviousness; future land use from the statutory master plan |
| Soils and groundwater | HSG map (Annex 3A); seasonal high groundwater; aquifer and recharge zones |

| Data | Minimum requirement |
|---|---|
| Sewer interaction | Known sewage cross-connections, dry-weather flow in drains, and solid-waste hotspots |

**Commentary.** The 0.15 m accuracy has no direct precedent; this Manual sets it because on the valley floors and river terraces of the Teesta, the Rangit and the Rongni Chu at Singtam, Rangpo, Melli, Majitar and Jorethang, where the flood of October 2023 left a flattened, wider river bed metres above the old one, and on the benches and pokhari margins of the ridge towns, where a raised road, a dumped fill or a low wall can turn an overflow from one side of a flat to the other, a small error in ground level moves the flood edge a long way, and the 1% extent from the BSMP sets floor levels (Chapter 6) and setbacks (Chapter 7). Past flood marks matter as much as models. The 9 June 1997 (Gangtok's 223.8 mm in 24 hours, in a June whose 1,281.3 mm is the station's highest monthly total, IMD, with the Gangtok landslides of that month, for which a single unofficial source gives 38 deaths, as reported), 25 September 2005 (212.5 mm at Tadong, its record, and 141.0 mm at Gangtok on the same day, IMD, at stations 4–5 km apart; no flood record of the day was found [TBC]) and 12–13 June 2024 (the rain and landslides of Mangan district, with 6 deaths reported at first and 9 in a later account, the Sangkalang bridge lost and tourists stranded at Lachung, and about 250 mm over the State in 1–13 June, all as reported; no IMD station rainfall for the event was found [TBC]) events are the best calibration data Sikkim has, and much of the evidence is held in photographs, news reports and residents' records that should be collected before it is lost.

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## 11.6 Levels of service

11.6.1 Each BSMP shall adopt the following minimum levels of service. A BSMP may adopt stricter levels.

**Table 11.2 — Minimum levels of service**

| Element | Minimum level of service |
|---|---|
| Minor system | The design AEP of Chapter 6 (Table 6.1) |
| Habitable buildings | No flooding above floor level in the 1% AEP (100-yr) event |
| Critical facilities (hospitals, emergency services, substations, water and sewage plants) | No flooding of the facility in the 0.2% AEP (500-yr) event; access road passable in the 1% AEP event |
| Evacuation routes and arterial roads | Passable (hazard class H2 or better, Chapter 6) in the 1% AEP event |
| Ponding drain time | Surface water cleared from roads within **6 hours** after rain ends in the 10% AEP (10-yr) event |
| Tank and pokhari storage | No net loss of flood storage below the MWL in the basin, measured against the earliest available survey |
| Outfalls | Functioning under the joint and outfall-closed cases of Chapter 5 |

**Commentary.** The building and road levels repeat Chapter 6, so that the basin plan and the site designs aim at the same outcome. The 0.2% AEP for critical facilities, the 6-hour ponding drain time and the no-net-loss rule for tank storage have no direct precedent and are set by this Manual. The drain time reflects what residents notice most after a storm. The no-net-loss rule reflects a loss of storage that has been reported but rarely measured. Sikkim's storage is in its pokharis, its few wetlands, its benches and valley floors and its hydropower reservoirs more than in tanks; it has no irrigation tank cascades. Khecheopalri (Khachoedpalri) lake became the State's first Ramsar site in February 2025 (as reported; its area is given in figures that conflict, and none is used here), and Khecheopalri, Tamze, Tembao, Phedang, Guru Dongmar and Tsomgo were placed in the National Wetland

Conservation Programme (as reported); the State is said to hold "534 wetlands covering 7,477 ha" (as reported, from a summary). No notification constituting a State Wetland Authority and no wetland notified under rule 4 of the Wetlands (Conservation and Management) Rules, 2017 were found, and the River Rejuvenation Committee of the Forest and Environment Department is "the Nodal Agency for all water bodies" (Order No. 205/GOS/F&ED/SECY, 21 January 2021). The glacial lakes are not storage: there are 320 of them, Bhalay Pokhari and Doodh Pokhari among them despite their names (project proposal for the Lhonak valley, 2026), and they are hazard sources under Clause 2.3.6(i) and Chapter 7, to which no storage credit or tank clause applies. The hydropower reservoirs are operated for power, their levels are not published, and the flood of 2023 filled reaches of the Teesta with sediment, raising its bed by about 7.44 m at the Teesta Low Dam IV project and 6.00 m at Teesta-V (NHPC's estimates, in the same proposal). No survey of the storage of any pokhari, of any floodplain of the Teesta, Rangit or Rongni Chu inside a municipal area, or of the benches on which the ridge towns are built, was found.

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## 11.7 Modelling and scenarios

11.7.1 **Model.** Each BSMP shall use a coupled 1D–2D hydraulic model of:

- the minor system;
- the major (overland) system;
- rivers, canals and tanks; and
- the outfalls.

Methods shall follow Chapter 3. Tidal and river boundaries shall follow Chapter 5.

11.7.2 **Design storms.** The model shall be run for the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs. Areal reduction shall be applied under Clause 2.7.3.

11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms arrive, and how often heavy rain coincides with a closed outfall. The two-step approach of Clause 3.13.5 may be used: a simplified storage model is run for the whole record, and the coupled 1D–2D model of Clause 11.7.1 is run only for the design storms, starting from the tank levels the continuous run gives. A continuous run of the full 1D–2D model is not required.

11.7.4 **Scenarios.** Each BSMP shall model at least:

- (a) **Existing:** existing land use, network, tanks and outfalls;
- (b) **Future, uncontrolled:** future land use under the statutory master plan, with no site controls;
- (c) **Future, controlled:** future land use with the site controls of Chapter 4;
- (d) **Future, with plan:** scenario (c) plus the works of the CIP; and
- (e) **Climate:** scenarios (a) and (d), with the climate factors of Clause 2.8, used unchanged: no projection of heavy rainfall for Sikkim has been adopted with a design factor, and the Sikkim State Action Plan on Climate Change and NIH-DHAARA's projected depths were not read [TBC]; the trends are mixed, most indices of extreme precipitation over Sikkim having fallen over 1950–2018 while the count of days above 10 mm rose and the one- to five-day maxima changed mainly in the west and north (Dubey et al., 2022, as summarised), and June–September precipitation over the South Lhonak catchment rising by 8.6 mm a decade in ERA5 (Sattar et al., 2025), so the case for the factors rests on the record storms and the cascade risk, not on trend statistics; and in sub-areas SK-B1 and SK-C, and on the Teesta valley floor, the hazard screening of Clause 11.3.3 is made in every scenario.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the 9 June 1997 (Gangtok's 223.8 mm in 24 hours, in a June whose 1,281.3 mm is the station's highest monthly total, IMD, with the Gangtok landslides of that month, for which a single unofficial source gives 38 deaths, as reported), 25 September 2005 (212.5 mm at Tadong, its record, and 141.0 mm at Gangtok on the same day, IMD, at stations 4–5 km apart; no flood record of the day was found [TBC]) and 12–13 June 2024 (the rain and landslides of Mangan district, with 6 deaths reported at first and 9 in a later account, the Sangkalang bridge lost and tourists stranded at Lachung, and about 250 mm over the State in 1–13 June, all as reported; no IMD station rainfall for the event was found [TBC]) events where data exist.

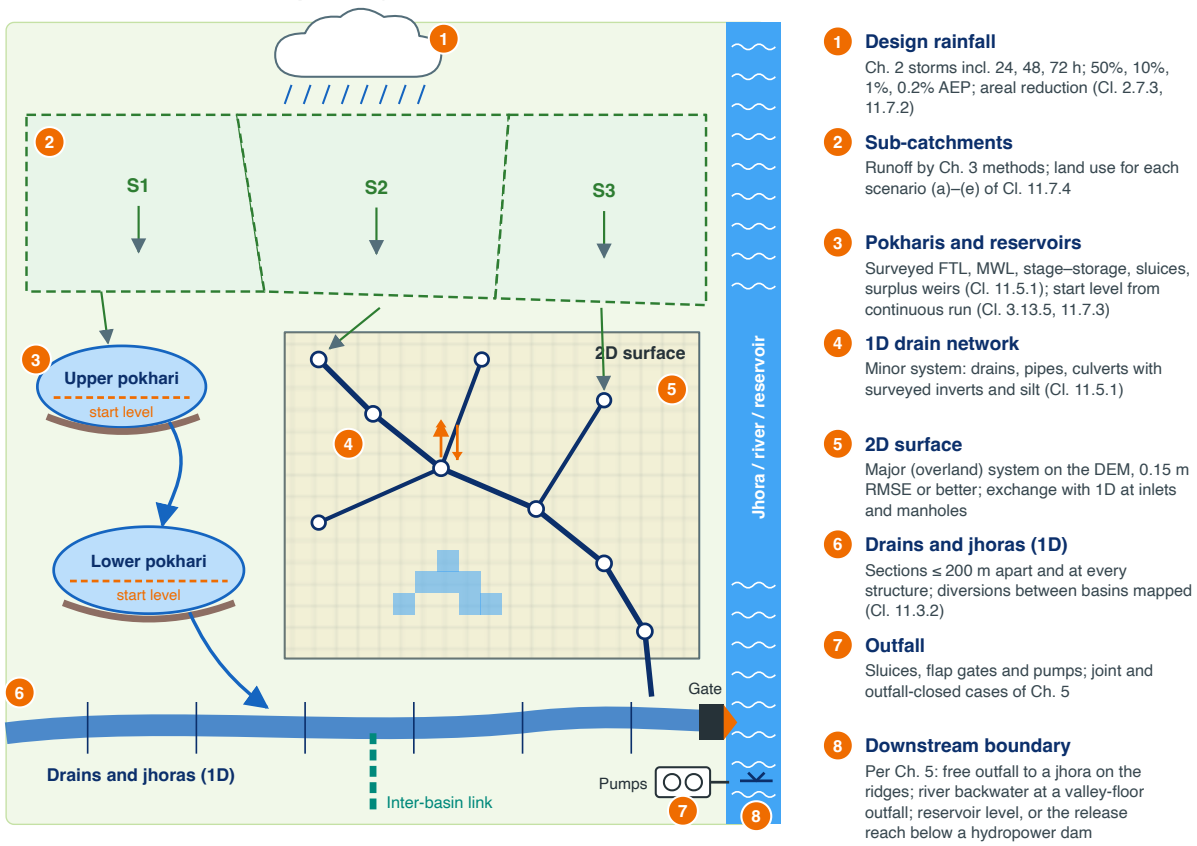


*Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and pokharis with starting levels from continuous simulation, and the tidal or river boundary at the outfall (schematic, not to scale). Original drawing for this Manual, adapted from common coupled 1D–2D urban flood modelling practice.*

> **Commentary.** Scenario (b) against scenario (c) shows what the site rules achieve on their own. Scenario (d) shows what the public works add. This comparison is also the evidence base for notifying flood-sensitive catchments (Clause 4.5.4) and for setting a stricter basin release rate (Clause 11.8.3).

## 11.8 Options, outputs and the Capital Improvement Programme

11.8.1 **Options hierarchy.** Options shall be considered in the following order, the basin-scale form of the hierarchy in Clause 1.2:

1. **Protect and restore storage:** pokharis, tanks, marshes and floodplains, including desilting to the original bed and recovering encroached area (Chapter 7);
2. **Regional retention and detention**, sited by modelling so that releases do not coincide with the main-stem peak (Clause 4.13);
3. **Conveyance** upgrades to drains, canals and culverts;
4. **Outfall works:** flap gates and penstocks on the outfalls of the valley-floor towns, Singtam, Rangpo, Melli, Majitar and Jorethang among them, to the Teesta, the Rangit and the Rongni Chu, with storage or pumping behind them where a river in flood can close an outfall, and outfall inverts reset above the river bed surveyed after October 2023; drop structures, chutes, energy dissipators and protected outfalls where the drains of the ridge towns reach a jhora, never an outfall onto an unprotected slope, and the training of the receiving jhoras to the standard of Clause 6.3.6(m) down to the next confluence or trained reach; debris racks, debris basins and silt traps where jhoras enter culverts and towns, with ramps for the machines that empty them, and the removal of spoil, garbage and slide debris from the jhoras; the interception and screening of dry-weather flow, and the separation of sewage, before the outfalls to a jhora that feeds a dhara, a pokhari or an intake and to the Rani Khola, the Roro Chu, the Rongni Chu and the Teesta within a town (Chapter 8, Clause 8.9); and the reservoir levels and release rules of the hydropower dams that set the receiving levels, obtained in writing from their operators;
5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example IMD district rainfall warnings and nowcasts issued by the Meteorological Centre Gangtok, CWC level monitoring on the Teesta and its tributaries, early-warning systems for the 40 high-risk glacial lakes, which the High Court has urged the State and the Union to install (as reported), with the GLOF evacuation maps prepared with SSDMA's participatory risk assessments of May 2024, warnings of releases by the hydropower operators, which no published rule was found to require [TBC], and level sensors with alarms at the main jhora and river outfalls of the towns, which none has today), flood-hazard zoning, emergency planning and public information.

11.8.2 **Option assessment.** Each option shall be assessed for:

- reduction in flood risk (buildings and people flooded; expected annual damage);
- capital and 30-year maintenance cost;
- land required;
- effect on the springs (dhara) on which most rural households and many town households depend, about 80% of rural Sikkim by one account (as reported), and their recharge areas above the intakes, which this Manual keeps free of paving and of infiltrated road runoff (the spring rule of Clause 8.8.1), the stability of hill slopes, where water put into colluvium, fill or slide debris raises the pore pressure and the stability zones of 2021 already treat "Wet", "Dripping" and "Flowing" ground as signs of instability, recharge on the tested river-terrace gravels of sub-area SK-A and the stable benches of stability zone 1, the only ground where it is allowed (Clause 4.11, recharge rule), and the quality of the springs, jhoras, rivers and pokharis that the runoff reaches (Chapter 8);
- effect on downstream basins and the receiving jhora, khola, river, reservoir or pokhari; and
- who benefits.

11.8.3 **Basin release rates.** Where scenario (c) does not meet the level of service, the BSMP may set a basin-specific **permissible site discharge** ($m^3/s/ha$) stricter than Chapter 4, by AEP and sub-catchment. The rate takes effect under the notification procedure of Clause 4.5.4.

11.8.4 **Outputs.** Each BSMP shall produce:

- (a) flood hazard maps (extent, depth, velocity, hazard class) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan. The **1% AEP future-with-plan map** becomes the reference map for floor levels (Chapter 6) and setbacks (Chapter 7);

- (b) recommended flood-sensitive catchments and any basin release rates (Clauses 4.5.4 and 11.8.3);
- (c) regional facility sites, with storage volumes, land needs and the sites they serve;
- (d) the fee-in-lieu unit rate for the basin (Clause 4.13.3);
- (e) the **Capital Improvement Programme**: works ranked by risk reduction per rupee, with cost, phasing and agency;
- (f) a pre-monsoon **maintenance programme**: desilting, gate and pump testing, and tank operating rules (Chapter 10); and
- (g) monitoring needs: new rain gauges, level sensors and flood-mark survey points.

Commentary. Restoring and adding storage comes first because no Sikkim document states a drainage design basis and the projects that exist convey: GSCDL's "Construction of drainage and jhora training works" in Gangtok (as reported) and the stormwater drains of about 60 km of roads in seven towns under SIUDP (ADB, December 2024). This Manual differs, for three reasons, and does not criticise the projects, which were scoped as works. First, every litre sent faster down a jhora arrives sooner, with more energy and more debris, on a slope that the stability zones of 2021 already treat as unstable when its jhora is "Untrained" or "erosional", with "Gully erosion & collapse of jhora facing slope" (Notification No. 17/DMG/20-21). Second, the jhoras end in a Teesta whose bed rose by "an average of 7-8 meters" in 2023 and whose valley-floor towns, Singtam, Rangpo and Melli among them, receive everything the ridge towns send. Third, the Municipality must already provide an outfall that does not cause "any nuisance … by flooding … any area surrounding the outfall" (Sikkim Municipalities Act, 2007, s.187), which makes the downstream effect a municipal duty. So the Manual requires on-site detention and keeps the pokharis, wetlands and flat benches as storage first (Chapters 4, 7 and 11). On the slopes storage means a lined tank or a shallow terrace, never a pond that soaks into the ground (Clause 4.11, hill rule), and on the valley floors a lined store checked for flotation (Clause 4.11, valley-floor rule); the rainwater storage of at least 25 litres per m² of roof that Clause 4.11 sets, where no rule requires rainwater harvesting in a private building, is the first of it, and it also serves the dry months, when springs fail. Where a project's terms govern, the designer states on the submittal which governs; this Manual does not override a contract. The storms are large for drains with no stated design basis: 310.3 mm in 24 hours at Gangtok on 30 May 1975 (IMD) and 504.2 mm at Singhik on 12 May 1981 (CWC Flood Estimation Report for subzone 2(a)). Conveyance upgrades on their own move water faster to an outfall that the Teesta, the Rangit or the Rongni Chu in flood, or a hydropower reservoir held near its full level, may close, to a jhora whose bed and banks shift with the boulders, spoil and slide debris it carries and whose slopes the stability zones already treat as unstable when it is untrained, or to a valley floor that receives everything the ridge towns send. Groundwater in Sikkim calls for storage and restraint, not recharge. The State has no plains aquifer: groundwater lies "largely in disconnected localized pockets and in deeper fracture zones", "springs are the main source", and on steep ground it emerges "as seepages and springs wherever the land surface intersects local ground water body" (CGWB, as quoted); no CGWB figure for depth to water or extraction was read [TBC]. The springs matter more than the wells: "about 80%" of rural Sikkim depends on them and "half of the perennial springs have already dried up or have become seasonal" (as reported); RMDD's Dhara Vikas programme, begun in 2008 (2010 in one source; a conflict), is reported to have mapped 704 springs for rejuvenation by one account and "more than 2000 springs" on a GIS platform by an RMDD presentation of 2018 (both as reported; the counts conflict), and an assessment by IISc is reported to have found a "15% enhancement in the spring discharge" (as reported). Water put into the ground can also do harm: GSCDL told the National Green Tribunal that "landslides are caused mainly due to loose soil by spring water generated at natural Jhora" (reply affidavit in O.A. No. 38 of 2022), and the stability zones of 2021 record the ground of zones 3 to 6 as "Wet", "Dripping" or "Flowing". No State groundwater Act and no spring-protection law or order was found. This is why springs and their recharge areas, slope stability, recharge only on the ground that can take it, and the quality of the springs and jhoras are all assessment criteria. This Manual ranks projects by risk reduction per rupee so that limited budgets go first where most people are protected.

## 11.9 Integration with land-use planning

11.9.1 An approved BSMP shall be incorporated into the statutory land-use plan: the development plans, regional plans and perspective plans of the Sikkim Town and Country Planning Act, 2024, once it commences (enacted in 2024 and amended in 2025, not yet commenced; no plan, Board or authority under it exists), with any master plan prepared under an earlier law, which that Act deems a perspective plan; until then, the GIS-based master plans for which UDD has sought proposals, for the Namchi Planning Area and, under SIUDP, for four towns other than Gangtok, if UDD takes the BSMP into them; the master plan or area plan to which the Sikkim Building Construction Regulations, 1991 refer setbacks and plot sizes (regs. 18 and 33); and the layouts and buildings permitted under them. In particular:

- (a) regional facility sites, restored tank flood storage, and major flow paths shall be **reserved** in the plan;
- (b) the 1% AEP hazard map shall be shown, and Chapter 7 setbacks applied to it;
- (c) land in hazard classes H5–H6 in the 1% AEP event shall not be zoned for new habitable development; and
- (d) the open space of layouts within a basin should be located, where possible, to form part of the major flow paths or regional storage shown in the BSMP.

11.9.2 Where a land-use plan is revised before a BSMP is approved, the planning authority shall use the best available flood mapping and record the BSMP as pending.

> Commentary. Sikkim draws one water line in statute, and it is a maximum. For the 103 scheduled rivers the river bank is "an area of sixty metres on either side of such river or area within high flood level mark, whichever is less" (Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988, s.29(1)), under the Forest Department "as if it were a forest" since 2000 (s.29(9)), with its occupation an offence (s.30); "whichever is less" makes it a maximum, not a minimum (this Manual's reading), so on an incised reach the high flood level line may lie a few metres from the channel, and after October 2023 the high flood level itself has moved. The Act counts a jhora as a river (s.2(m)), but the sixty metres apply only to the Schedule. No statutory line exists beside a jhora: the Sikkim Building Construction Regulations, 1991 set setbacks from the road only (reg. 18), and the stability zones of 2021 ask for jhora training "with safe distance" without defining it; the Sikkim Municipalities Act, 2007 makes the Municipality "protect any jhora, whether on a public land or on a private land" (s.172(2)) and lets the State "specify the limits of any jhora, watercourse or channel within a municipal area" by notification (s.173), and no such notification was found. No floodplain zoning law, notified flood line or post-flood setback from the Teesta was found; the project proposal for the Lhonak valley suggests "High-risk Zoning" of floodplains below glacial lakes, as a proposal (2026); and the Sikkim Town and Country Planning Act, 2024 would require development plans with "proposals for flood control, land stability and sloped linked controls", but has not commenced. Where a statutory line binds it applies; elsewhere the hydraulic corridor and setback zones of Chapter 7, with a Zone 1 of at least 15 m from the top of bank on every channel draining 8 ha or more, measured from the crest of the bank slope on an incised jhora or khola steeper than 10°, and a Zone 2 of the 1% AEP extent plus 10 m, whichever is wider, apply as this Manual's proposal, to new development and redevelopment approved under the Manual, with Zone 1 land that is private secured by agreement or donation, or reserved in a development plan once the 2024 Act commences, and never taken. A BSMP gives the development plans that the 2024 Act would require, and UDD's GIS-based master plans in the meantime, the 1% AEP drainage-flood map, the GLOF corridors and the valley floor of 2023 as a separate layer, and the buffer widths of Chapter 7 that they need. Using open space land as storage or flow path has no direct precedent; this Manual adopts it because the Sikkim Building Construction Regulations, 1991 already require setbacks and an open area round each building (reg. 18), a pucca storm-water or plinth drain leading to the road drain or a jhora (reg. 25(iv)) and plans that show the drainage and its connection to the main outlet (reg. 6), and the review conditions of the stability zones of 2021 ask for catchment drains that carry surface runoff to "natural waterways/Jhora", but no rule sets a detention or peak-runoff limit or reserves open space for water; storage placed in a layout's open space builds on these duties, and because that land still serves as open space, the storage must stay usable as one, and on a hill slope, in

> stability zones 3 to 6 or on a valley floor below the 1% AEP flood level it is a lined tank or a shallow terrace, never an infiltration basin (Clause 4.11). Placing it on the flow path costs the developer nothing extra and gives the basin storage it would otherwise have to buy.

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## 11.10 Consultation and publication

11.10.1 A draft BSMP shall be published for public comment for at least **60 days**, with public meetings in each affected local body.

11.10.2 After approval, the following shall be published as open data:

- the model files;
- the flood hazard maps;
- the data of Clause 11.5.1, except security-sensitive asset details; and
- the CIP.

They shall also be shown on a public map viewer.

> Commentary. Publishing the maps lets buyers, lenders, insurers and residents see flood hazard before they build or buy. Publishing the model lets designers use the same boundary conditions as the Authority, so site designs and the basin plan stay consistent. This matches the publication approach of Chapter 10.

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## 11.11 Approval, review and reporting

11.11.1 **Approval.** BSMPs shall be approved by the State Stormwater Technical Committee (Chapter 1), after review of the model and of the public comments.

11.11.2 **Review.** Each BSMP shall be reviewed:

- every **10 years**;
- within **2 years** of an event exceeding the 1% AEP design depth in the basin (Clause 2.14); and
- when the statutory land-use plan is revised.

11.11.3 **Annual report.** The Lead Authority shall publish an annual implementation report before each monsoon (by 31 March). The report shall show:

- CIP progress;
- the fee-in-lieu ledger (Clause 4.13.4);
- maintenance completed; and
- any flooding against the levels of service.

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## 11.12 Interim arrangements

11.12.1 Until a BSMP is approved for a basin:

- (a) all site criteria of Chapters 4 to 8 apply in full;

- (b) regional detention and fee-in-lieu under Clause 4.13 are not available, except the holding of fees under Clause 4.5.6.3;
- (c) floor levels and setbacks use the best available mapping, and the methods of Chapters 6 and 7 where no mapping exists; and
- (d) public drain projects shall include a basin-level check that their outfall and downstream reaches can take the design flow under the Chapter 5 tailwater cases.

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## References (chapter)


- *Sikkim Town and Country Planning Act, 2024* (Act 10 of 2024; Sikkim Government Gazette Extraordinary No. 317, 15 June 2024), as amended by Act 24 of 2025 (Gazette Extraordinary No. 13, 17 January 2026): development, regional and perspective plans; s.1(3) (commencement on a notified date; none found). https://prsindia.org/files/bills_acts/acts_states/sikkim/2024/Act10of2024SK.pdf
- *Sikkim Municipalities Act, 2007* (Act 5 of 2007), as amended to Act 3 of 2026: ss.172, 173, 187, 189, 193 and Chapter XXX. https://prsindia.org/files/bills_acts/acts_states/sikkim/2007/2007SK5.pdf
- *Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988* (Act 6 of 1988), as amended by Act 8 of 2000: ss.2(m), 29, 30 and 32, and the Schedule of rivers. https://prsindia.org/files/bills_acts/acts_states/sikkim/1988/1988SK6.pdf
- Government of Sikkim. Additional affidavit of 28 February 2026 in O.A. No. 171 of 2023 (EZ) before the National Green Tribunal, with the project proposal *GLOF Risk Mitigation in Lhonak Valley, Sikkim* (Science and Technology Department), the summary of the post-disaster needs assessment of 2023 and the Home Department's notifications Nos. 72/Home/2024 and 73/Home/2024 of 11 September 2024 and No. 10/Home/2025 of 7 February 2025. https://www.greentribunal.gov.in/
- Comptroller and Auditor General of India. *Report No. 3 of 2016* (Economic Sector, Government of Sikkim), Chapter II, performance audit of JNNURM, para 2.3.9.2 (Gangtok City Development Plan, 2006). https://www.cag.gov.in/uploads/download_audit_report/2017/Chapter_2_Economic_Sector_Sikkim_Report_No_3_of_2016.pdf
- Asian Development Bank. *Sikkim Integrated Urban Development Project* (57230-001), due-diligence report, December 2024 (outputs: road and stormwater drains in seven towns; urban infrastructure master plans for four towns; State climate change cell). https://www.adb.org/sites/default/files/project-documents/57230/57230-001-sddr-en.pdf
- Government of Sikkim, Urban Development Department. "Urban scenario" web page (request for proposal for a GIS-based master plan for the Namchi Planning Area). https://www.sikkim.gov.in/departments/urban-dev-housing-department/urban-scenario
- Sattar, A. et al. (2025). The Sikkim flood of October 2023: drivers, causes and impacts of a multihazard cascade. *Science*, doi:10.1126/science.ads2659 (accepted manuscript).
- Defra (2010). *Surface Water Management Plan Technical Guidance*. Department for Environment, Food and Rural Affairs, London.
- Mile High Flood District (Denver). Master planning programme and Urban Storm Drainage Criteria Manual.
- Mid-America Regional Council (2025). APWA Stormwater Standards Supplement; KC Metro APWA Section 5600, Version 2025.01.
- Department of Irrigation and Drainage Malaysia (2012). *Urban Stormwater Management Manual for Malaysia (MSMA)*, 2nd ed.
- Government of Sikkim, Department of Mines and Geology. Notification No. 17/DMG/20-21 of 19 March 2021 (Gazette Extraordinary No. 86, 6 April 2021): site stability zonation parameters; and *Sikkim Building Construction Regulations, 1991* (as amended), regs. 18, 25 and 33.
- Government of Sikkim, Forest and Environment Department. Order No. 205/GOS/F&ED/SECY of 21 January 2021 (River Rejuvenation Committee as the nodal agency for all water bodies), as recited in the State's filings before the National Green Tribunal.
- Government of Sikkim. Affidavit of 19 December 2025 in E.A. No. 35 of 2023 in O.A. No. 673 of 2018 before the National Green Tribunal, with the monthly progress report of September 2025 (sewer zones; treatment plants); six-monthly report in O.A. No. 606 of 2018; and GSCDL's reply affidavit in O.A. No. 38 of 2022 (EZ). https://www.greentribunal.gov.in/
- Central Ground Water Board. Aquifer mapping and State assessment reports for Sikkim (as quoted; not read in full).
- India Meteorological Department. *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)*: Gangtok (42299) and Tadong (22209); Central Water Commission (1991), *Flood Estimation Report for North Brahmaputra Subzone 2(a)*, Report No. NB/18/1991, Table 7.

- Dubey et al. (2022). Variability of precipitation extremes and drought intensity over the Sikkim State, India, during 1950–2018 (as summarised).
- South Asia Network on Dams, Rivers and People. Transcriptions of CWC site data for the Teesta basin (secondary source).
- India Water Portal, Scroll, The Wire, Sikkim Express, ThePrint and other news and web sources (2018–2026). Reports of the Dhara Vikas programme and the spring counts, Khecheopalri's designation as a Ramsar site, the wetland programme, the Sikkim Strategic Plan, GSCDL's jhora-training works, the storm of October 1968 and the events of 1997, 2024 and 2025 (secondary sources).

## Annexes and forms

| Annex / Form | Content |
|---|---|
| 11A | BSMP terms of reference template |
| 11B | Basin lists and boundaries for Tier A bodies |
| 11C | Depth–damage curves for Sikkim building types |
| 11D | BSMP data and model publication standard |
| Form 11-1 | Annual implementation report |

ANNEXES TO CHAPTER 1

# Policy, Applicability and Adoption

These annexes support Chapter 1. They hold the lists and maps that define where the Manual applies, the model text of the Policy Supplement and of the legal instruments that would give the Manual effect, and the two forms an Applicant files under Chapter 1. The Manual is a draft; it is not adopted by any government or agency: model legal text is offered for consideration by a competent authority and is not in force, and the forms are draft forms. An annex marked "To be prepared" states the data it needs and the rule to use until it is published (Clause 1.11.5).

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## Annex 1A — List of Tier A authorities, with the boundary of the Gangtok Municipal Corporation and, once a development plan is published under the Sikkim Town and Country Planning Act, 2024 (not yet commenced), the boundary of its planning area

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

1A.1 Clause 1.6.1 defines Tier A by class of authority. Table 1A.1 sets out the classes, and the authorities named in the clause, as Chapter 1 defines them. Every authority not in Table 1A.1 is Tier B (Clause 1.6.2).

**Table 1A.1 — Tier A authorities as defined in Clause 1.6.1**

| Item | Tier A authority | Clause |
|---|---|---|
| (a) | The Gangtok Municipal Corporation (GMC), for its whole area | 1.6.1(a) |
| (b) | Once a development plan under the Sikkim Town and Country Planning Act, 2024 (enacted in 2024 and amended in 2025, not yet commenced) is published for a planning area, every approving authority within that planning area, whichever has jurisdiction over a site (no such plan has been published) | 1.6.1(b) |
| — | A Tier B authority that opts into Tier A by council resolution, or that the Government notifies as Tier A | 1.6.4 |

1A.2 Whatever the tier, the design-aid route and the alternatives of Clause 1.7 are not available in a flood-sensitive catchment (Clause 1.6.5; Annex 1B).

**To be prepared.** This annex will contain the full list, by name, of every Approving Authority within the area of the Gangtok Municipal Corporation and, once a development plan is published under the Sikkim Town and Country Planning Act, 2024, within its planning area, with the date from which each is Tier A, and the boundaries of those areas as a map and as a GIS layer. It needs the limits of the Gangtok Municipal Corporation, whose wards rose from 19 to 21 by Ordinance 5 of 2026, and of the other urban local bodies, which the State counted as seven in its affidavit before the NGT of 19.12.2025 and the Urban Development Department as nine in its Notification No. 06/UDD/2026 of 23.04.2026 (a conflict; UDD); the list of notified areas to which the SBCR 1991 extend, and how plan approval in them is split between UDD and the urban local bodies outside Gangtok [TBC] (UDD); any development plan once the 2024 Act commences; and the district and sub-division boundaries (Land Revenue and Disaster Management Department, Survey of India). Until it is published, the tier is decided by the classes in Clause 1.6.1 and recorded on Form 1-1, and the Authority confirms it at the pre-application stage (Clause 1.5.9).

Table 1A.2 — Register of Tier A authorities (layout)

| No. | Authority | Class (Municipal Corporation / Municipal Council / Nagar Panchayat / UDD in a notified area outside an urban local body / other) | District | Basis (Clause 1.6.1(a), (b), (c) or 1.6.4) | Tier A from (date) | Notification or resolution reference |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

1A.3 The GMC and development-plan area boundary map shall be published as open data in a machine-readable format (Clause 10.17.4), with the date of the notification it shows.

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## Annex 1B — Maps of flood-sensitive catchments

Supports Clauses 1.4, 1.6.5 and 1.10.3(d) of Chapter 1, and Clauses 4.5.3 and 4.5.4 of Chapter 4.

1B.1 The flood-sensitive catchments are listed in Clause 4.5.3.2. Table 1B.1 repeats that list. The maps of this annex and the boundaries of Annex 4A are the same data set and shall be issued together.

Table 1B.1 — Flood-sensitive catchments listed in Clause 4.5.3.2

| Item | Catchment | Extent as described in Chapter 4 |
|---|---|---|
| (a) | Gangtok's jhoras to the Rani Khola and the Roro Chu | The catchments of the jhoras of Gangtok, with Tadong and Ranipool, that drain to the Rani Khola and the Roro Chu, including the named jhoras of the city's waterbody network (as reported) and the slide-prone wards above them [TBC] |
| (b) | The Teesta valley floor in the October 2023 corridor | The land of Chungthang, Dikchu, Singtam, Rangpo and Melli, with Toong Naga, that drains to the Teesta at or below the level of the flood of October 2023 and of the river bed it raised, and every jhora and side stream that falls to that land |
| (c) | The Rangit at Jorethang and Majitar | The land of Jorethang (Nayabazar-Jorethang) and Majitar that drains to the Rangit |
| (d) | The Rongni Chu at Ranipool and Singtam | The land of Ranipool and Singtam that drains to the Rongni Chu, above its confluence with the Teesta |
| (e) | Mangan town and the slopes of the North Sikkim road | The land of Mangan town and the catchments of the jhoras that cross the North Sikkim road in Mangan district, where the rain and landslides of June 2024 struck |
| (f) | Lachen and Chaten, and every catchment below a high-risk glacial lake | The land of Lachen and of Chaten, where the landslide of 1 June 2025 struck, and every catchment that drains from a glacial lake listed as high-risk or very high-risk, down to its confluence with the Teesta |
| (g) | The hydropower reservoirs and release reaches | The land that drains to the reservoirs of Teesta-III (once restored), Teesta-V, Teesta-VI, the Teesta Low Dam III and IV projects, Chuzachen, Dikchu, Jorethang, Tashiding, Rongnichu and Rangit-III, below or near their starting levels of Clause 3.12.5, and the land along the reaches below their dams |
| (h) | The NH-10 corridor along the Teesta | The land that drains to NH-10 and its drains where the highway runs along the Teesta |
| (i) | Namchi | The land of the Namchi Municipal Council area and of its jhoras |
| (j) | Soreng | The land of the Soreng Nagar Panchayat area and of its jhoras |
| (k) | Notified catchments | Any catchment notified under Clause 4.5.4 |

**To be prepared.** This annex will contain a map of each catchment in Table 1B.1 at a scale fit for deciding whether a plot lies inside it, and the same boundaries as a GIS layer. It needs catchment boundaries drawn from a digital elevation model and the drain and jhora network, with the drain and jhora register of Table 1.5 (GMC, the other urban local bodies, UDD, Survey of India); the jhoras and drains with their outfalls, the dry-weather interceptions on them and the flap gates where any exist [TBC], with levels on a stated datum (the urban local bodies, PHED); the extent and levels of the flood and aggradation of October 2023 along the Teesta, surveyed after the event (WRD, SSDMA, the District Collectors) [TBC]; the CWC levels at Khanitar, Melli, Singtam and Majitar with their datums, and a level at Rangpo, where none was found (CWC) [TBC]; the stability zones and landslide inventories of the ridge towns and of the North Sikkim road (the Mines and Geology Department, SSDMA, the Geological Survey of India) [TBC]; the glacial-lake lists and GLOF hazard and evacuation maps (the Science and Technology Department, NDMA, SSDMA) [TBC]; and the levels, release records and release reaches of the hydropower reservoirs (the operators) [TBC]. Pakyong, Ravangla, Gyalshing and the other ridge towns are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The corridors of Chapter 7 are governed by Chapter 7 rather than by this list. Until it is published, the Authority decides at the pre-application stage whether a site lies in a listed catchment, from the best boundary available, and the decision and its basis are recorded on Form 1-1 and in the drainage report (Clauses 1.5.9 and 1.11.5).

**Table 1B.2 — Attributes of the flood-sensitive catchment layer (layout)**

| Field | Content | Unit or format |
|---|---|---|
| catchment_id | Unique identifier | text |
| name | Catchment name | text |
| basis | Clause 4.5.3.2 item (a) to (j), or the notification under Clause 4.5.4 | text |
| notification_ref | Gazette notification number, where notified | text |
| notified_on | Date of notification | date |
| applies_from | Date from which the rule applies to applications (Clause 4.5.4.2, step 5) | date |
| boundary_source | Source and date of the boundary | text |
| area_km2 | Catchment area | km² |

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## Annex 1C — Policy Supplement: text of alternatives S-1 to S-5 and model council resolution

Supports Clauses 1.6.3, 1.6.5 and 1.7.1 to 1.7.3 of Chapter 1.

**Model text for consideration by a competent authority. Not in force.** The text below shows how the Policy Supplement of Clause 1.7 could be written. It has no effect unless and until it is issued by the Government and adopted by an Approving Authority under Clause 1.7.3.

## Part 1 — General provisions

P1.1 **Scope.** This Supplement sets out alternatives S-1 to S-5 to the requirements of the Sikkim Stormwater Design Manual (the Manual) named in each alternative. An alternative applies within the area of an Approving Authority (the Authority) only from the date on which the Authority adopts it under P1.3.

P1.2 **No lower criterion.** No alternative lowers any criterion of the Manual. S-1 and S-2 are simplified methods for meeting the same criterion (Clause 1.7.3(a)).

P1.3 **Adoption.**

- (a) A Tier B authority adopts an alternative by council resolution in the form of Part 3, and sends a copy to the State Stormwater Technical Committee (the Committee) within 30 days of the resolution.
- (b) A Tier A authority adopts an alternative only after the Committee has concurred in writing.
- (c) The Authority publishes the alternatives it has adopted on its website and in the register of Clause 10.17.

P1.4 **Retention.** No alternative replaces the retention requirement (Annex 2E depth), except where fee-in-lieu under S-5 funds equivalent retention in the same basin (Clause 1.7.3(d)).

P1.5 **Tables.** The tables used by S-1, S-2 and S-3 are those issued by the Committee, and are reviewed with Chapter 2 of the Manual (Clauses 1.7.3(e) and 2.14). An alternative that depends on a table cannot be used until that table is issued.

P1.6 **Record.** An Applicant who uses an alternative states it on Form 1-1 and in the drainage report, with the resolution or concurrence under which it was adopted.

## Part 2 — The alternatives

### S-1 — Design-aid route for storage

S-1.1 *Replaces:* storage sized by a hydrograph method under Chapter 3.

S-1.2 *Alternative:* retention and detention volumes may be taken from the unit-storage tables issued for Annex 4B (m³ per ha, by rainfall zone, hydrologic soil group and impervious fraction) and the compliance calculator, by the method of Clause 4.14.2.

S-1.3 *Eligibility:* sites of 2 ha or less outside flood-sensitive catchments, and of 0.5 ha or less within them (Table 1.2; Clause 4.14.1).

S-1.4 *Conditions:* the post-development imperviousness used shall be that shown on the approved plans; the outlet, spillway, RWH accounting and safety provisions of Clause 4.14.2 apply; the compliance calculator may be the sole calculation (Table 1.1).

### S-2 — Permissible site discharge (PSD)

S-2.1 *Replaces:* the release rate $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$ computed for the site (Clause 2.11.2).

S-2.2 *Alternative:* the release rate for each AEP may be taken as the tabulated unit-area release rate for the site's zone and AEP, multiplied by the site area. The tabulated rates are derived from the $0.9 \times Q_{pre}$ rule (Table 1.2).

S-2.3 *Eligibility:* any site outside a flood-sensitive catchment.

S-2.4 *Conditions:* storage is then sized to hold every duration of Clause 2.5.2 at the PSD; drawdown, minimum orifice and spillway rules of Chapter 4 apply unchanged.

### S-3 — Fixed-width waterbody setback

S-3.1 *Replaces:* the waterbody setback extended to the mapped 1% AEP flood extent plus margin (Chapter 7).

S-3.2 *Alternative:* where no 1% AEP extent is mapped, the setback shall be the fixed width for the class of waterbody in the table of Clause 7.4.6 (and Annex 7B), measured as in Clause 7.4.3.

S-3.3 *Eligibility:* waterbodies with no mapped 1% AEP extent.

S-3.4 *Conditions:* no setback under this alternative is less than the Zone 1 minimum of Clause 7.4.7 (Clause 1.10.3(c)); the no-fill zone of Chapter 7 applies; where a 1% AEP extent is later mapped and adopted, the mapped setback applies to new applications.

**S-4 — Downstream screening checklist**

S-4.1 *Replaces:* downstream analysis by hydraulic model under Chapter 5.

S-4.2 *Alternative:* the Applicant completes a screening checklist of downstream capacity and known flooding, covering at least the conditions of Clause 5.3.4: that the receiving public drain has documented capacity for its minor-system design flow (Chapter 6), and that no flood-prone location is recorded within 500 m downstream. A hydraulic model under Chapter 5 is required only where the screen fails.

S-4.3 *Eligibility:* sites of less than 1 ha, outside flood-sensitive catchments, not discharging to a tidal outfall.

S-4.4 *Conditions:* the checklist is signed by the registered professional who signs the drainage report (Clause 10.6); flood-prone locations are those recorded by the local body, the District Collector and the District Disaster Management Authority, SSDMA, the Water Resources Department (WRD) or the Mines and Geology Department (Clause 5.3.3(d)).

**S-5 — Fee-in-lieu toward regional storage**

S-5.1 *Replaces:* on-site detention under Chapter 4.

S-5.2 *Alternative:* all or part of the detention requirement may be met by a fee-in-lieu toward a regional detention facility or restored pokhari or tank storage identified in the basin plan (Clause 4.13.1).

S-5.3 *Eligibility:* sites in a basin for which a basin plan has been notified (Table 1.2).

S-5.4 *Conditions:*

- (a) the conditions of Clause 4.13.2 apply, including interim on-site detention until the regional facility or restored tank is operational, and retention and WQv treatment on site;
- (b) the fee is computed under Clause 4.13.3 and held in the ring-fenced basin account;
- (c) the volume credited and the fee are entered in the public ledger of Clause 4.13.4; and
- (d) in a flood-sensitive catchment, fee-in-lieu is available only as allowed by Clause 1.10.3(d).

## Part 3 — Model council resolution

> **Model text for consideration by a competent authority. Not in force.**

**Resolution No. _____ of _____ (name of Municipal Corporation / Municipal Council / Nagar Panchayat), dated _____**

*Subject:* Adoption of alternatives under the Policy Supplement to the Sikkim Stormwater Design Manual.

The Council, having considered the report of the Municipal Commissioner / Chief Municipal Officer dated _____, and noting that:

- (i) the Sikkim Stormwater Design Manual and its Policy Supplement have been given effect by _____ (instrument and date);
- (ii) this local body is a Tier B / Tier A authority under Clause 1.6 of the Manual; and

- (iii) for a Tier A authority, the State Stormwater Technical Committee concurred on _____ (reference _____),

**resolves:**

1. to adopt the following alternatives of the Policy Supplement within its area, under the conditions of Clause 1.7.3 of the Manual:

**Table 1C.1 — Alternatives adopted by this resolution**

| Alternative | Adopted (Yes / No) | Area to which it applies (whole area, or wards / zones) | Applies from (date) |
|---|---|---|---|
| S-1 Design-aid route | | | |
| S-2 Permissible site discharge | | | |
| S-3 Fixed-width setback | | | |
| S-4 Downstream screening checklist | | | |
| S-5 Fee-in-lieu | | | |

2. that no adopted alternative shall apply within a flood-sensitive catchment except as the Manual allows (Clause 1.6.5);
3. that a copy of this resolution be sent to the State Stormwater Technical Committee within 30 days;
4. that the adopted alternatives be published on the local body's website and entered in the register of Clause 10.17; and
5. that this resolution be reviewed when the tables of Clause 1.7.3(e) are revised.

Mayor / Chairperson [TBC]: _____ Municipal Commissioner / Chief Municipal Officer: _____ Date: _____

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## Annex 1D — Model SBCR 1991 amendment and model ULB bye-law

Supports Clauses 1.3.1, 1.3.4, 1.11 and 1.12 of Chapter 1.

> **Model text for consideration by a competent authority. Not in force.** The text shows one way the instruments of Clause 1.3.1 could be drafted. Rule and section numbers are left blank.

> **Drafting note D1D.1.** The rule numbers of the Sikkim Building Construction Regulations, 1991 at which the new rule and the conditions would be inserted, and the enabling sections of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 and the municipal and panchayat Acts, are to be confirmed by the Government's legal advisers. None is stated here.

### Part A — Model amendment to the Sikkim Building Construction Regulations, 1991

A.1 **Short title and commencement.**

- (1) These rules may be called the Sikkim Building Construction (Stormwater Management) (Amendment) Regulations, _____.
- (2) They shall come into force on the date six months after their publication in the Sikkim Government Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building regulations made by the Government under section 7(2) of the Sikkim Allotment of House Sites and Construction of Building (Regulation and Control) Act, 1985 for the notified areas of the State, the following rule shall be inserted:

> **Rule [_____]. Stormwater management.**
>
> (1) *Definitions.* In this rule, "the Manual" means the Sikkim Stormwater Design Manual as notified by the Government, with its annexes and amendments; other words have the meanings given in Clause 1.4 of the Manual.
>
> (2) *Application.* This rule applies to every development for which planning permission, building permit or layout approval is required under these rules.
>
> (3) *Runoff control.* Where a development, over its common plan of development, involves land disturbance of 0.1 ha or more, or new or replaced impervious area of 500 m² or more, the development shall comply with Chapters 4 and 5 of the Manual (retention, detention, downstream and tailwater analysis).
>
> (4) *Provisions for every development.* Every development, whatever its size, shall comply with Clause 1.5.4 of the Manual: no sewage connection to a storm drain; floor levels; waterbody setbacks and the no-fill zone; and no obstruction of a drainage path.
>
> (5) *Exemptions.* A single dwelling on its own plot below the thresholds of sub-rule (3), and linear road resurfacing that adds no impervious area, are exempt from sub-rule (3) but not from sub-rule (4) or the rainwater harvesting provisions of these rules.
>
> (6) *Conditions of approval.* The competent authority shall not grant:
>
> - (a) planning permission or layout approval, unless a preliminary drainage report under the Manual has been accepted;
> - (b) a building permit, or permission to commence, unless the final drainage design has been accepted; or
> - (c) a completion certificate, unless the as-built certificate has been accepted and the maintenance declaration has been registered, or the public assets have been handed over,
>
> for a development to which sub-rule (3) applies (Manual, Clause 10.3).
>
> (7) *Certification.* Drainage reports and designs shall be signed by a registered professional, and, where Clause 10.6.1 of the Manual so requires, by an empanelled Stormwater Design Professional.
>
> (8) *Rainwater harvesting.* Nothing in this rule alters the rainwater harvesting provisions of these rules.
>
> (9) *Variances and waivers.* The competent authority may grant a variance or waiver only on the grounds and by the procedure of Clause 1.10 of the Manual, and shall publish each decision.
>
> (10) *Transition.* Applications filed complete before the commencement of this rule, and Tier B authorities, are governed by Clause 1.11 of the Manual.

## Part B — Model ULB bye-law

B.1 **Title and commencement.** These bye-laws may be called the _____ (name of local body) Stormwater Management Bye-laws, _____. They come into force on _____.

B.2 **Adoption of the Manual.** The Sikkim Stormwater Design Manual, as notified by the Government, applies to:

- (a) every development approved by the local body; and

- (b) every drainage, road, culvert, waterbody and flood-mitigation work executed by the local body, including its own drains and roads (Clause 1.3.1(b)).

B.3 **Public works.** Every detailed project report and contract for a work under B.2(b) shall require compliance with the Manual, from the dates in Clause 1.11 (Clause 1.3.4).

B.4 **Tier and alternatives.** The local body is a Tier _____ authority under Clause 1.6 of the Manual. The alternatives of the Policy Supplement adopted by the local body are listed in the Schedule, with the resolution under which each was adopted.

B.5 **Submittals and review.** Submittals shall be made in the stages of Clause 10.3 of the Manual and reviewed within the periods of Clause 10.7.

B.6 **Maintenance, inspection and enforcement.** Maintenance declarations, inspections, handover of public assets and enforcement shall follow Clauses 10.10 to 10.15 of the Manual.

B.7 **Publication.** The local body shall publish the registers and reports of Clause 10.17 of the Manual.

B.8 **Review.** These bye-laws shall be reviewed whenever the Manual is amended under Clause 1.12.

**Table 1D.1 — Schedule: alternatives adopted (layout)**

| Alternative | Resolution number and date | Committee concurrence (Tier A only) | Applies from | Area |
|---|---|---|---|---|
| | | | | |
| | | | | |

---

## Form 1-1 — Applicability Determination

Supports Clauses 1.5.1 to 1.5.9 and 1.6 of Chapter 1, and Clause 10.3 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Lodged at the pre-application meeting (Stage 0) or with the preliminary drainage report (Stage 1), as Clause 10.3.2 requires.

**Table 1F.1 — Form 1-1: Applicability Determination**

| No. | Item (clause) | Entry |
|---|---|---|
| | **A. Applicant and site** | |
| A1 | Applicant (owner, developer or department) | _____ |
| A2 | Site address and survey numbers | _____ |
| A3 | Site coordinates (latitude, longitude) | _____ |
| A4 | Approving Authority (Clause 1.4) | _____ |
| A5 | Tier of the Authority: A / B (Clause 1.6; Annex 1A) | _____ |
| A6 | Approval sought: planning permission / building permit / layout approval / public work (DPR) | _____ |
| A7 | Type of development: building / layout / sub-division / road / paving / land-use change / other (Clause 1.4) | _____ |
| A8 | Stage at which this form is lodged: Stage 0 / Stage 1 (Clause 10.3) | _____ |
| | **B. Coverage (Clause 1.5.1)** | |
| B1 | Development requiring approval under the Sikkim Building Construction Regulations, 1991 — 1.5.1(a): Yes / No | _____ |
| B2 | Public work by a ULB, State department, board or State undertaking — 1.5.1(b): Yes / No | _____ |
| B3 | Work by a Central agency needing the Authority's approval or no-objection — 1.5.1(c): Yes / No | _____ |
| | **C. Areas over the common plan of development (Clauses 1.4, 1.5.5)** | |
| C1 | Phases, plots and sub-divisions included (one layout approval or one ownership) | _____ |
| C2 | Total site area (ha) | _____ |
| C3 | Land disturbance (ha) | _____ |
| C4 | Existing impervious area (m²) | _____ |
| C5 | New impervious area (m²) | _____ |
| C6 | Replaced impervious area, removed to subgrade and rebuilt (m²) | _____ |
| C7 | New plus replaced impervious area, C5 + C6 (m²) | _____ |
| C8 | Plot area for the RWH mandate (m²) (Clause 1.5.3) | _____ |
| | **D. Thresholds and exemptions** | |
| D1 | Land disturbance 0.1 ha or more — 1.5.2(a): Yes / No | _____ |
| D2 | New or replaced impervious area 500 m² or more — 1.5.2(b): Yes / No | _____ |
| D3 | Redevelopment (existing impervious cover on the site) — 1.5.6: Yes / No | _____ |
| D4 | Constrained redevelopment route of Clause 4.5.6 proposed: Yes / No | _____ |

| No. | Item (clause) | Entry |
|---|---|---|
| D5 | Linear public work: added impervious area per drainage catchment crossed given in Table 1F.2 — 1.5.7: Yes / No / not applicable | _____ |
| D6 | Exemption claimed — 1.5.8(a) single dwelling below the thresholds / 1.5.8(b) resurfacing with no added impervious area / none | _____ |
| D7 | RWH mandate applies (Sikkim Municipalities Act, 2007, s.186: buildings owned or occupied by the State Government, a statutory body or a company or institution owned or controlled by the State Government; the SBCR 1991 and no other rule found require RWH of a private building) — 1.5.3: Yes / No | _____ |
| | **E. Site conditions** | |
| E1 | Site in a flood-sensitive catchment (Annex 1B; Clause 4.5.3): No / Yes — name | _____ |
| E2 | Source of the catchment boundary used | _____ |
| E3 | 1% AEP level mapped or determinable for the site (Clause 1.5.4(b)): Yes / No; source | _____ |
| E4 | Waterbody on or adjoining the site (Clause 1.5.4(c); Chapter 7): No / Yes — name | _____ |
| E5 | Natural drainage path or major-system flow path crossing the site (Clause 1.5.4(d)): No / Yes | _____ |
| E6 | Site drains to a tidal outfall (Clause 10.3.2(d)): Yes / No | _____ |
| E7 | Variance, waiver, regional facility or fee-in-lieu proposed (Clause 10.3.2(c)): No / Yes — Form 1-2 attached | _____ |
| | **F. Determination** | |
| F1 | Result: (i) Chapters 4 and 5 apply, with Clause 1.5.4 and the RWH mandate; (ii) Clause 1.5.4 and the RWH mandate only (below thresholds); (iii) exempt under 1.5.8, Clause 1.5.4 and the RWH mandate still apply | _____ |
| F2 | Stage 0 mandatory under Clause 10.3.2: Yes (state item (a) to (d)) / No | _____ |
| F3 | Storage method: hydrograph method (Chapter 3) / design-aid route S-1 (Clause 1.7, where adopted and eligible) | _____ |
| F4 | Other Policy Supplement alternatives relied on (S-2 to S-5), with the adopting resolution | _____ |
| F5 | Tier B phased start applies (Clause 1.11.3): Yes / No | _____ |
| | **G. Declaration** | |
| G1 | I declare that the information above is correct and covers the whole common plan of development. Applicant: name, signature, date | _____ |
| G2 | Prepared by (registered professional, Clause 1.4): name, registration number, signature, date | _____ |
| | **H. For the Authority (Clause 1.5.9)** | |
| H1 | Determination confirmed / corrected | _____ |
| H2 | Corrections and reasons | _____ |
| H3 | Officer: name, designation, signature, date | _____ |

### Table 1F.2 — Form 1-1: added impervious area by drainage catchment, linear works (Clause 1.5.7)

| Drainage catchment crossed | Chainage from – to | Added impervious area (m²) | 500 m² or more (Yes / No) | Storage location: right of way / regional facility |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## Form 1-2 — Variance / Waiver Request

Supports Clause 1.10 of Chapter 1.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Lodged with the preliminary drainage report (Clause 1.10.4(a)), with one form for each requirement concerned.

**Table 1F.3 — Form 1-2: Variance / Waiver Request**

| No. | Item (clause) | Entry |
|---|---|---|
| | **A. Applicant and site** | |
| A1 | Applicant | _____ |
| A2 | Site address and coordinates | _____ |
| A3 | Form 1-1 reference and date | _____ |
| A4 | Tier of the Authority: A / B | _____ |
| A5 | Site area (ha) | _____ |
| A6 | Site in a flood-sensitive catchment: Yes / No | _____ |
| | **B. Request** | |
| B1 | Type: variance from a numeric requirement (1.10.1) / waiver of Chapter 4 detention (1.10.2) | _____ |
| B2 | Clause of the Manual concerned | _____ |
| B3 | Value required by the Manual | _____ |
| B4 | Value or arrangement proposed | _____ |
| | **C. Matters that cannot be varied or waived (Clause 1.10.3)** — confirm that the request does not concern any of them | |
| C1 | (a) a sewage connection to a storm drain | Not concerned: _____ |
| C2 | (b) the lowest habitable floor level of Chapter 6 | Not concerned: _____ |
| C3 | (c) a waterbody setback below the Zone 1 minimum of Clause 7.4.7, or fill or construction in the no-fill zone of Chapter 7 | Not concerned: _____ |
| C4 | (d) retention in a flood-sensitive catchment, except by fee-in-lieu under Clause 1.7 | Not concerned: _____ |
| | **D. Variance: grounds (Clause 1.10.1(a))** | |
| D1 | Site condition: high groundwater table / contaminated soil / rock / site too small for the required facility / other | _____ |
| D2 | Evidence (tests, surveys, plans), with references | _____ |
| D3 | Options assessed and why each is impracticable | _____ |
| | **E. Variance: equal performance or make-up (Clause 1.10.1(b))** | |
| E1 | Downstream point used (Chapter 5) | _____ |
| E2 | Performance at that point with full compliance and with the variance (peak flows, water levels) | _____ |

| No. | Item (clause) | Entry |
|---|---|---|
| E3 | Or: shortfall made up by fee-in-lieu or off-site works in the same catchment — volume (m³), works or fee | _____ |
| | **F. Waiver of detention: grounds (Clause 1.10.2)** | |
| F1 | Site discharges directly to the sea / to a tidal reach with no flood-prone property downstream | _____ |
| F2 | Analysis showing that undetained flow does not worsen the outfall-closed condition of Chapter 5 — reference | _____ |
| F3 | Retention still provided in full: Yes | _____ |
| | **G. Attachments (Clause 1.10.4(a))** | |
| G1 | Report certified under Clause 10.6 | _____ |
| G2 | Preliminary drainage report | _____ |
| | **H. Certification and declaration** | |
| H1 | Certified by (registered professional; empanelled professional where Clause 10.6.1 applies): name, registration or empanelment number, signature, date | _____ |
| H2 | Applicant: name, signature, date | _____ |
| | **I. For the Authority (Clause 1.10.4)** | |
| I1 | Referred to the State Stormwater Technical Committee (Tier B, site 1 ha or more): Yes / No; date | _____ |
| I2 | Decision: granted / granted with conditions / refused | _____ |
| I3 | Reasons and conditions | _____ |
| I4 | Entry number in the public register (Clause 10.17) | _____ |
| I5 | Note: a variance runs with the approval and lapses if the approval lapses (Clause 1.10.4(d)) | — |
| I6 | Officer: name, designation, signature, date | _____ |

ANNEXES TO CHAPTER 2

# Design Rainfall and Design Storms

These annexes support Chapter 2. Annexes 2A to 2E will hold the statewide rainfall tables that Chapter 2 refers to: the benchmark checks and zone map, sub-daily ratios, grid-to-point factors, temporal patterns and retention depths. Each needs analysis of NIH-DHAARA and IMD records that has not yet been done for this Manual, so each is marked "To be prepared" and gives its intended layout and the rule to use until it is published (Clause 1.11.5). Form 2-1 is a draft form for the Design Rainfall Sheet that every hydrologic submittal must include (Clause 2.13). The Manual is a draft; it is not adopted by any government or agency.

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## Annex 2A — NIH-DHAARA vs IMD station and IMD gridded checks at benchmark points; zone map

Supports Clauses 2.3.1 to 2.3.5 of Chapter 2.

**To be prepared.** This annex will compare, at benchmark points across the State, the NIH-DHAARA design depths with frequency analyses of long IMD daily station records and of IMD gridded daily data (converted to point values with Annex 2C), for 24 hours and longer and for the AEPs of Table 2.1. It will also contain the map of rainfall zones used by Annexes 2B, 2C and 2E and by the Tier B tables of Chapter 4. It needs NIH-DHAARA values at the benchmark coordinates (NIH), IMD daily and recording-gauge station records and IMD gridded rainfall (IMD), State rain-gauge records (the district network of the Meteorological Centre Gangtok, among them Namchi, Gyalshing, Pakyong and Soreng, whose types and record lengths are to be confirmed, the ordinary rain gauges at Singhik and Dikchu used by the CWC 2(a) report, the gauges at Mangan and Chungthang, the hydro-meteorological gauges of the hydropower projects (Teesta-V, Dikchu, Chuzachen), the India-WRIS station at Lachen and the gauges of the Water Resources Department [TBC]), and district and basin boundaries (Survey of India, WRD). Until it is published, design depths are taken from NIH-DHAARA under Clause 2.3.1, the cross-checks of Clause 2.3.3 are reported on Form 2-1, and the zone of a site is the one agreed with the Authority and recorded on Form 2-1.

**Table 2A.1 — Benchmark comparison of design depths (layout)**

| Benchmark point | IMD station ID | Latitude, longitude | Years of record | Duration (h) | AEP | NIH-DHAARA (mm) | IMD station analysis (mm) | IMD gridded, point value (mm) | NIH-DHAARA / IMD station | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 24 | | | | | | |
| | | | | 48 | | | | | | |
| | | | | 72 | | | | | | |

2A.1 The zone names below are the working names used in the Tier B table template of Chapter 4 (Clause 4.14.2). Their boundaries, and whether further zones are needed, are to be set by the analysis of this annex.

Table 2A.2 — Rainfall zones (layout)

| Zone (working name) | Extent (districts, basins) | Representative stations | Notes |
|---|---|---|---|
| SK-Z1 Southern hills and valleys | The south of the State, from the Teesta, Rangit and Rongni Chu valley floors to the ridges of about 2,500 m, in CWC subzone 2(a), North Brahmaputra, where Plates 8–10 draw contours (Clause 2.3.6(b)); catchments that cross a zone or sub-area line take the higher value | Gangtok (IMD 42299, rainfall 1958–2012) and Tadong (IMD 22209, 1978–2007); the district network of the Meteorological Centre Gangtok (Namchi, Gyalshing, Pakyong, Soreng; types and record lengths [TBC]) | FER 2(a) 50-yr 24-h about 240 mm at Gangtok rising to about 360 mm at Jorethang and Melli, in steep west–east bands (NEER reading, low confidence); 2(a) ratios, 1-h ratio 0.260 (Clause 2.3.6(f)); growth factors and 72/24 factor 1.75 (Clause 2.3.6(d), (e)). NIH-DHAARA reported for comparison only (Clause 2.3.6(m)). Thin brown hill soils and colluvium over the phyllites and schists of the Daling Group and the gneisses of the Higher Himalaya; boulder and gravel terraces on the valley floors |
| SK-Z1 Southern hills and valleys: SK-A Lower valleys (Rangpo–Singtam–Melli–Jorethang) | The Teesta, Rangit and Rongni Chu valley floors and their river terraces below about 1,000 m: Rangpo, Singtam, Melli, Majitar and Jorethang, the valley parts of Namchi and Pakyong districts and the Teesta valley floor from Singtam down to the State border; boundaries [TBC] | None with a long record in the sub-area; Gangtok and Tadong lie in SK-B and do not reach it under Clause 2.3.6(h) | FER 2(a) 2% / 1% AEP 24-h: Singtam and Rangpo 280 / 360 mm, Jorethang 360 / 400 mm, Melli 360 / 440 mm (NEER reading, ±1 contour). NIH-DHAARA 50-yr 24-h 282 mm at Rangpo and 284 mm at Jorethang (comparison only). Valley-floor rule of Clause 4.11; recharge only on tested terrace gravels above the 1% AEP flood level and outside the 2023 aggradation zone. Receiving waters: the Teesta at Singtam, Rangpo and Melli on a bed raised in October 2023 (CWC levels at Khanitar, Melli and Singtam, with the conflict at Melli; none at Rangpo [TBC]); the Rangit at Majitar and Jorethang; the release reaches of Teesta-V, Teesta-VI, the Teesta Low Dam projects and Jorethang. Kalimpong's 419.2 mm (5 October 1968, IMD) is flagged on Form 2-1 for Melli, Rangpo and Jorethang |
| SK-Z1 Southern hills and valleys: SK-B Ridge towns (Gangtok–Pakyong–Namchi–Gyalshing) | The ridges and slopes of about 1,000–2,500 m: Gangtok with Tadong and Ranipool, Pakyong, Namchi, Ravangla, Gyalshing (Geyzing), Pelling and Soreng; two record-check domains, east and west of the Teesta (Clause 2.3.6(h)); boundaries [TBC] | Gangtok (42299), the Meteorological Office at 27°20' N, 88°38' E and 1,765 m (IMD); Tadong (22209) | FER 2(a) 2% / 1% AEP 24-h: Gangtok and Pakyong 240 / 320 mm, raised to 270.3 / 320 mm by Gangtok's record of 310.3 mm (30 May 1975) within 25 km east of the Teesta; Ravangla 280 / 320 mm, Gyalshing 280 / 360 mm, Namchi 320 / 400 mm, Soreng 320 / 400 mm (not read; the higher of Gyalshing and Namchi [TBC]). NIH-DHAARA 50-yr 24-h 195 mm at Gangtok (comparison only). Hill rule of Clause 4.11; stability zones of 2021. Receiving waters: steep jhoras to the Rani Khola, the Roro Chu, the Rongni Chu, the Rangit and the Teesta, with free outfalls (Clause 5.8.5(a)). The Gangtok landslides of June 1997 (as reported) |
| SK-Z2 North Sikkim | The Teesta valley above Dikchu and the land of Mangan district north of it, in subzone 2(a) but north of the plates' last contour, where no contour is drawn (Clause 2.3.6(b)) | Singhik and Dikchu (ordinary rain gauges of the CWC 2(a) report, record lengths [TBC]); Mangan and Chungthang gauges; the Lachen automatic weather station and the India-WRIS Lachen station [TBC] | No CWC value: SK-B1 takes the record floors of Clause 2.3.6(c)(ii), SK-C the plate's last values of Clause 2.3.6(c)(iii). The GLOF corridors of the Teesta, the Lachen Chu and the Lachung Chu, and 40 high-risk glacial lakes (State affidavit before the NGT, 2026), are screened under Clause 2.3.6(i) |

| Zone (working name) | Extent (districts, basins) | Representative stations | Notes |
|---|---|---|---|
| SK-Z2 North Sikkim: SK-B1 Middle Teesta valley (Dikchu–Mangan–Singhik–Chungthang) | The Teesta valley and its slopes from Dikchu to the Lachen–Lachung confluence at Chungthang, below about 2,500 m, including Mangan town. (The research for this Manual put Mangan town in SK-B and Chungthang in SK-C; both are here because no plate contour reaches them and because they share the valley of the Singhik and Dikchu records.) Boundaries [TBC] | Singhik (504.2 mm, 12 May 1981) and Dikchu (400.8 mm, 25 August 1969) (CWC, 2(a), Table 7); hydropower gauges (Teesta-V, Dikchu, Chuzachen) [TBC] | 24-h not less than 464.2 / 504.2 mm at 2% / 1% AEP until a station fit of at least 25 years is made, then not below 360.8 / 400.8 mm (Clause 2.3.6(c)(ii)); probably high. The plate implies 200–240 mm at 50 years; NIH-DHAARA 183 mm at Mangan and 154 mm at Chungthang at 50 years (comparison only). Hill rule of Clause 4.11. Receiving waters: the Teesta in the GLOF corridor, the reservoir of Teesta-V at Dikchu and the site of Teesta-III at Chungthang, under restoration (State affidavit before the NGT, 2026). The June 2024 slides in Mangan district (as reported) |
| SK-Z2 North Sikkim: SK-C High valleys (Lachen–Lachung–Thangu) | The Lachen Chu and Lachung Chu valleys above Chungthang and the land above about 2,500 m, with the army and hydropower camps; seasonal snow, glaciers and the glacial lakes; boundaries [TBC] | Lachen automatic weather station (hourly data of 2023 used by Sattar et al., 2025); India-WRIS Lachen station [TBC] | 24-h not less than 240 / 320 mm at 2% / 1% AEP (Clause 2.3.6(c)(iii)); the Singhik and Dikchu floors do not reach it. NIH-DHAARA 50-yr 24-h 138 mm at Lachen and 121 mm at Lachung (not used). Every cross-drainage structure and outfall of more than 1 km², and every catchment with permanent snow, a glacier or a mapped glacial lake, has a site-specific study with GLOF, landslide-lake and debris-flow screening (Clause 2.3.6(i)). The South Lhonak lake, whose outburst of 3–4 October 2023 began the cascade down the Teesta, and the Chaten landslide near Lachen of 1 June 2025 (as reported) |

## Annex 2B — Sub-daily ratios P(t)/P(24h) by zone: NIH-DHAARA (hourly-based) vs the one-third rule

Supports Clauses 2.6.1 to 2.6.4 of Chapter 2.

**To be prepared.** This annex will tabulate, for each zone of Annex 2A, the ratios of the t-hour to the 24-hour design depth from NIH-DHAARA, which are derived from hourly records, against the ratios implied by IMD Das et al. (2022) and by the one-third rule. It needs NIH-DHAARA depths for each duration at representative points in each zone (NIH), IMD recording-gauge data and the IDF values of Das et al. (2022) (IMD). Until it is published, sub-daily depths are read directly from NIH-DHAARA or an approved station IDF (Clause 2.6.1). Where only daily depths are available, the ratios used are those agreed with the Authority, which in Sikkim are those of Clause 2.3.6(f) in every sub-area of Table 2B.1, the ratios of the CWC report for subzone 2(a), applied to the 24-hour depth of Clause 2.3.6(c) or (d) after the record check of Clause 2.3.6(h), with the 1-hour limit of Clause 2.3.6(g) where a station fit replaces them (Clause 2.6.2), and are recorded on Form 2-1. The one-third rule is not used (Clause 2.6.4).

2B.1 The first row of Table 2B.1 gives the ratios of the one-third rule P(t) = P(24)·(t/24)^(1/3), for comparison only. The 1, 3, 6 and 12 h values are those stated in the commentary to Clause 2.6; the 2 h value is computed from the same formula. The rule shall not be used for design unless this annex confirms it for the zone concerned (Clause 2.6.4).

**Table 2B.1 — Ratios P(t)/P(24h) by zone (layout)**

| Zone | Source | 1 h | 2 h | 3 h | 6 h | 12 h | 24 h |
|---|---|---|---|---|---|---|---|
| All (reference only, not for design) | One-third rule | 0.35 | 0.44 | 0.50 | 0.63 | 0.79 | 1.00 |
| SK-Z1 (SK-A Lower valleys; SK-B Ridge towns) and SK-Z2 (SK-B1 Middle Teesta valley; SK-C High valleys) | CWC FER 2(a), NB/18/1991, §3.1.2, p. 24, 50-yr basis, 12 IMD self-recording rain gauges, none identified in Sikkim (interim design ratios in every sub-area, Clause 2.3.6(f); 2-h value from Fig. 10, equal to logarithmic interpolation; 9 h 0.720, 15 h 0.875, 18 h 0.930). On the 24-h depth of Clause 2.3.6(c) or (d) after Clause 2.3.6(h); 72-h = 24-h × 1.75 (Clause 2.3.6(e)) | 0.260 | 0.37 | 0.457 | 0.615 | 0.805 | 1.00 |
| Every sub-area, every 24-h depth below 2% AEP | Growth factors of Clause 2.3.6(d), set by this Manual: the 50%, 20%, 10% and 4% AEP 24-h depths = the 2% AEP depth after Clause 2.3.6(h) × 0.42, 0.61, 0.73 and 0.89 (upper envelope of the twelve NIH-DHAARA growth curves), with the 4% AEP depth not below Plate 8 where the plate draws one; not ratios of duration | | | | | | |
| SK-B1, 24-h depths | Floor of Clause 2.3.6(c)(ii), set by this Manual: not less than 464.2 mm at 2% AEP and 504.2 mm at 1% AEP (Singhik, CWC, 2(a), Table 7); once a station fit of at least 25 years governs, not below 360.8 mm and 400.8 mm (Dikchu); not ratios of duration | | | | | | |
| SK-C, 24-h depths | Floor of Clause 2.3.6(c)(iii), set by this Manual: not less than 240 mm at 2% AEP and 320 mm at 1% AEP (the Plate 9 and 10 readings at Gangtok carried north); not ratios of duration | | | | | | |
| Every sub-area, where a station fit replaces Clause 2.3.6(f) | 1-hour limit of Clause 2.3.6(g), set by this Manual: 1-h ratio not below 0.26 | | | | | | |
| SK-B: Gangtok cell | NIH-DHAARA, IMDAA, 50-yr (queried 14 Nov 2026; comparison only) | 0.16 | 0.27 | | | 0.76 | 1.00 |
| SK-B: Pakyong cell | NIH-DHAARA, IMDAA, 50-yr (comparison only; the 1-h and 2-h maxima of the twelve cells) | 0.19 | 0.31 | | | 0.78 | 1.00 |
| SK-B1: Mangan cell | NIH-DHAARA, IMDAA, 50-yr (comparison only) | 0.16 | 0.27 | | | 0.74 | 1.00 |
| SK-C: Lachung cell | NIH-DHAARA, IMDAA, 50-yr (comparison only; the lowest 1-h ratio of the twelve cells) | 0.13 | 0.22 | | | 0.70 | 1.00 |

2B.2 Depths from fixed observation windows are converted to true-interval depths with the factors of Clause 2.6.3, repeated in Table 2B.2. They are the standard WMO (Hershfield) values and are not provisional.

**Table 2B.2 — Fixed-interval adjustment factors (Clause 2.6.3)**

| Number of fixed observation intervals in the duration | Factor |
|---|---|
| 1 | 1.13 |
| 2 | 1.04 |
| 3–4 | 1.02 |

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## Annex 2C — Grid-to-point factors

Supports Clauses 2.7.1 and 2.7.4 of Chapter 2.

**To be prepared.** This annex will give the factors that convert grid-average design depths (for example from 0.25° cells) to point depths, by zone, duration and AEP. It needs paired frequency analyses of IMD gridded rainfall and of the IMD and State gauges inside each cell (IMD, the gauges of the Water Resources Department, the hydro-meteorological gauges of the hydropower projects, the India-WRIS station at Lachen and the Lachen automatic weather station [TBC]), the benchmark points of Annex 2A, and a stated method for deriving the factors. Until it is published, design depths are taken as point values from NIH-DHAARA or an approved station IDF (Clauses 2.3.1 and 2.3.2). Grid-average values are not used as design depths unless a conversion agreed with the Authority is recorded on Form 2-1 (Clause 1.11.5).

2C.1 The commentary to Clause 2.7 shows why the factors matter. In Sikkim NIH-DHAARA was queried at thirteen points for this Manual. In the south its reanalysis cells lie within about one contour of the CWC plates, but its Gangtok cell gives 195 mm at 50 years in 24 hours, against the 310.3 mm that IMD's Gangtok gauge recorded on 30 May 1975, and its Mangan cell 183 mm, against the 504.2 mm recorded at Singhik (NIH-DHAARA, queried 14 Nov 2026; IMD, *Extremes*; CWC, 2(a), Table 7). Gauges a few kilometres apart differ widely: on 25 September 2005 Tadong recorded 212.5 mm and Gangtok 141.0 mm (IMD, *Extremes*). Values of this kind are grid- or area-average values and need these factors before any use as point depths; under Clause 2.3.6 NIH-DHAARA is never a design value in Sikkim and is reported for comparison only (Clause 2.3.6(m)).

**Table 2C.1 — Grid-to-point factors (layout)**

| Zone | Grid product and cell size | Duration (h) | AEP | Factor (point / grid) | Stations used | Years of record |
|---|---|---|---|---|---|---|
| | | 24 | | | | |
| | | 48 | | | | |
| | | 72 | | | | |

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## Annex 2D — Sikkim temporal patterns (Huff curves)

Supports Clauses 2.9.3 and 2.9.4 of Chapter 2, and Clause 11.7.3 of Chapter 11.

**To be prepared.** This annex will give dimensionless time-distribution (mass) curves of Sikkim storms, in the form introduced by Huff (1967), by zone, storm-duration class and quartile, at stated probability levels. It needs storm hyetographs from recording gauges and automatic weather stations (IMD, its recording gauges and automatic weather stations in the State under the Meteorological Centre Gangtok, among them Gangtok (42299) and Tadong (22209), the Lachen automatic weather station used by Sattar et al. (2025), and any recording gauges of the hydropower projects, SSDMA and GSCDL, whose hourly archive is a first data request of Clause 2.3.6(a) [TBC]), separated into independent storms by a stated rule, and the Gangtok storm of 30 May 1975 (310.3 mm in 24 hours), the Gangtok storm of 9 June 1997 (223.8 mm), the storm of 25 September 2005 (212.5 mm at Tadong and 141.0 mm at Gangtok), the Singhik storm of 12 May 1981 (504.2 mm), the rain of 12–13 June 2024 over Mangan district and of 30 May–1 June 2025 over north Sikkim, for which no IMD rainfall was found [TBC], and the hourly record of the Lachen automatic weather station for September–October 2023 among them. Until it is published, design storms use the alternating-block pattern of Clause 2.9.1 and the 48- and 72-hour pattern of Clause 2.9.2; for catchments of 25–5,000 km², the CWC Flood Estimation Report curves may be used with a sensitivity run under Clause 2.9.1 (Clause 2.9.4). SCS Type distributions are not used (Clause 2.9.3). For the disaggregation of daily records in continuous simulation (Clause 11.7.3), the method is agreed with the Authority and recorded (Clause 1.11.5).

**Table 2D.1 — Cumulative fraction of storm depth against cumulative fraction of storm time (layout, one table per zone, duration class and quartile)**

| Fraction of storm time | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10% probability curve | 0 | | | | | | | | | | 1.0 |
| 50% probability curve | 0 | | | | | | | | | | 1.0 |
| 90% probability curve | 0 | | | | | | | | | | 1.0 |

2D.1 Each table shall state the zone, the duration class, the quartile (the quarter of the storm in which most rain fell), the number of storms analysed and the period of record.

*Reference:* Huff, F.A. (1967). Time distribution of rainfall in heavy storms. *Water Resources Research* 3(4), 1007–1019.

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## Annex 2E — Retention percentile depths by zone

Supports Clauses 2.8.3 and 2.10.1 to 2.10.2 of Chapter 2, Clause 4.4 of Chapter 4 and Chapter 8.

**To be prepared.** This annex will give, for each zone of Annex 2A, the retention design depth P_R: the 24-hour rainfall depth not exceeded on 90% of days with rain (≥ 2.5 mm) in the long-term record (Clause 2.10.1). It needs long daily records at stations in each zone (IMD, the gauges of the Water Resources Department, the hydro-meteorological gauges of the hydropower projects, the India-WRIS station at Lachen and the Lachen automatic weather station [TBC]) and IMD gridded data with the factors of Annex 2C where stations are sparse. Until it is published, P_R is computed by the definition of Clause 2.10.1 from the long-term daily record of a station agreed with the Authority, by the steps in 2E.1, and recorded on Form 2-1 (Clause 1.11.5).

2E.1 **Computing P_R from a daily record.**

1. Take the daily (24-hour) rainfall series of the station for its full record.

2. Keep only the days with rain of 2.5 mm or more (wet days).
3. Rank the wet-day depths and take the depth not exceeded on 90% of them (the 90th percentile).
4. Do not apply the climate factor (Clause 2.8.3) or the fixed-interval factor; P_R is a statistic of everyday rainfall, not an AEP design depth.
5. Record the station, the period of record, the number of wet days and P_R on Form 2-1.

**Table 2E.1 — Retention depth P_R by zone (layout)**

| Zone | Stations or grid cells used | Period of record | Number of wet days (≥ 2.5 mm) | P_R, 90th percentile (mm) | Issued on |
|---|---|---|---|---|---|
| SK-Z1 Southern hills and valleys | | | | | |
| SK-Z2 North Sikkim | | | | | |

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## Form 2-1 — Design Rainfall Sheet

Supports Clauses 2.3 to 2.13 of Chapter 2, and Clause 10.4.1(d) of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One sheet for each hydrologic submittal. The steps follow Figure 2.3 of Chapter 2.

**Table 2F.1 — Form 2-1: site, source and storms**

| No. | Item (clause) | Entry |
|---|---|---|
| | **A. Site (Clause 2.13, item 1)** | |
| A1 | Project and site | _____ |
| A2 | Site coordinates (latitude, longitude, decimal degrees) | _____ |
| A3 | Rainfall zone (Annex 2A, or as agreed with the Authority) | _____ |
| A4 | Contributing catchment area (km²) (Clause 2.7) | _____ |
| A5 | Design life: more than 25 years / temporary works, 5 years or less (Clause 2.8.2) | _____ |
| A6 | Outfall under tidal or river backwater influence: Yes / No (Clauses 2.5.3, 2.12) | _____ |
| | **B. Source (Clauses 2.3, 2.3.5; item 2)** | |
| B1 | NIH-DHAARA: version or access date | _____ |
| B2 | Coordinates queried | _____ |
| B3 | Screenshot or export of the values extracted attached: reference | _____ |
| B4 | Station IDF used (Clause 2.3.2): No / Yes — station, ID, distance from site (km) | _____ |
| B5 | Station IDF: years of recording-gauge data (30 or more); published or approved by | _____ |
| B6 | Station IDF: change of terrain or coastal exposure between gauge and site: None / describe | _____ |
| | **C. AEPs and durations (Clauses 2.4, 2.5)** | |
| C1 | Elements designed and their AEPs (Table 2.1) | _____ |
| C2 | Conveyance: Tc and design duration (not less than 10 min) (Clause 2.5.1) | _____ |
| C3 | Storage: durations checked from {1, 2, 3, 6, 12, 24, 48, 72 h}; 24, 48 and 72 h included (Clause 2.5.2) | _____ |
| C4 | Critical duration found for each storage element | _____ |
| | **D. Conversions** | |
| D1 | Sub-daily depths: read directly / from Annex 2B ratios / from ratios agreed with the Authority (Clauses 2.6.1, 2.6.2) | _____ |
| D2 | Fixed-interval factor applied: none (true-interval source) / 1.13 / 1.04 / 1.02 (Clause 2.6.3) | _____ |
| D3 | Grid-to-point factor: not needed (point source) / Annex 2C / agreed value (Clause 2.7.1) | _____ |
| D4 | ARF: 1.0 (10 km² or less; single-site storage) / CWC curve / interpolated (Clauses 2.7.2–2.7.4) | _____ |
| D5 | Climate factor: 1.20 (≤ 6 h) and 1.10 (> 6–72 h) / 1.0 temporary works / projected depths under Clause 2.8.4 | _____ |
| | **E. Cross-checks (Clause 2.3.3; item 4)** | |
| E1 | IMD Das et al. (2022) values for 1–24 h: reported in Table 2F.2 | _____ |

| No. | Item (clause) | Entry |
|---|---|---|
| E2 | CWC subzone 2(a) (in sub-areas SK-B1 and SK-C no contour is drawn: enter "none") 24-hour point value, catchments of 25–5,000 km²: subzone used | _____ |
| E3 | CWC floor governs for any AEP: No / Yes — AEPs | _____ |
| | **F. Retention depth (Clause 2.10)** | |
| F1 | P_R (mm) and source: Annex 2E zone value / computed under Annex 2E, 2E.1 — station and period | _____ |
| F2 | No climate factor applied to P_R (Clause 2.8.3): confirmed | _____ |
| | **G. Design storms (Clauses 2.9, 2.11, 2.12; items 5 and 6)** | |
| G1 | Storms up to 24 h: alternating block, peak at 50%; time step (≤ Tc/3 and ≤ 15 min) | _____ |
| G2 | 48 and 72 h storms: built under Clause 2.9.2 (Table 2F.3) | _____ |
| G3 | Other pattern used: none / Annex 2D / CWC FER with sensitivity run (Clauses 2.9.3, 2.9.4) | _____ |
| G4 | Hyetographs attached as a table and a plot for each design storm: reference | _____ |
| G5 | AMC: III for every design storm of 1 May–30 September in every sub-area, whatever its duration; III for every design storm of 1 April–31 October on valley-floor land below the 1% AEP flood level, on the 2023 aggradation zone, where the seasonal high water table is within 2 m and in stability zones 3–6; III at any time in catchments draining to a hydropower reservoir, its backwater, a release reach below a dam or a river reach above its CWC warning level; at any other site or time, III for a storm that follows or contains a 5-day total of more than 53 mm; II otherwise (Clause 2.11.4) | _____ |
| G6 | Pre-development condition: greenfield, open land in good condition for the mapped HSG (Clause 2.11.5) | _____ |
| G7 | Release criterion: standard, Q_post ≤ 0.9 × Q_pre (Clause 2.11.2) / flood-sensitive, mixed-frequency rule (Clause 2.11.3) | _____ |
| G8 | Tailwater joint cases run (Clause 2.12): case (a) MHWS + sea-level allowance; case (b) 10% AEP 48 h storm with 1% AEP still-water level + sea-level allowance; governing case | _____ |
| | **H. Prepared by** | |
| H1 | I confirm that the values above are those extracted and used in the submittal. Name, registration number, signature, date | _____ |

Design depth = source depth × fixed-interval factor × grid-to-point factor × ARF × climate factor. Where the design depth is lower than the CWC floor for the same AEP, the floor is adopted (Clause 2.3.3).

### Table 2F.2 — Form 2-1: depth table (Clause 2.13, item 3)

| AEP (T-yr) | Duration | Source depth (mm) | Fixed-interval factor | Grid-to-point factor | ARF | Climate factor | Design depth (mm) | IMD Das et al. (2022) (mm) | CWC floor (mm) | Adopted depth (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

### Table 2F.3 — Form 2-1: 48- and 72-hour storm construction (Clause 2.9.2)

| AEP (T-yr) | Duration (h) | Total design depth (mm) | 24 h design depth, final 24 h (mm) | Remainder (mm) | Hours before the final 24 h | Uniform intensity before the final 24 h (mm/h) |
|---|---|---|---|---|---|---|
| | 48 | | | | 24 | |
| | 72 | | | | 48 | |

ANNEXES TO CHAPTER 3

# Hydrologic Methods

These annexes support Chapter 3. Annex 3C sets out benchmark test problems for software acceptance, and Forms 3-1 and 3-2 are the submittal forms required by Clause 3.17. Annexes 3A, 3B, 3D and 3E need survey, gauging or published report data that this draft does not yet contain; each gives the intended layout and the interim rule of Chapter 3 that applies until it is published. The forms are draft forms and have no statutory status.

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## Annex 3A — Sikkim soil series to HSG lookup; seasonal high water table map

Supports Clauses 3.7 and 3.10 of Chapter 3.

**To be prepared.** This annex will contain (a) a lookup from each soil series mapped in Sikkim to its hydrologic soil group (HSG), in both the drained and the undrained state, and (b) a map of the depth to the seasonal high groundwater table in the monsoon season (April–October). It needs NBSS&LUP and State soil-survey agency of Sikkim [TBC] series maps with their scales, measured saturated hydraulic conductivity and depth to an impermeable layer for each series, and observation-well records from the Central Ground Water Board and the WRD, supplemented by piezometers in the boulder and gravel terraces and valley floors of the Teesta, the Rangit and the Rongni Chu at Rangpo, Singtam, Melli, Majitar and Jorethang, the river bed and terraces raised by the flood of October 2023, the margins of the pokharis and of the hydropower reservoirs and their backwaters, the seepage zones below springs (dhara) on the slopes, and the ground of stability zones 3 to 6, which the Mines and Geology Department's notification of 2021 records as "Wet", "Dripping" or "Flowing". Until it is published, use the interim rules of Chapter 3: assign HSG from measured saturated hydraulic conductivity and depth to an impermeable layer or water table by the criteria of NEH Part 630, Ch. 7 (Clause 3.7.2); verify it by site infiltration tests wherever retention relies on infiltration (Clause 3.7.3); take the seasonal high water table from site piezometers, trial pits or the nearest observation well (Clause 3.10.2); and assign HSG D wherever that level is within 0.6 m of the ground surface (Clause 3.10.1).

**Table 3A.1 — Soil series to HSG lookup (layout)**

| Soil series | District(s) | Taxonomic class | Surface texture | Saturated hydraulic conductivity (mm/h) | Depth to impermeable layer (m) | HSG, drained | HSG, undrained | Source map and scale |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Table 3A.2 — Seasonal high water table, by mapping unit (layout)**

| Mapping unit or grid cell | Observation wells used | Years of April–October record | Highest April–October level below ground (m) | Within 0.6 m of ground (Clause 3.10.1)? | Data source |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

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## Annex 3B — Sikkim CN calibration and supplementary land covers (forest, terraced fields, slide scars, debris fans and hill-road cuts and fills, bare rock and scree, alpine pasture, moraine and snow, boulder-bed jhoras, the river bed raised in October 2023, and pokhari and reservoir beds)

Supports Clauses 3.8 and 3.15 of Chapter 3.

**To be prepared.** This annex will contain (a) curve numbers calibrated against observed rainfall and runoff in Sikkim catchments, compared with the TR-55 values of Table 3.5, and (b) curve numbers for land covers that Table 3.5 does not list: the forest that covers much of the hills, with its litter; the terraced fields of the slopes, with their risers and channels; the fresh scars, slide debris and debris fans of landslides, such as those of Gangtok in June 1997 and of Mangan district in June 2024 (as reported), and the cut slopes and fills of hill roads, such as NH-10 along the Teesta, which became "prone to submergence and subsidence" after the flood of October 2023 (State Government's pre-project report on GLOF risk mitigation in the Lhonak valley, 2026); bare rock and scree; the alpine pasture, moraine, snow and frozen ground of sub-area SK-C; the boulder beds of the jhoras; the bed of the Teesta, which the flood of October 2023 raised "by an average of 7-8 meters" (the same report), with the debris it left at Rangpo and the other valley-floor towns; and the beds of pokharis and of the hydropower reservoirs, drawn down or dry at the start of a storm. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from WRD gauging sites, agricultural research stations and tank gauges, analysed by event and by antecedent moisture. Until it is published: the pre-development reference stays open space in good condition for every site (Clause 3.3.2), so these covers do not enter the pre-development run; for off-site existing conditions, use the nearest Table 3.5 or TR-55 cover row, including the cultivated rows (Clause 3.8.3(c)), and state the row chosen and the reason on Form 3-1; land under standing water at the start of the design storm is modelled as water surface with no losses (Table 3.5; Clause 3.10.4(b)). Any departure from these defaults requires calibration under Clause 3.15 (Clause 3.15.1(d)).

### Table 3B.1 — Supplementary land covers, AMC II (layout)

| Cover type | HSG A | HSG B | HSG C | HSG D | Ia ratio | Basis (catchments, events, years) |
|---|---|---|---|---|---|---|
| Forest of the hills, with the litter and the depth of soil over rock recorded | | | | | | |
| Terraced fields of the slopes, with the terrace risers and any kulo (कुलो; irrigation channel) recorded | | | | | | |
| Fresh landslide scar, slide debris or debris fan; hill-road cut slope or fill (NH-10 and the like) | | | | | | |
| Bare rock and scree | | | | | | |
| Alpine pasture and moraine of sub-area SK-C; frozen or snow-covered ground recorded separately | | | | | | |

| Cover type | HSG A | HSG B | HSG C | HSG D | Ia ratio | Basis (catchments, events, years) |
|---|---|---|---|---|---|---|
| Boulder bed of a jhora, dry at the start of the storm | | | | | | |
| River bed and debris raised by the flood of October 2023 (the Teesta at Rangpo, Singtam, Melli and the like), with the depth to water recorded | | | | | | |
| Pokhari or reservoir bed dry or drawn down at the start of the storm | | | | | | |
| Other (state) | | | | | | |

**Table 3B.2 — CN calibration catchments (layout)**

| Catchment | District | Area (km²) | Dominant HSG and cover | Events used | Table 3.5 CN | Calibrated CN | Calibrated ÷ Table 3.5 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

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## Annex 3C — Benchmark test problems for software acceptance

Supports Clauses 3.5, 3.6, 3.8, 3.9, 3.11, 3.12 and 3.16 of Chapter 3.

**Purpose.** Software not listed in Clause 3.16.1 shall reproduce the results of the five problems below (Clause 3.16.3). Each problem is fully specified and uses only the methods and tables of Chapter 3, so every answer can be checked by hand. The acceptance tolerance is ±5% on each tabulated result, the equivalence threshold of Clause 3.16.2; for closed-form results (Problems 3C-1 to 3C-4), software should agree to the rounding shown. The submittal shall report the software result next to each answer below.

*Illustrative — not design values.* The inputs (areas, intensities, rainfall depths, slopes and the basin) are chosen for testing only. They are not design data for any site.

### Problem 3C-1 — Rational Method peak (Clause 3.5)

**Inputs.** A 2.0 ha catchment draining to one inlet: 1.2 ha concrete paving and roofs, C = 0.90 (Table 3.2, upper half of 0.80–0.95); 0.8 ha lawns on sandy soil, average slope, C = 0.15 (Table 3.2, upper half of 0.10–0.15). Design AEP 1% (100-yr). Rainfall intensity at Tc, including the climate factor: i = 120 mm/h.

Part (b): a separate 0.5 ha fully paved catchment, C = 0.90, design AEP 1%, i = 150 mm/h.

**Table 3C.1 — Problem 3C-1 solution**

| Step | Calculation | Result |
|---|---|---|
| Composite C (Clause 3.5.4) | (1.2 × 0.90 + 0.8 × 0.15) / 2.0 | 0.60 |
| Frequency factor (Table 3.3) | 1% AEP | Cf = 1.25 |
| C · Cf (≤ 1.0) | 0.60 × 1.25 | 0.75 |
| Peak flow (Clause 3.5.1) | 0.75 × 120 × 2.0 / 360 | **Q = 0.500 m³/s** |
| Part (b): C · Cf | 0.90 × 1.25 = 1.125, capped at 1.0 (Clause 3.5.3) | 1.00 |
| Part (b): peak flow | 1.00 × 150 × 0.5 / 360 | **Q = 0.208 m³/s** |

## Problem 3C-2 — Time of concentration by the segment method (Clause 3.6)

**Inputs.** Pre-development flow path: sheet flow over greenfield, n = 0.15 (Clause 3.6.3), L = 30 m, S = 0.01; P2 (50% AEP 24-hour rainfall, no climate factor) = 80 mm. Shallow concentrated flow, unpaved, L = 200 m, S = 0.01. Channel flow, L = 400 m, bank-full velocity V = 1.0 m/s (given).

**Table 3C.2 — Problem 3C-2 solution**

| Segment | Calculation | Travel time |
|---|---|---|
| Sheet flow (Clause 3.6.2(a)) | 0.091 × (0.15 × 30)^0.8 / (80^0.5 × 0.01^0.4) = 0.2138 h | 12.83 min |
| Shallow concentrated (Clause 3.6.2(c)) | V = 4.918 × 0.01^0.5 = 0.4918 m/s; 200 / (3,600 × 0.4918) = 0.1130 h | 6.78 min |
| Channel (Clause 3.6.2(d)) | 400 / (3,600 × 1.0) = 0.1111 h | 6.67 min |
| **Tc** (Clause 3.6.1; ≥ 10 min) | 12.83 + 6.78 + 6.67 | **26.27 min** |
| Lag (Clause 3.6.5) | 0.6 × 26.27 | 15.76 min |

## Problem 3C-3 — SCS-CN runoff depth, AMC and Ia sensitivity (Clause 3.8)

**Inputs.** Pre-development reference on HSG C: CN = 74 at AMC II (Table 3.5), all pervious. Cumulative rainfall P = 100 mm; second case P = 25 mm.

**Table 3C.3 — Problem 3C-3 solution**

| Case | S (mm) | Ia (mm) | Runoff Q (mm), P = 100 mm | Runoff Q (mm), P = 25 mm |
|---|---|---|---|---|
| (a) AMC II, Ia = 0.2S: S = 25,400 / 74 − 254 | 89.24 | 17.85 | **39.38** | **0.53** |
| (b) AMC III, Ia = 0.2S: CN(III) = 23 × 74 / (10 + 0.13 × 74) = 86.75 | 38.80 | 7.76 | **64.93** | — |
| (c) AMC II, Ia = 0.05S: S0.05 = 25.4 × 1.33 × (89.24 / 25.4)^1.15 | 143.31 | 7.17 | **36.49** | **1.97** |

Runoff is Q = (P − Ia)² / (P − Ia + S). Case (c) gives less runoff than case (a) at 100 mm but more at 25 mm, as Clause 3.8.5 and Figure 3.3 describe.

## Problem 3C-4 — Separate vs composite impervious representation, and SCS unit hydrograph peak (Clauses 3.9 and 3.11.2)

**Inputs, part (a).** A site that is 50% directly connected impervious (CN 98) and 50% open space on HSG B (CNp = 61), AMC II, Ia = 0.2S, P = 25 mm.

**Inputs, part (b).** A sub-area of A = 2.5 km² with Tc = 1.0 h and computation interval Δt = 0.1 h.

**Table 3C.4 — Problem 3C-4 solution**

| Step | Calculation | Result |
|---|---|---|
| (a) Impervious half (Clause 3.9.2) | S = 5.18 mm, Ia = 1.04 mm; Q = 23.96² / (23.96 + 5.18) | 19.70 mm |
| (a) Pervious half | S = 162.39 mm, Ia = 32.48 mm > P | 0 mm |
| (a) Area-weighted runoff, separate sub-areas | 0.5 × 19.70 + 0.5 × 0 | **9.85 mm** |

| Step | Calculation | Result |
|---|---|---|
| (a) Composite CN (Clause 3.9.4) | 61 + 0.50 × (98 − 61) | 79.5 |
| (a) Runoff with composite CN | S = 65.50 mm, Ia = 13.10 mm; Q = 11.90² / (11.90 + 65.50) | **1.83 mm** |
| (b) Interval check (Clause 3.11.3(a)) | 0.133 × 1.0 = 0.133 h ≥ Δt = 0.1 h | satisfied |
| (b) Lag and time to peak (Clause 3.11.2) | tL = 0.6 × 1.0 = 0.60 h; tp = 0.1 / 2 + 0.60 | tp = 0.65 h |
| (b) Unit hydrograph peak, Q = 1 mm | 0.208 × 2.5 × 1 / 0.65 | **qp = 0.800 m³/s per mm** |

Part (a) reproduces the comparison in the commentary to Clause 3.9 (about 9.9 mm vs 1.8 mm).

## Problem 3C-5 — Level-pool (modified Puls) storage routing (Clause 3.12.1)

**Inputs.** A detention basin with vertical sides and plan area 500 m², with the stage–storage–discharge relationship of Table 3C.5. Triangular inflow hydrograph: 0 at t = 0, rising linearly to 0.50 m³/s at t = 30 min, falling linearly to 0 at t = 90 min. Basin empty at t = 0. Routing interval Δt = 10 min (600 s). No tailwater.

**Table 3C.5 — Problem 3C-5 stage–storage–discharge relationship**

| Stage (m) | Storage S (m³) | Outflow O (m³/s) |
|---|---|---|
| 0.0 | 0 | 0.00 |
| 0.5 | 250 | 0.05 |
| 1.0 | 500 | 0.10 |
| 1.5 | 750 | 0.15 |
| 2.0 | 1,000 | 0.20 |
| 2.5 | 1,250 | 0.25 |

**Method.** The storage-indication equation is (I1 + I2) + (2S1/Δt − O1) = (2S2/Δt + O2). The table gives O = S / 5,000 (S in m³, O in m³/s), so 2S/Δt + O = 17.667 O and 2S/Δt − O = 15.667 O, and each step is O2 = [(I1 + I2) + 15.667 O1] / 17.667. Software interpolating linearly in Table 3C.5 shall give the same result.

**Table 3C.6 — Problem 3C-5 routed outflow**

| Time (min) | Inflow I (m³/s) | Outflow O (m³/s) | Storage (m³) | Stage (m) |
|---|---|---|---|---|
| 0 | 0.0000 | 0.0000 | 0.0 | 0.000 |
| 10 | 0.1667 | 0.0094 | 47.2 | 0.094 |
| 20 | 0.3333 | 0.0367 | 183.3 | 0.367 |
| 30 | 0.5000 | 0.0797 | 398.4 | 0.797 |
| 40 | 0.4167 | 0.1226 | 612.8 | 1.226 |
| 50 | 0.3333 | 0.1511 | 755.7 | 1.511 |
| 60 | 0.2500 | 0.1670 | 835.2 | 1.670 |
| **70** | 0.1667 | **0.1717** | **858.6** | **1.717** |
| 80 | 0.0833 | 0.1664 | 832.1 | 1.664 |
| 90 | 0.0000 | 0.1523 | 761.5 | 1.523 |

| Time (min) | Inflow I (m³/s) | Outflow O (m³/s) | Storage (m³) | Stage (m) |
|---|---|---|---|---|
| 120 | 0.0000 | 0.1062 | 531.1 | 1.062 |
| 180 | 0.0000 | 0.0517 | 258.3 | 0.517 |

**Results.** Peak outflow 0.172 m³/s at 70 min; peak storage 859 m³; peak stage 1.72 m. The inflow peak of 0.50 m³/s is reduced to 34% of its value.

**Table 3C.7 — Benchmark results to be reported by the applicant**

| Problem | Result | Benchmark | Software result | Difference (%) | Within ±5%? |
|---|---|---|---|---|---|
| 3C-1 | Q, main case (m³/s) | 0.500 | | | |
| 3C-1 | Q, part (b) (m³/s) | 0.208 | | | |
| 3C-2 | Tc (min) | 26.27 | | | |
| 3C-3 | Q, case (a), P = 100 mm (mm) | 39.38 | | | |
| 3C-3 | Q, case (b), P = 100 mm (mm) | 64.93 | | | |
| 3C-3 | Q, case (c), P = 100 mm (mm) | 36.49 | | | |
| 3C-3 | Q, case (c), P = 25 mm (mm) | 1.97 | | | |
| 3C-4 | Runoff, separate sub-areas (mm) | 9.85 | | | |
| 3C-4 | Runoff, composite CN (mm) | 1.83 | | | |
| 3C-4 | qp (m³/s per mm) | 0.800 | | | |
| 3C-5 | Peak outflow (m³/s) | 0.172 | | | |
| 3C-5 | Peak storage (m³) | 859 | | | |

## Annex 3D — Peak rate factor study for flat coastal land

Supports Clauses 3.11.5 and 3.15 of Chapter 3.

> **Not required in Sikkim.** Sikkim is landlocked and mountainous, so no land in the State meets Clause 3.11.5(a), and the standard factor 484 (PRF' = 0.208) applies to all land (Clause 3.11.5). The valley floors and terraces of the Teesta, the Rangit and the Rongni Chu are flat in places and slow to drain when the river is high, but they are not coastal plain; their slow response is represented by storage and backwater (Clauses 3.10.4 and 3.12.4) and by the outfall-closed check of Chapter 5, not by a lower peak rate factor, while the ridges and the jhoras respond fast. The annex and the layout of Table 3D.1 are kept only so that the annex numbering is unchanged.

**Table 3D.1 — Calibrated peak rate factors (layout)**

| Catchment | Area (km²) | Mean slope (m/m) | Drainage condition | Events used | Calibrated PRF (US customary) | PRF' (SI) | Range of applicability |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

## Annex 3E — CWC SUH parameters for subzone 2(a), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

**To be prepared.** This annex will tabulate, for CWC subzone 2(a) (North Brahmaputra), the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs the one CWC Flood Estimation Report that covers Sikkim, the North Brahmaputra subzone 2(a) report (Design Office Report No. NB/18/1991), which covers the whole State, and of which only the unit hydrograph relationships, the design loss rate and base flow, the table of ratios of t-hour to 24-hour rainfall, Table 7 and Plates 8, 9 and 10 have been checked against the page images; from that report, its areal reduction curves, its time distribution of rainfall, its worked example, its simplified formulae, whose exponents were read only by optical character recognition, and its table of calibration catchments, which would confirm that none lies in Sikkim (see the References of Chapter 3) [TBC]; and written confirmation from CWC that the report has not been revised and that no separate report for the Teesta exists or is in preparation [TBC], transcribed and checked against the published reports, and a catchment with physiographic parameters measured from survey or a DEM. Until it is published, take all SUH inputs directly from the applicable Flood Estimation Report (Clause 3.11.4(a)), apply the 24-hour design rainfall of Clauses 2.3.3(b) and 2.7.3 with the climate factor of Clause 2.8 (Clause 3.11.4(b)), report the SUH result alongside the HEC-HMS or SWMM result for the existing natural condition (Clause 3.11.4(c)), and, where the hydrograph model gives a lower 1% AEP peak, either justify it by calibration under Clause 3.15 or adopt the SUH peak (Clause 3.11.4(d)).

### Table 3E.1 — SUH relationships by subzone (layout)

| Parameter | Symbol | Unit | Subzone 2(a) (North Brahmaputra) relationship |
|---|---|---|---|
| Peak discharge per unit area | qp | m³/s per km² | qp = 2.272 (L·Lc/S)^−0.409, with S as printed (not √S) |
| Peak discharge of the 1-hour unit hydrograph | Qp | m³/s | Qp = qp · A |
| Time from centre of unit rainfall to peak | tp | h | tp = 2.164 qp^−0.940 |
| Width of UH at 50% of peak | W50 | h | W50 = 2.084 qp^−1.065 |
| Width of UH at 75% of peak | W75 | h | W75 = 1.028 qp^−1.071 |
| Width of rising limb at 50% of peak | WR50 | h | WR50 = 0.856 qp^−0.865 |
| Width of rising limb at 75% of peak | WR75 | h | WR75 = 0.440 qp^−0.918 |
| Base width of UH | TB | h | TB = 5.428 tp^0.852 |
| Time to peak from start of rise | Tm | h | Tm = tp + tr/2 |
| Unit duration | tr | h | 1 |
| Design storm duration | TD | h | TD = TB (it gave the higher peak on 16 of the 21 catchments), rounded to the nearest hour |

| Parameter | Symbol | Unit | Subzone 2(a) (North Brahmaputra) relationship |
|---|---|---|---|
| Design loss rate | — | mm/h | 2.4 (printed "0.24 cm/hr", the modal value of about 233 flood events on the 21 catchments); a plains value, for rural SUH runs only |
| Design base flow | — | m³/s per km² | 0.05 |
| Ratio of t-hour to 24-hour rainfall | — | — | 50-yr, 12 IMD self-recording gauges, none identified in Sikkim: 1 h 0.260; 3 h 0.457; 6 h 0.615; 9 h 0.720; 12 h 0.805; 15 h 0.875; 18 h 0.930; 24 h 1.000. Used in this Manual in every sub-area (Clause 2.3.6(f)) |
| Time distribution of rainfall | — | cumulative fraction by hour | [TBC] |
| Conversion of 1-day to 24-hour rainfall | — | factor | 1.15 |
| Areal reduction factor | ARF | % of point rainfall | [TBC] |
| Simplified formula | — | m³/s | Q50 = 0.7262 A^0.90265 L^−0.37461 Lc^−0.19224 S^0.31348 R^1.09719, with A in km², L and Lc in km, S in m/km and R the 50-yr 24-hour point rainfall, as read by optical character recognition; the exponents have not been checked against the page images [TBC]; for preliminary use only, never for design |
| 24-hour point rainfall over Sikkim | — | mm | Plates 8, 9 and 10 (25-, 50- and 100-yr), read under Clause 2.3.6(c)(i) in sub-areas SK-A and SK-B; north of Gangtok no contour is drawn, and sub-areas SK-B1 and SK-C take the depths of Clause 2.3.6(c)(ii) and (c)(iii) |
| Sikkim stations in the report | — | mm | Table 7 (highest daily rainfall): Singhik 504.2 (12 May 1981) and Dikchu 400.8 (25 August 1969), checked against the page image; flags that do not qualify under Clause 2.3.6(h), used for the floor of Clause 2.3.6(c)(ii) |
| Catchment area for which the relationships apply | A | km² | 25–2,500; up to 5,000 with judgement |
| Report reference | — | — | NB/18/1991: the unit hydrograph relationships, the loss rate, the base flow, the ratio table, Table 7 and Plates 8, 9 and 10 |

Note: relationships as printed in the CWC subzone 2(a) report (References of Chapter 3), read from a scanned copy; the unit hydrograph relationships, the loss rate and the ratios were checked against the page images for earlier editions of this series, and this table follows the Assam edition's checked values. A is the catchment area in km², L the length of the main stream in km, Lc the length to the point nearest the catchment centroid in km and S the equivalent slope in m/km. **Coverage.** The report says that the subzone covers "mainly parts of Assam, and small portion of Sikkim …" (p. 8) and names "Gangtok the capital of Sikkim" first among its important towns (p. 28); its river table lists the "Tista" at 10,616.74 km² (p. 29). Its plates run the 88° E meridian through west Sikkim and draw the border with Nepal, and no other subzone lies over the State, so the whole of Sikkim is in subzone 2(a) (NEER reading). **There is no separate report for the Teesta or for Sikkim. Basis.** The relationships rest on 21 representative catchments gauged at railway bridges of the North Frontier Railway (p. 8), in the foothills and plains of the subzone, with slopes of about 1–10 m/km. Sikkim had no railway in the report's period, so none of them can lie in the State (NEER reading; the report's catchment table was not checked [TBC]), and none rests on an urban, steep or snow-fed catchment. **Slope.** The 2(a) peak uses L·Lc/S, so slope enters it, but Sikkim's catchments have equivalent slopes of tens to hundreds of m/km, far outside the data. For a yardstick catchment with L = 40 km and Lc = 20 km, the relationships give qp ≈ 0.29 m³/s per km², tp ≈ 7.0 h and TB ≈ 29 h at S = 5 m/km, within the data, but qp ≈ 0.97 m³/s per km², tp ≈ 2.2 h and TB ≈ 11 h at S = 100 m/km, an extrapolation that no gauged catchment supports (NEER's computation; yardsticks, not design values). The SUH is therefore untested on Sikkim slopes, and a peak from it is a benchmark, not a check that the State's hydrology has passed. **Loss rate.** The design loss rate of 2.4 mm/h is a φ-index fitted to the floods of rural plains and foothill catchments; on Sikkim's thin soils over rock it may be too high in a wet monsoon and too low in the pre-monsoon

storms of April and May (NEER reading). It is used only in rural SUH runs, is not a soil infiltration capacity and is not used to assign HSG (Clause 3.7), in urban SCS-CN or SWMM models, or to size infiltration practices (Chapter 4). **Use in the State.** The SUH applies only to rain-fed rural catchments of 25–2,500 km² (up to 5,000 km² with judgement) in sub-areas SK-A, SK-B and SK-B1 that enter or pass the towns, where the catchment holds no permanent snow, glacier or mapped glacial lake, and is computed only as the benchmark of their natural condition (Clause 3.11.4). The urban catchments of Gangtok, Namchi, Gyalshing, Pakyong and the other towns, and their jhoras, are far smaller than 25 km² and far steeper than the gauged catchments; they are designed by the Rational Method or a hydrograph model under Clause 3.4, delineated by jhora, with the segment Tc and the rules for steep ground of the Commentary to Clause 3.7. **No SUH for snow, glaciers, glacial lakes or the Teesta trunk.** No CWC unit hydrograph applies to a catchment with permanent snow or a glacier, as in much of sub-area SK-C, to any catchment with a mapped glacial lake, or to the Teesta trunk at any point: the Teesta drains about 3,021 km² above its confluence with the Lachung Chu at Chungthang (Sattar et al., 2025) and 10,616.74 km² to its outfall in the subzone (the report's river table), its flood is fed by snow and glaciers, and in the South Lhonak lake outburst and Teesta flood of 3–4 October 2023 its flood, on its water alone, matched "a 1–100 year meteorological flood at Chungthang", with its sediment far larger (Sattar et al., 2025; the State has attributed that flood primarily to a cloudburst, and its cause is disputed). Every cross-drainage structure and outfall of more than 1 km² in sub-area SK-C, every catchment with permanent snow, a glacier or a mapped glacial lake, and every work on the Teesta trunk needs a site-specific study under Clause 2.3.6(i), with screening for a glacial lake outburst flood, a landslide-dammed lake and debris flow (set by this Manual, as in the mountain editions of this series). Below a dam the flood is set by releases (Clause 5.8.5(c)).

**Table 3E.2 — Worked example outline (layout)**

| Step | Content | Clause |
|---|---|---|
| 1 | Catchment area, main stream length, length to centroid and equivalent slope, from survey or DEM | 3.11.4(a) |
| 2 | SUH parameters from Table 3E.1 and the plotted unit hydrograph | 3.11.4(a) |
| 3 | Design storm duration, point and areal 24-hour rainfall with climate factor, time distribution | 3.11.4(a), (b) |
| 4 | Effective rainfall after the design loss rate; convolution with the SUH; base flow added | 3.11.4(a) |
| 5 | 1% AEP peak compared with the HEC-HMS or SWMM peak for the existing natural condition | 3.11.4(c), (d) |

## Form 3-1 — Hydrologic Calculation Summary

Supports Clauses 3.4, 3.6, 3.7, 3.8, 3.10–3.13, 3.15–3.17 of Chapter 3.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One form per submittal. Attach the documents listed in Section H.

### A. Project

**Table 3F.1 — Form 3-1: project**

| Field | Entry |
|---|---|
| A1. Project name and applicant | |
| A2. Location (village or ward, survey numbers, district) | |
| A3. Site area (ha) and number of points of comparison (POCs) | |
| A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3) | |
| A5. Design Rainfall Sheet reference (Form 2-1) | |

### B. Method and software (Clauses 3.4, 3.11, 3.12, 3.16)

**Table 3F.2 — Form 3-1: method and software**

| Field | Entry |
|---|---|
| B1. Purpose of each calculation (conveyance, storage, comparison, catchment study) | |
| B2. Contributing area for each purpose (ha or km²) | |
| B3. Method used and the row of Table 3.1 that permits it | |
| B4. Reason for the choice of method | |
| B5. Software and version; engine and version for packages built on SWMM or HEC (Clause 3.16.1, 3.16.2) | |
| B6. For other software: benchmark results of Annex 3C attached (Table 3C.7) and the 5% comparison of Clause 3.16.2 | |
| B7. Runoff transform (Clause 3.11.1) | |
| B8. Computation interval Δt (h), with 0.133 Tc of the smallest sub-area and the hyetograph time step (Clause 3.11.3(a)) | |
| B9. Storage routing and channel routing methods (Clauses 3.12.1, 3.12.2) | |
| B10. Dynamic-wave routing required? If yes, which condition of Clause 3.12.4 | |
| B11. CWC SUH benchmark required (25–5,000 km², Clause 3.11.4)? Result reference | |
| B12. Continuous simulation required (Clause 3.13.1)? Record used and starting tank levels (Clause 3.13.5) | |
| B13. Calibration required (Clause 3.15.1)? Calibration report reference | |

### C. Soils and groundwater (Clauses 3.3.3(b), 3.7, 3.10)

**Table 3F.3 — Form 3-1: soils and groundwater**

| Field | Entry |
|---|---|
| C1. HSG source map, scale and lookup used (Clause 3.7.1, Annex 3A) or NEH Part 630, Ch. 7 assignment (Clause 3.7.2) | |
| C2. Infiltration tests: number, locations, depths, results (Clause 3.7.3) | |
| C3. Seasonal high water table: depth below ground and source (Clause 3.10.2) | |
| C4. Areas within 0.6 m assigned HSG D (Clause 3.10.1) | |
| C5. Disturbed pervious areas and HSG downgrade applied (Clause 3.3.3(b)) | |

## D. Parameters by sub-area and condition (Clauses 3.3, 3.5, 3.8, 3.9; Clause 3.17 item 4)

**Table 3F.4 — Form 3-1: parameters by sub-area and condition**

| Sub-area | Condition (pre / post) | Area (ha) | Impervious: roofs / paved / roads (ha) | DCIA (ha) | Disconnected (ha) | HSG | CN, AMC II | CN, AMC III (pervious part) | C and Cf (if Rational) | Tc (min) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

## E. Time of concentration worksheet (Clause 3.6)

One worksheet per sub-area and condition.

**Table 3F.5 — Form 3-1: time of concentration worksheet**

| Segment | Flow type | Surface and n (Table 3.4) | L (m) | S (m/m) | P2 (mm) | V (m/s) | Tt (min) |
|---|---|---|---|---|---|---|---|
| 1 | Sheet | | | | | — | |
| 2 | Shallow concentrated | | | | — | | |
| 3 | Channel or pipe | | | | — | | |
| | **Tc (not less than 10 min)** | | | | | | |

E1. Is the post-development Tc shorter than the pre-development Tc? If not, explain (Clause 3.6.6): _____

## F. Rainfall and losses (Clauses 3.8.4, 3.8.5, 3.11.5, 3.12, 3.3.5)

**Table 3F.6 — Form 3-1: rainfall, losses and starting levels**

| Field | Entry |
|---|---|
| F1. AEPs and durations run; climate factor applied (Chapter 2) | |
| F2. AMC used for each duration (Clause 3.8.4) | |
| F3. Ia ratio for design runs; Ia = 0.05S sensitivity run made (Clause 3.8.5) | |
| F4. Peak rate factor used; if lower than 484, the Annex 3D value and the land it applies to (Clause 3.11.5) | |
| F5. Starting water level of each tank or waterbody, and its basis (Clauses 3.12.5, 3.13.5) | |

| Field | Entry |
|---|---|
| F6. Off-site run-on: land use assumed for conveyance and for the comparison (Clause 3.3.5) | |
| F7. Incidental storage counted? If yes, the authority's acceptance (Clause 3.12.3) | |

## G. Departures

### Table 3F.7 — Form 3-1: departures from Chapter 3

| No. | Clause departed from | Value used in place of the Chapter 3 value | Justification |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

## H. Attachments (Clause 3.17)

### Table 3F.8 — Form 3-1: attachments

| Item | Attached (yes / no / not applicable) | Reference |
|---|---|---|
| H1. Catchment maps, pre- and post-development, with sub-areas, Tc flow paths, POCs and off-site run-on | | |
| H2. HSG map, water-table data and infiltration test results | | |
| H3. Parameter tables (Section D) and Tc worksheets (Section E) | | |
| H4. Design Rainfall Sheet (Form 2-1) and hyetographs | | |
| H5. Hydrograph tables and plots; stage–storage and stage–discharge tables; routed outflows; peak water levels | | |
| H6. Form 3-2 for each POC | | |
| H7. Calibration report (Clause 3.15) | | |
| H8. Native model input and output files (Clause 3.16.4) | | |

## I. Statement by the responsible engineer (Clause 3.17 item 10)

I state that the methods and parameters of Chapter 3 of the Sikkim Stormwater Design Manual (Draft v1.0) have been used in this submittal, and that every departure is listed and justified in Section G.

### Table 3F.9 — Form 3-1: statement by the responsible engineer

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |
| Organisation | |
| Signature | |
| Date | |

## Form 3-2 — Pre- vs Post-Development Comparison

Supports Clauses 3.8.5, 3.11.5 and 3.14 of Chapter 3.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One form for each point of comparison (POC). Flows in $m^3/s$, volumes in $m^3$.

### A. Point of comparison (Clause 3.14.2)

**Table 3F.10 — Form 3-2: point of comparison**

| Field | Entry |
|---|---|
| A1. POC identifier and location | |
| A2. Area draining to the POC: site (ha) and off-site run-on (ha) | |
| A3. Off-site run-on passes through site storage? (Clause 3.14.2(c)) | |
| A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3) | |
| A5. Tailwater applied, including joint cases of Clause 2.12 (Clause 3.14.9(c)) | |
| A6. Flood-sensitive only: largest 10% AEP pre-development peak over all durations, the cap of Clause 2.11.3 (Clause 3.14.7) | |
| A7. Flood-sensitive only: 50% AEP pre-development peak at the pre-development critical duration (Clause 2.11.3) | |

### B. Peak flows (Clauses 3.14.7–3.14.10)

Limit: standard catchments 0.9 × Q_pre for the same AEP and duration (Clause 3.14.10(a)); flood-sensitive catchments the caps A6 (for 1% AEP) and A7 (for 50% AEP) (Clause 3.14.10(b)).

**Table 3F.11 — Form 3-2: peak flows by AEP and duration**

| AEP | Duration (h) | AMC | Q_pre | Q_post, uncontrolled | Q_post, routed | Limit | Met? |
|---|---|---|---|---|---|---|---|
| 50% (2-yr) | 1 | II | | | | | |
| 50% (2-yr) | 2 | II | | | | | |
| 50% (2-yr) | 3 | II | | | | | |
| 50% (2-yr) | 6 | II | | | | | |
| 50% (2-yr) | 12 | III | | | | | |
| 50% (2-yr) | 24 | III | | | | | |
| 50% (2-yr) | 48 | III | | | | | |
| 50% (2-yr) | 72 | III | | | | | |
| 10% (10-yr) | 1 | II | | | | | |
| 10% (10-yr) | 2 | II | | | | | |
| 10% (10-yr) | 3 | II | | | | | |
| 10% (10-yr) | 6 | II | | | | | |

| AEP | Duration (h) | AMC | Q_pre | Q_post, uncontrolled | Q_post, routed | Limit | Met? |
|---|---|---|---|---|---|---|---|
| 10% (10-yr) | 12 | III | | | | | |
| 10% (10-yr) | 24 | III | | | | | |
| 10% (10-yr) | 48 | III | | | | | |
| 10% (10-yr) | 72 | III | | | | | |
| 1% (100-yr) | 1 | II | | | | | |
| 1% (100-yr) | 2 | II | | | | | |
| 1% (100-yr) | 3 | II | | | | | |
| 1% (100-yr) | 6 | II | | | | | |
| 1% (100-yr) | 12 | III | | | | | |
| 1% (100-yr) | 24 | III | | | | | |
| 1% (100-yr) | 48 | III | | | | | |
| 1% (100-yr) | 72 | III | | | | | |

## C. Volumes and storage (Clauses 3.14.8–3.14.10)

**Table 3F.12 — Form 3-2: volumes and storage**

| AEP | Governing duration (h) | Runoff volume, pre | Runoff volume, post uncontrolled | Retention volume | Detention storage required | Peak water level in storage (m) |
|---|---|---|---|---|---|---|
| 50% (2-yr) | | | | | | |
| 10% (10-yr) | | | | | | |
| 1% (100-yr) | | | | | | |

C1. Governing duration for storage, and the 24, 48 and 72 h results (Clause 3.14.10): _____

## D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

**Table 3F.13 — Form 3-2: sensitivity runs**

| Run | Governing storm (AEP, duration) | Change in Q_post, routed (%) | Change in required storage (%) | Retention volume or WQv governing (Clause 3.8.5(c)) |
|---|---|---|---|---|
| Ia = 0.05S | | | | |
| Standard peak rate factor (only where a lower factor is used) | | | | — |

## E. Associated checks (Clause 3.14.12)

**Table 3F.14 — Form 3-2: associated checks**

| Check | Result | Reference in submittal |
|---|---|---|
| Drawdown times (Chapter 4) | | |
| Minimum orifice and trash screen (Chapter 4) | | |
| Emergency spillway (Chapter 4) | | |
| Outfall-closed storage check (Chapter 5) | | |
| Downstream analysis (Chapter 5) | | |

## F. Statement by the responsible engineer

I state that this comparison has been made by the procedure of Clause 3.14, with the same design storms in the pre- and post-development runs, and that no runoff has been diverted from one natural catchment to another to meet the criterion (Clause 3.14.2(b)).

**Table 3F.15 — Form 3-2: statement by the responsible engineer**

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |
| Signature | |
| Date | |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

ANNEXES TO CHAPTER 4

# Site Runoff Control: Retention and Detention

These annexes support Chapter 4. Annex 4C is a complete Tier A worked example with routing tables, built on the illustrative example of Clause 4.6.7. Annex 4B sets out the structure of the Tier B tables, the provisional fixed release coefficients and a standard orifice table computed from the Chapter 4 orifice equation; the values that need NIH-DHAARA depths are still to be derived. Annex 4A needs GIS and groundwater data that this draft does not yet contain; it gives the intended layout and the interim rules of Chapter 4. Forms 4-1 to 4-3 are the submittal forms required by Clause 4.17. They are draft forms and have no statutory status.

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## Annex 4A — Flood-sensitive catchment boundaries (GIS); shallow-groundwater zone map

Supports Clauses 4.5.3, 4.5.4 and 4.12 of Chapter 4.

4A.1 **Flood-sensitive catchment boundaries.** The catchments are those listed in Clause 4.5.3.2, with any catchment notified under Clause 4.5.4. Their maps and GIS layer are the same data set as Annex 1B, which lists the catchments and gives the attribute layout of the layer. The two annexes shall be issued together.

4A.2 **Shallow-groundwater zone map.** This map shows the areas where Clause 4.12 applies: the valley floors and river terraces of the Teesta, the Rangit and the Rongni Chu in sub-area SK-A (at Rangpo, Singtam, Melli, Majitar and Jorethang), land below the 1% AEP flood level of a river and the river bed and terraces raised by the flood of October 2023, the margins of the pokharis and of the hydropower reservoirs and their backwaters, the seepage zones below springs (dhara) on the slopes, and the ground of stability zones 3 to 6, which the Mines and Geology Department's notification of 2021 records as "Wet", "Dripping" or "Flowing", and any area where the groundwater table lies within 3 m of the surface at any time of year (Clause 4.12.1).

**To be prepared.** This annex will contain (a) the boundaries of the flood-sensitive catchments as a GIS layer and as maps at a scale fit for deciding whether a plot lies inside them, and (b) a map of the shallow-groundwater zone of Clause 4.12.1, with the seasonal high groundwater depth during and after the monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (WRD, NRSC, Survey of India), the river and jhora works of WRD, with their design levels [TBC], the CWC levels of the Teesta at Khanitar and Melli, of the Rongni Chu at Singtam and of the Rangit at Majitar (as transcribed by SANDRP, with the conflicts set out in the Commentary to Clause 3.10), surveyed marks of the flood of October 2023 and surveyed post-2023 bed levels along the Teesta [TBC], the river banks of the scheduled rivers under the Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988 from the Forest Department, the stability-zone maps of the Mines and Geology Department, the levels and release rules of the hydropower reservoirs from their operators [TBC], the GLOF evacuation maps of SSDMA and the District Disaster Management Authorities where they exist [TBC], the village spring atlas of the Dhara Vikas programme of RMDD, and any landslide inventory of GSI or SSDMA [TBC], town boundaries (UDD for the notified areas and the urban local bodies, the Gangtok Municipal Corporation, the Namchi Municipal Council and the Nagar Panchayats themselves, and the Land Revenue and Disaster Management Department for the revenue blocks and villages outside them [TBC]), flood maps held by SSDMA, observation-well records of the CGWB and the WRD, and the extent of the thin brown hill soils, colluvium and debris fans over the Daling Group and the Higher Himalayan rocks, the boulder and gravel terraces of the Teesta, the Rangit and the Rongni Chu, the river bed and terraces raised by the flood of October 2023, the alpine soils and moraine of sub-area SK-C and urban fill, with the slopes of more than 10° and the stability zones 3 to 6 to which the hill rule of Clause 4.11 applies and the valley-floor land to which its valley-floor rule applies from soil survey maps (NBSS&LUP, the State soil-survey agency of Sikkim [TBC]). Until it is published: (a) the catchments named in Clause 4.5.3.2 apply, and whether a site lies in one is decided and recorded as set out in Annex 1B; and (b) every site to which Clause 4.12.1 may apply establishes its design groundwater level from site piezometer readings over one April–November season or, failing that, from the nearest CGWB or State observation well plus 0.5 m and the design flood level of any adjacent river, khola, jhora, pokhari or reservoir, including the Teesta or the Rangit at a valley-floor town (Clause 4.12.1(b)). For the flotation check in the Teesta and Rangit valley floors and river terraces (at Rangpo, Singtam, Melli, Majitar and Jorethang), land below the 1% AEP flood level or on the river bed raised by the flood of October 2023, the pokhari and reservoir margins, and the seepage zones below springs (dhara) on slopes without piezometer readings, the design groundwater level is existing ground level (Clause 4.12.1).

Table 4A.1 — Attributes of the shallow-groundwater zone layer (layout)

| Field | Content | Unit or format |
|---|---|---|
| zone_id | Unique identifier | text |
| zone_class | Teesta, Rangit or Rongni Chu valley floor or river terrace (Rangpo, Singtam, Melli, Majitar, Jorethang or other); land below the 1% AEP flood level of a river or khola; river bed or terrace raised by the flood of October 2023; pokhari margin; hydropower reservoir margin or backwater (Teesta-V, Teesta-VI, Teesta Low Dam III or IV, Chuzachen, Dikchu, Jorethang, Tashiding, Rangit-III, Rongnichu or other); seepage zone below a spring (dhara) on a slope; stability zone 3 to 6 ("Wet", "Dripping" or "Flowing"); other area with groundwater within 3 m of the surface (Clause 4.12.1) | text |
| shgw_depth_m | Seasonal high groundwater depth below ground, monsoon season | m |
| shgw_basis | Wells or piezometers used, and period of record | text |
| tidal_influence | Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b)) | yes / no |
| source | Source agency and date of the data | text |
| geometry | Zone boundary | polygon |

## Annex 4B — Tier B tables: PSD and SSR (Table 4.3), retention credit factor C_R, standard outlet sizes; confirmed fixed release coefficients (Table 4.3A)

Supports Clauses 4.4.6.3, 4.14.1, 4.14.2 and 4.14.4 to 4.14.6 of Chapter 4.

4B.1 This annex will hold four tables. Their status in this draft is:

**Table 4B.1 — Contents of Annex 4B and their status**

| Table | Content | Clause | Status in this draft |
|---|---|---|---|
| 4B.2 | Tier B permissible site discharge (PSD) and site storage requirement (SSR), the values of Table 4.3 | 4.14.2 | To be prepared |
| 4B.3 | Retention credit factor C_R | 4.4.6.3 | To be prepared; C_R = 0 until published |
| 4B.4 | Standard outlet sizes | 4.14.2 step 4, 4.14.6 | Computed in this annex from the orifice equation of Clause 4.6.5.2 |
| 4B.5 | Fixed release coefficients C_10 and C_2 (Table 4.3A) | 4.14.4 | Provisional values of Table 4.3A; confirmed values to be prepared |

### 4B.2 PSD and SSR (Table 4.3)

**To be prepared.** This table will give, for each rainfall zone, hydrologic soil group and post-development imperviousness, the PSD for the 2-yr and 100-yr stages and the SSR, for standard and flood-sensitive catchments, in the layout of Table 4.3. It needs NIH-DHAARA design depths with the climate factor for each zone (Chapter 2, Annex 2A), the sub-daily ratios of Annex 2B, and routing of a set of standard sites by the full method of Clause 4.6 for every AEP and duration of Table 4.1. Each PSD shall be the governing release cap and each SSR the governing storage per hectare, with a margin so that the simplified method is never cheaper than routing. Until it is published, Tier B sites use Clause 4.6, or the fixed-coefficient route of Clause 4.14.3 where the site is 1 ha or less (Clauses 4.14.1 and 4.14.3).

**Table 4B.2 — Tier B PSD and SSR (layout of Table 4.3)**

| Zone (Annex 2A) | HSG | Imperviousness | PSD 2-yr (L/s/ha) | PSD 100-yr (L/s/ha), standard | PSD 100-yr (L/s/ha), flood-sensitive | SSR ($m^3$/ha), standard | SSR ($m^3$/ha), flood-sensitive |
|---|---|---|---|---|---|---|---|
| SK-Z1 Southern hills and valleys: SK-A Lower valleys (Rangpo–Singtam–Melli–Jorethang), at the depths of Clause 2.3.6(c)(i) | A / B / C / D | 50% / 70% / 90% | — | — | — | — | — |
| SK-Z1 Southern hills and valleys: SK-B Ridge towns (Gangtok–Pakyong–Namchi–Gyalshing), at the depths of Clause 2.3.6(c)(i) after the record check of Clause 2.3.6(h) | C / D | 50% / 70% / 90% | — | — | — | — | — |

| Zone (Annex 2A) | HSG | Imperviousness | PSD 2-yr (L/s/ha) | PSD 100-yr (L/s/ha), standard | PSD 100-yr (L/s/ha), flood-sensitive | SSR (m³/ha), standard | SSR (m³/ha), flood-sensitive |
|---|---|---|---|---|---|---|---|
| SK-Z2 North Sikkim: SK-B1 Middle Teesta valley (Dikchu–Mangan–Singhik–Chungthang), at the floor of Clause 2.3.6(c)(ii); where a station fit replaces the floor, Clause 4.6 applies | C / D | 50% / 70% / 90% | — | — | — | — | — |
| SK-Z2 North Sikkim: SK-C High valleys (Lachen–Lachung–Thangu) | — | — | Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(iii) and (i)) | — | — | — | — |

## 4B.3 Retention credit factor C_R

**To be prepared.** This table will give C_R for each rainfall zone, hydrologic soil group and design infiltration or drawdown rate of the retention practice (Clauses 4.4.3 and 4.4.6.3). It needs routing of the full duration set of Clause 2.5.2 with NIH-DHAARA depths, with the retention practice modelled as in Clause 4.4.6.2, and the credit expressed as the reduction in governing storage per cubic metre of retention provided. Until it is published, **C_R = 0** (Clause 4.4.6.3).

**Table 4B.3 — Retention credit factor C_R (layout)**

| Zone (Annex 2A) | HSG | Design infiltration or drawdown rate (mm/h) | C_R (–) |
|---|---|---|---|
| | | | |
| | | | |

## 4B.4 Standard outlet sizes

4B.4.1 Table 4B.4 gives the largest circular orifice, in 5 mm steps, whose discharge does not exceed a stated permissible discharge at a stated head. It is computed from the orifice equation with the discharge coefficient of Clause 4.6.5.2:

$$Q = 0.60 \times (\pi d^2 / 4) \times \sqrt{(2 g H)}$$

where Q is the discharge (m³/s), d the orifice diameter (m), g = 9.81 m/s² and H the head from the water level to the centre of the orifice (m). Sizes are rounded **down**, so that the orifice never passes more than the permissible discharge. Where the computed size is below 50 mm, the 50 mm minimum of Clause 4.8.2 is shown; it is deemed to comply under Clause 4.5.5.1.

4B.4.2 The table assumes free discharge. Where the tailwater can rise above the orifice (Clause 4.6.6), H is the difference between the upstream and downstream water levels and the orifice shall be checked by routing. The State Stormwater Technical Committee may replace this table when it issues Annex 4B.

Table 4B.4 — Largest orifice diameter (mm) for a permissible discharge at a given head (Cd = 0.60, free discharge)

| Permissible discharge (L/s) | H = 0.5 m | H = 1.0 m | H = 1.5 m | H = 2.0 m |
|---|---|---|---|---|
| 5 | 55 | 50 | 50 | 50 |
| 10 | 80 | 65 | 60 | 55 |
| 15 | 100 | 80 | 75 | 70 |
| 20 | 115 | 95 | 85 | 80 |
| 30 | 140 | 115 | 105 | 100 |
| 50 | 180 | 150 | 135 | 130 |
| 75 | 225 | 185 | 170 | 155 |
| 100 | 260 | 215 | 195 | 180 |
| 150 | 315 | 265 | 240 | 225 |
| 200 | 365 | 305 | 275 | 260 |
| 300 | 450 | 375 | 340 | 315 |

Check: for 50 L/s at H = 1.0 m, the area is 0.050 / (0.60 × √(2 × 9.81 × 1.0)) = 0.0188 m², so d = √(4 × 0.0188 / π) = 0.155 m, rounded down to 150 mm.

### 4B.5 Fixed release coefficients (Table 4.3A)

4B.5.1 Table 4B.5 repeats the provisional coefficients of Table 4.3A. They may be used now under the fixed-coefficient route (Clause 4.14.4).

Table 4B.5 — Fixed release coefficients C_10 and C_2 (provisional, Table 4.3A)

| Hydrologic soil group | C_10 | C_2 | Clause | Status |
|---|---|---|---|---|
| A (sandy, well drained) | 0.05 | 0.02 | 4.14.4 | Provisional |
| B | 0.08 | 0.03 | 4.14.4 | Provisional |
| C | 0.15 | 0.08 | 4.14.4 | Provisional |
| D (clay, poorly drained) | 0.25 | 0.15 | 4.14.4 | Provisional |

**To be prepared.** The confirmed coefficients will replace Table 4B.5. They need NIH-DHAARA depths for each zone and the greenfield curve numbers of Clause 3.3, as described in the commentary to Clause 4.14. Until they are published, the provisional values of Table 4.3A apply.

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## Annex 4C — Worked example (Tier A) with full routing tables

Supports Clauses 4.4 to 4.9, 4.15 and 4.17 of Chapter 4.

**Illustrative — not design values.** This example continues the illustrative example of Clause 4.6.7. Its inputs are invented to be plausible for a hillside colony in Gangtok draining to a jhora; they are not NIH-DHAARA values and must not be used for design. Part 1 sets out the inputs, hydrographs and routing step by step, for a trial outlet. Part 2 finds that the trial outlet fails the drawdown check with the blockage of Clause 4.8.3, and revises it to the outlet reported in Table 4.2. Part 3 completes the spillway, outlet, safety and retention checks. The outfall-closed check of Chapter 5 for the same facility on an outfall to a jhora below a hillside colony in Gangtok is in Annex 5C.

## Part 1 — Inputs, hydrographs and routing (Clauses 4.6.1 to 4.6.4)

4C.1 **Inputs.**

**Table 4C.1 — Inputs (Illustrative — not design values)**

| Item | Value | Basis |
|---|---|---|
| Site area A | 2.0 ha (0.02 km²), one outfall | Clause 4.6.7 |
| Catchment class | Flood-sensitive (Clause 4.5.3) | Clause 4.6.7 |
| Land cover and curve numbers, AMC II | Pre-development: all pervious, CN 70. Post-development, as two sub-areas: directly connected impervious 1.57 ha at CN 98, and pervious open space 0.43 ha at CN 70 (same soil as pre-development). Impervious fraction f = (92 − 70) / (98 − 70) = 0.786, so the area-weighted CN is 92 | Clauses 3.9.2, 4.6.7 |
| AMC III conversion | Pervious areas only, for storms of 12 h and longer: CN_III = 23·CN / (10 + 0.13·CN) = 84.3. The impervious CN 98 is not converted | Clause 3.8.4 |
| Initial abstraction | Ia = 0.2S; Ia = 0.05S as a sensitivity run | Clause 3.8.5 |
| Time of concentration Tc | 45 min pre-development; 15 min post-development, used for both sub-areas, because the open space is small and drains through the same site system | Clause 4.6.7 |
| Unit hydrograph | SCS triangular; tL = 0.6 Tc; tp = Δt/2 + tL; base 2.67 tp | Clauses 3.6.5, 3.11.2 |
| Time step Δt | 5 min (= Tc/3 of the post-development site) | Clause 4.6.2, step 8 |
| 24-h depths, 2-, 10-, 100-yr | 110, 200, 350 mm, taken as including the climate factor | Clause 4.6.7 |
| Shorter durations | P(t) = P24 · (t/24)^0.40 (assumed ratio set, not Annex 2B) | Clause 4.6.7 |
| 48-h and 72-h depths | 1.25 and 1.40 × P24, with the 24-h depth on the last day | Clauses 4.6.7, 2.9.2 |
| Storage | Open, vertical-walled, 2,500 m² plan area, excavated, no embankment, not publicly accessible | Clause 4.6.7 |
| Trial outlet | Stage 1: 120 mm orifice at the floor. Stage 2: 470 mm orifice, invert 0.533 m above the floor. No Stage 3 | Trial for this annex; Part 2 revises it |
| Outfall | Free outfall to a receiving drain whose level stays below the outlet invert | Illustrative input |

The example follows Clauses 3.8.4 and 3.9.2: the runoff of each sub-area is computed separately and the two are added before routing.

4C.2 **Design rainfall.** Table 4C.2 gives the depths. For example, the 100-yr 6-hour depth is 350 × (6/24)^0.40 = 350 × 0.574 = 201.0 mm.

**Table 4C.2 — Design rainfall depths, mm (Illustrative — not design values)**

| Duration (h) | 1 | 2 | 3 | 6 | 12 | 24 | 48 | 72 |
|---|---|---|---|---|---|---|---|---|
| 50% AEP (2-yr) | 30.9 | 40.7 | 47.9 | 63.2 | 83.4 | 110.0 | 137.5 | 154.0 |
| 10% AEP (10-yr) | 56.1 | 74.0 | 87.1 | 114.9 | 151.6 | 200.0 | 250.0 | 280.0 |
| 1% AEP (100-yr) | 98.2 | 129.5 | 152.3 | 201.0 | 265.3 | 350.0 | 437.5 | 490.0 |

4C.3 **Hyetographs.** Storms up to 24 h use the alternating-block method in 5-minute blocks with the peak block at mid-storm (Clause 2.9.1). The 48- and 72-hour storms spread the depth in excess of the 24-hour depth uniformly over the first 24 or 48 h and place the 24-hour alternating-block storm on the last day (Clause 2.9.2). For the 100-yr 72-hour storm: (490.0 − 350.0) / 576 blocks = 0.243 mm per 5 minutes for the first 48 h; the peak 5-minute block on the last day is 350 × (5/1440)^0.40 = 36.3 mm, at 60:00–60:05 h.

4C.4 **Losses.** Table 4C.3 gives S = 25,400/CN − 254 (mm) and Ia = 0.2S. The runoff depth for a rainfall depth P is Q = (P − Ia)² / (P − Ia + S) for P > Ia, and zero otherwise.

**Table 4C.3 — Curve numbers and abstractions (Illustrative — not design values)**

| Condition | AMC | CN | S (mm) | Ia = 0.2S (mm) |
|---|---|---|---|---|
| Pre-development | II (durations ≤ 6 h) | 70 | 108.9 | 21.8 |
| Pre-development | III (durations ≥ 12 h) | 84.3 | 47.3 | 9.5 |
| Post-development pervious open space (0.43 ha) | II (durations ≤ 6 h) | 70 | 108.9 | 21.8 |
| Post-development pervious open space (0.43 ha) | III (durations ≥ 12 h) | 84.3 | 47.3 | 9.5 |
| Post-development directly connected impervious (1.57 ha) | All durations (not converted) | 98 | 5.2 | 1.0 |

Check: 100-yr 24 h, post-development. Impervious: Q = (350.0 − 1.0)² / (350.0 − 1.0 + 5.2) = 343.9 mm. Pervious, AMC III: Q = (350.0 − 9.5)² / (350.0 − 9.5 + 47.3) = 299.0 mm. Site: 0.786 × 343.9 + 0.214 × 299.0 = 334.2 mm. The post-development columns of Table 4C.4 are these area-weighted site depths.

**Table 4C.4 — Storm runoff depth Q, mm (Illustrative — not design values)**

| Duration (h) | AMC | 2-yr pre | 2-yr post | 10-yr pre | 10-yr post | 100-yr post |
|---|---|---|---|---|---|---|
| 1 | II | 0.7 | 20.1 | 8.2 | 41.3 | 79.2 |
| 2 | II | 2.8 | 28.2 | 16.9 | 57.2 | 108.5 |
| 3 | II | 5.1 | 34.2 | 24.5 | 69.0 | 130.2 |
| 6 | II | 11.4 | 47.5 | 42.9 | 94.7 | 177.1 |
| 12 | III | 45.0 | 70.5 | 106.6 | 137.2 | 249.9 |
| 24 | III | 68.4 | 96.4 | 152.6 | 185.1 | 334.2 |
| 48 | III | 93.5 | 123.3 | 201.0 | 234.7 | 421.5 |
| 72 | III | 108.9 | 139.6 | 230.3 | 264.5 | 473.9 |

The runoff volume is 10 × Q × A = 20 × Q m³ for this 2.0 ha site: for example 9,478 m³ for the 100-yr 72-hour storm. The routed hydrographs carry up to 0.5% less, because the 5-minute alternating-block storm places 349.5 mm rather than 350.0 mm on the last day.

4C.5 **Unit hydrographs.** The runoff in each 5-minute block (for the post-development site, the sum of the two sub-areas) is convolved with the triangular unit hydrograph of Table 4C.5. The peak is qp = 0.208 × A × Q / tp, with A in km² and Q = 1 mm (Clause 3.11.2).

**Table 4C.5 — Unit hydrograph parameters (Illustrative — not design values)**

| Condition | Tc (h) | tL = 0.6 Tc (h) | tp = Δt/2 + tL (h) | Base 2.67 tp (h) | qp (L/s per mm of runoff) |
|---|---|---|---|---|---|
| Pre-development | 0.75 | 0.45 | 0.492 | 1.313 | 8.5 |
| Post-development | 0.25 | 0.15 | 0.192 | 0.512 | 21.7 |

4C.6 **Release caps (Clause 4.5.3).** The site is flood-sensitive, so the mixed-frequency rule applies. The 100-yr cap is the largest pre-development 10-yr peak over all durations: **356 L/s** (72 h; Table 4.2). The 2-yr cap is the largest pre-development 2-yr peak: **180 L/s** (72 h). Each cap applies to every post-development duration (Clause 4.5.3.1).

4C.7 **Stage–storage–discharge.** The basin is vertical-walled, so storage S = 2,500 × h (m³), where h is the stage above the floor (m). Outlet discharge follows Clause 4.6.5.2 with Cd = 0.60:

- Stage 1, for h ≥ d: Q1 = 0.60 × A1 × √(2g (h − d/2)). For h < d (orifice part-full), the head is taken as d/2 and the result is multiplied by h/d.
- Stage 2 is counted once the water is above its centre: Q2 = 0.60 × A2 × √(2g (h − z2 − d2/2)), where z2 is its invert. Below its centre its flow is ignored, which slightly over-states storage.

**Table 4C.6 — Stage–storage–discharge, trial outlet (Illustrative — not design values)**

| Stage h (m) | Storage (m³) | Stage 1, 120 mm (L/s) | Stage 2, 470 mm (L/s) | Total (L/s) |
|---|---|---|---|---|
| 0.00 | 0 | 0.0 | 0.0 | 0.0 |
| 0.06 | 150 | 3.7 | 0.0 | 3.7 |
| 0.12 | 300 | 7.4 | 0.0 | 7.4 |
| 0.20 | 500 | 11.2 | 0.0 | 11.2 |
| 0.30 | 750 | 14.7 | 0.0 | 14.7 |
| 0.40 | 1,000 | 17.5 | 0.0 | 17.5 |
| 0.50 | 1,250 | 19.9 | 0.0 | 19.9 |
| 0.60 | 1,500 | 22.1 | 0.0 | 22.1 |
| 0.70 | 1,750 | 24.0 | 0.0 | 24.0 |
| 0.80 | 2,000 | 25.9 | 83.0 | 108.9 |
| 0.90 | 2,250 | 27.5 | 167.8 | 195.3 |
| 1.00 | 2,500 | 29.1 | 222.3 | 251.4 |
| 1.10 | 2,750 | 30.7 | 265.8 | 296.5 |
| 1.20 | 3,000 | 32.1 | 303.2 | 335.3 |
| 1.30 | 3,250 | 33.5 | 336.4 | 369.9 |
| 1.40 | 3,500 | 34.8 | 366.7 | 401.5 |

Check at h = 1.00 m: Q1 = 0.60 × 0.01131 × √(19.62 × 0.94) = 0.0291 m³/s; Q2 = 0.60 × 0.1735 × √(19.62 × (1.00 − 0.533 − 0.235)) = 0.2223 m³/s.

4C.8 **Routing.** Each storm is routed by level-pool continuity (Clause 4.6.1): over each 5-minute step, the change in storage equals inflow volume minus outflow volume. The computation used six 50-second sub-steps per 5-minute step. Each row of Table 4C.7 can be checked by hand as $\Delta S \approx (I - \bar{O}) \times 300$ s, where I is the mean inflow over the 5-minute step ending at the time shown and $\bar{O}$ is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: $\Delta S = 2{,}853.0 - 2{,}613.3 = 239.7$ m³, and $(1.0891 - (0.2655 + 0.3069)/2) \times 300 = 240.9$ m³.

**Table 4C.7 — Routing of the 100-yr 72-hour storm through the trial outlet, around the peak (Illustrative — not design values)**

| Time (h:min) | Rainfall in step (mm) | Inflow I (L/s) | Outflow O (L/s) | Storage S (m³) | Stage h (m) |
|---|---|---|---|---|---|
| 60:00 | 8.44 | 286.3 | 169.5 | 2,164.0 | 0.866 |
| 60:05 | 36.33 | 354.2 | 184.1 | 2,216.9 | 0.887 |
| 60:10 | 11.61 | 703.3 | 218.0 | 2,367.1 | 0.947 |
| 60:15 | 6.88 | 1,066.0 | 265.5 | 2,613.3 | 1.045 |
| 60:20 | 5.23 | 1,089.1 | 306.9 | 2,853.0 | 1.141 |
| 60:25 | 4.34 | 897.5 | 334.8 | 3,025.0 | 1.210 |
| 60:30 | 3.77 | 653.2 | 349.9 | 3,117.6 | 1.247 |
| 60:35 | 3.36 | 403.6 | 353.8 | **3,132.9** | **1.253** |
| 60:40 | 3.05 | 301.5 | 352.3 | 3,117.3 | 1.247 |
| 60:45 | 2.81 | 254.8 | 348.6 | 3,088.7 | 1.235 |
| 60:50 | 2.61 | 224.9 | 343.7 | 3,052.4 | 1.221 |
| 60:55 | 2.45 | 203.3 | 337.9 | 3,011.3 | 1.205 |

Storage is greatest at the end of the step ending at 60:35. In the next step the mean inflow (302 L/s) is below the outflow (about 352 L/s), so storage falls.

**Table 4C.8 — Routing of the 100-yr 72-hour storm through the trial outlet, hourly (Illustrative — not design values)**

| Time (h) | Cumulative rainfall (mm) | Inflow (L/s) | Outflow (L/s) | Stage (m) | Storage (m³) |
|---|---|---|---|---|---|
| 12 | 35.0 | 14 | 8 | 0.130 | 325 |
| 24 | 70.0 | 15 | 12 | 0.215 | 536 |
| 36 | 105.0 | 16 | 14 | 0.264 | 660 |
| 48 | 140.0 | 16 | 15 | 0.294 | 736 |
| 54 | 181.7 | 47 | 19 | 0.469 | 1,172 |
| 57 | 213.5 | 69 | 23 | 0.623 | 1,559 |
| 59 | 248.5 | 120 | 91 | 0.789 | 1,971 |
| 60 | 293.3 | 286 | 170 | 0.866 | 2,164 |
| 61 | 378.0 | 187 | 332 | 1.187 | 2,967 |
| 62 | 399.3 | 106 | 237 | 0.968 | 2,421 |
| 63 | 414.5 | 80 | 142 | 0.829 | 2,072 |
| 66 | 446.9 | 51 | 52 | 0.771 | 1,927 |

| Time (h) | Cumulative rainfall (mm) | Inflow (L/s) | Outflow (L/s) | Stage (m) | Storage (m³) |
|---|---|---|---|---|---|
| 72 | 489.5 | 33 | 33 | 0.768 | 1,920 |
| 84 | 489.5 | 0 | 18 | 0.405 | 1,012 |
| 96 | 489.5 | 0 | 10 | 0.167 | 418 |
| 108 | 489.5 | 0 | 4 | 0.058 | 146 |

The routed outflow volume equals the inflow volume (about 9,470 m³): detention delays the volume but does not remove it.

4C.9 **Results, trial outlet.** Table 4C.9 gives the peaks, maximum stages and drawdown times for the trial outlet.

**Table 4C.9 — Results for the trial outlet (120 mm and 470 mm orifices) (Illustrative — not design values)**

| Duration (h) | 2-yr detained (L/s) | 2-yr max stage (m) | 10-yr detained (L/s) | 10-yr max stage (m) | 100-yr detained (L/s) | 100-yr max stage (m) | 100-yr storage (m³) | 10-yr 90% drawdown, clean (h) | 10-yr 90% drawdown, 50% blocked (h) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9 | 0.15 | 15 | 0.30 | 22 | 0.59 | 1,468 | 27.2 | 54.2 |
| 2 | 11 | 0.20 | 18 | 0.42 | 89 | 0.79 | 1,966 | 28.3 | 57.0 |
| 3 | 13 | 0.24 | 20 | 0.50 | 135 | 0.82 | 2,058 | 29.3 | 59.1 |
| 6 | 15 | 0.31 | 23 | 0.64 | 190 | 0.89 | 2,229 | 31.1 | 63.4 |
| 12 | 17 | 0.40 | 49 | 0.77 | 279 | 1.06 | 2,647 | 36.2 | 69.2 |
| 24 | 19 | 0.45 | 87 | 0.79 | 334 | 1.20 | 2,991 | 42.8 | 75.4 |
| 48 | 20 | 0.51 | 144 | 0.83 | 353 | 1.25 | 3,129 | 42.5 | 72.7 |
| 72 | 20 | 0.52 | 147 | 0.84 | 354 | 1.25 | **3,133** | 42.5 | 71.9 |

The drawdown time is measured from the time of maximum 10-yr storage until 90% of that storage has been released (Clause 4.7.1).

## Part 2 — Checks and revision of the outlet (Clauses 4.5, 4.7 and 4.8)

4C.10 **Release caps.** Every 100-yr detained peak is at or below 356 L/s, and every 2-yr detained peak is far below the 2-yr cap of 180 L/s. Both caps are met. The 2-yr peaks are not compared duration by duration with the pre-development peaks: for a flood-sensitive site the 2-yr cap is the single largest pre-development 2-yr peak (Clause 4.5.3.1).

4C.11 **Drawdown.** Clause 4.8.3 requires the low-flow orifice to be assumed **50% blocked** when drawdown is checked. With the 120 mm orifice at half its area, 90% of the 10-yr storage takes 54 to 75 h to drain (Table 4C.9), against the 48-hour limit of Clause 4.7.1. **The trial outlet fails.** With a clean orifice it would drain in about 42 h.

4C.12 **Revised outlet.** The low-flow orifice was increased in 10 mm steps until the blocked drawdown met 48 h for every duration, and Stage 2 was then re-sized so that the 100-yr cap was still met. The result:

- Stage 1: **170 mm** orifice at the floor;
- Stage 2: **460 mm** orifice, invert 0.53 m above the floor (centre at 0.76 m);
- no Stage 3.

The larger low-flow orifice releases more in frequent storms. That is acceptable here because the 2-yr cap of a flood-sensitive site is the largest pre-development 2-yr peak (Clause 4.5.3.1). The WQv is assumed to be treated in a separate practice upstream (Chapter 8), so Stage 1 is not required to hold the WQv for 24–48 h (Clause 4.6.5.1); where Stage 1 also releases the WQv, Clause 4.7.2 must be checked as well.

**Table 4C.10 — Stage–storage–discharge, revised outlet (Illustrative — not design values)**

| Stage h (m) | Storage (m³) | Stage 1, 170 mm (L/s) | Stage 2, 460 mm (L/s) | Total (L/s) |
|---|---|---|---|---|
| 0.00 | 0 | 0.0 | 0.0 | 0.0 |
| 0.085 | 213 | 8.8 | 0.0 | 8.8 |
| 0.17 | 425 | 17.6 | 0.0 | 17.6 |
| 0.30 | 750 | 28.0 | 0.0 | 28.0 |
| 0.40 | 1,000 | 33.9 | 0.0 | 33.9 |
| 0.50 | 1,250 | 38.9 | 0.0 | 38.9 |
| 0.60 | 1,500 | 43.3 | 0.0 | 43.3 |
| 0.70 | 1,750 | 47.3 | 0.0 | 47.3 |
| 0.76 | 1,900 | 49.6 | 0.0 | 49.6 |
| 0.80 | 2,000 | 51.0 | 88.3 | 139.3 |
| 0.90 | 2,250 | 54.5 | 165.3 | 219.7 |
| 1.00 | 2,500 | 57.7 | 216.4 | 274.1 |
| 1.10 | 2,750 | 60.8 | 257.5 | 318.3 |
| 1.17 | 2,925 | 62.8 | 282.8 | 345.6 |
| 1.20 | 3,000 | 63.7 | 293.0 | 356.7 |
| 1.30 | 3,250 | 66.5 | 324.6 | 391.1 |

**Table 4C.11 — Results for the revised outlet (170 mm and 460 mm orifices) (Illustrative — not design values)**

| Duration (h) | 2-yr detained (L/s) | 2-yr max stage (m) | 10-yr detained (L/s) | 10-yr max stage (m) | 10-yr storage (m³) | 100-yr detained (L/s) | 100-yr max stage (m) | 100-yr storage (m³) | 10-yr 90% drawdown, 50% blocked (h) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 0.14 | 28 | 0.29 | 734 | 42 | 0.57 | 1,426 | 31.3 |
| 2 | 20 | 0.19 | 34 | 0.40 | 990 | 79 | 0.76 | 1,911 | 32.1 |
| 3 | 22 | 0.22 | 37 | 0.46 | 1,147 | 139 | 0.80 | 1,999 | 32.8 |
| 6 | 25 | 0.26 | 41 | 0.56 | 1,386 | 194 | 0.86 | 2,154 | 34.2 |
| 12 | 30 | 0.33 | 46 | 0.68 | 1,692 | 276 | 1.01 | 2,512 | 39.0 |
| 24 | 32 | 0.37 | 49 | 0.75 | 1,870 | 320 | 1.11 | 2,766 | 45.3 |
| 48 | 34 | 0.40 | 82 | 0.77 | 1,913 | 343 | 1.17 | **2,913** | 44.8 |
| 72 | 34 | 0.41 | 84 | 0.77 | 1,915 | 343 | 1.16 | 2,911 | 44.7 |

Findings:

- **100-yr cap:** largest detained peak 343 L/s ≤ 356 L/s. Met.
- **2-yr cap:** largest detained peak 34 L/s ≤ 180 L/s. Met.
- **Drawdown:** longest blocked drawdown 45.3 h ≤ 48 h (Clause 4.7.1). Met.
- **Governing storage: 2,913 m³** (100-yr, 48 h), at a maximum stage of **1.17 m**. The larger low-flow orifice releases more water early in the long storms, so the revised outlet needs about 220 m³ less storage than the trial outlet. Table 4.2 in Clause 4.6.7 reports this revised design.
- **Governing storms (Clause 4.6.2, step 12):** storage, the 100-yr 48-hour storm; Stage 1, the 10-yr 24-hour storm (drawdown); Stage 2, the 100-yr 48-hour storm (cap).

## Part 3 — Sensitivity, retention, spillway, outlet details and safety

4C.13 **Ia = 0.05S sensitivity (Clause 3.8.5).** With S converted as S0.05 = 25.4 × 1.33 × (S0.20 / 25.4)^1.15, the governing 100-yr 48-hour run gives 2,898 m³ of storage and a 341 L/s peak, slightly below the default run. The pre-development 10-yr peak, and so the 100-yr cap, falls to 344 L/s. The design is based on the default run (Clause 3.8.5(c)); the sensitivity results are reported on Form 3-2.

4C.14 **Retention and retention credit (Clauses 4.4.2 and 4.4.6).** With an illustrative retention depth P_R = 40 mm, Q_R is computed for each sub-area at AMC II, because a composite CN is not used for retention (Clause 3.9.4). Impervious, CN 98: S = 5.2 mm, Ia = 1.0 mm, Q_R = (40 − 1.0)² / (40 − 1.0 + 5.2) = 34.4 mm. Pervious, CN 70: S = 108.9 mm, Ia = 21.8 mm, Q_R = (40 − 21.8)² / (40 − 21.8 + 108.9) = 2.6 mm. RRV = 10 × (34.4 × 1.571 + 2.6 × 0.429) = **552 m³**. The retention is modelled as a store that is empty at the start of the storm and captures all runoff until full, with no infiltration during the storm (Clause 4.4.6.2).

**Table 4C.12 — Retention credit by routing, revised outlet (Illustrative — not design values)**

| 100-yr storm | Storage without retention (m³) | Storage with retention (m³) | Reduction (m³) |
|---|---|---|---|
| 24 h | 2,766 | 2,628 | 138 |
| 48 h | 2,913 | 2,906 | 7 |
| 72 h | 2,911 | 2,911 | 0 |

The governing storage falls from 2,913 to 2,906 m³, so the retention credit is 7 m³, about 1% of the RRV. The retention is still required in full for its own purposes (Clause 4.4.1, Chapter 8).

4C.15 **Emergency spillway (Clause 4.9).** The facility is excavated, with no embankment, so Clause 4.9.7 applies: the overflow route is treated as the spillway and must meet Clause 4.9.1.

- Design flow: the 1% AEP peak inflow, 1,089 L/s, with the outlet blocked and the basin full to the crest.
- Crest: the 1% AEP maximum water level with the outlet working is 1.17 m; with the recommended 0.15 m clearance (Clause 4.9.3) the crest is set at **1.35 m**.
- Crest length: a broad-crested weir with Q = C × L × H^1.5, C = 1.7 (an illustrative coefficient for a broad-crested weir in SI units; Clause 4.6.5.2 requires a coefficient suited to the shape). With L = 4.0 m: H = (1.089 / (1.7 × 4.0))^(2/3) = 0.295 ≈ **0.30 m**.
- Maximum level with the spillway flowing: 1.35 + 0.30 = 1.65 m. With 0.3 m freeboard (Clause 4.9.1), the top of the walls is at least **1.95 m** above the floor.
- The spillway discharges to the 1% AEP overland flow path, away from buildings (Clause 4.9.4).

4C.16 **Outlet details (Clause 4.8).**

**Table 4C.13 — Outlet checks, revised outlet (Illustrative — not design values)**

| Item | Requirement | Value | Result |
|---|---|---|---|
| Minimum orifice | ≥ 50 mm (Clause 4.8.2) | 170 mm | Met |
| Rack bar spacing | ≤ half the smallest opening and ≥ 25 mm (Clause 4.8.3) | ≤ 85 mm | Set at 75 mm |
| Rack open area | ≥ 10 × area protected (Clause 4.8.3) | 10 × (0.0227 + 0.1662) m² = 1.89 m² for one rack around both orifices | Provide ≥ 1.89 m² |
| Anti-vortex, Stage 1 | Needed if head > 1.5 d (Clause 4.8.4) | Head up to 1.08 m > 0.26 m | Required |
| Anti-vortex, Stage 2 | Needed if head > 1.5 d (Clause 4.8.4) | Head above centre up to 0.41 m < 0.69 m | Not required |
| Isolation | Facility serving > 1 ha (Clause 4.8.6) | Serves 2.0 ha | Stop-log slot or penstock, normally open |
| Outlet barrel | ≥ 300 mm (Clause 4.8.5) | Sized under Chapter 9 for 343 L/s | To be designed |

4C.17 **Safety (Clause 4.15).** The 10-yr depth (0.77 m) exceeds the 0.45 m limit for publicly accessible storage (Clause 4.15.1(a)), so the facility is not open to the public. It has vertical walls higher than 0.6 m and a depth of more than 1.2 m when the spillway flows, so a non-climbable fence at least 1.2 m high with a lockable gate is required (Clause 4.15.3). Signs and a depth marker are provided (Clause 4.15.5).

4C.18 **Summary of the design (Illustrative — not design values).**

**Table 4C.14 — Summary of the revised design (Illustrative — not design values)**

| Item | Value |
|---|---|
| Storage | 2,500 m² plan area; 2,913 m³ at the 1% AEP maximum level of 1.17 m |
| Stage 1 | 170 mm orifice at the floor, with trash rack and anti-vortex plate |
| Stage 2 | 460 mm orifice, invert 0.53 m |
| Spillway | Crest 1.35 m, length 4.0 m, maximum level 1.65 m |
| Top of walls | ≥ 1.95 m above the floor |
| 100-yr peak release | 343 L/s (cap 356 L/s) |
| 2-yr peak release | 34 L/s (cap 180 L/s) |
| 10-yr drawdown, 50% blocked | 45.3 h (limit 48 h) |
| Retention | RRV 552 m³ provided in addition; credit 7 m³ |
| Still to be checked | Outfall-closed check on an outfall to a jhora below a hillside colony in Gangtok (Annex 5C); downstream analysis (Chapter 5); groundwater and flotation (Clause 4.12); WQv (Chapter 8) |

## Form 4-1 — Site Runoff Control Report

Supports Clauses 4.3 to 4.17 of Chapter 4.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One form for each site. Where the site drains to more than one outfall, complete Sections E to J for each outfall (Clause 4.5.1.3). Tier B sites using Clause 4.14.2 attach Form 4-2 in place of Sections F and G; sites using the fixed-coefficient route attach Form 4-3 in place of Sections F and G (Clause 4.17).

### A. Site and route

**Table 4F.1 — Form 4-1: site and route**

| Field | Entry |
|---|---|
| A1. Project name and applicant | |
| A2. Location (village or ward, survey numbers, district) | |
| A3. Approving Authority and tier (Tier A / Tier B) | |
| A4. Site area, land disturbance and new or replaced impervious area (ha, ha, m²) (Clause 4.1.2) | |
| A5. Number of outfalls (Clause 4.5.1.3) | |
| A6. Sizing route: full method (Clause 4.6) / Tier B tables (Clause 4.14.2) / fixed-coefficient route (Clause 4.14.3) | |
| A7. Constrained redevelopment route used (Clause 4.5.6)? If yes, attach the Constraint Statement, the existing-condition model and the shortfall and fee computation | |

### B. Inputs (Clause 4.17, item 1)

**Table 4F.2 — Form 4-1: inputs**

| Field | Entry |
|---|---|
| B1. Design Rainfall Sheet reference (Form 2-1) | |
| B2. Hydrologic Calculation Summary reference (Form 3-1) | |
| B3. HSG of each sub-area and the tests that confirm it (Clause 4.6.2, step 1) | |
| B4. Pre-development condition and CN (Clause 4.5.1.2) | |
| B5. Post-development CN of each sub-area, and Tc pre and post | |
| B6. Routing method and software, with version; time step (Clauses 4.6.1, 4.6.2) | |

### C. Order of measures (Clause 4.3.1; Clause 4.17, item 2)

**Table 4F.3 — Form 4-1: order of measures**

| Step | What the design does | Why this step cannot do more |
|---|---|---|
| 1. Preserve | | |
| 2. Retain | | |

| Step | What the design does | Why this step cannot do more |
|---|---|---|
| 3. Detain | | |
| 4. Convey | | |

## D. Retention (Clause 4.4; Clause 4.17, items 3 and 4)

### Table 4F.4 — Form 4-1: retention

| Field | Entry |
|---|---|
| D1. Retention depth P_R (mm) and zone (Annex 2E) | |
| D2. Runoff depth Q_R (mm) by sub-area and RRV (m³) (Clause 4.4.2) | |
| D3. Retention practices and volume provided (m³) | |
| D4. Infiltration tests: number, locations and depths, measured rates (mm/h) (Clause 4.4.3(a)) | |
| D5. Design infiltration rate (mm/h), not more than half the measured rate (Clause 4.4.3(b)) | |
| D6. Seasonal high groundwater depth below the base of each practice (m), at least 1.0 m (Clause 4.4.3(c)) | |
| D7. Reuse demand calculation, where retention is by reuse (Clause 4.4.3) | |
| D8. Retention drawdown time (h), not more than 72 h (Clause 4.4.5) | |
| D9. Shortfall in RRV (m³), if any, treated as WQv (Clause 4.4.4.2) | |
| D10. Governing storage without and with retention, and the retention credit (m³) (Clause 4.4.6) | |
| D11. Preservation credit areas and covenant reference (Clause 4.4.7) | |

## E. Release criteria (Clause 4.5; Clause 4.17, item 5)

### Table 4F.5 — Form 4-1: release criteria

| Field | Entry |
|---|---|
| E1. Catchment class: standard (Clause 4.5.2) or flood-sensitive (Clause 4.5.3), with the Annex 4A map extract | |
| E2. Release caps by AEP (L/s), and the duration that sets each cap | |
| E3. Clause 4.5.5 used (50 mm orifice deemed to comply, or the short-duration 2-yr relief)? Report any 2-yr exceedance | |

## F. Results (Clause 4.6; Clause 4.17, item 6)

Complete one row for each duration, in the format of Table 4.2. Mark the governing case for storage, for each outlet stage and for the spillway (Clause 4.6.2, step 12).

### Table 4F.6 — Form 4-1: results by duration (L/s; m³)

| Duration (h) | 2-yr pre | 2-yr post, detained | 10-yr pre | 10-yr post, detained | 100-yr post, uncontrolled | 100-yr post, detained | 100-yr storage used |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

| Duration (h) | 2-yr pre | 2-yr post, detained | 10-yr pre | 10-yr post, detained | 100-yr post, uncontrolled | 100-yr post, detained | 100-yr storage used |
|---|---|---|---|---|---|---|---|
| 3 | | | | | | | |
| 6 | | | | | | | |
| 12 | | | | | | | |
| 24 | | | | | | | |
| 48 | | | | | | | |
| 72 | | | | | | | |

## G. Facility, drawdown and outlet (Clauses 4.7, 4.8, 4.10; Clause 4.17, items 7 to 9)

### Table 4F.7 — Form 4-1: facility, drawdown and outlet

| Field | Entry |
|---|---|
| G1. Facility type (Clause 4.10) and storage provided ($m^3$) | |
| G2. Stage–storage and stage–discharge tables and plots; inflow and outflow hydrographs for the governing cases (attach) | |
| G3. 10-yr drawdown: time to release 90% of the maximum stored volume (h), with the low-flow orifice 50% blocked (Clauses 4.7.1, 4.8.3) | |
| G4. WQv release time (h), 24 to 48 h (Clause 4.7.2) | |
| G5. Tidal outfall: drawdown with the tidal tailwater, and any pumped drawdown (Clause 4.7.4) | |
| G6. Each outlet stage: type, size (mm), invert level (m) | |
| G7. Trash racks: clear bar spacing (mm) and open area ($m^2$) (Clause 4.8.3) | |
| G8. Anti-vortex devices (Clause 4.8.4); outlet barrel diameter and seepage control (Clause 4.8.5); isolation (Clause 4.8.6) | |
| G9. Proprietary devices: certified head–discharge curve and minimum clear opening (Clause 4.6.5.3) | |

## H. Spillway, freeboard and embankment (Clause 4.9; Clause 4.17, item 10)

### Table 4F.8 — Form 4-1: spillway and freeboard

| Field | Entry |
|---|---|
| H1. Hazard classification, with reasons (Clause 4.9.2) | |
| H2. 1% AEP peak inflow (L/s); 0.2% AEP peak inflow for high-hazard facilities (L/s) | |
| H3. 1% AEP maximum water level with the outlet working (m); spillway crest level (m) (Clause 4.9.3) | |
| H4. Spillway or overflow route: type, dimensions, maximum level with the outlet blocked (m) | |
| H5. Freeboard to the embankment crest or wall top (m), at least 0.3 m (Clause 4.9.1) | |
| H6. Spillway location and discharge path (Clause 4.9.4) | |
| H7. Embankment height (m); geotechnical report where more than 2 m (Clause 4.9.6) | |

## I. RWH accounting, groundwater and flotation (Clauses 4.11, 4.12; Clause 4.17, items 11 and 12)

**Table 4F.9 — Form 4-1: RWH, groundwater and flotation**

| Field | Entry |
|---|---|
| I1. RWH storage provided (m³), assumed full at the start of every storm (Clause 4.11.2) | |
| I2. Combined RWH and detention tanks: zone levels and the detention orifice level (Clause 4.11.3); attach tank sections | |
| I3. Design groundwater level and its basis (Clause 4.12.1) | |
| I4. Lined or unlined storage; volume below the design groundwater level not counted (Clause 4.12.2) | |
| I5. Flotation factor of safety, at least 1.2 (Clause 4.12.3) | |

## J. Downstream, tailwater, safety and maintenance (Clause 4.17, items 13 and 14)

**Table 4F.10 — Form 4-1: downstream, tailwater, safety and maintenance**

| Field | Entry |
|---|---|
| J1. Downstream and Tailwater Report (Form 5-1) or Simplified Downstream Statement (Form 5-2) reference | |
| J2. Tailwater used in routing, and flap gate where tailwater governs (Clause 4.6.6) | |
| J3. Public access, depths in the 10% and 1% AEP storms, slopes, fencing, grates, signs and depth markers (Clause 4.15) | |
| J4. Draft maintenance declaration reference (Chapter 10) | |

## K. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 4 of the Sikkim Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 4 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

**Table 4F.11 — Form 4-1: statement by the registered professional**

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |
| Empanelment number, where Clause 10.6.1 requires it | |
| Organisation | |
| Signature | |
| Date | |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

## Form 4-2 — Tier B Site Sheet

Supports Clauses 4.4.6.3, 4.14.1 and 4.14.2 of Chapter 4.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for Tier B sites using Clause 4.14.2. It can be used only after Table 4.3 is published in Annex 4B; until then, Tier B sites use Clause 4.6 or, for sites of 1 ha or less, the fixed-coefficient route (Clauses 4.14.1 and 4.14.3).

### A. Eligibility (Clause 4.14.1)

**Table 4F.12 — Form 4-2: eligibility**

| Field | Entry |
|---|---|
| A1. Local body (Tier B) | |
| A2. Site area A (ha): 2 ha or less outside flood-sensitive catchments; 0.5 ha or less inside them | |
| A3. Catchment class: standard or flood-sensitive (Annex 4A) | |

### B. Table 4.3 values (Clause 4.14.2, step 1)

**Table 4F.13 — Form 4-2: values read from Table 4.3**

| Field | Entry |
|---|---|
| B1. Rainfall zone (Annex 2A) | |
| B2. Hydrologic soil group | |
| B3. Post-development imperviousness (%) | |
| B4. PSD 2-yr (L/s/ha) | |
| B5. PSD 100-yr (L/s/ha), for the catchment class | |
| B6. SSR (m³/ha), for the catchment class | |

### C. Storage and release (Clause 4.14.2, steps 2 and 3)

**Table 4F.14 — Form 4-2: storage and release**

| Line | Quantity | Computation | Value |
|---|---|---|---|
| C1 | RRV provided (m³) | Clause 4.4 | |
| C2 | C_R | Annex 4B; 0 until published | |
| C3 | V_credit (m³) | C2 × C1 (Clause 4.4.6.3) | |
| C4 | Required storage V (m³) | B6 × A − C3 | |
| C5 | Storage provided (m³) | From drawings | |
| C6 | Q_PSD,2 (L/s) | B4 × A | |
| C7 | Q_PSD,100 (L/s) | B5 × A | |

## D. Outlet and other provisions (Clause 4.14.2, steps 4 and 5)

**Table 4F.15 — Form 4-2: outlet and other provisions**

| Field | Entry |
|---|---|
| D1. Low-flow orifice: diameter (mm) from the Annex 4B outlet table, head (m), at least 50 mm | |
| D2. Upper control: type, size and level | |
| D3. Spillway or overflow (Clause 4.9) | |
| D4. RWH accounting (Clause 4.11) | |
| D5. Safety provisions (Clause 4.15) | |

## E. Statement

I state that the values above are taken from Annex 4B for the site's zone, soil group, imperviousness and catchment class, and that the storage and outlets shown on the drawings match them.

**Table 4F.16 — Form 4-2: statement**

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |
| Signature | |
| Date | |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

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## Form 4-3 — Fixed-coefficient Route Sheet (Clauses 4.14.3 to 4.14.7)

Supports Clauses 4.14.3 to 4.14.7 of Chapter 4.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for sites using the fixed-coefficient route. Complete it for each point where runoff leaves the site (Clause 4.14.4). Figure 4.3 shows the method.

### A. Eligibility (Clause 4.14.3)

**Table 4F.17 — Form 4-3: eligibility**

| Check | Yes / No |
|---|---|
| A1. Site area 1 ha or less | |
| A2. The design does not count tank or waterbody storage (Clause 4.14.3(a)) | |
| A3. No part of the site lies within a waterbody setback (Clause 4.14.3(b)) | |
| A4. The site does not drain to a tank cascade whose storage is counted in a downstream design (Clause 4.14.3(c)) | |

### B. Release caps (Clause 4.14.4)

**Table 4F.18 — Form 4-3: release caps**

| Line | Quantity | Source or computation | Value |
|---|---|---|---|
| B1 | Site area A (ha) | Survey | |
| B2 | Area of each hydrologic soil group (ha) | Clause 3.7 | |
| B3 | C_10 and C_2, area-weighted | Table 4.3A | |
| B4 | i_10 and i_2 (mm/h), 15-minute duration, with the climate factor | Form 2-1; Clause 2.8 | |
| B5 | Q_cap,10 (L/s) | 2.78 × C_10 × i_10 × A | |
| B6 | Q_cap,2 (L/s) | 2.78 × C_2 × i_2 × A | |
| B7 | Discharge of a 50 mm orifice at the corresponding stage (L/s), where a cap is smaller (Clause 4.5.5.1) | Orifice equation, Clause 4.6.5.2 | |

### C. Volumetric coefficient (Clause 4.14.5)

**Table 4F.19 — Form 4-3: volumetric coefficient C_v**

| Line | Quantity | Value |
|---|---|---|
| C1 | Composite C of Table 3.2 (upper half of each range) | |
| C2 | Cf of Table 3.3 for the 1% AEP | |
| C3 | C_v for durations below 12 h (C1 × C2) | |
| C4 | C_v for durations of 12 h or more, with C for every pervious surface not less than 0.50 | |

## D. Storage (Clause 4.14.5)

For each duration: inflow = 10 × C_v × P(d) × A (m³); release = 1.8 × Q_cap × d (m³); difference = inflow − release. V_100 and V_2 are the largest differences; V is the larger of the two.

**Table 4F.20 — Form 4-3: storage by duration**

| d (h) | P_100(d) (mm) | 100-yr inflow (m³) | 1.8 × Q_cap,10 × d (m³) | 100-yr difference (m³) | P_2(d) (mm) | 2-yr inflow (m³) | 1.8 × Q_cap,2 × d (m³) | 2-yr difference (m³) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 6 | | | | | | | | |
| 12 | | | | | | | | |
| 24 | | | | | | | | |
| 48 | | | | | | | | |
| 72 | | | | | | | | |

**Table 4F.21 — Form 4-3: storage required and provided**

| Line | Quantity | Value |
|---|---|---|
| D1 | V_100 (m³) and governing duration | |
| D2 | V_2 (m³) and governing duration | |
| D3 | V = larger of D1 and D2 (m³) | |
| D4 | Storage provided (m³) | |

## E. Outlet, retention and other checks (Clauses 4.14.3, 4.14.6, 4.14.7)

**Table 4F.22 — Form 4-3: outlet, retention and other checks**

| Field | Entry |
|---|---|
| E1. Low-flow orifice: diameter (mm) and invert; discharge (L/s) with the storage holding V_2 full, not more than Q_cap,2 | |
| E2. Upper orifice or weir: size and level; total release (L/s) at the top of V, not more than Q_cap,10 | |
| E3. Retention volume of Clause 4.4 provided in addition to V (m³); no retention credit taken | |
| E4. Drawdown (Clause 4.7), trash racks (Clause 4.8), spillway (Clause 4.9): reference to Form 4-1 Sections G and H | |
| E5. Downstream and tailwater checks (Chapter 5) and water quality (Chapter 8): references | |

## F. Statement

I state that the site meets the eligibility conditions of Clause 4.14.3 and that the caps, storage and outlets above have been computed by Clauses 4.14.4 to 4.14.7.

**Table 4F.23 — Form 4-3: statement**

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |
| Signature | |
| Date | |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

ANNEXES TO CHAPTER 5

# Downstream and Tailwater Analysis

These annexes support Chapter 5. Annex 5C is a worked example of the outfall-closed check of Clause 5.10, for the illustrative facility of Annex 4C. Annexes 5A and 5B need tidal, surge, survey and river data that this draft does not yet contain; each lists what the chapter already sets, gives the intended layout and states the interim rule of Chapter 5 that applies until it is published. Forms 5-1 and 5-2 are the submittal forms required by Clause 5.14. They are draft forms and have no statutory status.

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## Annex 5A — Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment

Supports Clauses 5.7, 5.9, 5.10, 5.11 and 5.12 of Chapter 5.

5A.1 Table 5A.1 shows how the values of this annex enter the design tailwater levels of Table 5.1. The sea-level allowance is set by Clause 5.7.4 and does not depend on this annex.

**Table 5A.1 — Use of the Annex 5A values in the design tailwater (Table 5.1)**

| Design case | Tailwater | Annex 5A values used | Chapter value |
|---|---|---|---|
| Minor-system design | MHWS + SLA | MHWS | SLA ≥ +0.3 m (Clause 5.7.4) |
| Major-system and storage design | HAT + surge + SLA | HAT; 10% AEP surge (Clause 5.7.3(a)) | SLA ≥ +0.3 m |
| Joint case (Clause 2.12(b)) | 1% AEP still-water level + SLA | 1% AEP still-water level (Clause 5.7.3(b)) | SLA ≥ +0.3 m |
| Datum conversion | Chart datum to project datum | Offset from chart datum to the Survey of India datum (Clause 5.7.2(b)) | — |

**Not prepared for Sikkim.** Sikkim has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Sikkim content (Clause 5.1.4). Its tables are kept, empty, so that the annex and table numbers match the other editions of this Manual. Rows F1 to F7 of Form 5-1 are entered as "not applicable", and the tailwater is derived under rows F8 to F10; for an outfall to a jhora (झोरा; a natural watercourse), row F10 records the study, the flood marks, the bed survey and the check of the jhora to the next confluence or trained reach of Clause 5.8.5(a); for a valley-floor outfall, the CWC level, the surveyed October 2023 flood mark and the post-2023 bed survey of Clause 5.8.5(b); and for an outfall to a reservoir reach, the operator's levels and their datum, or the interim rule, of Clause 5.8.5(c).

**Table 5A.2 — Tidal datums, surge and still-water levels by coastal segment (layout)**

| Coastal segment | Reference port and tide-table edition | MSL (m CD) | MHWS (m CD) | HAT (m CD) | CD to Survey of India datum (m) | 10% AEP surge (m) | 1% AEP still-water level (m CD) | Wave set-up (m), open-sea outfalls | Sources |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

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## Annex 5B — Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map

Supports Clauses 5.2, 5.3, 5.8 and 5.13 of Chapter 5.

5B.1 Table 5B.1 lists the water bodies that Chapter 5 already names. It is not complete: the annex will add the extents of each reach, the other rivers, canals and mouths of the State, and a map.

**Table 5B.1 — Water bodies named in Chapter 5**

| Water body | Region | Listed as | Clause |
|---|---|---|---|
| Jhoras of the ridge towns: Pakyong, Namchi, Ravangla, Gyalshing, Pelling, Soreng and others | Statewide | Major drains; ungauged, no published flood level [TBC]; free outfall with energy dissipation; 1% AEP study with bulking and blockage and surveyed flood marks; check of the jhora to the next confluence or trained reach (s.187 of the Municipalities Act); outfall at least 0.5 m above the highest surveyed bed level; lock (where the invert is below the design level) the storm plus recession, not less than 24 hours; no outfall within 15 m of a dhara | 5.2, 5.8.1, 5.8.5 |
| Jhoras of Gangtok, the Rani Khola and the Roro Chu | Gangtok | Major drains and city streams; ungauged, no published flood level [TBC]; item (a) rule with the SK-B rainfall; Zone III sewerage of Gangtok for "Pollution abatement of Rani chu through Ro-Ro Chu" (Clause 8.9); whether the Rani Khola is the scheduled "Rongni chu" of the 1988 Act is a NEER reading to be confirmed | 5.2, 5.8.1, 5.8.5 |
| Teesta (Tista) at Chungthang, Mangan, Dikchu, Singtam, Rangpo and Melli | Mangan, Gangtok, Pakyong and Namchi districts | Riverine outfall reach and GLOF corridor; scheduled river no. 1 (1988 Act); CWC sites Khanitar (HFL 297.7 m, 1974; 298.4 m, 4 October 2023) and Melli (225.5 m vs 228.0 m, 4 October 2023, conflict; 228.0 m for a check), as reported, datums [TBC]; no CWC level at Rangpo [TBC]; bed raised about 2–7.4 m in October 2023; design tailwater the higher of the CWC level and the surveyed October 2023 flood mark, or a model; inverts above the post-2023 bed; flap gates; lock the whole 72-hour storm, not less than 72 hours; assets sited above the 2023 flood and aggradation level | 5.8.1, 5.8.5 |
| Rangit (Rangeet) at Jorethang and the CWC site at Majitar | Namchi district; State border | Riverine outfall reach; scheduled river no. 2; Majitar HFL 279.29 m (17 October 1985, as reported), to be resurveyed; valley-floor rule of Clause 5.8.5(b); lower reach on the State border, where the West Bengal edition governs | 5.8.1, 5.8.5 |
| Rongni Chu at Ranipool and the CWC site at Singtam | Gangtok district | Riverine outfall reach; scheduled river no. 14; Singtam danger level 355.09 m and HFL 356.09 m (undated, as reported); Ranipool active, no HFL; valley-floor rule of Clause 5.8.5(b) | 5.8.1, 5.8.5 |
| Dik Chu at the CWC site at Bakcha | Sikkim | Riverine outfall reach; active site, no HFL (as reported); model and surveyed flood marks | 5.8.1, 5.8.5 |

| Water body | Region | Listed as | Clause |
|---|---|---|---|
| Lachen Chu and Lachung Chu, to Chungthang | Mangan district (SK-C) | GLOF corridors; screened under Clause 2.3.6(i); no drain sized for a GLOF; site-specific study for every outfall of more than 1 km²; assets sited above the 2023 flood and aggradation level and outside any mapped GLOF path | 2.3.6, 5.8.5 |
| Maney Khola | East Sikkim | Major drain; a former polluted stretch, delisted, and the State's model river for bathing quality (Clause 8.9); item (a) or (b) rule as its setting requires | 5.8.1, 5.8.5 |
| Reservoirs of Teesta-III (under restoration), Teesta-V, Teesta-VI, Chuzachen, Dikchu, Rongnichu, Jorethang, Tashiding and Rangit-III, and the reaches below them | Teesta and its tributaries | Reservoir outfalls and release reaches; no FRL, MWL, spillway rating or release rule found [TBC]; operator's levels in writing (data, not an approval); until then sited above the October 2023 flood mark, or the surveyed shore line or spillway crest + 0.5 m; release: largest recorded, else spillway capacity, else unattenuated 1% AEP inflow; releases, not notices; the High Court's safety direction of 1 March 2021 | 5.8.1, 5.8.3, 5.8.5 |
| Teesta below Melli and the Rangit's lower reach | State border | The West Bengal edition governs those reaches; its levels bound the model's downstream boundary only | 5.8.5 |
| Khecheopalri lake (Khachoedpalri) | Sikkim | Sikkim's first Ramsar site (February 2025, as reported; area figures conflict and none is cited); no town's drains named as discharging to it; no outfall without its custodian's consent (Chapter 7) | 5.8.5 |
| Pokharis that receive a town's drains | Statewide | None named in the sources [TBC]; spill level plus head; start full to the outlet; custodian's consent; debris, waste and sediment traps; no sewage; never a glacial lake | 5.8.5 |
| Drains and jhoras of the Gangtok Municipal Corporation and the other urban local bodies, GSCDL, the Roads and Bridges Department (PWD), NHIDCL, BRO, WRD, PHED and RMDD, 1.0 m wide or more | Sikkim | Major drains; owner's consent (ss.172, 187 and 189 of the Municipalities Act within municipal areas), design water level and flap gate; jhoras outside municipal limits or on forest land have no named owner | 5.2, 5.8.5 |
| River banks of the scheduled rivers (1988 Act, s.29) | Statewide | Forest Department's consent for any work in the bank; the bank is 60 m or the high-flood-level line, whichever is less (a maximum) | 5.8.5 |
| River mouths subject to sand-bar closure | None in Sikkim | Not applicable (Clause 5.1.4) | 5.13.1 |

**To be prepared.** This annex will list and map (a) the major drains of each basin plan, (b) the riverine outfall reaches where backwater shall be modelled, with their upstream and downstream limits and the source of their design flood levels, and (c) the river mouths and creek inlets subject to seasonal sand-bar closure, with the most recent pre-monsoon bar crest levels and any WRD mouth-maintenance programme. It needs WRD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (WRD), the drain inventories of GMC and other local bodies, basin stormwater master plans (Chapter 11), and base mapping from the Survey of India and NRSC. Until it is published: every river, WRD canal, the Rani Khola and the Roro Chu below Gangtok and the jhoras that feed them, the jhoras of Pakyong, Namchi, Ravangla, Gyalshing, Pelling, Soreng and the other ridge towns, every drain that discharges through a flap gate on the valley floors of Rangpo, Singtam, Melli, Majitar, Jorethang or Dikchu, any drain built or held by the Gangtok Municipal Corporation or another urban local body, GSCDL, the Roads and Bridges Department (PWD), NHIDCL, BRO, WRD, the Public Health Engineering Department (PHED) or the Rural Management and Development Department (RMDD) with an internal width of 1.0 m or more, and every jhora, khola or other natural channel that drains 8 ha or more, whether or not it has been trained and every tidal creek is a major drain (Clause 5.2); the water bodies of Table 5B.1 are riverine outfall reaches (Clause 5.8.1); and the mouths of the coastal States' rivers (there is none in Sikkim) are assumed closed at the start of the monsoon unless the Water Resources Department certifies otherwise (Clause 5.13.2).

Table 5B.2 — Attributes of the Annex 5B layers (layout)

| Field | Content | Unit or format |
|---|---|---|
| feature_id | Unique identifier | text |
| name | Name of the drain, river, canal, creek or mouth | text |
| category | Major drain; riverine outfall reach; mouth subject to sand-bar closure | text |
| clause | Clause of Chapter 5 under which it is listed | text |
| reach_limits | Upstream and downstream limits of the reach | text |
| design_flood_level_source | WRD design or highest recorded flood level, or hydraulic model (Clause 5.8.2) | text |
| reservoir_release | Upstream reservoir or tank and its operating rule, where any (Clause 5.8.3) | text |
| bar_crest_level | Most recent pre-monsoon bar crest level, for mouths | m (Survey of India datum) |
| mouth_programme | WRD mouth-maintenance programme and certification (Clause 5.13.2) | text |
| source | Source agency and date | text |
| geometry | Line (drains and reaches) or point (mouths) | line / point |

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## Annex 5C — Worked example: outfall-closed check for a hillside colony in Gangtok draining to a jhora

Supports Clauses 5.9, 5.10, 5.11 and 5.12 of Chapter 5 and Clause 4.6.6 of Chapter 4.

**Illustrative — not design values.** This example applies the outfall-closed check of Clause 5.10 to the revised detention facility of Annex 4C. The site, its levels and its receiving drain are invented to show the method. No tidal level is used: the tide enters only through the illustrative statements in Table 5C.1 about whether the receiving drain is above or below the site outlet.

## Inputs

5C.1 The site is the 2.0 ha flood-sensitive site of Annex 4C, a hillside colony in Gangtok draining to a jhora (flood-sensitive catchment (a) of Clause 4.5.3.2, Gangtok's jhoras to the Rani Khola and the Roro Chu). It discharges through its own outlet chamber and a flap gate to a public storm drain that runs down a lined chute to the jhora, whose level rises over the drain's outlet when the jhora runs full in a storm and stays up while the storm and its recession last, so Clause 5.10.1 applies to the facility. To show the method, this example uses the two 6-hour lock windows of Clause 5.10.3, as the coastal editions of this Manual do. In Sikkim an outfall to a jhora whose invert is below its design level is closed for the design storm and the jhora's recession, and for not less than 24 hours, and for the whole storm where the 48- and 72-hour storms are run; an outfall on the valley floor of the Teesta, the Rangit or the Rongni Chu below the design tailwater of its river is held at that tailwater for the whole 72-hour storm and closed for not less than 72 hours; an outfall to a release reach below a hydropower dam is closed for not less than 72 hours; and an outfall below the design level of a reservoir or a pokhari is closed for the whole storm, under Clause 5.8.5. In each of those cases that lasts longer than the windows used here, the facility must store or pump the volume of the longer closure, up to the whole storm volume (Clause 5.9.4); that needs more storage, or pumping, than this example shows. The routing, the volume balance of Clause 5.10.4 and the assessment are the same. The public drain's own outfall to the jhora would also need the energy dissipator, the check of the jhora to the next confluence or trained reach and the invert above the range of bed movement of Clause 5.8.5(a), and the debris rack and the bulking factor of Clause 6.3.6; and on Gangtok's slopes, on natural ground steeper than 10°, on colluvium or fill, or in stability zones 3 to 6, the facility itself would be a lined tank, not an infiltrating basin, and its overflow would go to a lined drain, never onto the slope (Clause 4.11 (hill rule)).

**Table 5C.1 — Inputs (Illustrative — not design values)**

| Item | Value | Basis |
|---|---|---|
| Facility | Revised facility of Annex 4C: 2,500 m² plan area, vertical walls; 170 mm orifice at the floor; 460 mm orifice, invert 0.53 m | Annex 4C, Table 4C.14 |
| Storm | 1% AEP, 48 h, peak day last, AMC III; 72 h also run | Clause 5.10.2 |
| Inflow | Post-development 1% AEP hydrographs of Annex 4C (48 h: 8,420 m³; 72 h: 9,468 m³) | Annex 4C |
| Receiving drain levels at the connection, J1, J2 and J3 | Below the site outlet invert (from the drain owner's model) | Illustrative input |
| Receiving drain during each lock window | Backs up above the site outlet invert, so the site cannot discharge | Illustrative input; Clause 5.10.3(b) |
| Flap gate on the site outlet | Set 0.15 m below the orifice inverts in the outlet chamber, so that outside the lock windows its opening head and head loss do not affect the orifice control | Illustrative input; to be confirmed from the certified curve (Clause 5.11.2) |
| Lock windows | Two of 6 h each, starts 12.4 h apart (semi-diurnal tide) | Clause 5.10.3(a) |
| Pumps | None | — |

5C.2 **Cases of Table 5.2.** Because the receiving drain stays below the site outlet in J1, J2 and J3 (Table 5C.1), those cases give the free-outfall results of Annex 4C: in J2 the 1% AEP maximum water level is **1.17 m** (2,913 m³), and in J3 (10% AEP, 48 h) it is 0.77 m. R1 and R2 do not apply, because the site does not drain to a river. J4, the outfall-closed check, is worked below.

## Lock windows (Clause 5.10.3)

5C.3 The peak 1-hour block of the final 24 hours of the 48-hour storm is 35:35–36:35 h, with 98.2 mm (the 1-hour depth of Table 4C.2). Two runs are made:

- **Run A:** the first window is centred on that block: 33:05–39:05 h; the second starts 12.4 h later: 45:29–51:29 h.
- **Run B:** the first window starts at that block: 35:35–41:35 h; the second: 47:59–53:59 h.

For the 72-hour storm, every time is 24 h later.

5C.4 Gravity discharge is zero inside each window. Outside the windows the outlet discharges through the orifices of Table 4C.10. The routing is the same level-pool routing as in Annex 4C.

## Results

**Table 5C.2 — Outfall-closed check results (Illustrative — not design values)**

| Storm | Run | Lock windows (h:min) | Maximum stage (m) | Maximum storage (m³) | Time of maximum (h:min) | Largest release after a window (L/s) |
|---|---|---|---|---|---|---|
| 1% AEP, 48 h | A | 33:05–39:05; 45:29–51:29 | 2.01 | 5,019 | 39:05 | 566 |
| 1% AEP, 48 h | B | 35:35–41:35; 47:59–53:59 | **2.10** | **5,238** | 41:35 | 584 |
| 1% AEP, 72 h | A | 57:05–63:05; 69:29–75:29 | 2.00 | 5,012 | 63:05 | 565 |
| 1% AEP, 72 h | B | 59:35–65:35; 71:59–77:59 | 2.09 | 5,233 | 65:35 | 584 |

Run B of the 48-hour storm governs. The first window closes the outlet just as the storm peak arrives, so the whole peak is stored. The second window arrives when the facility has drained to about 0.7 m, below the Stage 2 orifice, and adds little.

5C.5 **Volume balance (Clause 5.10.4).** Table 5C.3 gives the balance for Run B. The outflow in each period is found by continuity: outflow = storage at start + inflow − storage at end.

**Table 5C.3 — Volume balance, 1% AEP 48-hour storm, Run B (Illustrative — not design values)**

| Period (h:min) | Inflow (m³) | Gravity outflow (m³) | Pumped (m³) | Storage at start (m³) | Storage at end (m³) |
|---|---|---|---|---|---|
| 0:00–35:35, before window 1 | 3,817 | 2,213 | 0 | 0 | 1,604 |
| 35:35–41:35, window 1 | 3,634 | 0 | 0 | 1,604 | 5,238 |
| 41:35–47:59, between windows | 941 | 4,423 | 0 | 5,238 | 1,756 |
| 47:59–53:59, window 2 | 28 | 0 | 0 | 1,756 | 1,784 |
| After 53:59 | 0 | 1,784 | 0 | 1,784 | 0 |
| Total | 8,420 | 8,420 | 0 | — | — |

Check for window 1: $V_{inflow}$ = 3,634 m³ ≤ $V_{storage\ available} + V_{pumped} + V_{gravity}$ = (5,238 − 1,604) + 0 + 0 = 3,634 m³. The facility therefore needs **5,238 m³** of storage, which the routing confirms.

**Table 5C.4 — Stage hydrograph, 1% AEP 48-hour storm, Run B (Illustrative — not design values)**

| Time (h) | Inflow (L/s) | Outlet | Outflow (L/s) | Stage (m) | Storage (m³) |
|---|---|---|---|---|---|
| 24 | 20 | Open | 18 | 0.18 | 445 |
| 28 | 39 | Open | 24 | 0.25 | 621 |
| 32 | 59 | Open | 32 | 0.36 | 906 |
| 34 | 85 | Open | 37 | 0.47 | 1,166 |
| 36 | 286 | Closed | 0 | 0.78 | 1,944 |
| 38 | 106 | Closed | 0 | 1.73 | 4,321 |
| 40 | 66 | Closed | 0 | 1.96 | 4,904 |
| 42 | 51 | Open | 529 | 1.79 | 4,472 |
| 44 | 42 | Open | 204 | 0.87 | 2,181 |
| 46 | 37 | Open | 49 | 0.74 | 1,854 |
| 48 | 33 | Open | 47 | 0.70 | 1,756 |
| 50 | 0 | Closed | 0 | 0.71 | 1,784 |
| 54 | 0 | Closed | 0 | 0.71 | 1,784 |
| 56 | 0 | Open | 43 | 0.58 | 1,459 |
| 60 | 0 | Open | 32 | 0.37 | 921 |
| 66 | 0 | Open | 16 | 0.16 | 397 |
| 72 | 0 | Open | 7 | 0.06 | 162 |

## Assessment

5C.6 **Clause 5.10.4(a).** The facility of Annex 4C reaches 1.17 m in J2, and its spillway crest is at 1.35 m (Annex 4C). In the outfall-closed check the stage reaches 2.10 m, so the spillway would operate. **The facility of Annex 4C fails the check.**

5C.7 **Remedy.** Pumping (Clause 5.12) does not help here: during the lock windows the receiving drain is itself closed, and pumping into it would raise its level, which Clause 5.12.3 does not permit. The remedy is more storage. Keeping the plan area of 2,500 m² and the outlets of Annex 4C:

- the facility must hold 5,238 m³, to a stage of **2.10 m**;
- the spillway crest is set above that stage, with the 0.15 m clearance recommended in Clause 4.9.3: **2.25 m**;
- with the 4.0 m spillway of Annex 4C (head 0.30 m), the maximum level with the spillway flowing is 2.55 m, and with 0.3 m freeboard the top of the walls is at least **2.85 m** above the floor.

The outfall-closed check therefore governs the storage: 5,238 m³ against 2,913 m³ from the release-rate checks, about 80% more. A larger plan area would make the facility shallower; the outlet, caps and drawdown would then have to be re-checked, because the stage–discharge relationship changes.

5C.8 **Release after the lock.** When the first window ends, the stored water is released under a head of about 2 m, at up to 584 L/s. This is above the 100-yr cap of 356 L/s. Clause 5.10.4 allows this, because the release reaches a drain that has itself just reopened, and requires it to be included in the J4 run of the downstream analysis (Clauses 5.4 and 5.9) and reported on Form 5-1, Section H.

5C.9 **Drawdown after the storm (Clause 5.10.5).** The J1 tidal curve stays below the site outlet (Table 5C.1), so the drawdown of Annex 4C applies: 45.3 h for 90% of the 10-yr storage with the low-flow orifice 50% blocked, within the 48-hour limit of Clause 4.7. In Run B, 90% of the maximum J4 storage is released 22.6 h after the maximum.

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 31 March each year and after every event in which it closed against a storm flow (Clause 5.11.5).
- The deeper facility is checked for flotation with groundwater at the design groundwater level; in the Teesta and Rangit valley floors and river terraces (at Rangpo, Singtam, Melli, Majitar and Jorethang), land below the 1% AEP flood level or on the river bed raised by the flood of October 2023, the pokhari and reservoir margins, and the seepage zones below springs (dhara) on slopes without piezometer readings that level is existing ground level (Clauses 4.12.1 and 4.12.3).
- The fence and signs of Annex 4C apply to the deeper facility (Clause 4.15).

**Table 5C.5 — Summary (Illustrative — not design values)**

| Item | Value |
|---|---|
| Governing case | J4, 1% AEP 48-hour storm, Run B (first window starting at the peak 1-hour block) |
| Storage required | 5,238 m³ (Annex 4C release-rate design: 2,913 m³) |
| Maximum stage | 2.10 m, with 2,500 m² plan area |
| Spillway crest | 2.25 m |
| Top of walls | ≥ 2.85 m above the floor |
| Largest release after a lock window | 584 L/s, to be included in the downstream J4 run |
| Drawdown | Annex 4C result applies: 45.3 h with the low-flow orifice 50% blocked |

## Form 5-1 — Downstream and Tailwater Report

Supports Clauses 5.3 to 5.14 of Chapter 5.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One report for each project. Sites of less than 0.5 ha that meet Clause 5.3.4 may submit Form 5-2 instead, where the Authority accepts it. Attach the plans, model files and hydrographs referred to.

### A. Project

**Table 5F.1 — Form 5-1: project**

| Field | Entry |
|---|---|
| A1. Project name, applicant and location | |
| A2. Project type: site under Chapter 4; drainage project under Chapter 6; regional detention or tank restoration (Clause 5.1.2) | |
| A3. Site or project area (ha) and outfalls | |
| A4. Site Runoff Control Report reference (Form 4-1), where applicable | |

### B. Extent of the analysis (Clause 5.3; Clause 5.14, item 1)

**Table 5F.2 — Form 5-1: analysis points**

| Point | Location | Type (Clause 5.3.3 (a) to (e)) | Contributing catchment (ha) | Project area as % of it |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

**Table 5F.3 — Form 5-1: end point**

| Field | Entry |
|---|---|
| B1. End point and reason: 10% point, tank or pokhari, or major drain or the sea (Clause 5.3.1 (a) to (c)) | |
| B2. Where the end point is a tank or pokhari: change in maximum water level (m) and in surplus-weir discharge (m³/s); continuation below the weir if the level rises (Clause 5.3.2) | |
| B3. Plan of the analysis extent, showing the site, each point with its contributing area and percentage, and the end point (attach) | |

### C. Model (Clause 5.4.4; Clause 5.14, item 2)

**Table 5F.4 — Form 5-1: model**

| Field | Entry |
|---|---|
| C1. Software and version; hydrologic and hydraulic methods (Clause 5.4.4) | |
| C2. Network schematic, with the survey sources for drains and crossings (attach) | |
| C3. Land use and CN of off-site areas (present land use) | |

| Field | Entry |
|---|---|
| C4. Upstream detention included, with evidence that it is built, maintained and documented | |
| C5. Calibration or validation evidence, where available | |
| C6. Scenarios run: existing, with project, and future where the Authority requires it (Clause 5.4.1) | |
| C7. Storms run: AEPs and durations, AMC and areal reduction (Clause 5.4.3) | |

## D. Results at each analysis point (Clause 5.4.2; Clause 5.14, item 3)

Complete one row for each analysis point, AEP and duration. E = existing; P = with project.

**Table 5F.5 — Form 5-1: results by analysis point**

| Point | AEP | Duration (h) | Peak flow E / P ($m^3/s$) | Time to peak E / P (h) | Maximum water level E / P (m) | Peak velocity E / P (m/s) | Duration of inundation E / P (h) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

## E. Acceptance (Clause 5.5; Clause 5.14, item 4)

**Table 5F.6 — Form 5-1: acceptance criteria**

| Criterion | Met at every point? | Where not met, the remedy adopted (Clause 5.5.3) |
|---|---|---|
| E1. 1% AEP water level rise ≤ 10 mm at buildings, lowest openings and carriageways (Clause 5.5.1(a)) | | |
| E2. No building newly flooded; no building or road newly failing the Chapter 6 limits (Clause 5.5.1(b)) | | |
| E3. Peak flow not above existing at the minor-system AEP of each element or at 1% AEP (Clause 5.5.1(c)) | | |
| E4. Velocity in lined channels within the lining limit, 3.0 m/s maximum (Clause 5.5.1(d)) | | |
| E5. Velocity in unlined channels, 50% and 10% AEP, not increased by more than 10% (Clause 5.5.1(e)) | | |
| E6. Change in duration of road closure on arterial or emergency routes (Clause 5.5.2) | | |
| E7. Timing exception requested (Clause 5.5.4)? Give the conditions met | | |

## F. Tailwater derivation (Clauses 5.6 to 5.8; Clause 5.14, item 5)

**Table 5F.7 — Form 5-1: tailwater derivation**

| Field | Entry |
|---|---|
| F1. Tide-table edition and port, or port authority source (Clause 5.7.2(a)) | |

| Field | Entry |
|---|---|
| F2. MHWS, HAT and MSL (m above chart datum) | |
| F3. Connection from chart datum to the Survey of India benchmark and the project datum: offset (m) and source (Clause 5.7.2(b)) | |
| F4. Estuary, creek or canal outfall: levels used and any evidence for a departure from open-coast levels (Clause 5.7.2(c)) | |
| F5. 10% AEP surge and 1% AEP still-water level: values, source, method and record length (Clause 5.7.3) | |
| F6. Wave set-up, for outfalls facing the open sea (Clause 5.7.3(d)) | |
| F7. SLA (m), at least +0.3 m; design life; sensitivity run at twice the SLA for design lives over 50 years (Clause 5.7.4) | |
| F8. Non-tidal tailwater: receiving-system level and source (Clauses 5.6.2, 5.6.3) | |
| F9. River levels and sources; reservoir or tank releases included (Clauses 5.8.2, 5.8.3) | |
| F10. Jhoras, valley-floor rivers, reservoirs and release reaches, GLOF corridors, the West Bengal reaches, pokharis, and drains of other bodies: for a jhora (Clause 5.8.5(a)), the 1% AEP study with the rainfall of Clause 2.3.6 for the sub-area (SK-B for Gangtok), AMC, the bulking and blockage of Clause 6.3.6, the channel as surveyed net of encroachment, silt, slide debris and waste, the surveyed flood marks and their sources, the energy dissipator and the lined path to the jhora, the check of the jhora to the next confluence or trained reach (capacity with bulking, velocity, bank stability) and its result, the stability zone of the outfall and of the reach, the bed survey and range of bed movement, the invert at least 0.5 m above the highest surveyed bed level, the scour depth of the foundation, confirmation that no outfall lies within 15 m of a dhara or on its recharge area, and the lock where the invert is below the design level (storm plus recession, not less than 24 hours); for valley-floor land (Clause 5.8.5(b)), the highest recorded CWC level at the nearest site (Khanitar 298.4 m; Melli 228.0 m used for a check, with 225.5 m recorded beside it; Singtam 356.09 m; Majitar 279.29 m; Rangpo none) transferred to the outfall, the surveyed October 2023 flood mark and its source, the model on the post-2023 bed where neither exists or where it gives a higher level, every level with its gauge, date, datum and tie to the named CWC site and a Survey of India benchmark; the 10% AEP river level (danger level where reported, else the design level); the post-2023 bed survey and the invert at least 0.5 m above the highest surveyed post-2023 bed; the flap gate, its owner from the drain and jhora register, sill and closing level; the hillside-burst case with the river low and the multi-day case with the river at the design tailwater; drain behind the gate routed with its whole catchment, hill catchments included, and present storage, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the design river level; the river at the design tailwater for the whole 72-hour storm, the outfall closed for not less than 72 hours, or longer from a stage record, and its source; pump-down within 48 hours; gate jammed open or buried checked; for a reservoir (Clause 5.8.5(c)), the operator's MWL or FRL plus design-flood surcharge in writing with its datum, or the interim rule (sited above the October 2023 flood mark, or the surveyed shore line or spillway crest + 0.5 m), the outfall below the tailwater treated as closed for the whole of the 72-hour storm, the reservoir starting at FRL, and no gate operation, drawdown, release notice or reservoir attenuation credited; for a release reach, the design storm and the 72-hour storm with the largest recorded release, or the spillway capacity, or the unattenuated 1% AEP inflow until the operator gives either, placed before, during and after the storm, and, below Chungthang, the reported October 2023 inflow of about 10,000 m³/s recorded as the cascade, not a design release; for a GLOF corridor (Clause 5.8.5(d)), the screening of Clause 2.3.6(i), the surveyed October 2023 flood and aggradation level at the site, any mapped GLOF path and its source, and confirmation that every asset stands above that level and outside that path; for an outfall near the State border (Clause 5.8.5(e)), the West Bengal edition's level used only as the model's downstream boundary; for a pokhari (Clause 5.8.5(f)), the custodian's consent, the surveyed spill level plus head, the start full to the outlet, the debris, waste and sediment traps before it, and confirmation that it is not a glacial lake; owner's consent (WRD for works in or on a river; the Forest Department for a scheduled river's bank; the urban local body for its drains and jhoras; the Roads and Bridges Department (PWD), NHIDCL or BRO for a road drain; for a jhora outside municipal limits or on forest land, no named owner recorded and the landholder's and Forest Department's consent), permitted rate, design water level or computed channel level, and flap gate; and the lines checked (the 1988 Act's river bank, 60 m or the high-flood-level line, whichever is less; any closure under s.32; any jhora limits notified under s.173 of the Municipalities Act, none found) (Clause 5.8.5) | |

## G. Joint cases (Clause 5.9; Clause 5.14, item 6)

### Table 5F.8 — Form 5-1: joint-case results

| Case | Rainfall | Tailwater used (m, project datum) | Applies? | Governing result (storage, level, pipe size or pump capacity) |
|---|---|---|---|---|
| J1 | | | | |
| J2 | | | | |

| Case | Rainfall | Tailwater used (m, project datum) | Applies? | Governing result (storage, level, pipe size or pump capacity) |
|---|---|---|---|---|
| J3 | | | | |
| J4 | | | | |
| R1 | | | | |
| R2 | | | | |

## H. Outfall-closed check (Clause 5.10; Clause 5.14, item 7)

### Table 5F.9 — Form 5-1: outfall-closed check

| Field | Entry |
|---|---|
| H1. Reason the check applies (Clause 5.10.1) | |
| H2. Storm: AEP, 48 h and 72 h, AMC III (Clause 5.10.2) | |
| H3. Lock duration and basis: default of two 6-hour windows, or site study (Clause 5.10.6); extension for sand-bar closure (Clause 5.13.5) | |
| H4. Lock windows of the two runs (start and end times) (Clause 5.10.3(d)) | |
| H5. Maximum stage in each facility, against its 1% AEP maximum water level (Clause 5.10.4(a)) | |
| H6. Maximum stage in the minor and major systems, against the Chapter 6 limits (Clause 5.10.4(b)) | |
| H7. Property connections: surcharge level, or non-return valves fitted (Clause 5.10.4(c)) | |
| H8. Stage hydrographs (attach) | |
| H9. Drawdown after the storm under the J1 tidal curve, and pumping where needed (Clause 5.10.5) | |

### Table 5F.10 — Form 5-1: volume balance for each lock window (Clause 5.10.4)

| Period | Inflow ($m^3$) | Gravity outflow ($m^3$) | Pumped ($m^3$) | Storage at start ($m^3$) | Storage at end ($m^3$) |
|---|---|---|---|---|---|
| Before window 1 | | | | | |
| Window 1 | | | | | |
| Between windows | | | | | |
| Window 2 | | | | | |
| After window 2 | | | | | |

## I. Gates and valves (Clause 5.11; Clause 5.14, item 8)

### Table 5F.11 — Form 5-1: schedule of flap gates, tide gates and non-return valves

| Location | Type | Size (mm) | Invert (m, project datum) | Certified head–discharge data (reference) | Stop-log or penstock (outfalls > 600 mm) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

## J. Pumped outfalls (Clause 5.12; Clause 5.14, item 9)

**Table 5F.12 — Form 5-1: pumped outfalls**

| Field | Entry |
|---|---|
| J1. Reason pumping is needed (Clause 5.12.1) | |
| J2. Duty capacity (m³/s) at the static head for the J2 tailwater; standby capacity (Clause 5.12.2) | |
| J3. Effect on the receiving water level (Clause 5.12.3) | |
| J4. Power supply: two independent supplies, or standby generation with 72 h of fuel; automatic changeover (Clause 5.12.4) | |
| J5. Level of electrical panels, controls, generators and fuel, against the higher of the 1% AEP flood level + 0.5 m and HAT + surge + SLA + 0.5 m (Clause 5.12.5) | |
| J6. Discharge arrangement (Clause 5.12.6); controls, alarms and logging (Clause 5.12.7); screens (Clause 5.12.8) | |

## K. Sand bar (Clause 5.13; Clause 5.14, item 10)

**Table 5F.13 — Form 5-1: sand-bar assumption**

| Field | Entry |
|---|---|
| K1. River mouth or creek inlet concerned | |
| K2. Mouth assumed closed, or open with WRD certification attached (Clause 5.13.2) | |
| K3. Bar crest level from the most recent pre-monsoon survey (m) and the closed-mouth tailwater (Clause 5.13.3) | |
| K4. Extension of the lock duration, where required (Clause 5.13.5) | |

## L. Inspection and maintenance (Clause 5.14, item 11)

**Table 5F.14 — Form 5-1: inspection and maintenance**

| Field | Entry |
|---|---|
| L1. Gate and valve inspection before 31 March and after closure events (Clause 5.11.5) | |
| L2. Pump test runs before 31 March (Clause 5.12.9) | |
| L3. Other requirements for the maintenance plan (Chapter 10) | |

## M. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 5 of the Sikkim Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 5 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

**Table 5F.15 — Form 5-1: statement by the registered professional**

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |

| Field | Entry |
|---|---|
| Empanelment number, where Clause 10.6.1 requires it | |
| Organisation | |
| Signature | |
| Date | |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

## Form 5-2 — Simplified Downstream Statement (small sites)

Supports Clause 5.3.4 of Chapter 5.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* For sites of less than 0.5 ha. The Authority may accept this statement in place of the full analysis only where every answer in Section B is "Yes". Otherwise submit Form 5-1.

### A. Site

**Table 5F.16 — Form 5-2: site**

| Field | Entry |
|---|---|
| A1. Project name, applicant and location | |
| A2. Site area (ha), less than 0.5 ha | |
| A3. Receiving public drain: name or reference, type and size | |
| A4. Site Runoff Control Report reference (Form 4-1) | |

### B. Conditions (Clause 5.3.4)

**Table 5F.17 — Form 5-2: conditions**

| Condition | Yes / No | Evidence |
|---|---|---|
| B1. The receiving public drain has documented capacity for its minor-system design flow (Chapter 6) | | |
| B2. No flood-prone location is recorded within 500 m downstream of the site outfall. Records checked: local body, GMC, SSDMA, WRD (Clause 5.3.3(d)) | | |
| B3. The site does not drain to a tidal or backwater-affected outfall | | |

### C. Route plan

**Table 5F.18 — Form 5-2: attachments**

| Attachment | Attached? |
|---|---|
| C1. Plan of the drainage route from the site outfall for 500 m downstream, with the receiving drain and any recorded flood-prone locations | |
| C2. Copy or reference of the drain capacity record | |

### D. Statement

I state that the site meets the conditions of Clause 5.3.4 as shown above, and that the records listed have been checked.

**Table 5F.19 — Form 5-2: statement**

| Field | Entry |
|---|---|
| Name | |
| Qualification and registration number | |
| Signature | |
| Date | |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

ANNEXES TO CHAPTER 6

# Minor and Major Drainage Systems

These annexes support Chapter 6. Annex 6A (standard inlets and their capacity curves) and Annex 6B (sediment yield) need test and survey data that are not yet available; each states what it will contain and the interim rule to use until it is published. Annex 6C gives standard drawings that carry only the dimensions Chapter 6 and Chapter 9 already set; every other dimension is marked "to be confirmed in design". Form 6-1 is a draft form: it lists what Clause 6.15 requires and does not add to it.

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## Annex 6A — Standard inlet types for Sikkim with capacity curves (on grade and sag)

Supports Clauses 6.6.1 to 6.6.7 of Chapter 6 and Clause 9.11 of Chapter 9.

**To be prepared.** This annex will contain a short list of standard inlet types for Sikkim streets (kerb-opening, grate and combination inlets, including the road-level wall opening into a covered drain) and, for each type, capacity curves on grade and in a sag. It needs a fixed set of standard inlet geometries agreed with the road-owning agencies, and rating tests of those geometries (laboratory or full-scale), or HEC-22 calculations for each geometry checked against tests (data and likely sources: the Roads and Bridges Department (PWD), NHIDCL, BRO and Gangtok Municipal Corporation standard details, NIT Sikkim, Sikkim University and the Sikkim Manipal Institute of Technology, where no rainfall-frequency (IDF) study for the State's towns was found and whose hydraulic testing capability was not confirmed during research [TBC], or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

**Table 6A.1 — Interim requirements for inlets until Annex 6A is published (from Chapters 6 and 9)**

| Item | Requirement | Clause |
|---|---|---|
| Inlet type on public streets | Kerb-opening or combination inlets, unless the Approving Authority accepts grate-only inlets for a location | 6.6.1(a) |
| Inlet level | Openings at road level; gutter depression where practicable | 6.6.1(b) |
| Clean capacity | FHWA HEC-22 (4th ed., 2024) or the manufacturer's tested rating for the exact geometry; CPHEEO §5.6.2 equations as a cross-check only | 6.6.2 |
| Clogging, on grade | Grate 50%; kerb opening 10% | 6.6.3, Table 6.5 |
| Clogging, in a sag | Grate 50%; kerb opening 20% | 6.6.3, Table 6.5 |
| Spacing | By sequential calculation from the top of each gutter run; not more than 30 m on kerbed roads | 6.6.4 |
| Kerb opening size | Clear height at least 100 mm; length at least 1.0 m | 9.11.4 |

| Item | Requirement | Clause |
|---|---|---|
| Grate pattern | Openings parallel to the direction of travel not wider than 25 mm | 9.11.3(a) |
| Load class | D400 in carriageways and medians; C250 within 0.5 m of the kerb; B125 in footpaths and cycle tracks (or the equivalent IS class) | 9.11.2 |
| Connection pipe | At least 300 mm diameter; gradient giving at least 0.9 m/s at the inlet's design flow | 6.6.6 |
| Silt sump | At least 300 mm deep below the outlet pipe invert, cleanable from the surface | 6.6.7, 9.11.6 |

The intended layout of the annex is given in Tables 6A.2 to 6A.4.

**Table 6A.2 — Register of standard inlet types (layout)**

| Type code | Description | Grate size or kerb opening (mm) | Gutter depression (mm) | Load class | Standard drawing |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

**Table 6A.3 — Capacity on grade (layout; one table per inlet type)**

| Cross slope Sx (m/m) | Longitudinal slope SL (m/m) | Gutter flow Q (L/s) | Spread T (m) | Clean intercepted flow (L/s) | Design intercepted flow after clogging (L/s) | Bypass flow (L/s) |
|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**Table 6A.4 — Capacity in a sag (layout; one table per inlet type)**

| Ponded depth at the inlet (mm) | Clean capacity (L/s) | Clogging factor (Table 6.5) | Design capacity (L/s) | Flow regime (weir, orifice or transition) |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ |

---

## Annex 6B — Sediment yield for silt-trap sizing and calibration of the sediment allowance

Supports Clauses 6.7.4, 6.7.8, 6.13.3 and 6.13.10 of Chapter 6.

**To be prepared.** This annex will contain sediment yields for urban drains in Sikkim, by land use and drain type, for sizing the silt traps of Clause 6.13.3, and a calibration of the sediment allowance of Clause 6.7.8 against measured silt depths. It needs desilting records (volume or mass removed per drain length and per catchment area, with dates), silt-depth surveys before and after the monsoon season, and catchment land-use and soil data (data and likely sources: desilting records of Gangtok Municipal Corporation and other urban local bodies, WRD records for channels, land cover from NRSC, soils from the Sikkim soil survey and NBSS&LUP, rainfall from IMD). Until it is published, size each silt trap from the designer's stated estimate of the sediment expected between scheduled cleanings, based on the desilting records of the same drain or of similar drains in the same local body, and state the cleaning interval assumed; the interval shall not be longer than the yearly pre-monsoon desilting of Clause 6.13.10. Inlet silt sumps remain at least 300 mm deep (Clause 6.6.7), and the sediment allowance of Clause 6.7.8 applies unchanged.

The intended method is a simple volume balance, with every term to be stated in the design:

$$V_{trap} = Y \cdot A \cdot t_c$$

where $V_{trap}$ is the sediment storage volume of the trap below its outlet invert ($m^3$), $Y$ is the sediment yield for the catchment's land use and drain type ($m^3$/ha per year, from Table 6B.2 once published), $A$ is the catchment area draining to the trap (ha), and $t_c$ is the scheduled cleaning interval (years). The annex will state whether a safety margin is added.

**Table 6B.1 — Sediment allowances already set by Chapter 6 (provisional, to be calibrated)**

| Element | Sediment allowance at the invert | Clause |
|---|---|---|
| Open and covered drains | Greater of 75 mm and 10% of the clear internal depth | 6.7.8(a) |
| Pipes of 600 mm diameter or more | 5% of the internal diameter | 6.7.8(b) |
| Pipes below 600 mm | No allowance; minimum velocity of Clause 6.7.3(a) applies | 6.7.8(c) |
| Drains and pipes that cannot reach the minimum velocity | Allowance doubled; mechanical desilting access provided | 6.7.4(b), (c) |
| Inlet silt sumps | At least 300 mm below the outlet pipe invert | 6.6.7 |

**Table 6B.2 — Sediment yield by land use and drain type (layout)**

| Land use or catchment type | Drain type | Sediment yield Y ($m^3$/ha per year) | Bulk density (t/$m^3$) | Local body and records used | Years of record |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

**Table 6B.3 — Calibration of the sediment allowance (layout)**

| Drain or pipe ID | Clear internal depth or diameter (mm) | Allowance under Clause 6.7.8 (mm) | Measured silt depth before pre-monsoon desilting (mm) | Measured silt depth at the end of the monsoon (mm) | Ratio of measured to allowance |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

## Annex 6C — Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump

Supports Clauses 6.6, 6.7.6 to 6.7.10 and 6.13 of Chapter 6, and Clauses 9.11 and 9.12 of Chapter 9.

The drawings below are schematic standard drawings. They show only the dimensions that Chapter 6 and Chapter 9 set. Wall and slab thicknesses, reinforcement, concrete grade and cover, chamber plan sizes and frame details are to be confirmed in design: they come from the structural design (Clause 9.1.2) and the exposure class of Clause 9.13. Table 6C.1 lists the dimensions shown and their source clauses.

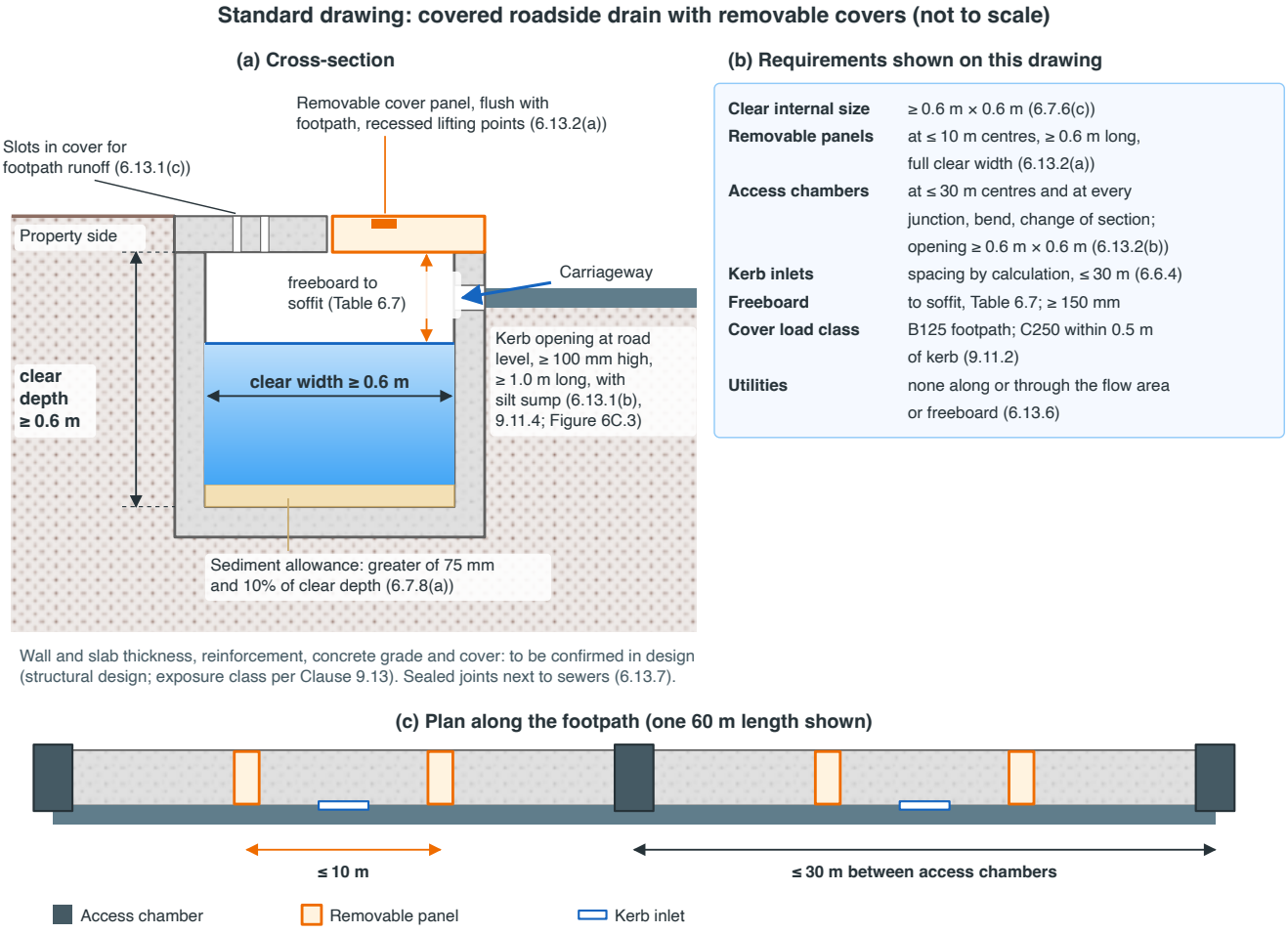


*Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 5, and IRC:SP:50-2013.*

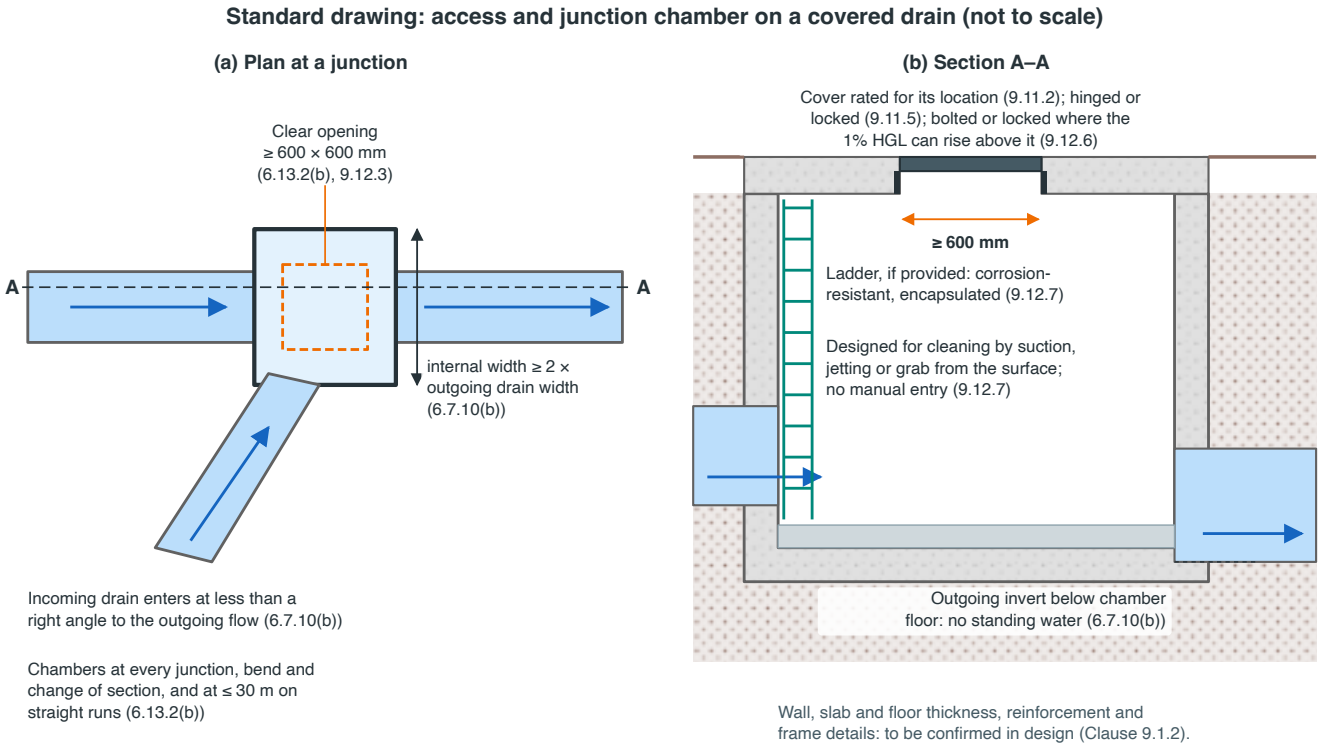


*Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), §5.3.4 and Chapter 11.*

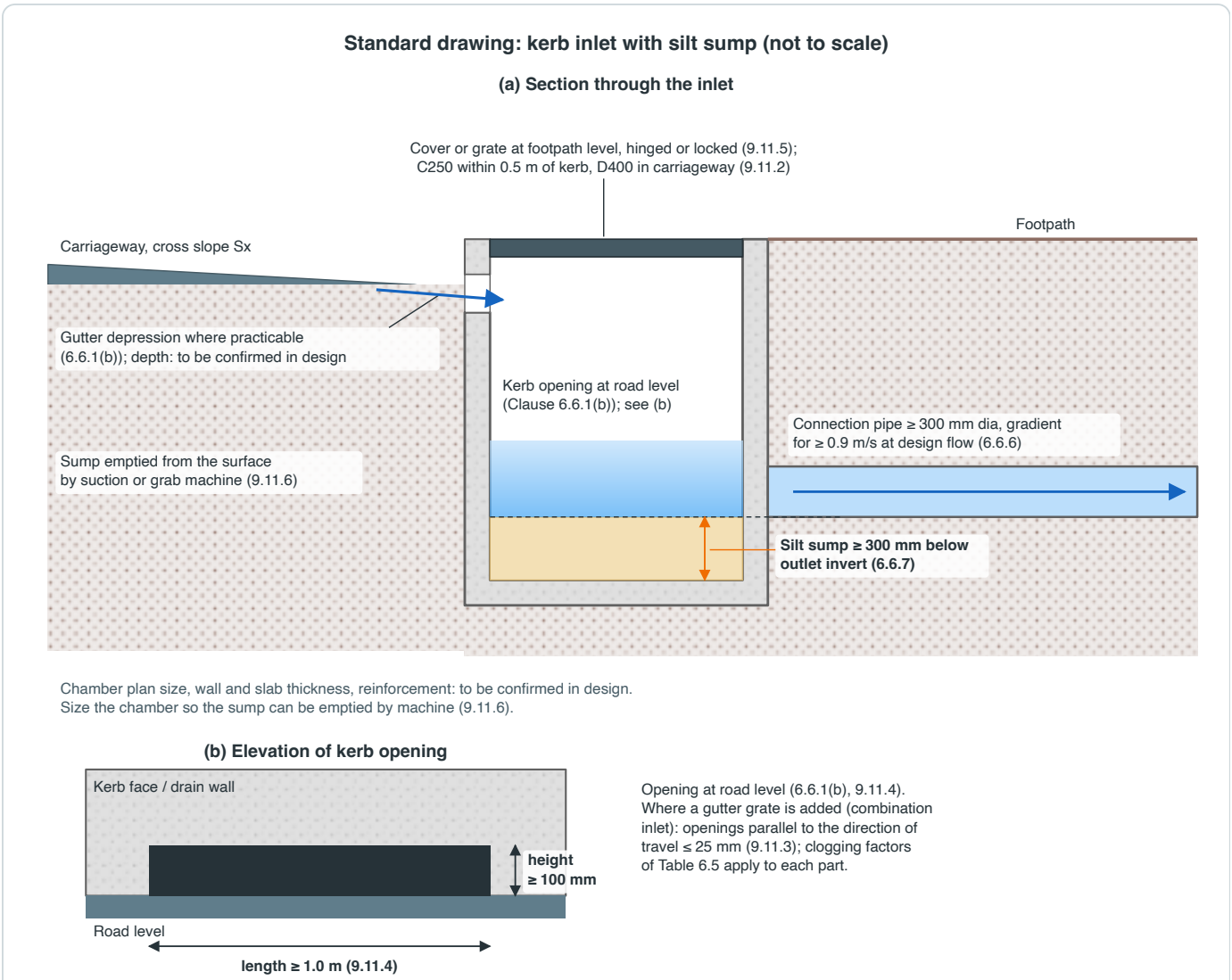


*Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).*

### Table 6C.1 — Dimensions on the standard drawings and their source clauses

| Drawing | Item | Dimension or rule | Clause |
|---|---|---|---|
| 6C.1 | Clear internal size of a covered public drain | At least 0.6 m wide and 0.6 m deep | 6.7.6(c) |
| 6C.1 | Freeboard to the cover soffit | Table 6.7; not less than 150 mm for any roadside drain | 6.7.9, 6.13.1(a) |
| 6C.1 | Sediment allowance | Greater of 75 mm and 10% of clear depth | 6.7.8(a) |
| 6C.1 | Removable cover panels | At not more than 10 m centres; each at least 0.6 m long and spanning the full clear width; recessed lifting points; flush with the footpath | 6.13.2(a) |
| 6C.1 | Footpath runoff | Through slots or grated openings in the cover | 6.13.1(c) |
| 6C.1 | Kerb inlets | Openings in the drain wall at road level, each with a silt sump; spacing by calculation, not more than 30 m | 6.13.1(b), 6.6.4 |
| 6C.1, 6C.2 | Access chambers | At every junction, bend and change of section, and at not more than 30 m centres on straight runs | 6.13.2(b) |

| Drawing | Item | Dimension or rule | Clause |
|---|---|---|---|
| 6C.2 | Clear access opening | At least 0.6 m × 0.6 m (600 mm) | 6.13.2(b), 9.12.3 |
| 6C.2 | Junction chamber | Internal width at least twice the outgoing drain width; incoming drains at less than a right angle; outgoing invert below the chamber floor | 6.7.10(b) |
| 6C.2 | Covers | Load class for the location; hinged or locked; bolted or locked where the 1% AEP HGL can rise above the cover | 9.11.2, 9.11.5, 9.12.6 |
| 6C.2 | Cleaning | By machine from the surface; ladders, where provided, corrosion-resistant and encapsulated | 9.12.7 |
| 6C.3 | Kerb opening | At road level; clear height at least 100 mm; length at least 1.0 m | 6.6.1(b), 9.11.4 |
| 6C.3 | Silt sump | At least 300 mm below the outlet pipe invert; emptied by suction or grab machine | 6.6.7, 9.11.6 |
| 6C.3 | Connection pipe | At least 300 mm diameter; at least 0.9 m/s at the design flow | 6.6.6 |
| 6C.3 | Grate in a combination inlet | Openings parallel to travel not wider than 25 mm; Table 6.5 clogging on each part | 9.11.3, 6.6.3 |
| All | Wall and slab thickness, reinforcement, concrete grade and cover, chamber plan size, gutter depression depth | To be confirmed in design | 9.1.2, 9.13 |

## Form 6-1 — Conveyance Design Report checklist

Supports Clause 6.15 of Chapter 6.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0. Not for statutory use.*

Attach this checklist to the front of the Conveyance Design Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

### Section A — Project

**Table 6F.1 — Form 6-1, Section A: project**

| Field | Entry |
|---|---|
| Project name and location | _____ |
| Local body, and Tier A or Tier B (Chapter 1) | _____ |
| Applicant | _____ |
| Designer (name and registration) | _____ |
| Total catchment area served (ha) | _____ |
| High-density area status for the 10% AEP minor system (Clause 6.4.4) | _____ |
| Within the coastal band of Clause 6.11.6 (Yes / No) | _____ |
| Date and revision | _____ |

### Section B — Contents required by Clause 6.15

**Table 6F.2 — Form 6-1, Section B: contents required by Clause 6.15**

| No. | Item | Clause | Provided (Yes / No / NA) | Drawing or page |
|---|---|---|---|---|
| 1 | Catchment plan: sub-catchments, minor system, inlet locations and the 1% AEP major-system overland flow paths | 6.3.2 | | |
| 2 | Land-use and road-class AEP adopted for each element, and the high-density area status | Table 6.1, 6.4.4 | | |
| 3 | Design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3 | 6.3.4 | | |
| 4 | Gutter spread, depth and D·V checks for the minor, check and 1% events | Tables 6.2, 6.3 | | |
| 5 | Inlet schedule: clean capacity, clogging factor, design capacity and bypass flow | 6.6 | | |
| 6 | Pipe and drain design tables: n, velocity, sediment allowance and freeboard | 6.7 | | |
| 7 | HGL profiles for the minor and check events, with the tailwater used | 6.8 | | |
| 8 | Sag ponding levels, including the fully-blocked check | 6.10 | | |
| 9 | Floor-level schedule for every building | 6.11 | | |
| 10 | Culvert and crossing calculations (with Form 9-1) | 6.12, Chapter 9 | | |

| No. | Item | Clause | Provided (Yes / No / NA) | Drawing or page |
|---|---|---|---|---|
| 11 | Utilities-crossing schedule and access-opening layout for covered drains | 6.13 | | |

### Section C — Design basis

### Table 6F.3 — Form 6-1, Section C: design basis

| Field | Entry | Clause |
|---|---|---|
| Minor-system design AEP adopted | _____ | Table 6.1 |
| Road class(es) and design / check AEPs for road drainage and crossings | _____ | Table 6.1, 6.4.2 |
| Rainfall source and climate factor applied | _____ | 6.3.4, Chapter 2 |
| Method: Rational Method (catchment ≤ 16 ha, single element) or hydrograph method with routing | _____ | 6.3.4(a), (b) |
| Minimum time of concentration used (not less than 10 min) | _____ | 6.3.4(c) |
| Tailwater at the outfall for the HGL (MHWS + 0.3 m at tidal outfalls, or the receiving level) | _____ | 6.8.2 |
| Any transfer of flow between natural catchments (none unless accepted under 6.3.5) | _____ | 6.3.5 |

### Section D — Compliance checks

### Table 6F.4 — Form 6-1, Section D: compliance checks

| No. | Check | Limit | Clause | Complies (Yes / No / NA) |
|---|---|---|---|---|
| D1 | Every inlet, sag, pipe, drain, culvert and storage element has a 1% AEP overland path | Shown on plan | 6.3.2 | |
| D2 | Major-system flow = 1% AEP peak less the clogged minor-system capacity | Computed at each point | 6.3.3 | |
| D3 | Spread in the minor event | Table 6.2 | 6.5.2 | |
| D4 | Depth in the check and 1% events | ≤ 150 mm at the crown; ≤ 350 mm at the deepest point | Table 6.2 | |
| D5 | Flow hazard (D·V) by location | Table 6.3 | 6.5.3 | |
| D6 | Inlet clogging factors applied | Table 6.5 | 6.6.3 | |
| D7 | Inlet spacing on kerbed roads | ≤ 30 m | 6.6.4(a) | |
| D8 | Sag inlet design capacity ≥ minor design flow arriving; flanking inlets where required | — | 6.6.5 | |
| D9 | Inlet connection pipes and silt sumps | ≥ 300 mm dia, ≥ 0.9 m/s; sump ≥ 300 mm | 6.6.6, 6.6.7 | |
| D10 | Manning's n not less than the minimum design values | Table 6.6 | 6.7.2 | |
| D11 | Minimum velocity at the minor design flow | 0.6 m/s drains; 0.9 m/s pipes | 6.7.3(a) | |
| D12 | Maximum velocity and Froude number | 3.0 m/s lined drains and pipes; Fr ≤ 0.8 | 6.7.3(b), (d) | |

| No. | Check | Limit | Clause | Complies (Yes / No / NA) |
|---|---|---|---|---|
| D13 | Where minimum velocity cannot be met: velocity reported, sediment allowance doubled, desilting access provided | — | 6.7.4 | |
| D14 | Pipes sized for pipe-full capacity, not the 0.95-depth peak | — | 6.7.5 | |
| D15 | Minimum sizes | Pipes 300 mm (450 mm public mains); open drain bed 0.3 m; covered public drains 0.6 m × 0.6 m | 6.7.6 | |
| D16 | Cover to pipes; flotation check where groundwater is within 1 m of the crown | ≥ 0.6 m; ≥ 0.9 m under carriageways | 6.7.7 | |
| D17 | Sediment allowance in capacity | 6.7.8 values | 6.7.8 | |
| D18 | Freeboard, including superelevation at bends | Table 6.7 | 6.7.9 | |
| D19 | Bend radii and junction sumps | 6.7.10 | 6.7.10 | |
| D20 | Manhole spacing on straight runs | Table 6.8 | 6.7.11 | |
| D21 | HGL below inlet rims and manhole covers in the minor event | ≥ 0.3 m | 6.8.3 | |
| D22 | Manholes that can surcharge above ground: bolted or locked covers | — | 6.8.4 | |
| D23 | Soffits matched or outgoing soffit lower; outgoing invert not above the lowest incoming invert | — | 6.8.6 | |
| D24 | Gate and valve losses included in the HGL; non-return valves on private connections where required | — | 6.8.7, 6.8.8 | |
| D25 | Overland flow paths outside streets: width, tenure, no obstruction, continuous fall | ≥ 1% top width + 0.5 m each side, ≥ 3.0 m | 6.9.2 | |
| D26 | Compound walls across mapped flow paths: openings pass the 1% flow at 50% blockage | — | 6.9.3 | |
| D27 | Access strip along open drains with top width ≥ 2 m | ≥ 3.5 m, linked to a road at ≤ 500 m | 6.9.4 | |
| D28 | Drainage reserve where required: width, separate plot, no structures, markers, services, 2 m stability check | Table 6.9 | 6.9.6–6.9.8 | |
| D29 | Sag ponding in the 1% event, overflow route, and fully-blocked check | ≤ 350 mm at the deepest point | 6.10.2, 6.10.3 | |
| D30 | Trapped sags and road underpasses | 6.10.4, 6.10.5 | 6.10.4, 6.10.5 | |
| D31 | Floor levels | ≥ 1% AEP level + 0.5 m; defaults of 6.11.3 where no level is computed | 6.11.1–6.11.3 | |
| D32 | Basements and building services | 6.11.4, 6.11.5 | 6.11.4, 6.11.5 | |
| D33 | Coastal band: floor ≥ 1% still-water level + 2 × SLA (+ wave set-up where applicable) + 0.5 m; no basement rooms or plant | — | 6.11.6 | |
| D34 | Culverts: design AEP, overtopping, 50% / 20% blockage check, minimum size | ≥ 900 mm | 6.12 | |

| No. | Check | Limit | Clause | Complies (Yes / No / NA) |
|---|---|---|---|---|
| D35 | Covered drains: removable panels and access chambers | ≤ 10 m; ≤ 30 m | 6.13.1, 6.13.2 | |
| D36 | Silt traps, screens with bypass and 50% blockage check | — | 6.13.3, 6.13.4 | |
| D37 | No building over drains; no utilities in the flow area or freeboard; existing crossings deducted with 50% blockage | — | 6.13.5, 6.13.6 | |
| D38 | No sewage connections; sealed joints next to sewers; edge protection on open drains deeper than 1.0 m | — | 6.13.7, 6.13.8 | |
| D39 | Outfalls: tailwater, flap gates or non-return valves below the 1% still-water level, outlet protection | — | 6.14 | |

### Section E — Variances

#### Table 6F.5 — Form 6-1, Section E: variances

| Clause | Requirement not met | Reason and proposed alternative | Approved by and date |
|---|---|---|---|
| _____ | _____ | _____ | _____ |

### Section F — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). Where a structure stands within 2 m of the edge of a drainage reserve, the stability design shall also be signed by a qualified structural engineer (Clause 6.9.8(f)).

#### Table 6F.6 — Form 6-1, Section F: signatures

| Role | Name | Registration or empanelment no. | Signature | Date |
|---|---|---|---|---|
| Designer | _____ | _____ | _____ | _____ |
| Structural engineer (Clause 6.9.8(f), where applicable) | _____ | _____ | _____ | _____ |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

ANNEXES TO CHAPTER 7

# Waterbodies, Pokharis, Jhoras, Springs and Setbacks

These annexes support Chapter 7. They give the inventory field specification, the fixed-width setback table, a template operating rule, the desilting and restoration specification, a glossary of Nepali waterbody terms, and the three forms that Clause 7.15 requires. Where an annex cannot yet be completed it says so and gives the rule to use in the meantime. The forms are draft forms; the template and model text are for consideration by a competent authority and are not in force.

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## Annex 7A — Statewide waterbody GIS layer and inventory fields

Supports Clauses 7.3.1, 7.3.3 and 7.3.5 of Chapter 7.

**To be prepared.** This annex will contain the statewide GIS layer of waterbodies required by Clause 7.3.1, prepared by each Authority with the Water Resources Department and the Land Revenue and Disaster Management Department. It needs the land records and maps of the Land Revenue and Disaster Management Department (LR&DMD) and the District Collectors, kept by revenue block (NEER reading [TBC]; no land record was read for this Manual); the Forest Department's records of the river banks of the 103 scheduled rivers under the 1988 Act, which are under its control, and of its slip reserves and road reserves; the jhoras that vest in each Municipality under section 172(1) of the Sikkim Municipalities Act, 2007, and any limits of a jhora notified under section 173 (none was found); the maps of the notified areas kept by the Urban Development Department (UDD) and the Mines and Geology Department's stability-zone maps of regulation 17 of the SBCR 1991; the GIS master plans of the Sikkim Integrated Urban Development Project for four towns other than Gangtok, and of the Namchi Planning Area, once prepared; the hydropower operators' records of reservoir levels and reservoir land; the spring inventories of RMDD's Dhara Vikas programme and its village spring atlas (whose counts conflict, as reported); the evacuation and risk maps of the Sikkim State Disaster Management Authority (SSDMA) and the District Disaster Management Authorities for the GLOF corridors, where they exist [TBC]; and each town's drain and jhora register (Chapter 6); the WRD and Gram Panchayat tank registers with FTL and MWL; surveyed levels on a common datum; the ISRO National Wetland Inventory and Assessment (NRSC); Survey of India topographic maps; and any list of waterbodies published under court directions. Until it is published, each Applicant identifies waterbodies from all the sources of Clause 7.3.3, with the larger extent governing, and records them on the Waterbody Sheet (Form 7-1).

The field specification below is complete. It is written so that every field the chapter asks for (Clause 7.3.1(a) to (g)) has a defined name, type and source, and so that the same fields can be filled from a project's Form 7-1.

### 7A.1 Layers

- **WB_POLY** — one polygon per waterbody: the Revenue record boundary (Clause 7.3.1(c)).
- **WB_FTL** — the surveyed FTL contour (tanks, lakes, ponds) or top of bank (channels), as a polygon or line.
- **WB_MWL** — the MWL contour of each tank, as a polygon.

- **WB_FLOOD** — the 1% AEP flood extent, where mapped (Clause 7.3.1(f)), with the floodway where delineated (Clause 7.6.1).
- **WB_STRUCT** — points for surplus weirs, sluices, regulators, inlets and drain outfalls.
- **WB_LINK** — lines for supply channels, surplus courses and the links between tanks in a cascade (Clause 7.3.1(e)).
- **WB_ENCR** — polygons of known encroachments, each with the date recorded (Clause 7.3.1(g)).
- **WB_SETBACK** — Zone 1 and Zone 2 polygons (Clause 7.4), derived from the layers above.

All layers shall carry the waterbody identifier (WB_ID) so that they can be joined. All levels shall be stated to one datum (Clause 7.3.5), named in the layer metadata.

**Table 7A.1 — Attribute fields of the waterbody inventory (WB_POLY)**

| Field | Type | Unit / domain | Required | Content | Clause |
|---|---|---|---|---|---|
| WB_ID | Text | District code + serial | Yes | Unique identifier, never reused | 7.3.1 |
| WB_NAME | Text | — | Yes | Name as in Revenue and WRD records, with local name | 7.3.1(a) |
| WB_NAME_NE | Text | Nepali script | Yes | Name in Nepali | 7.3.1(a) |
| WB_TYPE | Code | Table 7A.2 | Yes | Waterbody type | 7.2, 7.3.1(a) |
| SURVEY_NOS | Text | Village, survey and subdivision numbers | Yes | Revenue survey numbers of the waterbody | 7.3.1(a) |
| VILLAGE | Text | — | Yes | Revenue village, sub-division and district | 7.3.1(a) |
| CUSTODIAN | Code | Table 7A.2 | Yes | Custodian body | 7.3.1(b) |
| AREA_REC | Number | ha | Yes | Area within the Revenue record boundary | 7.3.1(c) |
| AREA_FTL | Number | ha | Tanks | Waterspread at FTL, surveyed | 7.2, 7.3.1(d) |
| FTL | Number | m (datum) | Tanks | Full tank level | 7.3.1(d) |
| MWL | Number | m (datum) | Tanks | Maximum water level (Clause 7.2 definition) | 7.3.1(d) |
| MWL_BASIS | Code | WRD record / 1% AEP computed | Tanks | Which value governs MWL | 7.2 |
| TBL | Number | m (datum) | Tanks | Top bund level, lowest point | 7.3.1(d) |
| WEIR_CREST | Number | m (datum) | Tanks | Surplus weir crest level | 7.3.1(d) |
| WEIR_LEN | Number | m | Tanks | Surplus weir crest length | 7.3.1(d) |
| WEIR_TYPE | Text | — | Tanks | Surplus weir type (for example fixed crest, with shutters or falling boards) | 7.3.1(d) |
| SLUICE_N | Integer | — | Tanks | Number of sluices; details in WB_STRUCT | 7.3.1(d) |
| SUPPLY_CH | Text | WB_ID(s) | Tanks | Supply channel(s) feeding the tank | 7.3.1(d) |
| SURPLUS_CS | Text | WB_ID(s) | Tanks | Surplus course(s) leaving the tank | 7.3.1(d) |
| UPSTR_WB | Text | WB_ID(s) | Cascades | Upstream tank(s) in the cascade | 7.3.1(e) |
| DNSTR_WB | Text | WB_ID | Cascades | Downstream tank, river, drain or sea outfall | 7.3.1(e) |
| CATCH_AREA | Number | ha | Channels | Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1) | 7.4.1 |

| Field | Type | Unit / domain | Required | Content | Clause |
|---|---|---|---|---|---|
| DATUM | Text | — | Yes | Datum of all levels; conversion from any older WRD datum | 7.3.5 |
| LEVEL_DATE | Date | — | Tanks | Date of the level survey | 7.7.1(a) |
| SSC_DATE | Date | — | Tanks | Date of the latest stage–storage survey | 7.7.1(b) |
| FLOOD_SRC | Code | Adopted map / site study / none | Yes | Source of the 1% AEP extent | 7.3.4 |
| FLOODWAY | Code | Delineated / whole 1% extent / below MWL | Yes | Basis of the floodway | 7.6.1 |
| ENCR_KNOWN | Code | Yes / No | Yes | Known encroachment; details in WB_ENCR | 7.3.1(g) |
| CREDITED | Code | Yes / No | Tanks | Storage counted under Clause 7.7, with the scheme reference | 7.7.1 |
| WETLAND | Code | Notified / listed / other | Wetlands | Status under Clause 7.12.1 | 7.12.1 |
| SOURCES | Text | — | Yes | Sources used, from the list in Clause 7.3.3(a) to (e) | 7.3.3 |
| UPDATED | Date | — | Yes | Date of the last edit, and by whom | 7.3.1 |

### Table 7A.2 — Code lists

| Code list | Values | Clause |
|---|---|---|
| WB_TYPE | River or khola (scheduled under the 1988 Act, or not); jhora (natural watercourse or ravine stream; trained or untrained); drain; pokhari (pond, lake or tank; natural or dug); hydropower reservoir or pondage (with its drawdown zone and release reach); dhara (spring or spring spout) and its recharge area; glacial lake (hazard source; never storage); wetland, marsh or seepage ground; kulo or other supply channel; surplus course | 7.2 |
| CUSTODIAN | Municipality: GMC, Namchi Municipal Council or a Nagar Panchayat (Municipalities Act, 2007, s.172); Forest and Environment Department (scheduled river bank, 1988 Act s.29(9); forest land; slip and road reserves; River Rejuvenation Committee); Water Resources Department (river and jhora works); hydropower operator (reservoir, dam and release reach; name the company); PHED (water-supply source or intake); RMDD (rural sewage; Dhara Vikas works); Roads and Bridges Department (PWD), NHIDCL or BRO (road drains and culverts); Gram Panchayat [TBC]; private owner or community; developer (until handed over); State Wetland Authority (wetland); none named (jhora outside municipal limits or on forest land); other (name) | 7.3.1(b) |
| Structure (WB_STRUCT) | Surplus weir; sluice; regulator; inlet; drain outfall; gross pollutant trap; crossing | 7.3.1(d), 7.10 |
| Encroachment (WB_ENCR) | Building; fill; road; wall; dumping; cultivation; other — each with date recorded, area (m²) and source | 7.3.1(g), 7.13 |

### Table 7A.3 — Attribute fields of structures (WB_STRUCT)

| Field | Type | Unit | Content | Clause |
|---|---|---|---|---|
| STR_ID | Text | — | Unique identifier | 7.3.1(d) |
| WB_ID | Text | — | Waterbody served | 7.3.1(d) |
| STR_TYPE | Code | Table 7A.2 | Structure type | 7.3.1(d) |
| CREST_SILL | Number | m (datum) | Weir crest or sluice sill level | 7.7.1(a) |
| LENGTH_SIZE | Text | m | Weir crest length, or sluice opening size | 7.7.1(a) |

| Field | Type | Unit | Content | Clause |
|---|---|---|---|---|
| GATED | Code | Yes / No | Controllable outlet (needed for a flood cushion, Clause 7.8.2(a)) | 7.8.2 |
| CONDITION | Code | Serviceable / defective | Result of the latest pre-monsoon inspection, with date | 7.7.1(d), 7.14.4 |

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## Annex 7B — Fixed-width setback table (alternative S-3, with Annex 1C)

Supports Clauses 7.3.4, 7.4.3, 7.4.6 and 7.4.7 of Chapter 7, and alternative S-3 of the Policy Supplement (Annex 1C).

### 7B.1 When the table may be used

The fixed-width setback may be used only where all of the following apply:

- (a) the Authority has not adopted a 1% AEP flood extent map for the waterbody (Clause 7.3.4);
- (b) Clause 7.3.4 does not require the Applicant to determine the 1% AEP extent by a hydraulic study: the site is not in a flood-sensitive catchment, is not a site of 1 ha or more adjoining a waterbody, and the Authority has not asked for a study; and
- (c) the waterbody is one to which setbacks apply (Clause 7.4.1): any recorded or found waterbody, and any natural channel draining 8 ha or more at the site.

Where an Authority adopts alternative S-3 under Clause 1.7, the table below is the S-3 table. Clause 1.7.3(e) provides for the S-3 table to be issued by the State Stormwater Technical Committee. Until it is issued, the values are those of Clause 7.4.6, repeated here without change.

**Table 7B.1 — Fixed-width setback by waterbody class (alternative S-3)**

| Waterbody class | Drainage area at the site | Total setback (Zone 1 + Zone 2) | Of which Zone 1 | Measured from |
|---|---|---|---|---|
| Channel, small | 8 ha to 65 ha | 25 m | 15 m | Top of bank (Clause 7.4.3) |
| Channel, medium | 65 ha to 20 km² | 40 m | 15 m | Top of bank |
| Channel, large, and rivers | More than 20 km² | 50 m | 20 m | Top of bank |
| Tank, lake or pond | Any | MWL contour + 25 m | To the MWL contour, and not less than 15 m from FTL | FTL contour (Zone 1); MWL contour (total) |
| Marsh, estuary or backwater | Any | As notified by the Authority, and not less than 50 m | 15 m | The waterbody boundary of Clause 7.13.1 |

Values from Clause 7.4.6 (Table 7.1). Zone 2 is the total setback less Zone 1.

### 7B.2 Rules of application

- (a) **Measurement.** Measure horizontally on plan, outward from the boundary of Clause 7.13.1: the larger of the Revenue record boundary and the surveyed FTL (or top of bank). Where FTL and top of bank both apply, use whichever gives the wider zone (Clause 7.4.3).
- (b) **Drainage area.** For a channel, use the drainage area at the downstream end of the reach that adjoins the site. Where a reach crosses a class limit within the site, apply the wider setback to the whole reach within the site.
- (c) **Both banks.** The setback applies on each bank of a channel and all round a tank, lake, pond or marsh.
- (d) **Minimum set by this Manual.** Zone 1 is never less than 15 m (Clause 7.4.7). A wider statutory or approval setback governs for the uses it restricts (Clause 7.4.5).

- (e) **Stricter of the two.** Where a hydraulic study is made voluntarily, the setback is the wider of Table 7B.1 and Clauses 7.4.3 and 7.4.4.
- (f) **Record.** The basis of the setback (fixed width) shall be stated on the Waterbody Sheet (Form 7-1) and in the approval (Clause 7.4, Disclosure).
- (g) **Review.** The table shall be reviewed within 2 years of the Authority adopting 1% AEP flood maps (Clause 7.16.1).

### 7B.3 Source of the channel widths

The channel widths were set by this Manual with reference to the 2006 Kansas City APWA default stream buffers, rounded up and floored at the 15 m minimum (Clause 7.4.6, commentary). The source values, as cited in the chapter, are:

**Table 7B.2 — Source buffers cited in Clause 7.4.6 (KC APWA 5600, 2006, §5605.3)**

| Drainage area (source, acres) | Approximate SI equivalent | Source buffer |
|---|---|---|
| Less than 40 ac | Less than 16 ha | 40 ft (12 m) |
| 40–160 ac | 16–65 ha | 60 ft (18 m) |
| 160–5,000 ac | 65 ha – 20 km² | 100 ft (30 m) |
| More than 5,000 ac | More than 20 km² | 120 ft (37 m) |

The 65 ha and 20 km² class limits in Table 7B.1 are the SI equivalents of 160 ac and 5,000 ac. The 8 ha lower limit is the 20-acre trigger of APWA 2025.01 (Clause 7.4.1(b)).

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## Annex 7C — Template tank operating rule, with flood cushion

Supports Clauses 7.7.1(c), 7.7.3, 7.8 and 7.14.4 of Chapter 7.

*Model text for consideration by a competent authority. Not in force.* For tanks under WRD control, the operating rule is WRD's rule (Clause 7.8.4); this template sets out the content that Clause 7.8 asks for, so that the custodian's rule can be checked against it. Text in square brackets is to be completed for each tank.

### 7C.1 Identification

1. Tank: [name, WB_ID of Annex 7A, village, sub-division, district].
2. Custodian: [WRD division / ULB / Gram Panchayat / other].
3. Cascade position: upstream tank(s) [ ]; downstream tank, river or drain [ ].
4. Datum: [ ]. Surveyed levels (Clause 7.7.1(a)), date of survey [ ]: FTL [ ] m; MWL [ ] m; TBL (lowest point) [ ] m; surplus weir crest [ ] m, length [ ] m; sluice sills [ ] m.
5. Stage–storage curve (Clause 7.7.1(b)): survey date [ ]; attached as Schedule 1.
6. Controllable outlets (Clause 7.8.2(a)): [gated sluice / regulator / none]; capacity at FTL [ ] m³/s.

### 7C.2 Purposes and priority

7. The tank serves [irrigation of a command area of [ ] ha / drinking water supply / recharge / flood storage]. Irrigation and water supply remain primary unless the custodian records otherwise (Clause 7.8.2(d)).

## 7C.3 Levels and dates through the year (Clause 7.8.1(a))

8. The tank shall be operated to the levels in Table 7C.1.

**Table 7C.1 — Rule levels by period (to be completed for each tank)**

| Period | Target level (m) | Upper limit (m) | Lower limit (m) | Purpose |
|---|---|---|---|---|
| [1 Jan – date] | [ ] | FTL | [ ] | Holding for irrigation / supply |
| [date – start of cushion period] | [ ] | FTL | [ ] | Holding |
| [Flood-cushion period, if any] | Cushion level [ ] | Cushion level [ ] | [ ] | Flood cushion (Clause 7.8.2) |
| [End of cushion period – 31 Dec] | [ ] | FTL | [ ] | Refilling |

9. Where no flood cushion is adopted, the starting level for design is FTL (Clause 7.7.3) and the row for the cushion period is deleted.

## 7C.4 Flood cushion (Clause 7.8.2)

10. Cushion level: [ ] m, which is [ ] m below FTL, giving a cushion volume of [ ] m³ from Schedule 1.
11. Dates: the cushion applies from [ ] to [ ].
12. Drawdown: the tank can be drawn down from FTL to the cushion level through [outlet] in [ ] hours, with a release not exceeding the maximum release rate of paragraph 18.
13. Reliability: continuous simulation (Clause 3.13) over the record [years] shows that the cushion is available at the start of a design storm in [ ]% of monsoon seasons, which shall be at least 90%. The simulation report is Schedule 2.
14. Yield: the custodian accepts the loss of irrigation or supply yield stated in Schedule 3 [and the compensation recorded there].
15. Where the tank has no controllable outlet, this section does not apply and no flood cushion is assumed (Clause 7.8.3).

## 7C.5 Releases (Clause 7.8.1(b) to (d))

16. Sluice and regulator settings at each level: Table 7C.2.
17. Operator: the sluices and regulators are operated by [post]. A release above [ ] m³/s may be ordered only by [post], or, in an emergency, by [post].
18. Maximum release rate: [ ] m³/s. This rate, added to the flow from the downstream catchment, does not flood buildings downstream (Schedule 4 gives the downstream check).
19. No person shall cut, lower or breach the bund or surplus weir except under the custodian's emergency procedure (Clause 7.14.5).

**Table 7C.2 — Outlet settings by level (to be completed for each tank)**

| Tank level (m) | Sluice 1 | Sluice 2 | Regulator | Expected outflow (m³/s) | Notes |
|---|---|---|---|---|---|
| Below cushion level | [ ] | [ ] | [ ] | [ ] | |
| Cushion level to FTL | [ ] | [ ] | [ ] | [ ] | |
| FTL (weir begins to spill) | [ ] | [ ] | [ ] | [ ] | |
| Above FTL to MWL | [ ] | [ ] | [ ] | [ ] | Check freeboard to TBL (Clause 7.7.4(b)) |

### 7C.6 Forecasts, warnings and communication (Clause 7.8.1(e) and (f))

20. The triggers and actions are in Table 7C.3.
21. Before any release under this rule, the operator shall inform the ULBs and the district administration downstream, and residents by the means stated in Schedule 5, at least [ ] hours before the release where the forecast allows.

**Table 7C.3 — Triggers and actions (to be completed for each tank)**

| Trigger | Source | Action | By whom |
|---|---|---|---|
| IMD district heavy-rainfall warning for the catchment | IMD | Read gauges [ ] hourly; check outlets are free; confirm the tank is at or below its rule level | [ ] |
| IMD or SSDMA red alert | IMD, SSDMA | Begin releases needed to reach the rule level, within the maximum release rate; notify downstream bodies (paragraph 21) | [ ] |
| City forecast system warning, where available | [ ] | [ ] | [ ] |
| Tank level reaches FTL | Gauge | Record outflow hourly; inspect bund and weir | [ ] |
| Tank level reaches [MWL − [ ] m] | Gauge | Emergency procedure; warning to the breach area of any emergency action plan (Clause 7.14.3(c)) | [ ] |

### 7C.7 Records and review (Clause 7.8.1(g))

22. During the monsoon (1 April to 31 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the monsoon, records shall be kept [weekly].
23. Records shall be kept with the O&M plan (Chapter 10) and given to the Authority on request.
24. The tank shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Clause 7.14.4).
25. This rule shall be reviewed after any event in which the tank surplused at a level above [ ] m, after any change to the weir, sluices or bund (Clause 7.7.6), and in any case with the review of the Manual.

Schedules: 1 stage–storage curve; 2 continuous simulation report; 3 yield and compensation; 4 downstream check of the maximum release; 5 communication list.

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## Annex 7D — Desilting and restoration specification

Supports Clauses 7.7.1(b), 7.9 and 7.14.4 of Chapter 7.

This specification applies to every desilting, restoration or deepening of a tank, pond or other waterbody under Clause 7.9. Values are those of Chapter 7. Where the chapter does not set a value, it is marked "to be confirmed in design" and shall be stated in the works design.

### 7D.1 Pre-works survey (Clause 7.9.1)

- (a) **Topographic and bathymetric survey** of the waterspread, foreshore (to the MWL contour), bund, surplus weir and sluices, levelled to the datum of Clause 7.3.5. Survey grid and point density: to be confirmed in design.
- (b) **Original bed level** found by test pits or augering on a grid (grid spacing to be confirmed in design), and from historical records where available. Each pit log shall show the silt thickness, the level of the original bed, and any clay or silt layer below it.

- (c) **Silt testing** where the tank receives urban runoff or sewage: samples from the pits of (b), tested for heavy metals and other contaminants before disposal is planned. The parameters and limits shall be those the Sikkim State Pollution Control Board (SSPCB) directs.
- (d) **Structures:** condition of the bund (seepage, slips, cracks, animal burrows, trees), surplus weir and sluices, as in Clause 7.14.4.
- (e) **Existing stage–storage curve** from the survey of (a).

## 7D.2 Limits of excavation (Clauses 7.9.2 and 7.9.3)

- (a) Desilting removes accumulated sediment down to the original bed level of 7D.1(b), and no deeper.
- (b) Deepening below the original bed only with a hydrogeological report showing each of Clause 7.9.3(a) to (c).
- (c) Storage created below the lowest sluice sill is not flood storage, and shall not be shown as such in the revised stage–storage curve.
- (d) Excavation shall stay clear of the bund toe by a distance to be confirmed in design, so that the bund's stability is not reduced.

## 7D.3 Edges and safety (Clause 7.9.4)

Where the public has access to the edge:

- (a) side slopes no steeper than **1V:4H** from **0.5 m above FTL** down to **1.2 m below FTL**; or
- (b) a level safety bench at least **3 m** wide, between **0.3 m and 0.5 m below FTL**; and
- (c) no isolated deep pit or vertical cut left in the bed. Borrow pits shall be regraded to the bed.

## 7D.4 Storage not reduced (Clause 7.9.5)

- (a) Islands, walkways, bund widening into the waterspread, ring roads, parking, buildings and lake-front platforms within the waterspread or foreshore are lost storage.
- (b) Lost storage shall be offset by compensatory storage at equivalent levels, band by band, using Form 7-3.

## 7D.5 Silt handling and disposal (Clause 7.9.6)

- (a) Desilted material shall not be placed within the setback, on the bund (except approved bund strengthening), or on any flood path.
- (b) Contaminated silt shall be disposed of as the Sikkim State Pollution Control Board (SSPCB) directs.
- (c) Haul routes and temporary stockpiles shall meet the construction erosion and sediment control rules of Clause 8.12, including stockpiles outside Zone 1.

## 7D.6 Inlets (Clause 7.9.7)

Every inlet that brings urban runoff shall have a sediment forebay, a constructed wetland inlet zone or a gross pollutant trap, designed under Chapter 8 (Annex 8D).

## 7D.7 Timing (Clause 7.9.8)

Desilting shall be complete, and the waterbody made safe, by **31 March**. No excavation shall be left open, and no sluice or weir left dismantled, during the monsoon.

### 7D.8 Completion records

- (a) As-built survey and revised stage–storage curve. The curve is the one that Clause 7.7.1(b) requires "after the last desilting".
- (b) Volume removed, its disposal site, and the silt test results.
- (c) Photographs of the bund, weir, sluices and inlet works.
- (d) Update of the inventory record (Annex 7A: SSC_DATE, LEVEL_DATE, CONDITION).

**Table 7D.1 — Hold points for desilting and restoration works**

| Hold point | Check | Clause |
|---|---|---|
| 1. Before excavation | Pre-works survey, pit logs, silt tests, and hydrogeological report if deepening | 7.9.1, 7.9.3 |
| 2. Original bed reached | Levels checked against pit logs; no excavation below the original bed unless approved | 7.9.2 |
| 3. Edges formed | Side slopes or safety bench as 7D.3 | 7.9.4 |
| 4. Inlet works | Forebay, wetland inlet zone or GPT built | 7.9.7 |
| 5. Completion (by 31 March) | As-built survey, stage–storage curve, silt disposal record | 7.9.8, 7.7.1(b) |

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## Annex 7E — Glossary of Nepali waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Nepali words for waterbodies, springs and channels in Sikkim, with the Devanagari spelling this Manual uses. Many of them appear in the names of rivers, lakes and places (the Rani Khola, the Maney Khola, Bhalay Pokhari, Dhara Vikas). The name used in the land, Forest Department, municipal or operator record for each waterbody, and the name its people use, should be recorded in the inventory (Annex 7A) alongside the Manual's term. A meaning is given below only where it was found in one dictionary, R. L. Turner's *A Comparative and Etymological Dictionary of the Nepali Language* (1931), read online in the Digital Dictionaries of South Asia; the page numbers are Turner's. **Two cautions apply.** Turner's headwords use his transliteration and sometimes an older spelling: he gives पोखरि for the modern पोखरी, खोलो for खोला and धारो for धारा, and this Manual spells the three in their modern form while noting Turner's headword once, here. And Turner marks *jhorā* as a Darjeeling word, so its use in Sikkim rests on the statutes that use it (the Sikkim Municipalities Act, 2007 and the 1988 Act), not on the dictionary. Bhutia (Tibetan) words such as *chu* (river) and *chho* or *tso* (lake), which occur in many names (the Lachen Chu, the Rongni Chu, Shako Chho, Tsomgo), were not checked in any dictionary and are used only inside proper names; no Lepcha term was checked, and none is used. The list is to be extended by the State Stormwater Technical Committee, with modern Nepali usage and dictionaries of the State's other languages.

The Manual's term for a pond, lake or tank in Sikkim is **pokhari**, written on first use in each chapter as "**pokhari (पोखरी; pond, lake or tank)**", plural **pokharis**. Turner gives it the full sense "Lake, pool, tank" (p. 391), which covers natural lakes and built ponds; it is in current use in Sikkim lake names (Bhalay Pokhari and Doodh Pokhari, in the State's affidavit to the National Green Tribunal of 2026); and the alternatives are weaker: *tāl* (ताल) also means musical time and a palm, and *talāu* (तलाउ) is less used in Sikkim (NEER reading). **Three rules apply to the word.** (i) It is glossed at first use in each chapter. (ii) Engineered storage built under this Manual is a "**detention pond**", with "[pokhari]" in brackets only where a Nepali reader needs it; a detention basin is never called a dhara. (iii) **A glacial lake keeps its own name**, even where the name contains "Pokhari", as Bhalay Pokhari and Doodh Pokhari do: a glacial lake is a hazard source under Clause 2.3.6(i) and Chapter 7, never storage, and no storage credit, flood cushion or tank clause applies to it.

**Table 7E.1 — Waterbodies and channels**

| Term | Nepali | Meaning (Turner, 1931, page) | Manual term (Clause 7.2) |
|---|---|---|---|
| pokhari | पोखरी (Turner पोखरि) | "Lake, pool, tank. — p˚ khelnu to swim" (p. 391) | Pokhari (pond, lake or tank), see the definitions after Clause 7.2 |
| jhora | झोरा | "(Darj.) s. Ravine. [B. jhorā watercourse.]" (p. 237) | Jhora (natural watercourse or ravine stream), the statutory word (Municipalities Act, 2007, ss. 2(24) and 163(b)); plural jhoras |
| khola | खोला (Turner खोलो) | *kholo*: "Small river, valley" (p. 130); no entry for खोला | Khola (river or large stream), as in names |
| kholso, kholsi | खोल्सो, खोल्सी | *kholso*: "Stream, ravine. — kholsā-kholsi streams, valleys"; *kholsi*: "Small stream, small ravine" (p. 131) | Used only inside the quotation of section 193 of the Municipalities Act ("khola-kholsas"); a jhora for this chapter |
| dhara | धारा (Turner धारो) | *dhāro*: "Spring of water. — ā̃su kā dhārā fountains of tears" (p. 328); no entry for धारा | Dhara (spring or spring spout), and the name of RMDD's Dhara Vikas programme |
| mul | मूल | "Root, element, source, origin; spring of water … mul phuṭnu a spring of water to burst out" (p. 515) | A spring source; not a defined term |
| kulo | कुलो | "Any channel for water, drain, ditch, irrigation-channel; small stream, watercourse" (p. 101) | Kulo (irrigation channel); a supply channel under Clause 7.2 where it feeds a pokhari |
| nali | नाली | "Ditch, drain, watercourse; pipe, tube" (p. 341) | Not used: this Manual writes "drain" for a built drain |
| tal | ताल | "tāl¹ … Pool; lake" (p. 281), with homographs for musical time and a palm | Not used; a pokhari for this chapter |
| talau | तलाउ | "Tank, pool, lake" (p. 275) | Not used; a pokhari for this chapter |
| kuwa | कुवा | "A well, water-hole" (p. 102) | A well; not a defined term |

### Table 7E.2 — Terms not found or not checked

These terms or senses are in use but were not confirmed in a dictionary during research for this Manual. They shall not be used in a record or a drawing as defined terms until verified.

| Term | Reported meaning or use | Status |
|---|---|---|
| *pahiro* | Landslide | Not found in Turner by headword search; not used |
| *bāḍhi* | Flood | Not found in Turner by headword search; not used |
| *chu* (Bhutia, Tibetan) | River, in names such as the Lachen Chu, the Roro chu and the Gangtok chu of the 1988 Act's Schedule | Not checked in a dictionary; used only inside proper names, never glossed |
| *chho*, *tso* (Bhutia, Tibetan) | Lake, in names such as Shako Chho, Khangchung Chho, La Chho and Tsomgo | Not checked; used only inside proper names, never glossed |
| Lepcha terms | Words for streams, springs and lakes | Not checked (no Lepcha dictionary was consulted); none used |
| Modern Nepali spellings | पोखरी, खोला, धारा as modern forms of Turner's headwords | From the research notes; to be checked against a modern Nepali dictionary before the Nepali edition |

**Notes for the Annex 7A fields.** The field WB_NAME_NE holds the waterbody's name in Nepali, written in Devanagari (the "Nepali script" of Table 7A.1); where the record or the people use a name in another official language of the State, such as Bhutia, Lepcha or Limbu, it is added in WB_NAME. The field VILLAGE asks for the "Revenue village": Sikkim's land records are taken to be kept by revenue block, and the revenue block is entered there with the sub-division and district

(NEER reading; no land record was read for this Manual [TBC]). The six districts are Gangtok, Mangan, Namchi, Gyalshing, Pakyong and Soreng. The rural local body named in the tank registers and the custodian codes is the Gram Panchayat, whose records were not researched [TBC].

The Manual uses the terms in the last column of Table 7E.1 and the Sikkim terms defined after Clause 7.2.

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## Form 7-1 — Waterbody Sheet

Supports Clauses 7.3.2, 7.4 and 7.15(1) of Chapter 7.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One sheet per waterbody. Attach the plan of Clause 7.3.2 at 1:1,000 or larger.

### Table 7F.1 — Form 7-1, Section A: Project and waterbody

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Project name and Authority file number | _____ | — |
| A2 | Waterbody name (English and Nepali) and inventory ID (Annex 7A), if any | _____ | 7.3.1 |
| A3 | Waterbody type (Clause 7.2) | _____ | 7.2 |
| A4 | Position: within the site / within 100 m of the site boundary / downstream within the Chapter 5 extent | _____ | 7.3.2 |
| A5 | Survey numbers and village | _____ | 7.3.1(a) |
| A6 | Custodian | _____ | 7.3.1(b) |
| A7 | Sources checked (tick): LR&DMD land records (by revenue block [TBC]), Forest Department river-bank and reserve records (1988 Act), Municipality records (s.172) and s.173 notifications, UDD notified-area and Mines and Geology stability-zone maps, SIUDP master-plan maps, operator reservoir records, Dhara Vikas spring inventories, SSDMA GLOF maps, drain and jhora register □; WRD / Gram Panchayat registers □; Authority inventory or court list □; historical maps and imagery, including NWIA □; site survey □ | _____ | 7.3.3 |
| A8 | Where sources conflict: which extent governs (the larger) | _____ | 7.3.3 |
| A9 | Datum of all levels, and conversion from any WRD datum | _____ | 7.3.5 |

### Table 7F.2 — Form 7-1, Section B: Levels and features

| No. | Field | Entry | Clause |
|---|---|---|---|
| B1 | FTL (tanks, lakes, ponds) or top of bank (channels), m | _____ | 7.2 |
| B2 | MWL (tanks), m, and basis (WRD record or 1% AEP computed) | _____ | 7.2 |
| B3 | TBL, lowest point (tanks), m | _____ | 7.3.1(d) |
| B4 | 1% AEP flood level, m, and source (adopted map / hydraulic study / not available) | _____ | 7.3.4 |
| B5 | Drainage area at the site (channels), ha | _____ | 7.4.1(b) |
| B6 | Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no) | _____ | 7.3.2 |
| B7 | Known encroachments, with date recorded | _____ | 7.3.1(g) |

### Table 7F.3 — Form 7-1, Section C: Setback

| No. | Field | Entry | Clause |
|---|---|---|---|
| C1 | Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B) | _____ | 7.15(1) |
| C2 | Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)? | _____ | 7.3.4 |
| C3 | Floodway outer edge, m from FTL or top of bank, and how delineated | _____ | 7.6.1 |
| C4 | Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour) | _____ | 7.4.3 |

| No. | Field | Entry | Clause |
|---|---|---|---|
| C5 | Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m) | _____ | 7.4.4 |
| C6 | Wider statutory or approval setback, if any, and its source | _____ | 7.4.5 |
| C7 | Setback applied: Manual standard / a wider statutory, plan or approval line: the river bank of a scheduled river (1988 Act, s.29(1): sixty metres on either side or the area within the high flood level mark, whichever is less, a maximum; where it is narrower than Zone 1 it is stated, never governing alone); a closure of a river bank, slip reserve or road reserve notified under s.32 of that Act; the limits of a jhora notified under s.173 of the Sikkim Municipalities Act, 2007 (none yet); a road setback of SBCR 1991 reg. 18 or a condition of the site's stability zone (Mines and Geology notification of 2021); a line in a development plan once the 2024 Act commences (not yet); the boundary of forest land, a slip reserve or a notified wetland; a GLOF corridor or relocation area fixed by an order (none found); a court or Tribunal line; a hydropower operator or Water Resources Department line; or other (state which) | _____ | 7.4, Disclosure |
| C8 | Uses proposed in Zone 1 and Zone 2, and the custodian's NOC for any work in Zone 1 | _____ | 7.5, 7.15(5) |
| C9 | Fill proposed in the flood fringe (yes / no); if yes, Form 7-3 attached | _____ | 7.6.3 |
| C10 | Zone 1 marker positions shown (not more than 30 m apart) | _____ | 7.13.4 |

### Table 7F.4 — Form 7-1, Section D: Prepared by

| Field | Entry |
|---|---|
| Name, registration and empanelment number (Clause 10.6) | _____ |
| Signature and date | _____ |
| Licensed surveyor for the levels (name, licence number) | _____ |

## Form 7-2 — Tank Storage Credit Sheet

Supports Clauses 7.7, 7.8, 7.11, 7.14 and 7.15(4) of Chapter 7.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One sheet per tank whose storage is counted. Storage that fails any item in Section B shall not be counted (Clause 7.7.1).

### Table 7F.5 — Form 7-2, Section A: Tank and scheme

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Tank name and inventory ID (Annex 7A); custodian | _____ | 7.3.1 |
| A2 | Scheme in which storage is counted: basin plan / regional facility / fee-in-lieu (S-5) | _____ | 7.7.1, 7.11 |
| A3 | Cascade modelled: uppermost tank _____ to outfall _____ | _____ | 7.7.2 |
| A4 | Datum | _____ | 7.3.5 |

### Table 7F.6 — Form 7-2, Section B: Conditions for counting storage

| No. | Condition | Date / reference | Met (yes / no) | Clause |
|---|---|---|---|---|
| B1 | FTL, MWL, TBL, weir crest and length, sluice sills surveyed within the previous 5 years | _____ | _____ | 7.7.1(a) |
| B2 | Stage–storage curve from a bathymetric and topographic survey within 5 years or after the last desilting, whichever is later | _____ | _____ | 7.7.1(b) |
| B3 | Documented operating rule agreed with the custodian (Annex 7C) | _____ | _____ | 7.7.1(c), 7.8 |
| B4 | Weir, sluices and bund under an O&M plan; latest pre-monsoon inspection found them serviceable | _____ | _____ | 7.7.1(d), 7.14.4 |
| B5 | Custodian's written concurrence | _____ | _____ | 7.7.1(e) |

### Table 7F.7 — Form 7-2, Section C: Levels and creditable volume

| No. | Item | Value | Clause |
|---|---|---|---|
| C1 | Starting level: FTL, or cushion level under a rule meeting Clause 7.8.2, m | _____ | 7.7.3 |
| C2 | If a cushion is used: controllable outlet (type) and drawdown time, h | _____ | 7.8.2(a) |
| C3 | If a cushion is used: reliability from continuous simulation, % of monsoon seasons (≥ 90%) | _____ | 7.8.2(c) |
| C4 | Computed maximum level, 1% AEP inflow with climate factor routed through the cascade, m | _____ | 7.7.4 |
| C5 | MWL, m; is C4 ≤ MWL? | _____ | 7.7.4(a) |
| C6 | Freeboard C4 to TBL, m; WRD freeboard standard, m; met? | _____ | 7.7.4(b) |
| C7 | Storage between C1 and C4, from the stage–storage curve, $m^3$ | _____ | 7.7.5 |
| C8 | Volume already committed to another facility or scheme, $m^3$ | _____ | 7.7.5 |
| C9 | Creditable volume = C7 − C8, $m^3$ | _____ | 7.7.5 |
| C10 | Register entry under Clause 10.17 (fee-in-lieu storage) | _____ | 7.11.2(d) |

### Table 7F.8 — Form 7-2, Section D: Bund safety

| No. | Item | Entry | Clause |
|---|---|---|---|
| D1 | Specified dam under the Dam Safety Act, 2021? Height, crest length, capacity, maximum flood discharge | _____ | 7.14.1 |
| D2 | Hazard class: high / low | _____ | 7.14.2 |
| D3 | High hazard: weir passes 1% AEP at MWL with freeboard; 0.2% AEP check without overtopping | _____ | 7.14.3(a) |
| D4 | High hazard: breach analysis and emergency action plan (references) | _____ | 7.14.3(b), (c) |
| D5 | High hazard: independent check under Clause 10.6 (name) | _____ | 7.14.3(d) |

### Table 7F.9 — Form 7-2, Section E: Signatures

| Role | Name and designation | Signature and date |
|---|---|---|
| Designer (Clause 10.6) | _____ | _____ |
| Independent checker, where Clause 7.14.3(d) applies | _____ | _____ |
| Custodian's concurrence (Clause 7.7.1(e)) | _____ | _____ |

## Form 7-3 — Compensatory Storage Calculation (by elevation band)

Supports Clauses 7.6.3 to 7.6.5, 7.9.5 and 7.15(3) of Chapter 7.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

### Method

1. Fix the **lower limit**: the normal water level of the waterbody, or the 50% AEP (2-yr) level where higher (Clause 7.6.4(b)).
2. Fix the **upper limit**: the 1% AEP flood level (with the climate factor).
3. Divide the range into **bands of not more than 0.3 m**. The top band may be thinner.
4. For each level z at a band boundary, measure on plan:
    - A_fill(z): the area of the fill footprint where existing ground is below z; and
    - A_cut(z): the area of the excavation where finished ground is below z and existing ground was above z (new flooded area).
5. For each band, by the average end-area method: V = (A(z_bottom) + A(z_top)) / 2 × band thickness. Do this for fill (volume lost) and for excavation (volume gained).
6. **Check each band:** volume gained ≥ volume lost. A surplus in one band does not make up a shortfall in another (Clause 7.6.4(b)).
7. Check the other conditions of Clause 7.6.4(c) to (f) in Section C.

Figure 7.2 in Chapter 7 shows the method.

**Table 7F.10 — Form 7-3, Section A: Levels**

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Waterbody, reach, and inventory ID | _____ | 7.6.4(c) |
| A2 | Normal water level, m; 50% AEP level, m; lower limit (the higher), m | _____ | 7.6.4(b) |
| A3 | 1% AEP flood level with climate factor, m (upper limit) | _____ | 7.6.4(b) |
| A4 | Band thickness, m (≤ 0.3) and number of bands | _____ | 7.6.4(b) |
| A5 | Datum | _____ | 7.3.5 |

**Table 7F.11 — Form 7-3, Section B: Band-by-band balance**

| Band | From (m) | To (m) | A_fill bottom (m²) | A_fill top (m²) | Volume lost (m³) | A_cut bottom (m²) | A_cut top (m²) | Volume gained (m³) | Gained ≥ lost? |
|---|---|---|---|---|---|---|---|---|---|
| 1 | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| Total | | | | | _____ | | | _____ | |

Add rows as needed.

**Table 7F.12 — Form 7-3, Section C: Other conditions**

| No. | Condition | Met (yes / no) and evidence | Clause |
|---|---|---|---|
| C1 | Fill is in the flood fringe, not the floodway, and for a permitted use | _____ | 7.6.2, 7.6.3 |
| C2 | Excavation is in the same reach of the same waterbody, hydraulically connected, and not further downstream than the fill | _____ | 7.6.4(c) |
| C3 | Excavation drains by gravity as the flood recedes; no pumping; no permanent pool below normal water level | _____ | 7.6.4(d) |
| C4 | Excavation built before, or at the same time as, the fill | _____ | 7.6.4(e) |
| C5 | Covenant or handover so that it is never filled (reference) | _____ | 7.6.4(f) |
| C6 | Not counted as detention or retention under Chapter 4 | _____ | 7.6.5 |
| C7 | Signature of designer (Clause 10.6) and date | _____ | 10.6 |

## Worked example

**Illustrative — not design values.** A site in the flood fringe of a channel needs a fill pad for a permitted Zone 2 use (Clause 7.5.2). The inputs are assumed.

- Normal water level 10.00 m; 50% AEP level 9.80 m. Lower limit = 10.00 m (the higher).
- 1% AEP flood level 11.20 m. Range 1.20 m, so four bands of 0.30 m.
- The fill footprint is 1,600 m². Existing ground across the footprint rises evenly from 10.00 m to 11.20 m, so the area of footprint below each level is: 0 m² at 10.00 m; 400 m² at 10.30 m; 800 m² at 10.60 m; 1,200 m² at 10.90 m; 1,600 m² at 11.20 m.
- The excavation is a graded cut beside the channel, with its floor at 10.00 m. The new flooded area below each level (first trial) is: 300 m² at 10.00 m; 900 m² at 10.30 m; 1,100 m² at 10.60 m; 1,500 m² at 10.90 m; 1,500 m² at 11.20 m.

Step 1 — volume lost, band by band (V = average area × 0.3 m):

- Band 1: (0 + 400) / 2 × 0.3 = 60 m³
- Band 2: (400 + 800) / 2 × 0.3 = 180 m³
- Band 3: (800 + 1,200) / 2 × 0.3 = 300 m³
- Band 4: (1,200 + 1,600) / 2 × 0.3 = 420 m³
- Total: 960 m³

Step 2 — volume gained, first trial:

**Table 7F.13 — Worked example: first trial (illustrative)**

| Band | From (m) | To (m) | Volume lost (m³) | A_cut bottom (m²) | A_cut top (m²) | Volume gained (m³) | Gained ≥ lost? |
|---|---|---|---|---|---|---|---|
| 1 | 10.00 | 10.30 | 60 | 300 | 900 | 180 | Yes |
| 2 | 10.30 | 10.60 | 180 | 900 | 1,100 | 300 | Yes |
| 3 | 10.60 | 10.90 | 300 | 1,100 | 1,500 | 390 | Yes |
| 4 | 10.90 | 11.20 | 420 | 1,500 | 1,500 | 450 | Yes |
| Total | | | 960 | | | 1,320 | |

Every band passes. Note that a simple total balance would hide a failure if, for example, the cut were made deeper and narrower: suppose the designer instead offers a cut with new flooded areas of 1,400 m² at 10.00 m, 1,400 m² at 10.30 m, 1,000 m² at 10.60 m, 600 m² at 10.90 m and 200 m² at 11.20 m.

**Table 7F.14 — Worked example: deeper, narrower cut (illustrative)**

| Band | From (m) | To (m) | Volume lost (m³) | A_cut bottom (m²) | A_cut top (m²) | Volume gained (m³) | Gained ≥ lost? |
|---|---|---|---|---|---|---|---|
| 1 | 10.00 | 10.30 | 60 | 1,400 | 1,400 | 420 | Yes |
| 2 | 10.30 | 10.60 | 180 | 1,400 | 1,000 | 360 | Yes |
| 3 | 10.60 | 10.90 | 300 | 1,000 | 600 | 240 | **No** |
| 4 | 10.90 | 11.20 | 420 | 600 | 200 | 120 | **No** |
| Total | | | 960 | | | 1,140 | |

The total gained (1,140 m³) exceeds the total lost (960 m³), but bands 3 and 4 are short by 60 m³ and 300 m³. The surplus low down cannot be counted against them: the low storage fills early in every flood and is not available when the fill takes away storage near the peak. This design fails Clause 7.6.4(b) and must be regraded so that the upper bands gain at least as much as they lose, as in the first trial.

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ANNEXES TO CHAPTER 8

# Water Quality and Recharge

These annexes support Chapter 8. They give the layout of the water quality rainfall tables, the Level of Service and Value Rating method in detail, the layout of the BMP calibration programme, design sheets for each BMP, standard details for construction erosion and sediment control, and the two forms that Clause 8.14 requires. Annexes 8A and 8C need data that are not yet available; they say so and give the rule to use in the meantime. The forms are draft forms.

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## Annex 8A — 3-month ARI 24-hour depth and IDF by zone

Supports Clauses 8.2, 8.4.1 and 8.4.5 of Chapter 8.

**To be prepared.** This annex will contain, for each rainfall zone of Chapter 2, the 24-hour 3-month ARI depth P_3m and the 3-month ARI intensity–duration relationship used for Q_wq. It needs long-term daily and sub-daily rainfall records (IMD station and gridded data, with NIH as the Chapter 2 primary source), analysed as a partial-duration series. Until it is published, the designer shall compute P_3m from the longest available daily record for the site's zone, as the 24-hour depth equalled or exceeded on average four times a year (Clause 8.2), state the record, its length and the method on the Water Quality Sheet (Form 8-1), and use P_wq = max (P_ret, P_3m) (Clause 8.4.1). The climate factor is not applied (Clause 8.4.3).

### 8A.1 Method to be used in preparing the annex

- (a) Use daily records of at least 30 years where available (as for station IDF in Chapter 2).
- (b) Form the partial-duration series of 24-hour depths, with independent events separated by at least one dry day.
- (c) Choose the threshold so that the number of events above it averages four per year; P_3m is that threshold.
- (d) Derive the 3-month ARI intensities for durations from 10 minutes to 24 hours from sub-daily records, or by the Chapter 2 method of scaling from the daily value, stating which.
- (e) Do not apply the climate factor (Clause 8.4.3).

**Table 8A.1 — Water quality rainfall depths by zone (layout)**

| Zone (Chapter 2) | Representative stations or grid | Record (years) | P_ret, Annex 2E (mm) | P_3m (mm) | P_wq = max (mm) |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

**Table 8A.2 — 3-month ARI intensity by duration (layout)**

| Zone | 10 min (mm/h) | 15 min (mm/h) | 30 min (mm/h) | 1 h (mm/h) | 2 h (mm/h) | 6 h (mm/h) | 24 h (mm/h) |
|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

| Zone | 10 min (mm/h) | 15 min (mm/h) | 30 min (mm/h) | 1 h (mm/h) | 2 h (mm/h) | 6 h (mm/h) | 24 h (mm/h) |
|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

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## Annex 8B — Redevelopment LoS table and treatment-train composite VR

Supports Clauses 8.6.2 to 8.6.5 of Chapter 8.

### 8B.1 Required Level of Service for redevelopment

**To be prepared.** This part will give the required Level of Service for redevelopment sites (existing impervious cover of 20% or more of the site, Clause 8.6.2). The MARC/APWA BMP Manual (2012, Table 4.3) sets the redevelopment LoS from the percentage of impervious cover within the disturbed area; the Sikkim values need to be set by the State Stormwater Technical Committee and checked against local redevelopment cases. Until it is published, the required LoS for a redevelopment site is **6** for the disturbed area. Where Table 8.2, applied to the change in CN from the existing condition to post-development, gives a higher LoS, that higher LoS applies. This interim value is set by this Manual. A redevelopment site that retains its whole WQv on site under Chapter 4 needs no further treatment for that area, apart from pretreatment, hotspot controls and the outfall requirements (Clause 8.4.4).

**Table 8B.1 — Required LoS for redevelopment (layout)**

| Existing impervious cover within the disturbed area (%) | Change in impervious cover | Required LoS |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

### 8B.2 Composite Value Rating: area-weighted method

The composite VR of a site is the area-weighted average of the VRs of the BMPs serving each part of the site (Clause 8.6.3):

$$VR_{site} = \Sigma (A_i \times VR_i) / \Sigma A_i + VR_{signage}$$

where:

- $A_i$ = the area of part i of the site, ha;
- $VR_i$ = the Value Rating (Table 8.3) of the BMP serving part i, which counts only if the BMP meets Clause 8.6.4 for the whole of $A_i$;
- $\Sigma A_i$ = the whole site area: every part of the site is assigned to one BMP, or to preserved native vegetation; a part served by no BMP is entered with $VR_i = 0$; and
- $VR_{signage} = 0.25$ where public education signage is provided (Table 8.3), otherwise 0.

The site complies where $VR_{site} \geq$ required LoS (Clause 8.6.3).

**Illustrative — not design values.** A 1.0 ha site that is not redevelopment, with ΔCN = 18. Required LoS = 8 (Table 8.2).

**Table 8B.2 — Worked example: composite VR (illustrative)**

| Part | Area A_i (ha) | BMP | VR_i (Table 8.3) | A_i × VR_i |
|---|---|---|---|---|
| Roofs and paving draining to bioretention | 0.60 | Bioretention | 8.5 | 5.100 |
| Car park | 0.25 | Permeable pavement | 7.5 | 1.875 |
| Preserved strip along boundary | 0.15 | Native vegetation (preserved) | 9.25 | 1.388 |
| Total | 1.00 | | | 8.363 |

- Area-weighted VR = 8.363 / 1.00 = 8.36
- Signage provided: + 0.25
- VR_site = 8.61 ≥ 8. The site complies.

Without the permeable pavement (car park draining untreated, VR = 0): (5.100 + 0 + 1.388) / 1.00 + 0.25 = 6.74 < 8. The site would not comply.

### 8B.3 Treatment trains

**To be prepared.** This part will give the composite VR of BMPs in series (a treatment train), following the approach of the MARC/APWA BMP Manual (2012, Table 4.6), with values to be confirmed for Sikkim by the calibration programme of Clause 8.13.4 (Annex 8C). Until it is published, each part of the site is credited with the VR of one BMP in the train that meets Clause 8.6.4 for that part, normally the last BMP before discharge, and no extra credit is given for BMPs in series. Pretreatment devices, silt traps and oil-grit separators upstream of the credited BMP earn no VR of their own (Clauses 8.6.4(c), 8.7.11(c) and 8.7.12(c)).

**Table 8B.3 — Composite VR of treatment trains (layout)**

| First BMP | Second BMP | Composite VR | Conditions |
|---|---|---|---|
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

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## Annex 8C — Sikkim BMP performance calibration

Supports Clauses 8.6.3, 8.13 and 8.15.1 of Chapter 8.

**To be prepared.** This annex will report the BMP performance calibration programme of the State Stormwater Technical Committee (Clause 8.13.4): measured inflow and outflow concentrations and volumes for BMPs built in Sikkim, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several monsoon seasons, with laboratory analysis to the CPCB methods, and the outfall monitoring of Clause 8.13.1 published under Clause 10.17. Until it is published, the Value Ratings of Table 8.3 (MARC/APWA 2012) apply, and a proprietary device earns a VR only from verified test data (Table 8.3).

The layouts below set the minimum records the programme shall keep, so that results from different authorities can be pooled.

**Table 8C.1 — Monitoring site register (layout)**

| Site ID | BMP type (Table 8.3) | Location and authority | Catchment area (ha) | Impervious (%) | Soil and groundwater setting | Date commissioned | Pretreatment |
|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**Table 8C.2 — Event record (layout; parameters of Clause 8.13.2)**

| Site ID | Event date | Rainfall (mm) | Inflow volume ($m^3$) | Outflow volume ($m^3$) | TSS in / out (mg/L) | BOD in / out (mg/L) | COD in / out (mg/L) | Faecal coliform in / out (MPN/100 mL) | TN in / out (mg/L) | TP in / out (mg/L) | Oil and grease in / out (mg/L) | Heavy metals (industrial catchments) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**Table 8C.3 — Performance summary and proposed VR (layout)**

| BMP type | Sites | Events | Volume reduction (%) | Median effluent TSS (mg/L) | Other findings | VR in Table 8.3 | Proposed VR |
|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

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## Annex 8D — BMP design sheets, media specification, plant lists

Supports Clauses 8.5, 8.7, 8.8 and 8.11 of Chapter 8.

Each design sheet collects the requirements of Chapter 8 for one BMP. Values marked "recommended starting value" in Clause 8.7.1 may be departed from with justification. Values that the Manual does not set are marked "to be confirmed in design"; the designer shall state and justify them. Every BMP also needs: sizing for the WQv or Q_wq (Clause 8.6.4(a)), pretreatment (Clause 8.5.3), a safe bypass for flows above Q_wq (Clause 8.4.6) and maintenance access (Chapter 10).

### 8D.1 Design sheets

**Table 8D.1 — Pretreatment (all BMPs)**

| Item | Requirement | Clause |
|---|---|---|
| Where needed | Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland, at each concentrated inflow | 8.5.3 |
| Types | Sediment forebay, grass filter strip, silt trap or proprietary device | 8.5.3 |
| Size | Holds at least 10% of the WQv of its contributing area; or sized for Q_wq (flow-through devices) | 8.5.3 |
| Access | Cleanable without entering or disturbing the main BMP | 8.5.4 |
| Silt traps and catch pits | At every inlet receiving runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody; sump at least 300 mm below the outlet invert; earn no VR | 8.7.12 |

### Table 8D.2 — Bioretention and rain gardens (Figure 8.2)

| Item | Requirement | Clause |
|---|---|---|
| Ponding depth | ≤ 300 mm above the mulch, with an overflow at maximum ponding level | 8.7.2(a) |
| Ponding drawdown | Within 48 h | 8.7.2(b) |
| Filter media | 600–900 mm engineered sandy loam, low fines, low phosphorus (Table 8D.12) | 8.7.2(c) |
| Mulch | 50–75 mm | 8.7.2(c) |
| Transition (choker) and gravel drainage layers | Required; thickness and grading to be confirmed in design | 8.7.2(d) |
| Underdrain | Perforated; required where the design infiltration rate cannot meet the 48 h drawdown, or where lined; diameter to be confirmed in design | 8.7.2(e) |
| Lining | Required where Clause 8.8 cannot be met, and at hotspots | 8.7.2(f) |
| Plants | Native or naturalised, tolerant of waterlogging and long dry spells (Tables 8D.13 and 8D.14) | 8.7.2(g) |
| VR | 8.5 (rain garden / infiltration 9.0) | Table 8.3 |

### Table 8D.3 — Vegetated swales

| Item | Requirement | Clause |
|---|---|---|
| Section | Trapezoidal or parabolic; side slopes no steeper than 1V:3H | 8.7.3(a) |
| Longitudinal slope | 0.5% to 4%; check dams where steeper | 8.7.3(b) |
| Flow at Q_wq | Depth not more than grass height; velocity ≤ 0.3 m/s | 8.7.3(c) |
| 1% AEP or bypass flow | No erosion (Chapter 9 permissible velocities) | 8.7.3(d) |
| Underdrained ("dry") swale | Where slope < 1% or subsoil is poorly drained; filter media as Table 8D.12 | 8.7.3(e) |
| VR | 4.0 (native vegetation swale) | Table 8.3 |

### Table 8D.4 — Vegetated filter strips

| Item | Requirement | Clause |
|---|---|---|
| Inflow | Sheet flow only; level spreader where flow arrives concentrated | 8.7.4(a) |
| Length in flow direction | ≥ 5 m | 8.7.4(b) |
| Slope | 1% to 8% | 8.7.4(b) |
| Use | Mainly pretreatment for bioretention, infiltration and swales | 8.7.4(c) |
| VR | 5.0 | Table 8.3 |

### Table 8D.5 — Permeable pavement

| Item | Requirement | Clause |
|---|---|---|
| Run-on | Impervious run-on area ≤ 2 × permeable area; none from unpaved or eroding areas | 8.7.5(a) |
| Base reservoir | Clean open-graded aggregate holding its share of the WQv in its voids; void ratio confirmed by test | 8.7.5(b) |
| Open (infiltrating) base | Only where Clause 8.8 is met; otherwise lined with underdrain and counted as filtration only | 8.7.5(c) |

| Item | Requirement | Clause |
|---|---|---|
| Structure | Designed for traffic loading to the road authority's standards | 8.7.5(d) |
| Exclusions | Not at hotspots; not where it will be resurfaced with impermeable material | 8.7.5(e) |
| VR | 7.5 | Table 8.3 |

### Table 8D.6 — Infiltration trenches and basins (Figure 8.3)

| Item | Requirement | Clause |
|---|---|---|
| Pretreatment | Always (Table 8D.1) | 8.7.6(a) |
| Fill | Clean washed aggregate, void ratio confirmed by test; geotextile on sides and top; sand base | 8.7.6(b) |
| Observation well | To the base of each trench | 8.7.6(c) |
| Storage | WQv (or Chapter 4 retention volume, if greater) held in the voids | 8.7.6(d) |
| Drawdown | Empty within 72 h at the design infiltration rate | 8.7.6(d), 8.8.7 |
| Overflow | At grade, to the minor or major system | 8.7.6(e) |
| Commissioning | Not in service until the contributing area is stabilised | 8.7.6(f) |
| Criteria | All of Clause 8.8 (Table 8D.11) | 8.8 |

### Table 8D.7 — Wet ponds (extended wet detention)

| Item | Requirement | Clause |
|---|---|---|
| Permanent pool | ≥ WQv | 8.7.7(a) |
| Extended detention | WQv above the pool, released over 24–48 h | 8.7.7(a), 8.4.7 |
| Forebay | At each inlet | 8.7.7(b) |
| Flow path | Length-to-width ≥ 3:1; no short-circuiting | 8.7.7(c) |
| Pool depth | 1.0–2.5 m, with safety bench (Clause 7.9.4) | 8.7.7(d) |
| Water balance | Monthly balance with IMD rainfall and pan evaporation: ≥ 50% of pool volume kept through the driest year in 10; no top-up with groundwater, potable water or sewage | 8.7.8 |
| Flood detention | Chapter 4 detention may sit above the extended detention level | 8.7.7(f) |
| VR | 5.0 | Table 8.3 |

### Table 8D.8 — Constructed wetlands

| Item | Requirement | Clause |
|---|---|---|
| Layout | Inlet sedimentation pond (forebay), then shallow macrophyte zone | 8.7.9(a) |
| Extended detention | WQv above normal water level, released over 24–48 h; depth ≤ 0.5 m | 8.7.9(b) |
| Flow path | Length-to-width ≥ 3:1; deep zones across the flow path | 8.7.9(c) |
| Bypass | High-flow bypass so that floods do not scour the macrophyte zone | 8.7.9(d) |
| At a tank inlet | Within the tank's setback, outside its waterspread; not counted as tank storage | 8.7.9(e) |
| Water balance | As wet ponds (minimum wetland depth kept) | 8.7.8 |

| Item | Requirement | Clause |
|---|---|---|
| VR | 7.0 (extended detention wetland) | Table 8.3 |

### Table 8D.9 — Gross pollutant traps and outfall screens

| Item | Requirement | Clause |
|---|---|---|
| Treatment flow | Q_wq; all flows up to 1% AEP pass without washing out captured material | 8.7.10(a) |
| Capture size | Down to about 5 mm | 8.7.10(b) |
| Head loss | In the drain HGL (Chapter 9), screen 50% blocked | 8.7.10(c), 8.10.3(a) |
| Storage | For the O&M cleaning interval; not less than 3-monthly cleaning | 8.7.10(d) |
| Access | Vehicle access for suction or grab cleaning; safe cleaning platform | 8.7.10(e), 8.10.3(d) |
| Blocked screen | Overflow or bypass path so that a fully blocked screen does not flood property | 8.10.3(b) |
| Bar spacing | Chosen for the hazard: closer for litter capture, wider where blockage would cause flooding; to be confirmed in design | 8.10.3(c) |

### Table 8D.10 — Oil-grit separators

| Item | Requirement | Clause |
|---|---|---|
| Where | Fuel stations; vehicle workshops and washing bays; bus and truck depots; parking areas of more than 50 spaces | 8.7.11(a) |
| Sizing | Q_wq, with high-flow bypass | 8.7.11(b) |
| Not alone | Followed by a filtering BMP where the site needs a VR above 5; lined filtering BMP before any infiltration at hotspots | 8.7.11(c), 8.8.8 |

### Table 8D.11 — Infiltration and recharge criteria (all infiltrating BMPs)

| Item | Requirement | Clause |
|---|---|---|
| Groundwater separation | Seasonal high groundwater ≥ 1.0 m below base (roof-only runoff in notified coastal sand: ≥ 0.5 m with mounding check, mound ≥ 0.3 m below base) | 8.8.1, 8.8.9(d) |
| Bedrock or impermeable layer | Base ≥ 1.0 m above, unless designed for rock-aquifer recharge under Clause 8.8.10 | 8.8.2 |
| Tests | Double-ring (ASTM D3385) for basins, bioretention, permeable pavement; falling-head borehole or trial-pit soakage (e.g. BRE Digest 365) for trenches, soakaways, pits, wells; ≥ 2 per facility and ≥ 1 per 100 m² of base or per 50 m of trench; Form 8-2 | 8.8.3 |
| Design rate | Measured rate ÷ 2.0 (tests meet 8.8.3(c) and vary by no more than a factor of 2), otherwise ÷ 3.0 | 8.8.4 |
| Minimum rates | ≥ 13 mm/h full infiltration; 3–13 mm/h partial, with underdrain, credit only for volume infiltrated within 72 h; < 3 mm/h no credit | 8.8.5 |
| Setbacks (runoff from paved surfaces) | Foundations 3 m, basements 5 m; property boundary 1.5 m; drinking-water well or borewell 30 m; septic tank or soak pit 15 m; crest of slope steeper than 1V:3H 6 m | 8.8.6 |
| Expansive soils | Foundation setback doubled | 8.8.11(b) |

| Item | Requirement | Clause |
|---|---|---|
| Drawdown | Empty within 72 h at design rate; tested after construction | 8.8.7 |
| Hotspots | No infiltration without treatment; none at all for waste sites and contaminated land | 8.8.8 |
| Road runoff | Never led directly into a well, borewell or recharge shaft | 8.11.3(b) |

## 8D.2 Bioretention drawdown check

The 48-hour ponding drawdown (Clause 8.7.2(b)) and the minimum rates of Clause 8.8.5 together decide whether a cell needs an underdrain.

- Rate needed to drain the maximum ponding depth in 48 h = 300 mm / 48 h = 6.25 mm/h.
- Design rate ≥ 13 mm/h: full infiltration, no underdrain, provided Clause 8.8 is met.
- Design rate from 6.25 mm/h to 13 mm/h: the ponding drains in time, but Clause 8.8.5(b) applies, so an underdrain is required.
- Design rate below 6.25 mm/h: the ponding cannot drain in 48 h by infiltration; an underdrain is required (Clause 8.7.2(e)), and below 3 mm/h no infiltration credit is given.

**Illustrative — not design values.** Two tests at the base of a proposed cell give 30 mm/h and 22 mm/h. The two results differ by a factor of 30 / 22 = 1.36, which is not more than 2, and the number of tests meets Clause 8.8.3(c), so the safety factor is 2.0. Taking the lower result, the design rate = 22 / 2.0 = 11 mm/h. This is above 6.25 mm/h, so the ponding drains in 300 / 11 = 27 h, within 48 h. It is below 13 mm/h, so the cell is a partial-infiltration design with an underdrain (Clause 8.8.5(b)).

## 8D.3 Filter media specification

**Table 8D.12 — Bioretention filter media and layers**

| Layer | Requirement from Chapter 8 | Values to be confirmed in design |
|---|---|---|
| Mulch | 50–75 mm (Clause 8.7.2(c)); shredded hardwood or similar organic mulch that does not float away at the ponding depth | Material and source |
| Filter media | 600–900 mm engineered sandy loam with low fines and low phosphorus content (Clause 8.7.2(c)) | Particle size grading; fines (silt + clay) limit; organic matter content; phosphorus limit; saturated hydraulic conductivity of the compacted media; source and test certificate for each batch |
| Transition (choker) layer | Between media and gravel, to stop media washing into the gravel (Clause 8.7.2(d)) | Thickness and grading, matched to the media and gravel |
| Gravel drainage layer | Below the transition layer, surrounding the underdrain (Clause 8.7.2(d)) | Thickness, grading, washed |
| Underdrain | Perforated pipe where Clause 8.7.2(e) applies, with cleanouts | Diameter, slope, perforation, outlet level |
| Liner | Where Clause 8.7.2(f) applies (cannot meet Clause 8.8; hotspots) | Liner type and protection |

Media shall be tested before placing, and placed in lifts without heavy compaction. The State Stormwater Technical Committee should set numeric limits for grading, fines, organic matter and phosphorus, with local sources of sand and compost, when it reviews this annex.

### 8D.4 Plant lists

No Sikkim source on planting for stormwater BMPs was found during research for this Manual, and none of the sources read names the native species to be used in bioretention, swales, filter strips or constructed wetlands in the State. This annex therefore lists **no species** for Sikkim, and gives no Nepali or other local plant names, rather than carry over lists drawn up for other States or invent local names. Until the State Stormwater Technical Committee issues lists, the species for each BMP shall be chosen, and recorded on the BMP design sheet, by a horticulturist or the Forest and Environment Department for the site's sub-area of Annex 2A, its altitude, its soil and its water table, under the following rules (set by this Manual):

- (a) **Native or long naturalised species only**, as the Forest and Environment Department confirms for the site; no species named in Table 8D.15 or otherwise known to be invasive in the State.
- (b) **Wet and dry ground.** Species that stand saturated ground through the season of 1 April to 31 October, when Gangtok's monthly normals from April to September run from about 300 to 630 mm, and survive the dry months of November to March without irrigation once established.
- (c) **Altitude and cold.** Species suited to the site's altitude, from the valley floors of SK-A below about 1,000 m to the ridges of SK-B and the high valleys of SK-C above about 2,500 m, where frost and seasonal snow occur.
- (d) **Slopes.** On the ridges and slopes, species chosen first to bind soil on banks, cut slopes and the margins of jhoras; bioretention on a slope is lined (Clause 8.8.1).
- (e) **Not in the waterway.** No planting in the bed or on the banks of a river, khola or jhora, on a scheduled river's bank, or on an embankment, without the consent of its custodian (the Municipality, the Forest and Environment Department, the Water Resources Department or the road owner, as the case may be), and none that would obstruct the flow of a channel, the outlet of a pokhari or the flow of a dhara.
- (f) **Not in the waterbodies.** No planting under this annex in a pokhari, lake, dhara or wetland, whose vegetation is managed by its custodian under Chapter 7.

**Table 8D.13 — Indicative plants for bioretention, swales and filter strips**

| Use | Botanical name | Local name | Notes |
|---|---|---|---|
| All BMPs of Clause 8.7 | None listed for Sikkim in this draft | — | Chosen under rules (a) to (f) above and recorded on the BMP design sheet (Annex 8D) |

**Table 8D.14 — Indicative plants for constructed wetlands and wet ponds**

| Zone | Botanical name | Local name | Notes |
|---|---|---|---|
| All zones | None listed for Sikkim in this draft | — | Chosen under rules (a) to (f) above; constructed wetlands are built outside the waterspread of any natural waterbody (Clause 8.7.9(e)) |

**Table 8D.15 — Species not to be planted**

| Botanical name | Local name | Reason |
|---|---|---|
| Any species the Forest and Environment Department lists as invasive in Sikkim | — | No list of invasive species for Sikkim was read for this Manual [TBC] |

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## Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

**Table 8E.1 — Selection of measures (Clause 8.12.3)**

| Situation | Measure | Detail |
|---|---|---|
| Sheet flow leaving a disturbed area, along its downslope edge | Silt fence | Figure 8E.1 |
| Concentrated flow from a disturbed area of up to 2 ha | Sediment trap | Figure 8E.2 |
| Disturbed area of more than 2 ha | Sediment basin with surface dewatering outlet | Figure 8E.2 |
| Existing drain inlet receiving site runoff | Inlet protection | Figure 8E.4 |
| Vehicle exit to a public road | Stabilised construction exit, with wheel washing | Figure 8E.3 |
| Stockpiles | Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the monsoon | Notes to Figure 8E.1 |
| Dewatering | Through a sediment basin, settling tank or filter bag; never pumped directly to a drain or waterbody | Notes to Figure 8E.2 |
| Concrete washout | Lined pit; never into a drain | Notes to Figure 8E.3 |

## 8E.1 Silt fence

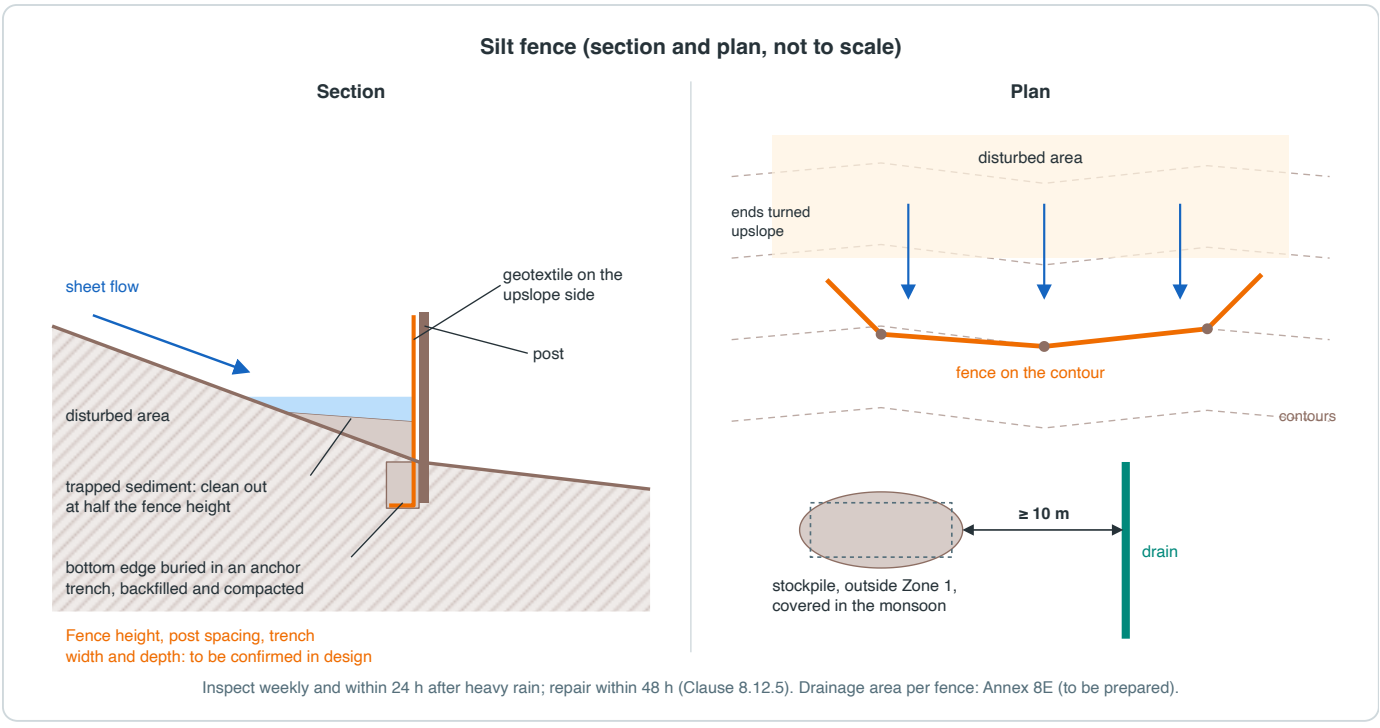



*Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.*

**To be prepared.** Clause 8.12.3(a) refers to this annex for the limit on the area draining to each silt fence. That limit, and the maximum slope length above a fence, need to be set by the State Stormwater Technical Committee for Sikkim rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

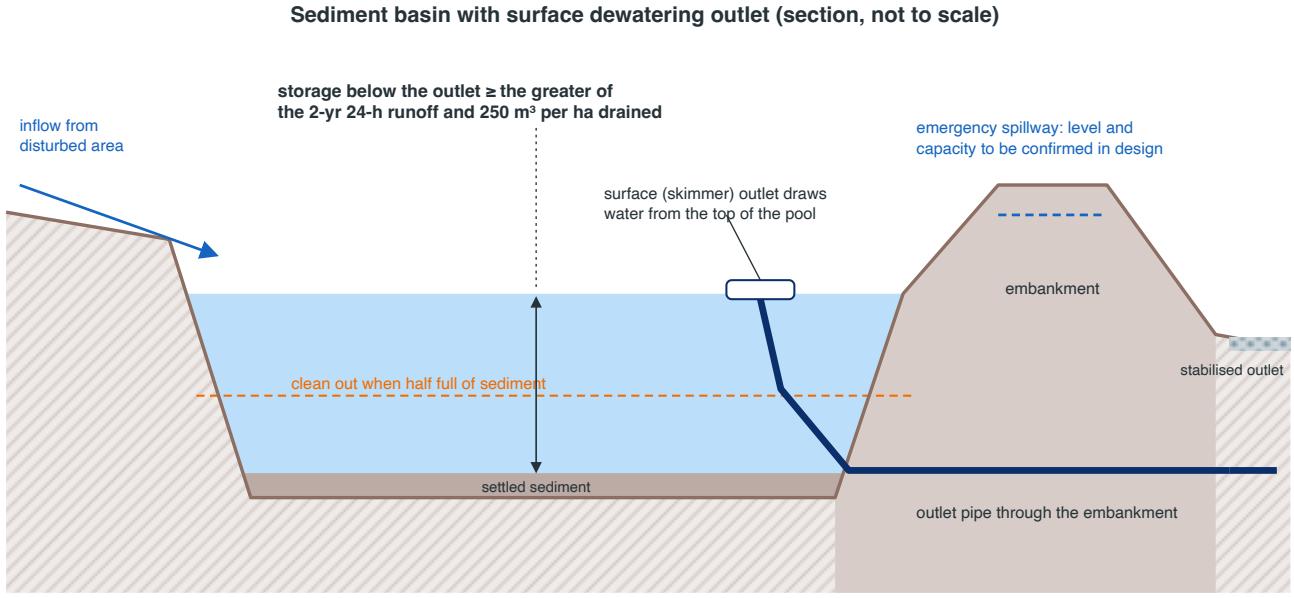
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used instead.

The designer shall show the drainage area and slope length served by each fence on the ESC plan.

Notes:

1. Place along the contour at the downslope edge of the disturbed area, never across a concentrated flow path.
2. Turn the ends upslope so that water cannot run round them.
3. Inspect weekly and within 24 hours after every heavy-rainfall event; repair within 48 hours; remove sediment when the deposit reaches half the fence height (Clause 8.12.5).
4. Remove only after the area draining to it is stabilised (Clause 8.12.6).
5. Stockpiles: outside Zone 1, at least 10 m from any drain, and covered during the monsoon (Clause 8.12.3(f)).

## 8E.2 Sediment trap and sediment basin




Sediment trap: disturbed area up to 2 ha. Sediment basin: more than 2 ha (Clause 8.12.3(b), (c)).
Design rainfall from Chapter 2 with climate factor 1.0 (Clause 8.12.4). Dewatering of excavations passes through the basin, a settling tank or a filter bag.

*Figure 8E.2 — Sediment trap or basin in section: inflow, storage volume below the outlet, surface dewatering outlet (skimmer) drawing water from the top of the pool, emergency spillway, and sediment cleanout level at half the storage. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).*

Notes:

1. **Sediment trap:** for concentrated flow from disturbed areas of up to 2 ha (Clause 8.12.3(b)). Storage volume, depth and outlet: to be confirmed in design.

2. **Sediment basin:** for disturbed areas of more than 2 ha. Storage below the outlet ≥ the greater of (a) the runoff from the 50% AEP (2-yr) 24-hour storm and (b) 250 m³ per hectare of drainage area (Clause 8.12.3(c)).
3. The dewatering outlet draws water from the surface (Clause 8.12.3(c)).
4. An emergency spillway and its capacity: to be confirmed in design. Where the basin is also a permanent detention facility, the Chapter 4 spillway rules apply.
5. Clean out when half full of sediment (Clause 8.12.5). Remove sediment from any permanent facility before its as-built survey (Clause 8.12.6).
6. Dewatering of excavations shall pass through a sediment basin, settling tank or filter bag (Clause 8.12.3(g)).

**Illustrative — not design values.** A sediment basin serves 3.0 ha of disturbed land. Assume a 2-yr 24-hour rainfall of 100 mm (climate factor 1.0, Clause 8.12.4) and a curve number of 86 for bare compacted ground under the antecedent moisture condition of Chapter 2.

- $S = 25{,}400 / 86 - 254 = 41.35$ mm; $I_a = 0.2S = 8.27$ mm
- $Q = (P - I_a)^2 / (P - I_a + S) = (100 - 8.27)^2 / (100 - 8.27 + 41.35) = 8{,}414 / 133.08 = 63.2$ mm
- (a) Runoff volume = $10 \times Q \times A = 10 \times 63.2 \times 3.0 = 1{,}896$ m³
- (b) 250 m³/ha × 3.0 ha = 750 m³
- Required storage below the outlet = max (1,896, 750) = 1,896 m³. Here the 2-yr runoff governs.

## 8E.3 Stabilised construction exit and concrete washout

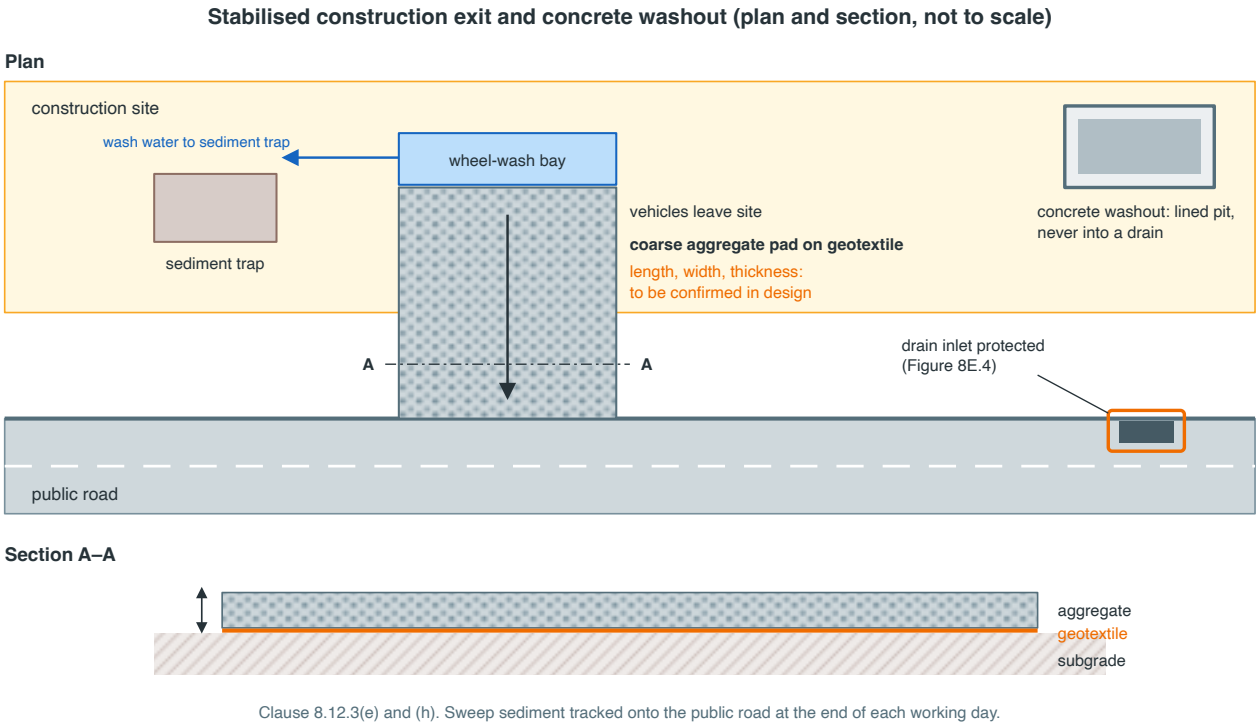



*Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).*

Notes:

1. Provide at every point where vehicles leave the site onto a public road, with wheel washing (Clause 8.12.3(e)).
2. Pad length, width, thickness and aggregate size: to be confirmed in design.
3. Wash water drains to a sediment trap or basin, never to a drain.
4. Concrete washout in a lined pit, never into a drain (Clause 8.12.3(h)).

5. Sweep any sediment tracked onto the public road at the end of each working day.

## 8E.4 Inlet protection

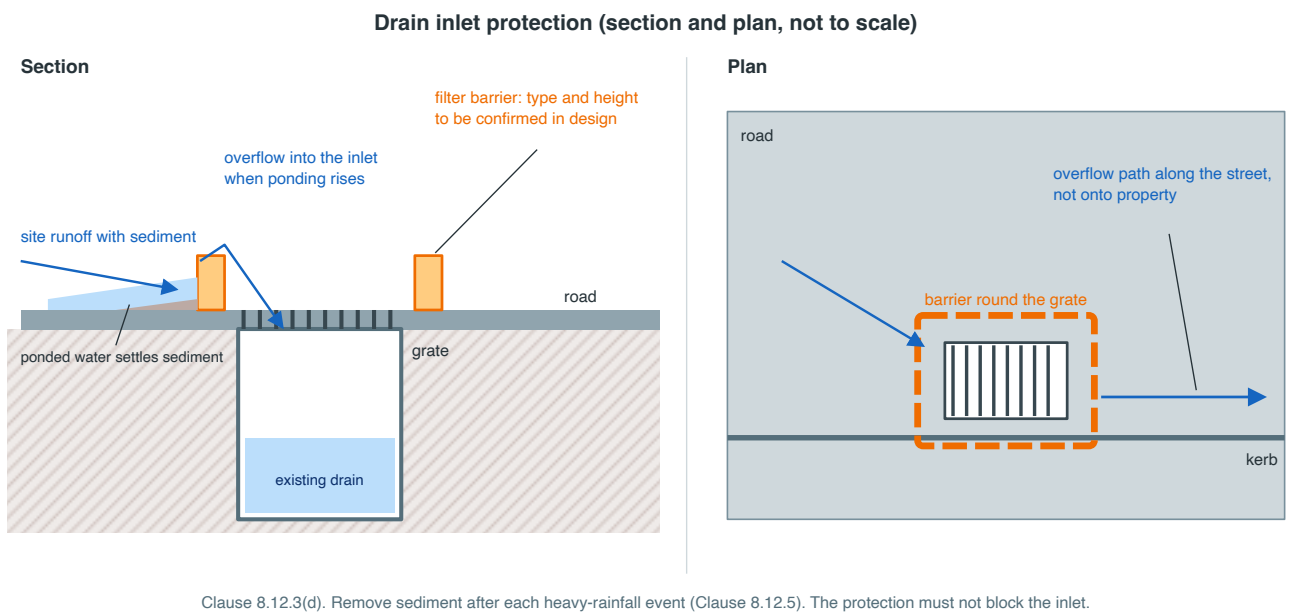



*Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.*

Notes:

1. At every existing drain inlet that receives runoff from the site (Clause 8.12.3(d)).
2. The protection must not block the inlet: water ponding behind it must be able to overflow into the inlet or along the street.
3. Barrier type and height: to be confirmed in design.
4. Remove sediment after each heavy-rainfall event (Clause 8.12.5).

## 8E.5 Timing and inspection

**Table 8E.2 — ESC timing and inspection (Clauses 8.12.2 and 8.12.5)**

| Item | Requirement |
|---|---|
| Completed earthworks | Stabilised by vegetation, mulch, matting or paving by 31 March |
| Area cleared between 1 April and 31 October | Sediment controls in place before clearing |
| Area exposed in the monsoon | As small as practicable |
| Inspection | Weekly, and within 24 h after every heavy-rainfall event (Chapter 10) |
| Repair | Within 48 h |
| Cleaning | When half full of sediment |
| Removal | Only after the area draining to the measure is stabilised |

## Form 8-1 — Water Quality Sheet

Supports Clauses 8.4, 8.6 and 8.14 of Chapter 8.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

### Table 8F.1 — Form 8-1, Section A: Site and rainfall

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Project name and Authority file number | _____ | — |
| A2 | Tier (A / B) and site area, ha | _____ | 8.6.1 |
| A3 | Rainfall zone (Chapter 2) | _____ | 8.4.1 |
| A4 | P_ret, mm (Annex 2E) | _____ | 8.4.1 |
| A5 | P_3m, mm (Annex 8A, or the interim calculation: record, years, method) | _____ | 8.4.1 |
| A6 | P_wq = max (P_ret, P_3m), mm (no climate factor) | _____ | 8.4.1, 8.4.3 |
| A7 | WQv method: SCS-CN, or Rv (sites < 0.5 ha and Tier B simplified method only) | _____ | 8.4.2 |
| A8 | Redevelopment (existing impervious ≥ 20%)? | _____ | 8.6.2 |

### Table 8F.2 — Form 8-1, Section B: Water quality volume and flow by drainage area

| Area ID | Area (ha) | Impervious I (%) | Q_wq runoff depth (mm) or Rv | WQv ($m^3$) | Q_wq ($m^3/s$) | Volume retained, Chapter 4 ($m^3$) | WQv not retained ($m^3$) | BMP serving the area | Pretreatment |
|---|---|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| Total | _____ | | | _____ | | _____ | _____ | | |

### Table 8F.3 — Form 8-1, Section C: Level of Service and Value Rating (Tier A)

| No. | Field | Entry | Clause |
|---|---|---|---|
| C1 | CN pre-development; CN post-development; ΔCN | _____ | 8.6.2 |
| C2 | Required LoS (Table 8.2, or Annex 8B for redevelopment) | _____ | 8.6.2 |
| C3 | Composite VR (Annex 8B calculation attached) | _____ | 8.6.3 |
| C4 | Composite VR ≥ required LoS? | _____ | 8.6.3 |
| C5 | Tier B: route used under Clause 8.6.5 (a) retained on site / (b) bioretention, rain garden or infiltration | _____ | 8.6.5 |

### Table 8F.4 — Form 8-1, Section D: Other submittals (Clause 8.14)

| No. | Item | Attached (yes / no / not applicable) | Clause |
|---|---|---|---|
| D1 | BMP designs to Clause 8.7 and Annex 8D, with pretreatment | _____ | 8.14(3) |

| No. | Item | Attached (yes / no / not applicable) | Clause |
|---|---|---|---|
| D2 | Infiltration Test Record (Form 8-2), seasonal high groundwater level and source, design rate, drawdown time, setbacks | _____ | 8.14(4) |
| D3 | Sewage and sullage connection plan; dye or smoke test record | _____ | 8.9.2, 8.14(5) |
| D4 | GPT and first-flush design for any outfall to a waterbody | _____ | 8.10, 8.14(6) |
| D5 | RWH layout separating harvesting, recharge and detention | _____ | 8.11, 8.14(7) |
| D6 | ESC plan | _____ | 8.12, 8.14(8) |
| D7 | Hotspot controls, where Clause 8.8.8 applies | _____ | 8.8.8 |

### Table 8F.5 — Form 8-1, Section E: Prepared by

| Field | Entry |
|---|---|
| Name, registration and empanelment number (Clause 10.6) | _____ |
| Signature and date | _____ |

## Form 8-2 — Infiltration Test Record

Supports Clauses 8.8.1 to 8.8.7 and 8.11.4 of Chapter 8.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* One record per facility. Attach a plan showing the test locations, and the readings for each test.

### Table 8F.6 — Form 8-2, Section A: Facility

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Project and facility ID; facility type | _____ | 8.8.3 |
| A2 | Infiltration base area (m²) or trench length (m) | _____ | 8.8.3(c) |
| A3 | Proposed base level of the facility, m (datum) | _____ | 8.8.3 |
| A4 | Runoff source: roof only / paved surfaces / mixed; hotspot (yes / no) | _____ | 8.8.6, 8.8.8 |
| A5 | Ground setting: sandy coastal / laterite or hard rock / delta clay or black cotton / other | _____ | 8.8.9–8.8.11 |

### Table 8F.7 — Form 8-2, Section B: Tests

| Test no. | Location (grid ref.) | Date | Method: double-ring (ASTM D3385) / falling-head borehole or trial-pit soakage (e.g. BRE Digest 365) | Test level, m | Groundwater level at time of test, m | Measured rate (mm/h) |
|---|---|---|---|---|---|---|
| 1 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ | _____ | _____ | _____ |

Minimum number of tests: 2 per facility, and 1 per 100 m² of base area or per 50 m of trench (Clause 8.8.3(c)).

### Table 8F.8 — Form 8-2, Section C: Design rate and drawdown

| No. | Item | Entry | Clause |
|---|---|---|---|
| C1 | Number of tests made; number required | _____ | 8.8.3(c) |
| C2 | Highest and lowest measured rates; ratio (highest ÷ lowest) | _____ | 8.8.4 |
| C3 | Safety factor: 2.0 (tests meet 8.8.3(c) and ratio ≤ 2) or 3.0 | _____ | 8.8.4 |
| C4 | Design rate = measured rate used ÷ safety factor, mm/h (state which measured rate was used) | _____ | 8.8.4 |
| C5 | Category: ≥ 13 mm/h full infiltration / 3–13 mm/h partial with underdrain / < 3 mm/h no credit | _____ | 8.8.5 |
| C6 | Depth of water to infiltrate, mm; drawdown time = depth ÷ design rate, h (≤ 72 h) | _____ | 8.8.7 |

### Table 8F.9 — Form 8-2, Section D: Separation and setbacks

| No. | Item | Entry | Clause |
|---|---|---|---|
| D1 | Seasonal high groundwater level, m, and its source (Clause 3.10.2) | _____ | 8.8.1 |
| D2 | Separation from facility base to seasonal high groundwater, m (≥ 1.0; ≥ 0.5 for roof-only runoff in notified coastal sand with mounding check) | _____ | 8.8.1, 8.8.9(d) |

| No. | Item | Entry | Clause |
|---|---|---|---|
| D3 | Depth to bedrock or impermeable layer below base, m (≥ 1.0 unless Clause 8.8.10) | _____ | 8.8.2 |
| D4 | Distances to: foundations / basement / property boundary / drinking-water well or borewell / septic tank or soak pit / crest of slope steeper than 1V:3H, m | _____ | 8.8.6 |
| D5 | Expansive soils: foundation setback doubled? | _____ | 8.8.11(b) |

### Table 8F.10 — Form 8-2, Section E: Declaration

| Field | Entry |
|---|---|
| Tester: name, qualification in geotechnical testing, organisation | _____ |
| I certify that the tests were made at the stated locations and levels, by the stated methods, and that the readings attached are complete. Signature and date | _____ |
| Designer (Clause 10.6): name and signature | _____ |

ANNEXES TO CHAPTER 9

# Hydraulic Design of Structures

These annexes support Chapter 9. Annex 9A gives the FHWA HDS-5 inlet-control equations in SI units, with published coefficients for common inlets, and a full worked culvert example. Annex 9B gives standard drawings that carry only the dimensions Chapter 9 and Chapter 6 already set; every other dimension is marked "to be confirmed in design". Annex 9C is a pump station design checklist with a standard control philosophy drawn from Clause 9.9. Form 9-1 is a draft form: it lists what Clause 9.14 requires and does not add to it.

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## Annex 9A — HDS-5 inlet-control coefficients and worked culvert example in SI units

Supports Clauses 9.4.1 to 9.4.7 of Chapter 9 and Clause 6.12 of Chapter 6.

### 9A.1 Inlet-control equations

FHWA *Hydraulic Design of Highway Culverts*, HDS-5, 3rd edition (2012), Appendix A, gives three inlet-control equations. In SI units:

> Unsubmerged, Form 1: HWi/D = Hc/D + K · [Ku · Q / (A · D^0.5)]^M + Ks · S

> Unsubmerged, Form 2: HWi/D = K · [Ku · Q / (A · D^0.5)]^M

> Submerged: HWi/D = c · [Ku · Q / (A · D^0.5)]² + Y + Ks · S

where HWi is the headwater depth above the inlet invert under inlet control (m), D is the interior height (rise) of the barrel (m), Hc is the specific head at critical depth, dc + Vc²/2g (m), Q is the discharge (m³/s), A is the full cross-sectional area of the barrel (m²), S is the barrel slope (m/m), K, M, c and Y are the constants of Table 9A.1, Ku = 1.811 in SI units (1.0 in US units), and Ks is the slope correction: −0.5, or +0.7 for mitred inlets.

Which equation applies depends on X = Ku · Q / (A · D^0.5):

- X ≤ 3.5: unsubmerged equation (Form 1 or Form 2 as listed in Table 9A.1);
- X ≥ 4.0: submerged equation;
- 3.5 < X < 4.0 (transition): use FHWA HY-8, which implements the HDS-5 transition. Where a hand calculation is used, take the higher of the unsubmerged and submerged results. This is a conservative simplification made by this annex, not an HDS-5 rule.

**Table 9A.1 — HDS-5 inlet-control coefficients for common inlets**

| Barrel | Inlet edge | Form | K | M | c | Y |
|---|---|---|---|---|---|---|
| Circular concrete | Square edge with headwall | 1 | 0.0098 | 2.0 | 0.0398 | 0.67 |
| Circular concrete | Groove (socket) end with headwall | 1 | 0.0018 | 2.0 | 0.0292 | 0.74 |
| Circular concrete | Groove (socket) end projecting | 1 | 0.0045 | 2.0 | 0.0317 | 0.69 |
| Circular corrugated metal | Headwall | 1 | 0.0078 | 2.0 | 0.0379 | 0.69 |
| Circular corrugated metal | Mitred to slope | 1 | 0.0210 | 1.33 | 0.0463 | 0.75 |
| Circular corrugated metal | Projecting | 1 | 0.0340 | 1.50 | 0.0553 | 0.54 |
| Rectangular box | Wingwalls flared 30° to 75° | 1 | 0.026 | 1.0 | 0.0347 | 0.81 |
| Rectangular box | Wingwalls flared 90° and 15° | 1 | 0.061 | 0.75 | 0.0400 | 0.80 |
| Rectangular box | Wingwalls at 0° (extensions of the sides) | 1 | 0.061 | 0.75 | 0.0423 | 0.82 |
| Rectangular box | 90° headwall with 19 mm (3/4 in) chamfers | 2 | 0.515 | 0.667 | 0.0375 | 0.79 |
| Rectangular box | 90° headwall with 45° bevels | 2 | 0.495 | 0.667 | 0.0314 | 0.82 |
| Rectangular box | 90° headwall with 33.7° bevels | 2 | 0.486 | 0.667 | 0.0252 | 0.865 |

Source: FHWA HDS-5 (2012), Appendix A, Table A.1 (the coefficients are dimensionless and apply in SI units with Ku = 1.811). The values were checked against HIF-12-026, Table A.1 (chart and scale numbers 1/1–1/3, 2/1–2/3, 8/1–8/3 and 10/1–10/3). Where a later edition of HDS-5 differs, the later table governs. Entrance loss coefficients for outlet control are in Table 9.1 of Chapter 9.

## 9A.2 Worked example: pipe culvert under a collector road

*Illustrative — not design values.* The inputs below are invented to show the method; the results are not design values for any site.

**Inputs.**

**Table 9A.2 — Inputs for the worked example**

| Item | Value | Source |
|---|---|---|
| Road class | Collector; design AEP 4% (25-yr), check event 2% (50-yr), and the 1% AEP check | Table 6.1, Clause 6.12.2 |
| Design flow, 4% AEP | 1.80 m³/s (including the climate factor) | Illustrative |
| Check flow, 2% AEP | 2.20 m³/s | Illustrative |
| 1% AEP flow | 3.00 m³/s | Illustrative |
| Barrel | One 1,200 mm RCC pipe with collar joints, n = 0.015 | Table 6.6 |
| Inlet | Square edge with headwall: ke = 0.5; K = 0.0098, M = 2.0, c = 0.0398, Y = 0.67, Form 1 | Tables 9.1 and 9A.1 |
| Length and slope | L = 20.0 m; S = 0.005 (inlet invert 20.00 m, outlet invert 19.90 m, local datum) | Illustrative |
| Road levels at the inlet | Shoulder edge 22.00 m; lowest point of the road crest 22.10 m | Illustrative |
| Tailwater above the outlet invert, TW | 0.60 m at 1.80 m³/s; 0.70 m at 2.20 m³/s; 0.85 m at 3.00 m³/s (normal depth in the downstream channel) | Illustrative; Clause 9.4.4 |
| Receiving channel | Unlined sandy loam | Table 9.2 |

Minimum size: 1,200 mm ≥ 900 mm (Clause 6.12.5). The span is below 1.5 m, so the blockage check uses 50% of the inlet area blocked (Clause 6.12.4(a)).

**Step 1 — Barrel properties.** A = π · 1.2² / 4 = 1.131 m²; full-barrel hydraulic radius R = D/4 = 0.300 m; D^0.5 = 1.095.

**Step 2 — Critical depth.** For each flow, dc is found by trial from the critical-flow condition for a circular section, $Q^2 \cdot T / (g \cdot Ac^3) = 1$, where Ac and T are the flow area and top width at depth dc.

**Table 9A.3 — Critical depth and specific head (D = 1.2 m)**

| Q (m³/s) | dc (m) | Ac (m²) | T (m) | Vc = Q/Ac (m/s) | Hc = dc + Vc²/2g (m) | Hc/D |
|---|---|---|---|---|---|---|
| 1.80 | 0.737 | 0.728 | 1.168 | 2.471 | 1.048 | 0.873 |
| 2.20 | 0.817 | 0.820 | 1.119 | 2.683 | 1.184 | 0.987 |
| 3.00 | 0.952 | 0.962 | 0.972 | 3.118 | 1.447 | 1.206 |

**Step 3 — Headwater under inlet control.** X = 1.811 · Q / (1.131 × 1.095) = 1.462 · Q.

**Table 9A.4 — Inlet-control headwater**

| Q (m³/s) | X | Equation | HWi/D | HWi (m) |
|---|---|---|---|---|
| 1.80 | 2.631 | Unsubmerged, Form 1: 0.873 + 0.0098 × 2.631² − 0.5 × 0.005 = 0.873 + 0.068 − 0.003 | 0.939 | 1.127 |
| 2.20 | 3.216 | Unsubmerged, Form 1: 0.987 + 0.0098 × 3.216² − 0.003 = 0.987 + 0.101 − 0.003 | 1.085 | 1.302 |
| 3.00 | 4.385 | Submerged: 0.0398 × 4.385² + 0.67 − 0.003 = 0.765 + 0.67 − 0.003 | 1.433 | 1.719 |

**Step 4 — Headwater under outlet control** (Clause 9.4.3). The friction term is 19.63 · n² · L / R^1.33 = 19.63 × 0.015² × 20.0 / 0.300^1.33 = 0.0883 / 0.2016 = 0.438, so H = (1 + 0.5 + 0.438) · V²/2g = 1.938 · V²/2g. L · S = 20.0 × 0.005 = 0.100 m.

**Table 9A.5 — Outlet-control headwater**

| Q (m³/s) | V = Q/A (m/s) | V²/2g (m) | H (m) | (dc + D)/2 (m) | TW (m) | ho (m) | HWo = ho + H − L·S (m) |
|---|---|---|---|---|---|---|---|
| 1.80 | 1.592 | 0.129 | 0.250 | 0.969 | 0.60 | 0.969 | 1.119 |
| 2.20 | 1.945 | 0.193 | 0.374 | 1.009 | 0.70 | 1.009 | 1.283 |
| 3.00 | 2.653 | 0.359 | 0.695 | 1.076 | 0.85 | 1.076 | 1.671 |

**Step 5 — Governing headwater** (Clause 9.4.1): the greater of HWi and HWo.

**Table 9A.6 — Governing headwater and checks**

| Event | Q (m³/s) | HWi (m) | HWo (m) | Control | HW (m) | HW level (m) | HW/D |
|---|---|---|---|---|---|---|---|
| Design, 4% AEP | 1.80 | 1.127 | 1.119 | Inlet | 1.127 | 21.13 | 0.94 |
| Check, 2% AEP | 2.20 | 1.302 | 1.283 | Inlet | 1.302 | 21.30 | 1.09 |
| 1% AEP | 3.00 | 1.719 | 1.671 | Inlet | 1.719 | 21.72 | 1.43 |

**Step 6 — Headwater limits at the design AEP** (Clause 9.4.5):

- (a) HW/D = 0.94 ≤ 1.2. Complies.
- (b) HW level 21.13 m ≤ shoulder edge 22.00 m − 0.30 m = 21.70 m. Complies.

- (c) Water levels at upstream buildings and property boundaries are compared with the existing condition under Clause 6.12.2(d). This needs the upstream survey and is not shown here.

**Step 7 — Road overtopping** (Clauses 6.12.2, 6.12.3 and 9.4.6). The 1% AEP headwater level, 21.72 m, is below the lowest road crest, 22.10 m, so the road is not overtopped in the check or 1% AEP events. Had the headwater exceeded the crest, the overtopping flow Qr = Cd · L · h^1.5 (Cd ≤ 1.66) would be balanced with the culvert flow at a common headwater, and the overtopping depth checked against Clause 6.12.2(a).

**Step 8 — Outlet velocity** (Clause 9.4.7). Under inlet control, the outlet velocity is the velocity at normal depth in the barrel. The barrel's full-flow capacity is (1/n) · A · R^(2/3) · S^0.5 = (1/0.015) × 1.131 × 0.448 × 0.0707 = 2.39 m³/s.

- 1.80 m³/s: normal depth 0.778 m, outlet velocity 2.32 m/s.
- 2.20 m³/s: normal depth 0.908 m, outlet velocity 2.40 m/s.
- 3.00 m³/s: above the full-flow capacity, so the barrel flows full at the outlet; velocity = Q/A = 2.65 m/s.

The receiving channel is unlined sandy loam, with a permissible velocity of 0.53 m/s (Table 9.2), so outlet protection is required (Clause 9.6.1). All barrel velocities are below 3.0 m/s (Clause 6.7.3(b)).

**Step 9 — Riprap apron** (Clause 9.6.3; Figure 9.2). D50 = 0.2 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D/TW), with g^0.5 · D^2.5 = 3.132 × 1.577 = 4.941.

**Table 9A.7 — Riprap apron sizing**

| Q (m³/s) | TW (m) | Q / (g^0.5 · D^2.5) | [ ]^(4/3) | D50 (m) |
|---|---|---|---|---|
| 1.80 | 0.60 | 0.364 | 0.260 | 0.2 × 1.2 × 0.260 × 2.00 = 0.125 |
| 2.20 | 0.70 | 0.445 | 0.340 | 0.2 × 1.2 × 0.340 × 1.71 = 0.140 |
| 3.00 | 0.85 | 0.607 | 0.514 | 0.2 × 1.2 × 0.514 × 1.41 = 0.174 |

Clause 9.4.7 requires the outlet to be protected for the design AEP and the 1% AEP, so the apron is sized here for the largest D50, 0.174 m. From Table 9.3, Class 2 (D50 = 150 mm) is too small, so **Class 3** (D50 = 250 mm) is used:

- apron length 5D = 5 × 1.2 = 6.0 m;
- apron thickness 2.4 × D50 = 2.4 × 0.25 = 0.60 m;
- apron width at the outlet at least 3D = 3.6 m, flaring to the downstream channel;
- stone placed on a granular filter or geotextile (Clause 9.6.4).

**Step 10 — Blockage check** (Clause 6.12.4(a)). Steps 3 to 7 are repeated for the 1% AEP flow with 50% of the inlet area blocked, and the results must meet Clause 6.12.2(a) and (d). This Manual does not yet set a standard way of representing a partly blocked inlet, so this check is carried out in HY-8 or by a method agreed with the Approving Authority. It is not worked here.

**Table 9A.8 — Summary of the worked example (Illustrative — not design values)**

| Check | Result | Clause |
|---|---|---|
| Minimum size | 1,200 mm ≥ 900 mm | 6.12.5 |
| Design HW/D | 0.94 ≤ 1.2 | 9.4.5(a) |
| Design HW below shoulder edge | 21.13 m ≤ 21.70 m | 9.4.5(b) |
| Overtopping in the check and 1% events | None (21.72 m < 22.10 m) | 6.12.2, 9.4.6 |
| Outlet protection | Class 3 riprap apron, 6.0 m long, 0.60 m thick, 3.6 m wide at the outlet | 9.6.1, 9.6.3 |
| Blockage check | To be run in HY-8 or by an agreed method | 6.12.4 |

## Annex 9B — Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers

Supports Clauses 9.4, 9.6, 9.7 and 9.8 of Chapter 9.

The drawings below are schematic standard drawings. They show only the dimensions and rules that Chapter 9 and Chapter 6 set. Structural dimensions, reinforcement, foundations and fixings are to be confirmed in design (Clause 9.1.2). The riprap apron standard drawing is Figure 9.2 of Chapter 9, with dimensions from Table 9.3; it is not repeated here. Table 9B.1 lists the dimensions shown and their source clauses.

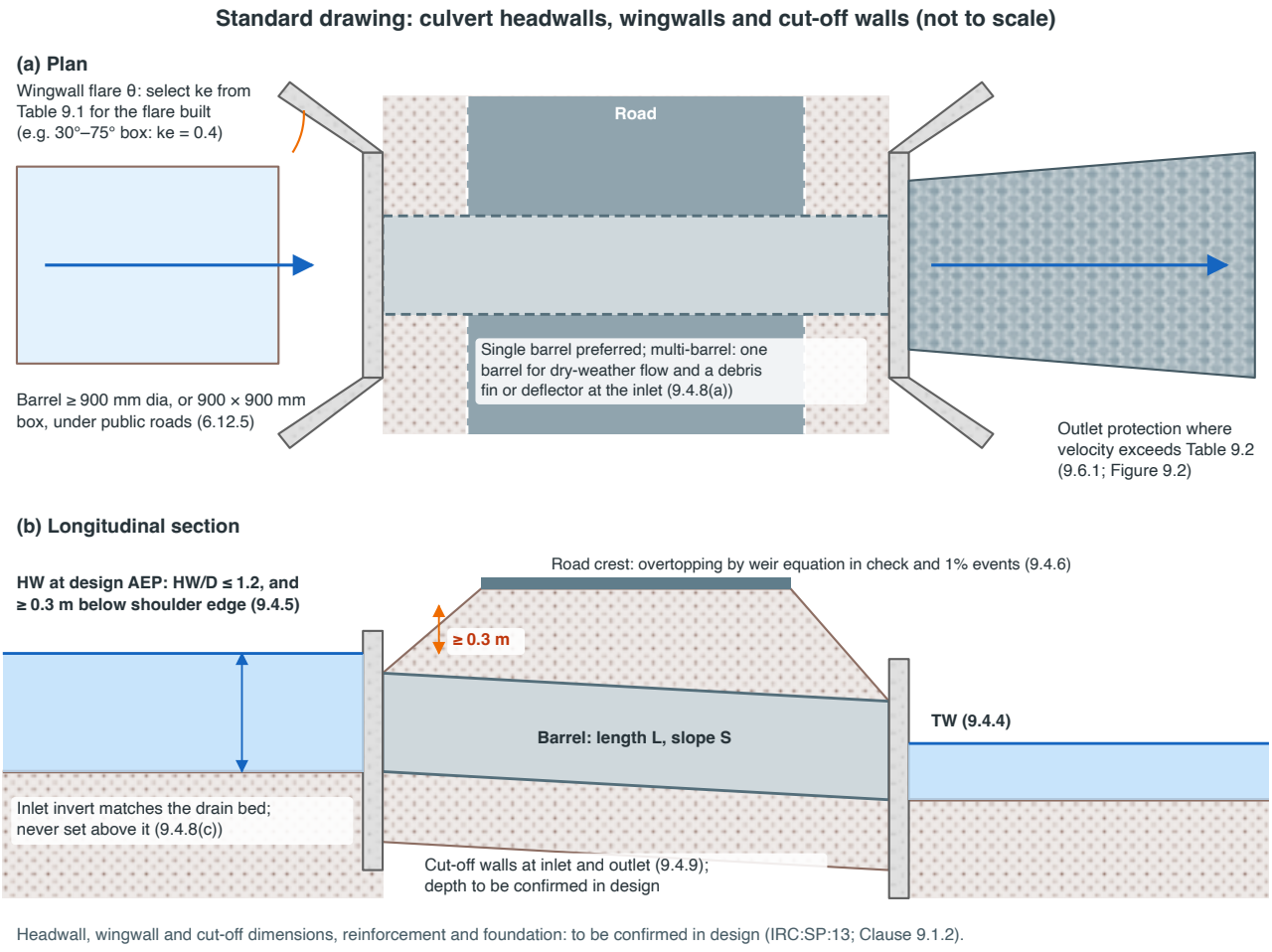


*Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).*

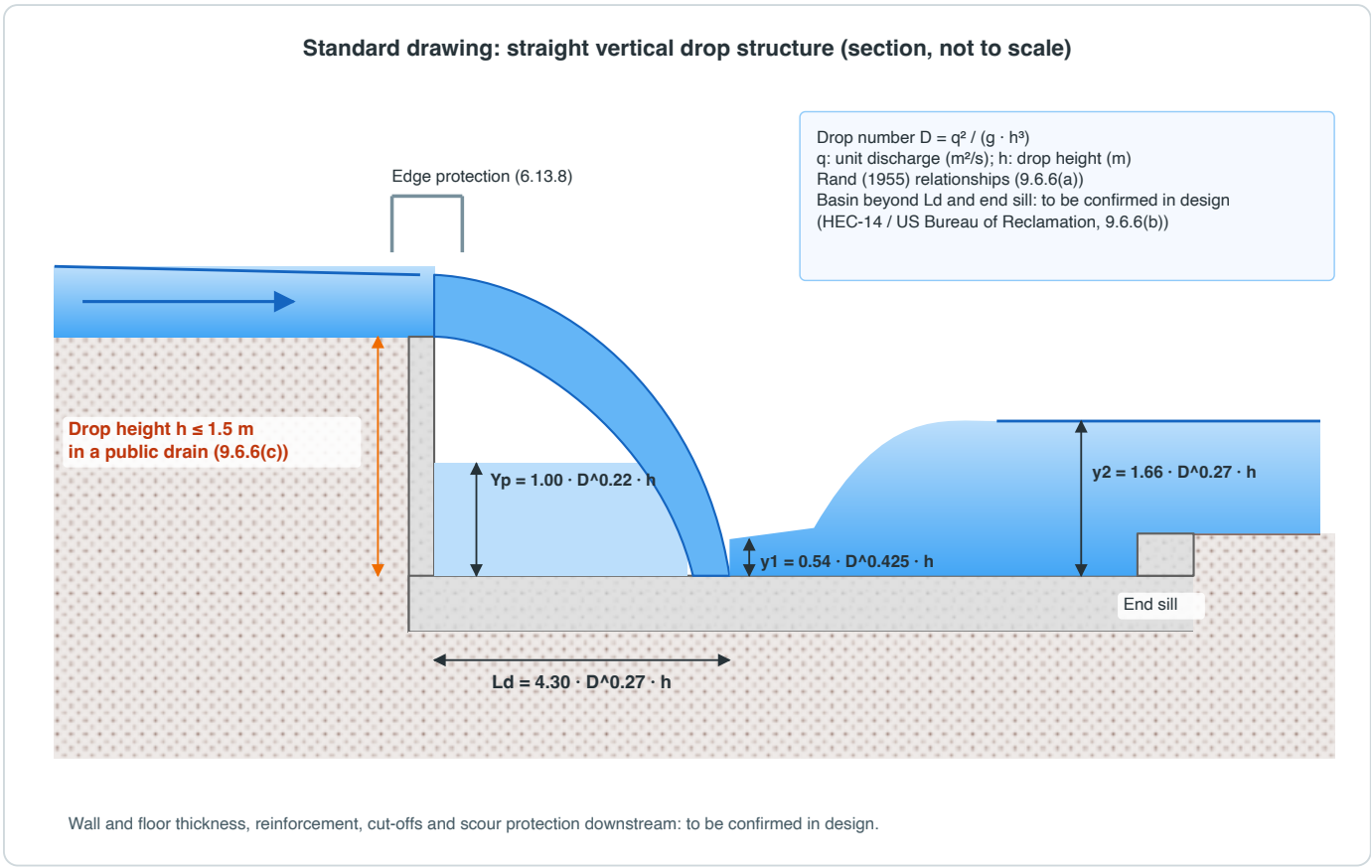


*Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).*

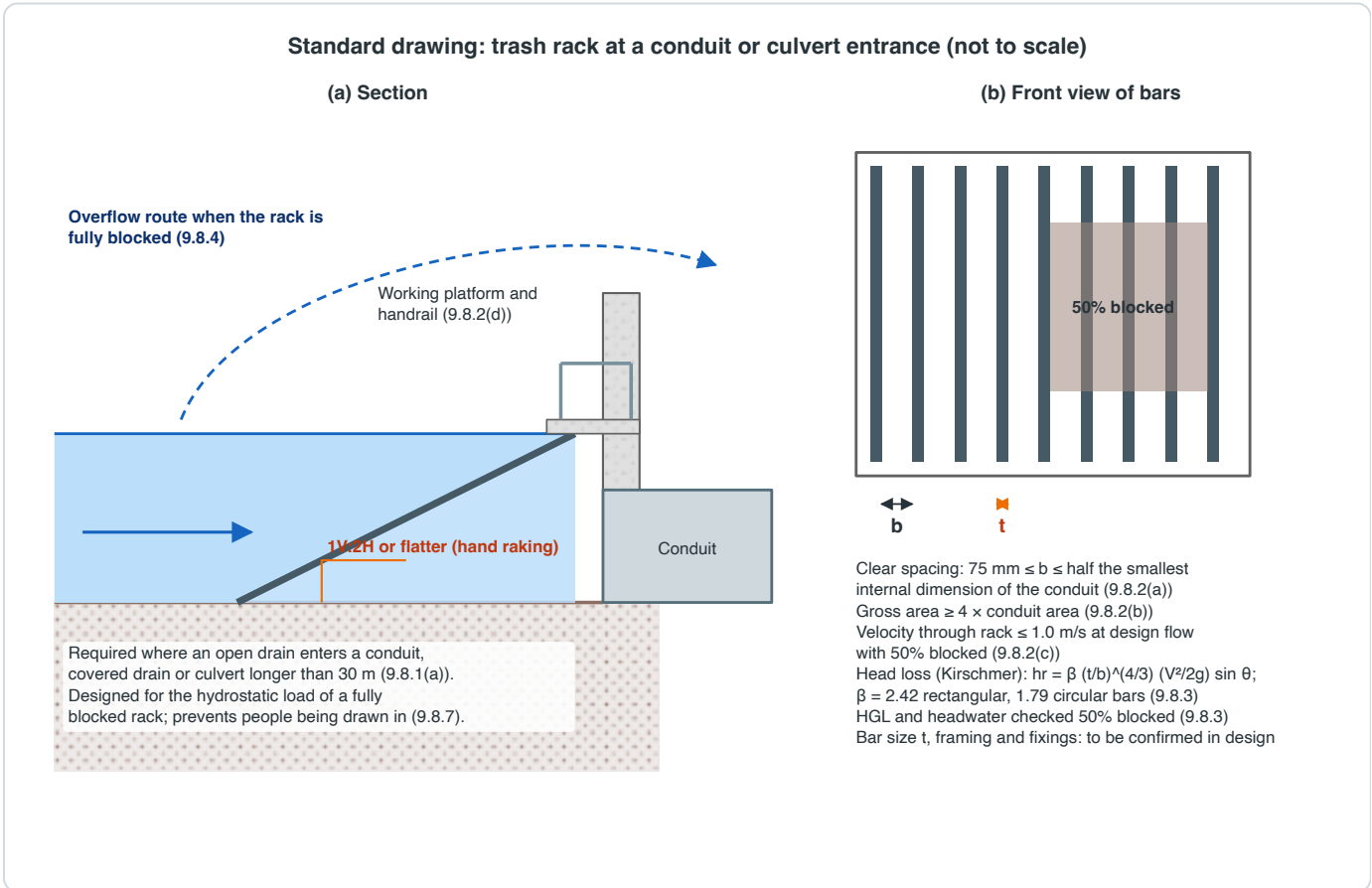

*Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm Water Drainage Systems (2019), §8.3.1.3.*

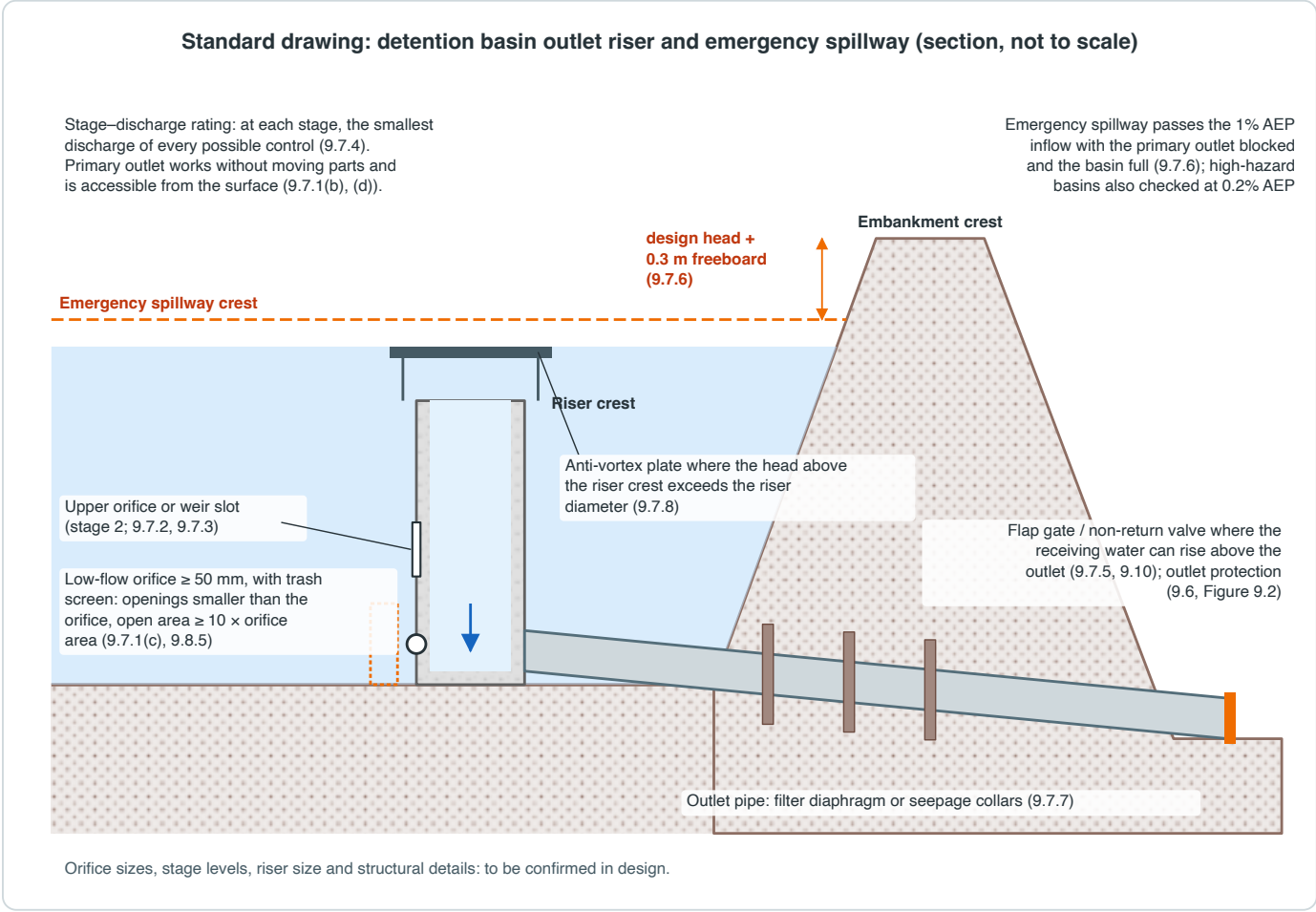


*Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).*

### Table 9B.1 — Dimensions and rules on the standard drawings and their source clauses

| Drawing | Item | Dimension or rule | Clause |
|---|---|---|---|
| 9B.1 | Minimum culvert size under public roads | 900 mm diameter, or 900 mm × 900 mm box | 6.12.5 |
| 9B.1 | Headwater at the design AEP | HW/D ≤ 1.2; at least 0.3 m below the shoulder edge at the upstream face | 9.4.5 |
| 9B.1 | Entrance loss coefficient | From Table 9.1 for the inlet built (for example 0.4 for a box with wingwalls at 30°–75°) | 9.4.3 |
| 9B.1 | Inverts | Match the drain bed; never above it | 9.4.8(c) |
| 9B.1 | Multi-barrel culverts | Avoided in debris-prone drains; where used, one barrel for dry-weather flow and a debris fin or deflector | 9.4.8(a) |
| 9B.1 | Headwalls, wingwalls, cut-off walls | Required; dimensions to be confirmed in design | 9.4.9 |
| 9B.1 | Road overtopping | Qr = Cd · L · h^1.5, Cd ≤ 1.66 | 9.4.6 |
| Figure 9.2 | Riprap apron | Width at the outlet ≥ 3D, flaring to the channel; length and thickness from Table 9.3; filter or geotextile | 9.6.3, 9.6.4 |

| Drawing | Item | Dimension or rule | Clause |
|---|---|---|---|
| 9B.2 | Single vertical drop in a public drain | Height h ≤ 1.5 m; edge protection | 9.6.6(c), 6.13.8 |
| 9B.2 | Pool geometry | D = q²/(g h³); Ld/h = 4.30 D^0.27; Yp/h = 1.00 D^0.22; y1/h = 0.54 D^0.425; y2/h = 1.66 D^0.27 | 9.6.6(a) |
| 9B.2 | Basin beyond Ld, end sill | To be confirmed in design (HEC-14 or US Bureau of Reclamation) | 9.6.6(b) |
| 9B.3 | Where required | Where an open drain enters a conduit, covered drain or culvert longer than 30 m | 9.8.1(a) |
| 9B.3 | Clear bar spacing b | Not less than 75 mm and not more than half the smallest internal dimension of the conduit | 9.8.2(a) |
| 9B.3 | Gross rack area | At least 4 times the conduit area | 9.8.2(b) |
| 9B.3 | Velocity through the rack | Not more than 1.0 m/s at the design flow with 50% blocked | 9.8.2(c) |
| 9B.3 | Inclination | No steeper than 1V:2H where raked by hand; working platform and handrail | 9.8.2(d) |
| 9B.3 | Head loss and blocked check | Kirschmer equation; HGL and headwater checked with 50% blocked | 9.8.3 |
| 9B.3 | Overflow and safety | Overflow route for a fully blocked rack; designed for the full hydrostatic load | 9.8.4, 9.8.7 |
| 9B.4 | Low-flow orifice | Not smaller than 50 mm; trash screen with openings smaller than the orifice and open area at least 10 times the orifice area | 9.7.1(c), 9.8.5 |
| 9B.4 | Orifice and weir flow | Q = Cd · A · (2gh)^0.5, Cd = 0.60 sharp-edged; weir coefficients of Clause 9.7.3 | 9.7.2, 9.7.3 |
| 9B.4 | Stage–discharge rating | Smallest discharge of every possible control at each stage | 9.7.4 |
| 9B.4 | Anti-vortex plate | Where the design head above the riser crest exceeds the riser diameter | 9.7.8 |
| 9B.4 | Outlet pipe through the embankment | Filter diaphragm or seepage collars; flared or headwalled inlet | 9.7.7 |
| 9B.4 | Flap gate or non-return valve | Where the receiving water can rise above the outlet | 9.7.5, 9.10 |
| 9B.4 | Emergency spillway | Passes the 1% AEP inflow with the primary outlet blocked and the basin full, with 0.3 m freeboard to the embankment crest; 0.2% AEP check for high-hazard basins | 9.7.6 |
| All | Structural dimensions, reinforcement, foundations, bar sizes, orifice sizes and stage levels | To be confirmed in design | 9.1.2 |

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## Annex 9C — Pump station design checklist and standard control philosophy

Supports Clauses 9.8.6, 9.9 and 9.10 of Chapter 9, with Clause 6.10.5 of Chapter 6 and the outfall-closed check of Chapter 5.

### 9C.1 Design checklist

Submit this checklist with the pump station design report of Clause 9.14, item 6.

**Table 9C.1 — Pump station design checklist**

| No. | Item | Requirement | Clause | Provided (Yes / No / NA) |
|---|---|---|---|---|
| 1 | Need for pumping | Gravity drainage cannot meet Chapters 5 and 6; reason stated | 9.9.1 | |
| 2 | Inflow | Inflow hydrograph routed through the catchment and any upstream storage | 9.9.2 | |
| 3 | Design standard | Design AEP of the element served; for underpasses, 2% AEP with a 1% AEP check | 9.9.2(a), 6.10.5(a) | |
| 4 | Tidal outfall | Storage plus pumps hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default two high tides of 6 h each) | 9.9.2(b), Chapter 5 | |
| 5 | Head range | Pumps selected from the lowest sump level against the lowest tailwater to the highest tailwater (HAT + surge + 0.3 m); pump and system curves submitted | 9.9.2(c), 9.14 | |
| 6 | Wet-well volume | Greatest of: 5 min of minimum inflow (variable speed and automatic control); 10 to 15 min of peak inflow, or the manufacturer's minimum cycle volume; $V = \Theta \cdot q / 4$ for each constant-speed pump | 9.9.3 | |
| 7 | Duty pumps | Same size where practicable | 9.9.4(a) | |
| 8 | Standby | At least equal to the largest duty pump, and not less than 50% of the number of duty pumps | 9.9.4(b) | |
| 9 | Alternation | Duty and standby roles alternate automatically | 9.9.4(c) | |
| 10 | Pump type | Solids-handling (non-clog); axial-flow only behind a screen meeting Clause 9.8.6 | 9.9.5 | |
| 11 | Sump and intake | Manufacturer's requirements and ANSI/HI 9.8; clear space 0.6 m (small and medium) or 1.0 m (large units) | 9.9.6 | |
| 12 | Model study | Physical model where any pump exceeds 1 $m^3/s$ or the sump departs from ANSI/HI 9.8 geometry | 9.9.6 | |
| 13 | Silt trap and screen | Upstream of the wet well; screen spacing smaller than the pumps' solids size; removable modules; mechanical raking where inflow exceeds 1 $m^3/s$ | 9.9.7, 9.8.6 | |
| 14 | Screen overflow | Overflow route when the screen is fully blocked | 9.8.4 | |
| 15 | Level control | Primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up | 9.9.8(a) | |
| 16 | Alarms | High-level and pump-fault alarms by telemetry to the local body's control room | 9.9.8(b) | |
| 17 | Records | Sump levels, pump run hours and power status logged and kept at least 5 years | 9.9.8(c) | |
| 18 | Power sources | Grid supply plus a standby generator or second independent feeder able to run all duty pumps at once | 9.9.9(a) | |
| 19 | Fuel | At least 72 h of all duty pumps, stored above the flood level of Clause 9.9.10 | 9.9.9(b) | |
| 20 | Changeover | Automatic changeover to standby power | 9.9.9(c) | |
| 21 | Flood protection | Electrical and control room floor, generator and transformer at least 0.5 m above the 1% AEP flood level; vehicle access usable in the 1% AEP event | 9.9.10 | |
| 22 | Discharge | Separate rising mains, or a non-return and an isolating valve where mains combine; delivery chamber or outfall with a flap gate or non-return valve; mains sized by a recognised friction formula | 9.9.11 | |

| No. | Item | Requirement | Clause | Provided (Yes / No / NA) |
|---|---|---|---|---|
| 23 | Gates | Flap or tide gate on outfalls below the 1% AEP still-water level; penstock or stop-log slot upstream for outfalls of 900 mm or more and every pumped outfall; head loss from tested data | 9.10.1, 9.10.3, 9.10.4 | |
| 24 | Sand and debris at the outfall | Gate in a chamber with surface access, or elastomeric check valves, at beach, estuary and creek outfalls | 9.10.5 | |
| 25 | Emergency connection | Hard-standing and quick-coupling connection for mobile pumps into the delivery chamber | 9.9.12 | |
| 26 | Materials | Exposure class of Clause 9.13; stainless steel grade 316, galvanised and coated steel, or non-metallic fixings within 5 km of the coast | 9.13 | |
| 27 | Design life | At least 50 years for civil works and 25 years for mechanical and electrical equipment | 9.2.4 | |
| 28 | Underpass stations | Depth markers and automatic warning or closure signals at 150 mm depth on the carriageway | 6.10.5(d) | |
| 29 | Certification | Designed by an empanelled professional and checked by an independent empanelled professional | 10.6.1(d), 10.6.4 | |

## 9C.2 Standard control philosophy

This is the standard control philosophy for a stormwater pump station designed under Clause 9.9. The designer adapts it to the station and submits it with the design report. Items marked "recommended" are good practice that Chapter 9 does not require; all others restate a clause.

**Table 9C.2 — Control levels (values to be set in design)**

| Level | Rule for setting it | Clause |
|---|---|---|
| Pump stop | Not below the minimum submergence required by the pump manufacturer and ANSI/HI 9.8 | 9.9.6 |
| Duty pump 1 start | Above the pump-stop level by at least the effective wet-well volume of Clause 9.9.3 | 9.9.3 |
| Duty pumps 2, 3 … start | Staged above duty pump 1 start; spacing to be confirmed in design | 9.9.2 |
| High-level alarm | Above the highest duty-pump start level; to be confirmed in design | 9.9.8(b) |
| Float back-up high | Independent float; starts the duty pumps | 9.9.8(a) |
| Float back-up low | Independent float; stops the pumps | 9.9.8(a) |

1. **Normal (automatic) operation.** As the wet-well level rises to the duty pump 1 start level, the lead pump starts. If the level keeps rising, each further duty pump starts at its start level. The pumps stop when the level falls to the pump-stop level. The primary level sensor controls this sequence (Clause 9.9.8(a)).
2. **Duty rotation.** The lead pump changes automatically, after each pump-down cycle or by run hours as set in the design, so that duty and standby roles alternate and wear is shared (Clause 9.9.4(c)).
3. **Pump fault.** A pump that trips or fails to start is locked out. The next available pump, including the standby pump, takes its place, and a pump-fault alarm is sent by telemetry (Clauses 9.9.4(b) and 9.9.8(b)).
4. **Level-sensor failure.** If the primary sensor fails, or disagrees with the float switches, control passes to the independent float back-up: at the float-high level the duty pumps run, and at the float-low level they stop. An alarm is sent (Clause 9.9.8(a), (b)).
5. **Power failure.** Supply changes over automatically to the standby generator or second feeder (Clause 9.9.9(c)). Recommended: pumps restart one at a time after changeover, to limit the starting load on the generator.

6. **High level.** At the high-level alarm level an alarm is sent by telemetry to the local body's control room (Clause 9.9.8(b)). At an underpass, the warning or closure signals operate at 150 mm depth on the carriageway (Clause 6.10.5(d)).
7. **Outfall and gates.** Rising mains discharge to a delivery chamber or outfall fitted with a flap gate or non-return valve (Clause 9.9.11). Flap gates open and close under head difference without control action. The upstream penstock or stop logs are closed only for maintenance, or if the flap gate jams open (Clause 9.10.3). Recommended: penstock position is shown at the control panel and logged.
8. **Tide-locked operation.** Where the outfall is tide-locked, storage and pumping together hold the 48 h design volume for the tidal-lock duration (Clause 9.9.2(b) and Chapter 5). Where the station also has a gravity outfall, gravity discharge resumes through the flap gate when the tide falls.
9. **Screens.** Mechanically raked screens (required where inflow exceeds 1 m³/s, Clause 9.8.6) are run automatically. Recommended: raking is started by a timer and by the level difference across the screen, with an alarm when the difference stays high.
10. **Manual operation.** Recommended: each pump has a hand–off–auto selector at the panel, and the float back-up high-level start remains active in hand mode.
11. **Mobile pumps.** When fixed pumps are out of service or overwhelmed, mobile pumps discharge into the delivery chamber through the quick-coupling connection (Clause 9.9.12).
12. **Records.** Sump levels, pump run hours and power status are logged and kept for at least 5 years (Clause 9.9.8(c)). Recommended: alarms, pump starts and stops, and changeovers are logged as well.
13. **Testing.** The controls, floats, alarms, telemetry, changeover and generator are tested in the pre-monsoon inspection of Chapter 10 (Clause 10.12), and the results reported in the Annual Maintenance Declaration (Form 10-7; Clause 10.10.3).

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## Form 9-1 — Hydraulic Structures Report checklist

Supports Clause 9.14 of Chapter 9.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0. Not for statutory use.*

Attach this checklist to the front of the Hydraulic Structures Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

### Section A — Project

**Table 9F.1 — Form 9-1, Section A: project**

| Field | Entry |
|---|---|
| Project name and location | _____ |
| Local body, and Tier A or Tier B (Chapter 1) | _____ |
| Applicant | _____ |
| Designer (name and registration) | _____ |
| Structures covered (culverts, channels, dissipators, outlets, screens, pumps, gates, inlets, manholes) | _____ |
| Tailwater conditions used: MHWS, HAT + surge, sea-level allowance, joint case (Clause 9.2.1) | _____ |
| Date and revision | _____ |

### Section B — Contents required by Clause 9.14

**Table 9F.2 — Form 9-1, Section B: contents required by Clause 9.14**

| No. | Item | Clause | Provided (Yes / No / NA) | Drawing or page |
|---|---|---|---|---|
| 1 | Culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check | 9.4, 6.12 | | |
| 2 | Channel water-surface profiles, velocities, Froude numbers and freeboard | 9.5 | | |
| 3 | Outlet protection and dissipator design, with riprap sizing | 9.6 | | |
| 4 | Detention outlet stage–discharge tables and the emergency spillway check | 9.7 | | |
| 5 | Screen and rack design with the 50% blocked check | 9.8 | | |
| 6 | Pump station design report: inflow hydrograph, storage, pump and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check (with Annex 9C) | 9.9 | | |
| 7 | Gate and valve selection with head-loss data | 9.10 | | |
| 8 | Inlet, grate and cover load classes | 9.11 | | |
| 9 | Exposure class and materials statement | 9.13 | | |

### Section C — Compliance checks

**Table 9F.3 — Form 9-1, Section C: compliance checks**

| No. | Check | Limit | Clause | Complies (Yes / No / NA) |
|---|---|---|---|---|
| C1 | Climate factor included in design flows | Clause 2.8 | 9.2.2 | |
| C2 | Blocked condition checked where debris can block; safe overflow route | — | 9.2.5 | |
| C3 | Pipes and box drains: design n (box drains ≥ 0.015); supercritical pipes: jump located in a structure, air venting | — | 9.3.1, 9.3.4 | |
| C4 | Pipe size does not decrease downstream; joins only at manholes or junction chambers; no change of direction over 90° | — | 9.3.5 | |
| C5 | Culvert design headwater = greater of HWi and HWo | — | 9.4.1 | |
| C6 | Culvert headwater at the design AEP | HW/D ≤ 1.2; ≥ 0.3 m below shoulder edge | 9.4.5 | |
| C7 | Road overtopping weir coefficient | Cd ≤ 1.66 | 9.4.6 | |
| C8 | Culvert inverts match the drain bed; headwalls, wingwalls and cut-off walls | — | 9.4.8(c), 9.4.9 | |
| C9 | Channel Froude number at the design flow | ≤ 0.8; none between 0.8 and 1.2 | 9.5.2 | |
| C10 | Channel velocity | Table 9.2 | 9.5.3 | |
| C11 | Channel slope in engineered channels | ≤ 0.4% natural, ≤ 0.2% concrete, or drops / chute | 9.5.4 | |
| C12 | Side slopes; low-flow channel where bed width ≥ 3 m; uplift or weep holes | — | 9.5.6, 9.5.7, 9.5.9 | |
| C13 | Outlet protection where outlet velocity exceeds Table 9.2 | Table 9.3 apron, or basin | 9.6.1, 9.6.3 | |
| C14 | Single vertical drop height | ≤ 1.5 m | 9.6.6(c) | |
| C15 | Detention primary outlet: no moving parts; minimum orifice | ≥ 50 mm with screen | 9.7.1 | |
| C16 | Emergency spillway | 1% AEP, outlet blocked, basin full, 0.3 m freeboard; 0.2% AEP for high-hazard basins | 9.7.6 | |
| C17 | Outlet pipe through embankment; anti-vortex plate where needed | — | 9.7.7, 9.7.8 | |
| C18 | Conduit-entrance racks | Spacing 75 mm to half the smallest conduit dimension; area ≥ 4×; ≤ 1.0 m/s at 50% blocked | 9.8.2 | |
| C19 | Detention orifice screens | Openings smaller than the orifice; open area ≥ 10× | 9.8.5 | |
| C20 | Pump station | Annex 9C checklist complete | 9.9 | |
| C21 | Gates on outfalls below the 1% AEP still-water level; secondary closure; corrosion-resistant fittings | — | 9.10 | |
| C22 | Grate load classes, parallel openings ≤ 25 mm, kerb openings ≥ 100 mm × 1.0 m, locked covers | — | 9.11 | |
| C23 | Manhole sizes (Table 9.4), 600 mm access openings, drops, benching, surcharge covers | — | 9.12 | |

| No. | Check | Limit | Clause | Complies (Yes / No / NA) |
|---|---|---|---|---|
| C24 | Exposure class (Table 9.5); chloride and sulphate tests in coastal and delta areas; sulphide protection; metalwork within 5 km of the coast | — | 9.13 | |

### Section D — Variances

#### Table 9F.4 — Form 9-1, Section D: variances

| Clause | Requirement not met | Reason and proposed alternative | Approved by and date |
|---|---|---|---|
| _____ | _____ | _____ | _____ |

### Section E — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). For a facility with an embankment, a high-hazard basin, a pumped facility, a tide gate or a regional facility, the signatory shall be an empanelled Stormwater Design Professional, and a second, independent empanelled professional shall sign as checker (Clauses 10.6.1(c), (d) and 10.6.4).

#### Table 9F.5 — Form 9-1, Section E: signatures

| Role | Name | Registration or empanelment no. | Signature | Date |
|---|---|---|---|---|
| Designer | _____ | _____ | _____ | _____ |
| Independent checker (Clause 10.6.4, where applicable) | _____ | _____ | _____ | _____ |

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.*

ANNEXES TO CHAPTER 10

# Submittals, Review, Operation & Maintenance and Enforcement

These annexes support Chapter 10. They give the specification and user-guide outline of the compliance calculator, the GIS data specification, the maintenance access dimensions that the Manual sets, model O&M plans for each facility type, model empanelment criteria, and the eight forms that Chapter 10 requires. The Design Rainfall Sheet (Form 2-1) is in the annexes to Chapter 2. The forms are draft forms. The model texts are for consideration by a competent authority and are not in force.

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## Annex 10A — Compliance calculator and user guide

Supports Clauses 10.4.1(g), 10.5 and 10.9.1(b) of Chapter 10.

> **Status.** The compliance calculator does not exist yet. Clause 10.5.1 requires the State Stormwater Technical Committee to issue and maintain it. This annex is the specification the calculator shall meet and the outline of its user guide. Until the calculator is issued, the designer completes Form 10-2 by hand from the calculations of Chapters 4, 5 and 8, enters "not issued" as the calculator version, and attaches the calculations.

### 10A.1 General requirements

The calculator shall:

- (a) be a spreadsheet or web tool, published free of charge with its user guide and the source of every table in it (Clause 10.5.4);
- (b) print its version number and release date on every output page and every exported file (Clause 10.5.3);
- (c) keep a public version log. A new version applies to new submittals 6 months after release; a submittal keeps one version from Stage 1 to Stage 4 unless the Applicant elects a later one (Clause 10.5.3);
- (d) work for one site at a time, with one or more drainage areas, each draining to its own outfall (Clause 4.5.1.3);
- (e) never apply a value that the Manual has not published. Where a table it needs has not been issued (for example Table 4.3 of Annex 4B, or the S-2 discharge tables of Annex 1C), the calculator shall show that route as "not available" rather than estimate the value; and
- (f) export its inputs and results as a machine-readable file (CSV or JSON) as well as Form 10-2, so that the Authority can load them into the facility register (Clause 10.17.1(b)).

### 10A.2 Inputs

**Table 10A.1 — Calculator inputs**

| No. | Input | Unit | Source |
|---|---|---|---|
| I1 | Authority, tier (A or B) and file number | — | Clause 1.6 |

| No. | Input | Unit | Source |
|---|---|---|---|
| I2 | Site area; land disturbance area | ha | Clause 1.5.2 |
| I3 | New impervious area; replaced impervious area; existing impervious area before demolition | m² | Clauses 1.5.2, 1.5.6, 4.5.6.1 |
| I4 | Development type: new, redevelopment, linear public work, single dwelling | — | Clauses 1.5.6–1.5.8 |
| I5 | Flood-sensitive catchment (yes / no), and basin with an approved BSMP (yes / no) | — | Clauses 4.5.3, 4.13, 11.12 |
| I6 | Rainfall zone | — | Annex 2A |
| I7 | Retention depth P_R; 3-month ARI 24-hour depth P_3m | mm | Annexes 2E, 8A |
| I8 | Design rainfall depths by duration (1–72 h) and AEP, with the climate factor, as recorded on Form 2-1 | mm | Clauses 2.5, 2.8, 2.13 |
| I9 | 15-minute intensities i_10 and i_2, with the climate factor (fixed-coefficient route only) | mm/h | Clause 4.14.4 |
| I10 | Drainage areas: for each, area, land cover, impervious percentage, HSG and curve number, pre- and post-development | ha, %, — | Clauses 3.3, 3.7, 3.9 |
| I11 | Areas preserved under a registered covenant | ha | Clause 4.4.7 |
| I12 | Seasonal high groundwater depth below the base of each retention practice | m | Clauses 4.4.3(c), 8.8 |
| I13 | Measured infiltration rate at each practice | mm/h | Clause 4.4.3 |
| I14 | Retention volume provided, by practice; reuse demand where retention is by reuse | m³, m³/d | Clauses 4.4.3, 4.4.5 |
| I15 | Route: full hydrograph method (Clause 4.6); design-aid S-1 (Clause 4.14.2); PSD S-2 (Clause 1.7); fixed-coefficient (Clause 4.14.3); constrained redevelopment (Clause 4.5.6) | — | Clauses 1.7, 4.5.6, 4.6, 4.14 |
| I16 | For the full method: model results for each AEP and duration — pre- and post-development peaks, storage used, retention credit found by routing | m³/s, m³ | Clauses 4.4.6.2, 4.6 |
| I17 | Outlet: low-flow orifice diameter or least slot dimension; drawdown times from routing | mm, h | Clauses 4.7, 4.8.2 |
| I18 | Outfall: tidal or non-tidal; outfall-closed check result | — | Chapter 5 |
| I19 | Fee-in-lieu unit rate notified for the basin, where the route applies | ₹/m³ | Clause 4.13.3 |
| I20 | Stage of submittal (1, 2 or 4) and, at Stage 4, the as-built values of I14, I16 and I17 | — | Clauses 10.5.2, 10.9.1(b) |

## 10A.3 Calculations, by clause

**Table 10A.2 — Calculations the calculator shall perform**

| Step | Calculation | Clause |
|---|---|---|
| C1 | **Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies by statute only to every building owned or occupied by the State Government, a statutory body or a company or institution owned or controlled by the State Government (Sikkim Municipalities Act, 2007, s.186, in a manner that the State Government or the Municipality is to specify and that has not been specified as far as found), and, as a condition of this Manual and not of statute, to other buildings where the Manual applies, as storage of at least 25 litres per m² of roof, credited as retention only through reuse, assumed full at the start of every monsoon design storm and never counted as detention (Clause 4.11, set by this Manual), since no rule found requires rainwater harvesting in a private building; recharge is credited only where Clause 4.11 (recharge rule) allows it, which is on tested river-terrace gravels of sub-area SK-A above the 1% AEP flood level and outside the zone raised by the flood of October 2023, and on benches of 10° or less in stability zone 1 proven by a geotechnical certificate, never on natural ground sloping more than 10°, on colluvium, fill or slide debris, in stability zones 3 to 6, in an area that is sinking, landslide prone or has scars of old landslides (SBCR 1991, reg. 35) or within twice the height of a cut slope or retaining wall upslope of it, unless a geotechnical certificate allows it, and in stability zones 4 to 6 not at all (Clause 4.11, hill rule). | 1.5.2–1.5.8 |
| C2 | **Process flags.** Stage 0 mandatory (≥ 2 ha, flood-sensitive, variance or regional route, tidal outfall or waterbody); Stages 1 and 2 may be combined (< 1 ha, not flood-sensitive); empanelled signatory required; independent check required. | 10.3.2, 10.3.3, 10.6.1, 10.6.4 |
| C3 | **Route eligibility.** Tier B simplified method: ≤ 2 ha, or ≤ 0.5 ha in a flood-sensitive catchment, and only once Table 4.3 is published. Fixed-coefficient route: ≤ 1 ha and none of the exclusions of Clause 4.14.3. Constrained redevelopment: existing ≥ 60% impervious and ≤ 1 ha. Regional detention or fee-in-lieu: only in a basin with an approved BSMP. | 4.5.6.1, 4.13.1, 4.14.1, 4.14.3, 11.12.1(b) |
| C4 | **Retention volume.** RRV = 10 × Q_R × A, with Q_R the SCS-CN runoff from P_R for each sub-area at AMC II, summed over sub-areas. The larger of the Ia = 0.2S and Ia = 0.05S results governs. The Rv form (RRV = 10 × P_R × Rv × A, Rv = 0.05 + 0.009 × I) is offered only for sites < 0.5 ha and the Tier B method. No climate factor. | 4.4.2, 3.8.5(c), 2.8.3 |
| C5 | **Preservation credit.** Preserved areas are modelled at their pre-development CN in the post-development condition. | 4.4.7 |
| C6 | **Retention checks.** Design infiltration rate ≤ half the measured rate; groundwater ≥ 1.0 m below the base; drawdown of the retained volume within 72 h at the design rate (or by the stated reuse demand). A practice that fails any check gets no credit; any shortfall is reported and treated as WQv. | 4.4.3–4.4.5, 4.4.6.4 |
| C7 | **Water quality volume.** P_wq = max(P_ret, P_3m); WQv = 10 × Q_wq × A by SCS-CN, or (P_wq / 1000) × Rv × A (A in m²) for sites < 0.5 ha and the Tier B method. The retained volume counts toward the WQv in full. No climate factor. | 8.4.1–8.4.4, 3.8.5(c) |
| C8 | **Retention credit.** Tier A: the credit found by routing is entered (I16); the calculator does not compute it. Tier B: V_credit = C_R × RRV provided, with C_R = 0 until Annex 4B is published. | 4.4.6 |
| C9 | **Design-aid route (S-1).** V = SSR × A − V_credit; Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages, from Table 4.3. Shown as "not available" until Table 4.3 is published. | 1.7.2, 4.14.2 |
| C10 | **Permissible site discharge (S-2).** Q = PSD (m³/s/ha) × A for each AEP, from the S-2 tables. Shown as "not available" until they are issued. | 1.7.2, 1.7.3(e) |
| C11 | **Fixed-coefficient route.** Q_cap,10 = 2.78 × C_10 × i_10 × A and Q_cap,2 = 2.78 × C_2 × i_2 × A (L/s); V_100 and V_2 = max over d of [10 × C_v × P(d) × A − 1.8 × Q_cap × d] for d = 1 to 72 h, with pervious C ≥ 0.50 for d ≥ 12 h; V = max(V_100, V_2); retention added without credit. Coefficients from Table 4.3A (provisional). | 4.14.4–4.14.7 |
| C12 | **Release-rate screen (full method).** For each AEP and duration: Q_post ≤ 0.9 × Q_pre (standard), or the two mixed-frequency caps (flood-sensitive). Report the governing duration and margin. | 4.5.2, 4.5.3 |
| C13 | **Constrained redevelopment.** Q_post ≤ 0.5 × Q_existing for 2-, 10- and 100-yr at each duration; shortfall volume = greenfield storage − storage provided; fee = shortfall × unit rate. | 4.5.6.2, 4.5.6.3 |
| C14 | **Minimum orifice.** Flag any orifice < 50 mm. Where a cap is below the discharge of a 50 mm orifice at the corresponding stage, report "50 mm orifice deemed to comply". | 4.5.5.1, 4.8.2 |

| Step | Calculation | Clause |
|---|---|---|
| C15 | **Drawdown.** Report the detention drawdown (90% of the 10-yr stored volume within 48 h), the WQv release time (24–48 h) and the retention emptying time (≤ 72 h). | 4.7 |
| C16 | **Fee-in-lieu.** Fee = detention volume required on site × notified unit rate. | 4.13.3 |
| C17 | **Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide. | 10.5.2(c) |
| C18 | **As-built re-run.** At Stage 4, repeat C4 to C17 with the as-built values and report each change from Stage 2. | 10.9.1(b), 10.9.2 |

### 10A.4 Outputs

The calculator produces:

- (a) **Form 10-2**, filled in, with the calculator version and release date on every page;
- (b) a machine-readable export of every input and result of Tables 10A.1 and 10A.2; and
- (c) a list of the flags raised (C1 to C3, C6, C14, C17), each with the clause on which it is based (Clause 10.7.7).

### 10A.5 Testing before release

Before each release the State Stormwater Technical Committee shall check that the calculator reproduces, within rounding, the worked examples of the Manual that use the same method, including the illustrative examples of Clauses 4.6.7 and 4.14, and the benchmark problems of Annex 3C where they apply. The test results shall be published with the version log.

### 10A.6 Outline of the user guide

The user guide shall contain at least:

1. Purpose, status and limits of the calculator: a summary and screening check outside the design-aid route (Clause 10.5.2(c)).
2. How to obtain the current version, and the version rule of Clause 10.5.3.
3. Each input of Table 10A.1, with where to find it in the Manual and its annexes.
4. Each calculation of Table 10A.2, with its equation and clause.
5. The tolerance used in step C17, and what the drainage report must explain where it is exceeded (Clause 10.5.2(c)).
6. How to read and sign Form 10-2, and what to attach.
7. At least one worked example for each route, labelled "Illustrative — not design values".
8. The sources of every table in the calculator (Clause 10.5.4), and the version log.

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## Annex 10B — GIS data specification and attribute schema

Supports Clauses 10.4.4, 10.14.1(d), 10.14.3 and 10.17 of Chapter 10.

### 10B.1 Format and reference systems

- (a) **Format.** One OGC GeoPackage (.gpkg) per submittal is preferred. Shapefiles are accepted, one per layer, zipped with all component files. Field names shall be as in Tables 10B.2 to 10B.6; shapefile names are limited to 10 characters, and the names below meet that limit.

- (b) **Horizontal reference.** WGS 84 geographic (EPSG:4326), or WGS 84 / UTM zone 45N (EPSG:32645), for the whole State, whichever contains the site (Clause 10.4.4(c)). One system shall be used for all layers.
- (c) **Vertical reference.** All levels shall be in metres relative to a named vertical datum, stated in the metadata. The metadata shall also state the relationship between that datum and the river datums of the CWC level-monitoring sites on the Teesta, the Rangit and the Rongni Chu, Khanitar, Melli, Singtam and Majitar among them (not stated in any source found [TBC]), of the reservoir levels of NHPC and the other hydropower operators (not found [TBC]), and of the flood marks of October 2023 and the post-2023 river beds surveyed at the outfalls and on ungauged kholas, jhoras and pokharis used in Chapter 5 (Clause 10.4.4(d)).
- (d) **Accuracy.** Positions shall come from the site survey or the approved drawings. At Stage 4 and at handover, positions and levels shall come from the as-built survey (Clause 10.9.1(a)).
- (e) **File name.** `<Authority file number>_<stage>_<yyyymmdd>.gpkg`, for example `GTK–BP–2026–0123_S2_20261015.gpkg`.
- (f) **Identifiers.** Every feature has an identifier unique within the submittal (FAC_ID, OUT_ID, CAT_ID, FLP_ID). The Authority replaces them with register identifiers on acceptance and returns the mapping to the Applicant.

## 10B.2 Layers

**Table 10B.1 — Layers**

| Layer | Geometry | Content | Required at |
|---|---|---|---|
| SW_SITE | Polygon | Site boundary | Stages 1, 2, 4 |
| SW_CATCH | Polygon | Catchment boundaries draining to and through the site, pre- and post-development (Clause 10.4.1(b)) | Stages 1, 2, 4 |
| SW_FAC | Polygon (point for buried items smaller than 5 m across) | Every stormwater facility: retention, detention, water quality, pumping, gate, conveyance element designed under this Manual | Stages 2, 4; handover |
| SW_OUTF | Point | Every outfall from the site, and every public outfall | Stages 1, 2, 4; handover |
| SW_FLOW | Line | Major-system flow paths through and from the site, and natural drainage paths (Clause 10.15.1(g)) | Stages 1, 2, 4 |
| SW_CONV | Line | Drains and pipes designed under Chapter 6 | Stage 4 for public works; handover |
| SW_META | Table (no geometry) | Metadata of Table 10B.6 | Every stage |

## 10B.3 Attribute schema

Types: T = text, I = integer, R = real, D = date (ISO 8601, yyyy-mm-dd). "Req." marks fields that shall not be empty; other fields are filled where they apply.

**Table 10B.2 — Attributes of SW_FAC (facilities)**

| Field | Type | Unit | Req. | Content | Source |
|---|---|---|---|---|---|
| FAC_ID | T | — | Yes | Facility identifier | 10B.1(f) |
| FAC_TYPE | T | — | Yes | Code from Table 10B.7 | Clause 4.10, Table 10.3 |
| FAC_NAME | T | — | | Name on the drawings | — |
| OWNER_TYP | T | — | Yes | PRIVATE / ASSOC / DEVELOPER / ULB / DEPT | Clauses 10.10, 10.14 |

| Field | Type | Unit | Req. | Content | Source |
|---|---|---|---|---|---|
| OWNER_NM | T | — | Yes | Name of a corporate owner or association only; for an individual, "private individual" (Clause 10.17.3) | Clause 10.17.3 |
| CTRL_AREA | R | ha | Yes | Area draining to the facility | Clause 4.5.1.3 |
| V_RET | R | m³ | | Retention volume provided | Clause 4.4 |
| V_WQ | R | m³ | | Water quality volume provided | Clause 8.4 |
| V_DET | R | m³ | | Detention volume at the top design level | Clause 4.6 |
| Q_2 | R | L/s | | Release at the 50% AEP (2-yr) design level | Clause 4.5 |
| Q_10 | R | L/s | | Release at the 10% AEP (10-yr) design level | Clause 4.5 |
| Q_100 | R | L/s | | Release at the 1% AEP (100-yr) design level | Clause 4.5 |
| ORIF_MM | R | mm | | Low-flow orifice diameter or least slot dimension | Clause 4.8.2 |
| INV_OUT | R | m | | Outlet invert level | Clause 10.9.1(a) |
| TWL_DES | R | m | | Top design water level | Clause 10.9.2(a) |
| SPILL_LV | R | m | | Spillway or overflow crest level | Clause 4.9 |
| PUMPED | T | — | Yes | Y / N | Clause 10.10.3 |
| REGIONAL | T | — | Yes | Y / N | Clause 4.13 |
| EMPANEL | T | — | Yes | Y / N: facility under Clause 10.6.1(c) or (d) | Clause 10.6.1 |
| STATUS | T | — | Yes | Code from Table 10B.8 | Clause 10.17.1(a) |
| APPR_DATE | D | — | | Date of Stage 2 approval | Clause 10.3 |
| ASB_DATE | D | — | | Date the as-built certificate was accepted | Clause 10.9 |
| DECL_REF | T | — | | Registration reference of the Maintenance Declaration (Form 10-6) | Clause 10.10.1(e) |
| HAND_DATE | D | — | | Date of the Asset Handover Certificate (Form 10-8) | Clause 10.14 |
| LAST_INSP | D | — | | Date of the latest inspection | Clause 10.12 |
| INSP_RES | T | — | | Code from Table 10B.9 | Clause 10.17.1(a) |
| OUT_ID | T | — | Yes | Outfall to which the facility discharges | — |

### Table 10B.3 — Attributes of SW_OUTF (outfalls)

| Field | Type | Unit | Req. | Content | Source |
|---|---|---|---|---|---|
| OUT_ID | T | — | Yes | Outfall identifier | 10B.1(f) |
| RECEIVER | T | — | Yes | Receiving drain, channel, waterbody or sea, by name | Clause 4.5.1.3 |
| RECV_TYPE | T | — | Yes | PUBLIC_DRAIN / CANAL / RIVER / TANK / SEA / OTHER | Chapter 5 |
| INV_LEVEL | R | m | Yes | Outfall invert level | Clause 10.9.1(a) |
| SIZE_MM | R | mm | Yes | Diameter, or width × height written in the drawing | Chapter 6 |
| TIDAL | T | — | Yes | Y / N | Chapter 5 |
| GATE_TYPE | T | — | | NONE / FLAP / TIDE / DUCKBILL / PENSTOCK / NRV | Clauses 5.11, 9.10 |
| GATE_REQ | T | — | Yes | Y / N: invert below the 1% AEP still-water level | Clause 5.11.1 |

| Field | Type | Unit | Req. | Content | Source |
|---|---|---|---|---|---|
| GPT | T | — | | Y / N: gross pollutant trap fitted | Clause 8.10.1 |
| Q_100 | R | L/s | | Design 1% AEP discharge | Chapter 5 |

### Table 10B.4 — Attributes of SW_CATCH (catchments)

| Field | Type | Unit | Req. | Content | Source |
|---|---|---|---|---|---|
| CAT_ID | T | — | Yes | Catchment identifier | 10B.1(f) |
| CONDITION | T | — | Yes | PRE / POST / EXTERNAL (land outside the site draining through it) | Clause 10.4.1(b) |
| AREA_HA | R | ha | Yes | Area | — |
| IMPERV_PC | R | % | Yes | Impervious percentage | Clause 3.9 |
| HSG | T | — | Yes | A / B / C / D, or mixed with area shares in NOTES | Clause 3.7 |
| CN | R | — | | Curve number, AMC II | Chapter 3 |
| OUT_ID | T | — | Yes | Outfall to which it drains | Clause 4.5.1.3 |
| FLOODSENS | T | — | Yes | Y / N | Clause 4.5.3 |
| NOTES | T | — | | Free text | — |

### Table 10B.5 — Attributes of SW_FLOW and SW_CONV (flow paths and conveyance)

| Field | Type | Unit | Req. | Content | Source |
|---|---|---|---|---|---|
| FLP_ID | T | — | Yes | Line identifier | 10B.1(f) |
| LINE_TYPE | T | — | Yes | OVERLAND / NATURAL / OPEN_DRAIN / COVERED_DRAIN / PIPE / CULVERT | Chapter 6 |
| US_LEVEL | R | m | | Upstream invert or ground level | Chapter 6 |
| DS_LEVEL | R | m | | Downstream invert or ground level | Chapter 6 |
| SIZE_MM | R | mm | | Pipe diameter, or drain width (depth in NOTES) | Clause 6.7.6 |
| Q_DES | R | L/s | | Design discharge | Chapter 6 |
| AEP_DES | T | — | | Design AEP, for example "10%" or "1%" | Clause 6.4 |
| RESERVE_M | R | m | | Drainage reserve width, where one applies | Clause 6.9.7 |
| NOTES | T | — | | Free text | — |

### Table 10B.6 — Metadata (SW_META)

| Field | Content |
|---|---|
| FILE_NO | Authority file number |
| STAGE | 1, 2, 4 or HANDOVER |
| H_CRS | EPSG code of the horizontal reference system |
| V_DATUM | Name of the vertical datum |

| Field | Content |
|---|---|
| TIDE_REL | Relationship of the vertical datum to the Chapter 5 river datums of the CWC level-monitoring sites on the Teesta, the Rangit and the Rongni Chu, Khanitar, Melli, Singtam and Majitar among them (not stated in any source found [TBC]), of the reservoir levels of NHPC and the other hydropower operators (not found [TBC]), and of the flood marks of October 2023 and the post-2023 river beds surveyed at the outfalls and on ungauged kholas, jhoras and pokharis (for example, MSL = x.xx m on the site datum) |
| SURVEYOR | Name and licence number of the surveyor |
| SURV_DATE | Date of the survey |
| PREP_BY | Name and registration number of the certifying professional |
| CALC_VER | Compliance calculator version (Annex 10A), or "not issued" |
| DATE | Date the file was prepared |

## 10B.4 Code lists

### Table 10B.7 — Facility type codes (FAC_TYPE)

| Code | Facility | Inspection row of Table 10.3 |
|---|---|---|
| RET_SOAK | Soakaway, recharge pit or shaft | Retention / infiltration |
| RET_TRENCH | Infiltration trench or basin | Retention / infiltration |
| RET_BIO | Bioretention or rain garden | Retention / infiltration |
| RET_PERM | Permeable pavement | Retention / infiltration |
| RET_REUSE | Retention by reuse (tank with demand) | Underground or podium detention tank, gravity outlet |
| DET_BASIN | Surface detention basin | Surface detention basin or multi-use open space area |
| DET_OSR | Multi-use detention in open space, park or playfield | Surface detention basin or multi-use open space area |
| DET_ROOF | Rooftop detention | Underground or podium detention tank, gravity outlet |
| DET_PODIUM | Podium or landscape-deck detention | Underground or podium detention tank, gravity outlet |
| DET_PARK | Parking-lot detention | Surface detention basin or multi-use open space area |
| DET_TANK | Underground tank or vault, gravity outlet | Underground or podium detention tank, gravity outlet |
| DET_PUMP | Pumped detention or pump station | Pumped detention, pumps and controls |
| WQ_POND | Wet pond or constructed wetland | Surface detention basin or multi-use open space area |
| WQ_SWALE | Swale or filter strip | Private drains and inlets |
| WQ_GPT | Gross pollutant trap, first-flush device or oil-grit separator | Gross pollutant trap / first-flush device |
| GATE | Flap or tide gate, non-return valve | Flap / tide gate, non-return valve |
| CONV | Private drain, inlet or culvert | Private drains and inlets |

### Table 10B.8 — Status codes (STATUS)

| Code | Meaning |
|---|---|
| PROPOSED | In a Stage 1 or Stage 2 submittal |
| APPROVED | Stage 2 approved; not yet built |

| Code | Meaning |
|---|---|
| ASBUILT | As-built certificate accepted (Clause 10.9) |
| HANDEDOVER | Accepted by the ULB (Clause 10.14) |
| ALTERED | Changed with the Authority's approval (Clause 10.3.5) |
| REMOVED | Removed with the Authority's approval |

Table 10B.9 — Inspection result codes (INSP_RES)

| Code | Meaning |
|---|---|
| OK | Working as designed; no defect |
| MINOR | Defect found and corrected; date in the inspection record |
| MAJOR | Defect affecting storage, outlet or safety; notice issued (Clause 10.15.2, step 1) |
| NOACCESS | Inspection could not be made |
| NOTFOUND | Facility missing, filled, covered or changed in use (Clause 10.15.1(c)) |

### 10B.5 Facility register extract

The public facility register of Clause 10.17.1(a) is an extract of SW_FAC: FAC_ID, FAC_TYPE, location (centroid), V_DET (and V_RET, V_WQ), Q_100 (and Q_2, Q_10), OWNER_NM, ASB_DATE, LAST_INSP and INSP_RES. It is published as CSV and GeoPackage under the licence of Clause 10.17.4. Personal data are not published (Clause 10.17.3).

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## Annex 10C — Maintenance access dimensions

Supports Clause 10.13 of Chapter 10.

Clause 10.13 sets access by function. This annex collects the access dimensions that the Manual already sets in other chapters, and lists the dimensions that it does not set. Where a dimension is not set by the Manual, the designer shall state it on the drawings, show that it suits the plant and equipment named in the O&M plan (Clause 10.11.1(h)), and mark it "to be confirmed in design".

Table 10C.1 — Access dimensions set by the Manual

| Element | Requirement | Clause |
|---|---|---|
| Open drains with a top width of 2 m or more | Maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m | 6.9.4 |
| Drainage reserves | Width not less than Table 6.9, based on the required drain size; where the access strip of Clause 6.9.4 is wider, the wider governs | 6.9.7 |
| Covered drains, minimum section | 0.6 m × 0.6 m clear | 6.7.6 |
| Covered drains, removable covers | Panels at not more than 10 m centres, each at least 0.6 m long and spanning the full clear width, liftable by two workers or a hand-operated device | 6.13.2(a) |
| Covered drains, access chambers | Clear opening at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than 30 m centres on straight runs | 6.13.2(b) |

| Element | Requirement | Clause |
|---|---|---|
| Manholes and access chambers on public drains | Clear access opening at least 600 mm | 9.12.3 |
| Inlet chambers on public roads | Silt sump at least 300 mm deep below the outlet pipe invert, cleanable from the surface | 6.6.7 |
| Underground tanks and vaults | Access openings over the outlet chamber and over every inlet; in tanks over 500 m², not more than 30 m apart; floor falling at least 1% to a sump at the outlet | 4.10.2(b), (c) |
| Detention outlets serving more than 1 ha | A means of isolating the outlet (stop-log slot or penstock) | 4.8.6 |
| Outfall gates | Stop-log slot or penstock upstream on outfalls larger than 600 mm (Chapter 5) and on outfalls of 900 mm or more or serving a pumped or storage system (Chapter 9); the gate chamber accessible at all tides, with its access above HAT + surge + sea-level allowance | 5.11.3(d), (e); 9.10.3 |
| Pump stations | Maintenance vehicle access usable in the 1% AEP event; hard standing and a quick-coupling connection for mobile pumps; clear space between adjacent pumps or motors of 0.6 m (small and medium units) or 1.0 m (large units) | 9.9.6, 9.9.10, 9.9.12 |
| Pretreatment devices | Cleanable without entering or disturbing the main BMP | 8.5.4 |
| Screens at outfalls, culvert inlets and pump sumps | Cleanable from a safe platform, with vehicle access | 8.10.3(d) |
| Infiltration trenches | Observation well to the base of each trench | 8.7.6(c) |
| Publicly accessible storage | Side slopes no steeper than 4H:1V, with at least a quarter of the perimeter at 6H:1V or flatter | 4.15.1(c) |
| Wet basins | Safety bench at least 3 m wide, no more than 0.3 m below normal water level | 4.15.2 |
| Fencing | At least 1.2 m high, non-climbable, with a lockable gate, where Clause 4.15.3 requires it | 4.15.3 |

### Table 10C.2 — Access dimensions not set by the Manual (to be confirmed in design)

| Element | What the designer shall state | Clause setting the function |
|---|---|---|
| Vehicle access route to the inlet, outlet and base of a basin, pond or open channel | Width, gradient, turning space and design load for the plant in the O&M plan | 10.13.2 |
| Maintenance strip beside a basin or pond | Width along at least one side | 10.13.2 |
| Ramp into a basin | Width, gradient and surface for the sediment-removal plant | 10.13.2 |
| Access openings of private tanks | Clear size of each opening over the inlet, outlet and each chamber | 10.13.3(a) |
| Ladders and steps | Type and spacing; ventilation for confined-space entry | 10.13.3(b) |
| Headroom in underground tanks | Clear height for manual cleaning | 10.13.3(d) |
| Reach to orifices and screens | How the outlet is cleaned without entering a full facility | 10.13.4 |

> **Commentary.** APWA 5600 (2006, §5608) required a maintenance access strip of 15 ft (about 4.5 m) for detention facilities. The Manual did not adopt a fixed width for private sites, because plot sizes in Sikkim towns vary widely (Clause 10.13, Commentary). The State Stormwater Technical Committee may add standard values to Table 10C.2 when it issues the standard drawings of Annexes 6C and 9B.

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## Annex 10D — Model O&M plans by facility type

Supports Clauses 10.11, 10.12 and 10.13 of Chapter 10.

The model plans below are starting points. The designer adapts them to each facility and completes the items marked "_____". Inspection frequencies are the minimum frequencies of Table 10.3; a plan may set more frequent inspection, never less. Where this annex leaves a value to the designer, the Manual does not set it.

### 10D.1 Contents of every O&M plan

Every plan shall contain the items of Clause 10.11.1:

**Table 10D.1 — Contents of an O&M plan**

| Item | Content | Clause |
|---|---|---|
| 1 | Inventory and plan drawing of each facility, with design levels, volumes and outlet details (from SW_FAC, Annex 10B) | 10.11.1(a) |
| 2 | Routine tasks and their frequency (Tables 10D.2 to 10D.8) | 10.11.1(b) |
| 3 | Trigger for sediment removal, as a depth (mm) or a percentage of design volume: _____ | 10.11.1(c) |
| 4 | Inspection checklist matching Form 10-7 | 10.11.1(d) |
| 5 | For pumps, gates and valves: operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning | 10.11.1(e) |
| 6 | Actions against standing water and mosquito breeding, consistent with the drawdown times of Clause 4.7 | 10.11.1(f) |
| 7 | Safety: confined spaces, deep water, public access | 10.11.1(g) |
| 8 | Access routes and equipment (Annex 10C) | 10.11.1(h) |
| 9 | Annual cost estimate (₹ _____ per year) and who pays it | 10.11.1(i) |
| 10 | Records to be kept, and for how long: _____ years (pump records at least 5 years, Clause 9.9.8(c)) | 10.11.1(j) |

### 10D.2 Model plans

**Table 10D.2 — Retention and infiltration (soakaways, trenches, bioretention, permeable paving)**

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Inspect surface, inlets, pretreatment and overflow | Every 6 months; before 31 March; after each heavy-rainfall day | No blockage; overflow clear | Table 10.3 |
| Check drawdown at the observation well or surface | At each inspection after rain | Empties within 72 h of the end of rain; if not, investigate clogging | 4.4.5, 8.7.6(c) |
| Clean pretreatment (forebay, filter strip, silt trap) | When the sediment trigger (item 3) is reached | Pretreatment cleaned without disturbing the main BMP | 8.5.3, 8.5.4 |

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Bioretention: mulch, plants, ponding | Every 6 months | Ponding drains within 48 h; dead plants replaced; mulch 50–75 mm | 8.7.2 |
| Permeable paving: surface | Every 6 months | Sweep or vacuum; no resurfacing with impermeable material | 8.7.5(e) |
| Keep the contributing area stable | Each inspection | Bare soil stabilised; no sediment washing in | 10.8.3(b) |
| Keep the facility in place and in use | Each inspection | Not filled, covered, paved or built over without approval | 10.10.1(d) |

### Table 10D.3 — Surface detention basin or multi-use open space area

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Inspect inlets, outlet, orifice, trash rack and spillway | Every 6 months; before 31 March; after each heavy-rainfall day | Orifice and rack clear; spillway unobstructed | Table 10.3, 4.8, 4.9 |
| Remove debris and sediment | When the sediment trigger is reached, and after events | Design volume restored | 10.11.1(c) |
| Check that the basin drains | After rain | No low point ponds for more than 72 h | 4.15.7 |
| Vegetation | As set in the plan | Grass cut; no woody growth on embankments or in the outlet zone | 10.11.1(b) |
| Safety features | Every 6 months | Signs in Nepali and English and a depth marker in place; fences and gates sound where required | 4.15.3, 4.15.5 |
| Embankment (if any) | Every 6 months and after events | No cracks, slips, seepage or animal burrows | 4.9.6 |

### Table 10D.4 — Underground or podium detention tank, gravity outlet

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Inspect from the access openings: inlets, outlet, orifice, screen, sump, vents | Every 6 months; before 31 March; after each heavy-rainfall day | Clear; vents open | Table 10.3, 4.10.2 |
| Clean the sump and floor | When the sediment trigger is reached | Floor falls freely to the sump | 4.10.2(c) |
| Inlet silt trap or GPT | Every 3 months (Table 10.3 row for GPTs) | Cleaned | 4.10.2(e) |
| Overflow route | Each inspection | Operates when the outlet is blocked; route to the overland path unobstructed | 4.9.5 |
| Confined-space entry | Each entry | Entry procedure stated in the maintenance declaration followed; covers locked after | 4.15.6 |
| Use of the space | Each inspection | Not used for parking or storage; volume not reduced | 10.10.1(d) |

### Table 10D.5 — Pumped detention, pumps and controls

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Test run of each pump, duty and standby | Monthly | Each pump starts on level control; roles alternate | Table 10.3, 9.9.4(c) |

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Full duty test | Before 31 March | Station meets its design duty point | Table 10.3, 10.9.3 |
| Standby power | Monthly with the test run; full test before 31 March | Automatic changeover works; fuel for at least 72 h of all duty pumps on site | 9.9.9 |
| Level sensors, float back-up, alarms, telemetry | Monthly | High-level and fault alarms reach the control room | 9.9.8 |
| Screens and silt trap | Every 3 months and after events | Clean | 9.9.7 |
| Records | Continuous | Sump levels, run hours and power status logged; kept at least 5 years | 9.9.8(c) |
| Warning actions | On an IMD heavy-rainfall or cyclone warning | Actions written in the plan: _____ (for example staff on site, fuel topped up, mobile pump connection checked) | 10.11.1(e), 9.9.12 |

### Table 10D.6 — Flap or tide gate, non-return valve

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Inspect and operate | Every 3 months; after each heavy-rainfall day | Opens at a small head; no debris, sand or growth holding it | Table 10.3, 9.10.4 |
| Seal test | Before 31 March | Seals against the receiving water | Table 10.3, 10.9.3 |
| Beach, estuary and creek outfalls | After every high-tide or surge event in the monsoon season | Sand and debris cleared | 9.10.5(b) |
| Isolation | Before 31 March | Stop-log slot or penstock operable | 9.10.3 |
| Hinges, pins and fixings | Before 31 March | No corrosion that would stop the gate working | 9.10.6 |
| Property non-return valves | Every 3 months | Cleaning eye accessible; valve seals | 5.11.4 |

### Table 10D.7 — Gross pollutant trap or first-flush device

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Inspect and empty | Every 3 months; before 31 March; after each heavy-rainfall day | Emptied before the capture chamber is full; bypass clear | Table 10.3, 8.4.6 |
| Screens | Each inspection | Clean; overflow path clear | 8.10.3(b) |
| Disposal | Each cleaning | Material taken to an authorised solid-waste facility | — |

### Table 10D.8 — Private drains and inlets

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Inspect and clean drains, inlets and silt sumps | Every 6 months; before 31 March | Free of silt and debris | Table 10.3 |
| Check for sewage connections | Each inspection | None; any cross-connection removed | 1.5.4, 8.9 |

| Task | Frequency | Standard or trigger | Clause |
|---|---|---|---|
| Overland flow paths | Each inspection | Not obstructed by walls, fill or stored material | 6.9.2, 10.15.1(g) |

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## Annex 10E — Empanelment criteria for Stormwater Design Professionals and reviewers

Supports Clauses 10.6, 10.7.4 and 11.4.3 of Chapter 10.

> *Model text for consideration by a competent authority. Not in force.* Clause 10.6.2 assigns the issue of empanelment criteria to UDD. The text below is a model. Values shown as "[ ]" are for the competent authority to set; the Manual does not set them.

### 10E.1 Model criteria

1. **Lists.** The competent authority shall keep three public lists:
    - (a) **Stormwater Design Professionals**, who may sign designs under Clause 10.6.1 and act as independent checkers under Clause 10.6.4;
    - (b) **Empanelled Reviewers**, who may review submittals for an Authority under Clause 10.7.4; and
    - (c) a **basin modelling endorsement**, held by a Stormwater Design Professional who may prepare or direct a BSMP under Clause 11.4.3.
2. **Eligibility for list (a).** An applicant shall:
    - (a) hold a degree in civil engineering, or an equivalent qualification recognised by the competent authority (Clause 10.6.2);
    - (b) be registered as a professional under the Sikkim Building Construction Regulations, 1991 (Clause 1.4);
    - (c) have at least [ ] years of experience in drainage design after graduation, shown by a list of at least [ ] projects with the applicant's role in each (Clause 10.6.2); and
    - (d) have completed a training course on this Manual, with an assessment, within the [ ] years before application (Clause 10.6.2).
3. **Eligibility for list (b).** As for list (a), with at least [ ] years of experience, of which at least [ ] years in the design or review of drainage under this Manual or an equivalent standard.
4. **Basin modelling endorsement (c).** A Stormwater Design Professional who shows experience in basin-scale 1D–2D modelling, including calibration, on at least [ ] studies (Clause 11.4.3).
5. **Independence of a checker.** A checker under Clause 10.6.4 shall not be employed by, or a partner of, the designer's firm or the Applicant, and shall not have worked on the design.
6. **Conflict of interest of a reviewer.** An Empanelled Reviewer shall not review a site on which the reviewer, or the reviewer's firm, has worked in any capacity (Clause 10.7.4), and shall declare any other interest before accepting a review. The Authority remains the decision-maker (Clause 10.7.4).
7. **Application.** The application shall include proof of degree and registration, the project list with references, the training certificate, and a signed declaration that the information is true.
8. **Term and renewal.** Empanelment is valid for [ ] years. Renewal requires evidence of continuing practice and of any refresher training issued after a revision of the Manual (Clause 1.12).
9. **Suspension and removal.** The competent authority may suspend or remove an empanelled person after a false or negligent certificate (Clause 10.6.5), on a report under step 6 of Table 10.4, or on loss of registration. The person shall be given notice and an opportunity to be heard. Every suspension and removal shall be published on the list.
10. **Publication.** The lists shall be published and kept current, with each person's name, registration number, list, endorsement and validity date.

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## Form 10-1 — Drainage Report Checklist

Supports Clauses 10.4.1 to 10.4.4 and 10.7.1 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Lodge with every Stage 1 and Stage 2 submittal. For each item give the page or sheet where it is addressed, or the reason it does not apply. The Authority does not start technical review without a completed Form 10-1 (Clause 10.4.3).

### Table 10F.1 — Form 10-1, Section A: Submittal

| No. | Field | Entry |
|---|---|---|
| A1 | Authority and file number | _____ |
| A2 | Site name and address; survey numbers | _____ |
| A3 | Stage: 1 / 2 / combined 1 and 2 (Clause 10.3.3) / public work DPR or tender (Clause 10.3.4) | _____ |
| A4 | Applicant | _____ |
| A5 | Certifying professional (name, registration and empanelment number) | _____ |

### Table 10F.2 — Form 10-1, Section B: Stage 1 contents (Clause 10.4.1)

| No. | Item | Clause | Page / sheet | Not applicable: reason |
|---|---|---|---|---|
| B1 | Form 1-1; Form 1-2 where a variance or waiver is sought | 10.4.1(a) | _____ | _____ |
| B2 | Site plan: existing and proposed levels, impervious areas, catchment boundaries to and through the site | 10.4.1(b) | _____ | _____ |
| B3 | Soils (HSG), seasonal high groundwater, infiltration tests or test plan | 10.4.1(c) | _____ | _____ |
| B4 | Design Rainfall Sheet (Form 2-1) | 10.4.1(d) | _____ | _____ |
| B5 | Pre-development condition and hydrologic method | 10.4.1(e) | _____ | _____ |
| B6 | Order of measures: areas preserved, retention method, detention concept, conveyance | 10.4.1(f) | _____ | _____ |
| B7 | Preliminary retention, WQ and detention volumes and release rates, with Form 10-2 | 10.4.1(g) | _____ | _____ |
| B8 | Downstream extent and tailwater case | 10.4.1(h) | _____ | _____ |
| B9 | Waterbodies, setbacks and the 1% AEP level | 10.4.1(i) | _____ | _____ |
| B10 | Land reserved for facilities and maintenance access | 10.4.1(j) | _____ | _____ |
| B11 | Professional Design Certificate (Form 10-3) | 10.4.5 | _____ | _____ |

### Table 10F.3 — Form 10-1, Section C: Stage 2 contents (Clause 10.4.2)

| No. | Item | Clause | Page / sheet | Not applicable: reason |
|---|---|---|---|---|
| C1 | Updated Stage 1 contents (Section B) | 10.4.2 | _____ | _____ |
| C2 | Final calculations for every storage duration and AEP, with the outfall-closed check | 10.4.2(a) | _____ | _____ |

| No. | Item | Clause | Page / sheet | Not applicable: reason |
|---|---|---|---|---|
| C3 | Stage–storage–discharge tables; emergency spillway design | 10.4.2(b) | _____ | _____ |
| C4 | Hydraulic design of conveyance, inlets and structures | 10.4.2(c) | _____ | _____ |
| C5 | Water quality design; first-flush device or GPT where required | 10.4.2(d) | _____ | _____ |
| C6 | Construction drawings, details and specifications of every facility | 10.4.2(e) | _____ | _____ |
| C7 | Construction sequence, with protection of retention and infiltration areas | 10.4.2(f) | _____ | _____ |
| C8 | Hold-point schedule (Form 10-4, Section A) | 10.4.2(g) | _____ | _____ |
| C9 | Draft O&M plan and draft Maintenance Declaration (Form 10-6) | 10.4.2(h) | _____ | _____ |
| C10 | Model input files and GIS data | 10.4.2(i) | _____ | _____ |
| C11 | Certificates (Form 10-3, signed by designer and, where required, checker) | 10.4.2(j) | _____ | _____ |

### Table 10F.4 — Form 10-1, Section D: Digital submittal (Clause 10.4.4)

| No. | Item | Clause | Provided (yes / no) | Detail |
|---|---|---|---|---|
| D1 | Reports and drawings as searchable PDF | 10.4.4(a) | _____ | _____ |
| D2 | Models in native, runnable format; software name and version | 10.4.4(b) | _____ | _____ |
| D3 | GIS data to Annex 10B; horizontal reference system (EPSG code) | 10.4.4(c) | _____ | _____ |
| D4 | Vertical datum named; relationship to the Chapter 5 river datums of the CWC level-monitoring sites on the Teesta, the Rangit and the Rongni Chu, Khanitar, Melli, Singtam and Majitar among them (not stated in any source found [TBC]), of the reservoir levels of NHPC and the other hydropower operators (not found [TBC]), and of the flood marks of October 2023 and the post-2023 river beds surveyed at the outfalls and on ungauged kholas, jhoras and pokharis | 10.4.4(d) | _____ | _____ |

### Table 10F.5 — Form 10-1, Section E: Declaration and completeness check

| Field | Entry |
|---|---|
| I confirm that this checklist is complete and correct. Certifying professional: name, signature, date | _____ |
| For the Authority: date received | _____ |
| Date of completeness check (within 5 working days, Clause 10.7.1) | _____ |
| Result: accepted for review / returned | _____ |
| Missing items, if returned | _____ |
| Officer: name, designation, signature | _____ |

## Form 10-2 — Compliance Calculator Summary

Supports Clauses 10.4.1(g), 10.5 and 10.9.1(b) of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Produced by the compliance calculator (Annex 10A) with Stage 1, 2 and 4 submittals. Until the calculator is issued, complete it by hand and enter "not issued" in A3. One column per drainage area where the site has more than one outfall.

**Table 10F.6 — Form 10-2, Section A: Site and route**

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Authority, file number, stage (1 / 2 / 4) | _____ | 10.5.2(a) |
| A2 | Site area, ha; land disturbance, ha; new + replaced impervious area, m² | _____ | 1.5.2 |
| A3 | Calculator version and release date | _____ | 10.5.3 |
| A4 | Tier (A / B); flood-sensitive (yes / no); approved BSMP for the basin (yes / no) | _____ | 1.6, 4.5.3, 11.12 |
| A5 | Route: full method / S-1 / S-2 / fixed-coefficient / constrained redevelopment / regional or fee-in-lieu | _____ | 1.7, 4.5.6, 4.13, 4.14 |
| A6 | Flags raised by the calculator (list) | _____ | Annex 10A.4 |

**Table 10F.7 — Form 10-2, Section B: Rainfall and soils**

| No. | Field | Entry | Clause |
|---|---|---|---|
| B1 | Rainfall zone; Form 2-1 reference | _____ | 2.13 |
| B2 | Retention depth P_R, mm; 3-month ARI depth P_3m, mm | _____ | 2.10, 8.4.1 |
| B3 | Climate factor applied (≤ 6 h; > 6–72 h) | _____ | 2.8 |
| B4 | HSG by sub-area; seasonal high groundwater, m below base | _____ | 3.7, 4.4.3 |
| B5 | Measured and design infiltration rates, mm/h | _____ | 4.4.3 |

**Table 10F.8 — Form 10-2, Section C: Volumes**

| No. | Quantity | Required (m³) | Provided (m³) | Clause |
|---|---|---|---|---|
| C1 | Retention volume (RRV) | _____ | _____ | 4.4.2 |
| C2 | Water quality volume (WQv) | _____ | _____ | 8.4.2 |
| C3 | Retention credit against detention | _____ | — | 4.4.6 |
| C4 | Detention volume | _____ | _____ | 4.6, 4.14 |
| C5 | Fee-in-lieu or regional volume, and fee (₹) | _____ | _____ | 4.5.6.3, 4.13.3 |

**Table 10F.9 — Form 10-2, Section D: Release rates (each outfall)**

| AEP | Q_pre or cap (L/s) | Q_post (L/s) | Governing duration (h) | Meets criterion (yes / no) | Clause |
|---|---|---|---|---|---|
| 50% (2-yr) | _____ | _____ | _____ | _____ | 4.5 |
| 10% (10-yr) | _____ | _____ | _____ | _____ | 4.5 |

| AEP | Q_pre or cap (L/s) | Q_post (L/s) | Governing duration (h) | Meets criterion (yes / no) | Clause |
|---|---|---|---|---|---|
| 1% (100-yr) | _____ | _____ | _____ | _____ | 4.5 |

Table 10F.10 — Form 10-2, Section E: Outlets, drawdown and stage comparison

| No. | Field | Entry | Clause |
|---|---|---|---|
| E1 | Low-flow orifice, mm (minimum 50 mm) | _____ | 4.8.2 |
| E2 | Detention: time to release 90% of the 10-yr stored volume, h (≤ 48 h) | _____ | 4.7.1 |
| E3 | WQv release time, h (24–48 h) | _____ | 4.7.2 |
| E4 | Retention emptying time, h (≤ 72 h) | _____ | 4.7.3 |
| E5 | Model result differs from the calculator screen by more than the guide tolerance? If yes, report section that explains it | _____ | 10.5.2(c) |
| E6 | Stage 4 only: changes from the Stage 2 values (list), and whether every criterion is still met | _____ | 10.9.2 |
| E7 | Prepared by (name, registration number), signature, date | _____ | 10.6.3(b) |

## Form 10-3 — Professional Design Certificate

Supports Clauses 10.6.1 to 10.6.5 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Signed by the designer with every Stage 1 and Stage 2 submittal, and by an independent checker for facilities under Clause 10.6.1(c) and (d).

### Table 10F.11 — Form 10-3, Section A: Project and signatory

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Authority, file number, stage | _____ | — |
| A2 | Site and facilities covered by this certificate | _____ | — |
| A3 | Designer: name, qualification, SBCR 1991 registration number | _____ | 10.6.1 |
| A4 | Empanelment number, where required, and the reason: Tier A ≥ 1 ha / flood-sensitive / embankment or high-hazard basin / pumped, tide gate or regional facility | _____ | 10.6.1(a)–(d) |
| A5 | Variances or waivers approved (Form 1-2 references), or "none" | _____ | 10.6.3(a) |

### Table 10F.12 — Form 10-3, Section B: Certificate of the designer

| No. | I certify that: | Initials |
|---|---|---|
| B1 | the design complies with the Sikkim Stormwater Design Manual, except for the variances listed at A5, which have been approved | _____ |
| B2 | the rainfall, soils and tailwater inputs are as recorded on Form 2-1 and Form 10-2 | _____ |
| B3 | the models submitted reproduce the results reported | _____ |
| B4 | I understand that a false or negligent certificate is a contravention under Clause 10.15 | _____ |

### Table 10F.13 — Form 10-3, Section C: Certificate of the independent checker (Clause 10.6.4)

| No. | Field or statement | Entry |
|---|---|---|
| C1 | Checker: name, registration and empanelment number | _____ |
| C2 | I am independent of the designer and the Applicant and have not worked on this design | _____ |
| C3 | I have checked the facilities listed: _____, and agree with the certificate in Section B | _____ |
| C4 | Matters on which I do not agree, if any | _____ |

### Table 10F.14 — Form 10-3, Section D: Signatures

| Role | Name | Signature | Date |
|---|---|---|---|
| Designer | _____ | _____ | _____ |
| Independent checker (where required) | _____ | _____ | _____ |

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## Form 10-4 — Hold-Point Inspection Record

Supports Clauses 10.4.2(g), 10.8 and 10.9.3 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Section A is the hold-point schedule, approved at Stage 2. Section B is completed at each hold point, with dated, geotagged photographs (Clause 10.8.2). Work shall not proceed past a hold point until Section B is signed. See Figure 10.2.

**Table 10F.15 — Form 10-4, Section A: Hold-point schedule**

| Hold point | Facility (FAC_ID) | Stage of work | Planned date | Notice to Authority sent (date)* | Authority attended (yes / no) |
|---|---|---|---|---|---|
| (a) Excavated base, before media, liner or structure | _____ | _____ | _____ | _____ | _____ |
| (b) Outlet structure, orifice and trash screen, before backfill or first filling | _____ | _____ | _____ | _____ | _____ |
| (c) Infiltration and verification tests (Clause 10.9.3) | _____ | _____ | _____ | – | _____ |
| (d) Outfall, flap or tide gate and non-return valve, before downstream connection | _____ | _____ | _____ | – | _____ |
| (e) Pumps and controls, at commissioning | _____ | _____ | _____ | – | _____ |
| Other hold points added by the Authority | _____ | _____ | _____ | _____ | _____ |

* For sites under Clause 10.6.1, at least 3 working days' notice of hold points (a) and (b) (Clause 10.8.2).

**Table 10F.16 — Form 10-4, Section B: Inspection record (one per hold point)**

| No. | Field | Entry |
|---|---|---|
| B1 | Hold point and facility | _____ |
| B2 | Date and time of inspection; weather | _____ |
| B3 | Inspected by (certifying professional); others present | _____ |
| B4 | Approved drawing and revision checked against | _____ |
| B5 | Levels, dimensions and materials found, against approved values | _____ |
| B6 | For (a): retention and infiltration areas protected from traffic and stockpiles (Clause 10.8.3(a)) | _____ |
| B7 | For (b): orifice size and invert; screen in place | _____ |
| B8 | For (c): infiltration test result and emptying time (≤ 72 h); pump duty point; gate opening and sealing | _____ |
| B9 | For (d) and (e): gate type, seating and test; pump commissioning record | _____ |
| B10 | Photograph references (dated, geotagged) | _____ |
| B11 | Result: released / not released; corrective work required | _____ |
| B12 | Corrective work checked (date, by) | _____ |
| B13 | Signature of the certifying professional, date | _____ |

## Form 10-5 — As-built Certificate

Supports Clauses 10.9 and 10.3.5 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Lodged before the completion certificate. The Authority shall not issue the completion certificate until this form is accepted (Clause 10.9.4).

### Table 10F.17 — Form 10-5, Section A: Project and survey

| No. | Field | Entry | Clause |
|---|---|---|---|
| A1 | Authority, file number; Stage 2 approval reference and date | _____ | — |
| A2 | Licensed surveyor: name, licence number, date of survey | _____ | 10.9.1(a) |
| A3 | Vertical datum | _____ | 10.4.4(d) |
| A4 | GIS data to Annex 10B, as built (file name) | _____ | 10.4.4(c) |

### Table 10F.18 — Form 10-5, Section B: Approved against as built (one block per facility)

| Item | Approved | As built | Accepted (yes / no) | Clause |
|---|---|---|---|---|
| Storage volume at each design level, m³ | _____ | _____ | _____ | 10.9.2(a) |
| Outlet dimensions (orifice, weir), mm | _____ | _____ | _____ | 10.9.2(b) |
| Outlet and outfall inverts, m | _____ | _____ | _____ | 10.9.2(b) |
| Spillway or overflow level, m | _____ | _____ | _____ | 4.9 |
| Retention volume, m³ | _____ | _____ | _____ | 4.4 |

### Table 10F.19 — Form 10-5, Section C: Re-run and tests

| No. | Field | Entry | Clause |
|---|---|---|---|
| C1 | Compliance calculator re-run with as-built values: version, and Form 10-2 (Stage 4) attached | _____ | 10.9.1(b) |
| C2 | Model re-run with as-built values (where a model was used): file name | _____ | 10.9.1(b) |
| C3 | Every criterion of Chapters 4 and 5 met on re-run (yes / no; list any not met) | _____ | 10.9.2(c) |
| C4 | Infiltration retention: measured emptying time, h (≤ 72 h) | _____ | 10.9.3 |
| C5 | Pumps: duty point achieved (flow at head) | _____ | 10.9.3 |
| C6 | Tide gates and non-return valves: shown to open and seal | _____ | 10.9.3 |
| C7 | Deviations, and how corrected or re-certified under Clause 10.3.5 | _____ | 10.9.2 |

### Table 10F.20 — Form 10-5, Section D: Attachments and certificate

| No. | Field | Entry |
|---|---|---|
| D1 | Completed hold-point records (Form 10-4) | _____ |
| D2 | Final O&M plan | _____ |
| D3 | Executed Maintenance Declaration (Form 10-6) or handover documents (Form 10-8) | _____ |

| No. | Field | Entry |
|---|---|---|
| D4 | I certify that the facilities listed were built as approved, except as stated at C7, and perform as designed. Certifying professional: name, registration number, signature, date | _____ |
| D5 | For the Authority: accepted / returned; officer, date | _____ |

## Form 10-6 — Maintenance Declaration

Supports Clauses 10.10.1, 10.10.2, 10.10.4 and 10.13.1 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0. Model text for consideration by a competent authority. Not in force.* Executed by the owner of every private stormwater facility before the completion certificate is issued, and registered so that it runs with the land.

> **Drafting note D10A.1.** The instrument under which this declaration is registered, and the Act that gives the Authority its right of entry and its power to carry out works in default, are to be confirmed by the competent authority. This form does not cite statute sections.

**Table 10F.21 — Form 10-6, Section A: Parties and land**

| No. | Field | Entry |
|---|---|---|
| A1 | Owner (the declarant): name and address; for a company or association, its registration number | _____ |
| A2 | Authority | _____ |
| A3 | Land: survey numbers, village, sub-division, district; extent | _____ |
| A4 | Approval reference (file number, Stage 2 approval date) | _____ |
| A5 | For multi-owner developments: the association or body that takes over after the developer (Clause 10.10.2) | _____ |

**Table 10F.22 — Form 10-6, Section B: Schedule of facilities**

| Facility (FAC_ID) | Type | Location on the attached plan | Design volume (m³) | Outlet | O&M plan reference |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

**Model declaration.** I/We, the owner named in Section A, declare and undertake, for myself/ourselves and for every successor in title to the land:

1. to operate, inspect and maintain each facility in Section B under the approved O&M plan, and to make the inspections of Clause 10.12 (Clause 10.10.1(b));
2. to give the Authority, its officers and its contractors a right of entry to inspect each facility and the access route shown on the plan, and to carry out works in default under Clause 10.15, with the cost recoverable from the owner (Clause 10.10.1(c));
3. not to remove, fill, cover, reduce or change the use of any facility, or obstruct its access route, without the Authority's written approval (Clauses 10.10.1(d), 10.13.5);
4. where Clause 10.10.3 applies, to lodge an Annual Maintenance Declaration and Inspection Report (Form 10-7) by 31 March each year;
5. for underground tanks, to follow the confined-space entry procedure stated here: _____ (Clause 4.15.6);
6. on sale or transfer of the land or any part of it, to disclose this declaration and the latest Form 10-7 to the purchaser, who takes on these obligations from the date of transfer (Clause 10.10.4); and
7. for a multi-owner development, that the developer remains responsible until the body named at A5 is legally constituted and has accepted this declaration in writing (Clause 10.10.2).

**Table 10F.23 — Form 10-6, Section C: Execution and registration**

| Field | Entry |
|---|---|
| Owner: signature, name, date | _____ |
| Witness 1: signature, name, address | _____ |
| Witness 2: signature, name, address | _____ |
| Acceptance by the association or body at A5 (when constituted): signature, date | _____ |
| Registration: office, document number, date | _____ |
| For the Authority: received and recorded in the facility register; officer, date | _____ |

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## Form 10-7 — Annual Maintenance Declaration and Inspection Report

Supports Clauses 10.10.3, 10.11.1(d) and 10.12 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Due by **31 March** each year from every owner of a facility in a Tier A area, and from every owner of a pumped facility, tide gate or regional facility anywhere (Clause 10.10.3). See Figure 10.3.

**Table 10F.24 — Form 10-7, Section A: Owner and facilities**

| No. | Field | Entry |
|---|---|---|
| A1 | Reporting year (1 April to 31 March) | _____ |
| A2 | Owner or association; Maintenance Declaration registration reference | _____ |
| A3 | Facilities covered (FAC_ID and type) | _____ |
| A4 | Any facility under Clause 10.6.1(c) or (d) (yes / no). If yes, Section E is required | _____ |

**Table 10F.25 — Form 10-7, Section B: Inspections made during the year (Table 10.3)**

| Facility | Routine inspections (dates) | Pre-monsoon inspection (date) | After heavy-rainfall events (dates) | Monthly pump test runs (number) |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ |

**Table 10F.26 — Form 10-7, Section C: Pre-monsoon checklist (one per facility)**

| No. | Item | Condition (OK / defect) | Defect and date corrected |
|---|---|---|---|
| C1 | Inlets, pretreatment and silt traps clear | _____ | _____ |
| C2 | Orifice, trash screen and outlet clear; orifice size unchanged | _____ | _____ |
| C3 | Sediment below the trigger in the O&M plan | _____ | _____ |
| C4 | Storage volume not reduced; no filling, covering or change of use | _____ | _____ |
| C5 | Overflow and spillway route clear | _____ | _____ |
| C6 | Retention drains within 72 h (observation well or surface) | _____ | _____ |
| C7 | Pumps: full duty test; standby pump and standby power tested; fuel for 72 h on site | _____ | _____ |
| C8 | Alarms and telemetry tested | _____ | _____ |
| C9 | Flap or tide gates and non-return valves: operated and seal tested | _____ | _____ |
| C10 | Safety: covers locked, fences, signs and depth markers in place | _____ | _____ |
| C11 | Access routes clear and not used for parking | _____ | _____ |

**Table 10F.27 — Form 10-7, Section D: Declaration of the owner**

| Field | Entry |
|---|---|
| I/We declare that the pre-monsoon inspection of Clause 10.12 has been made, that the defects found have been corrected as listed in Section C, and that the facilities are maintained under the approved O&M plan. Owner: name, signature, date | _____ |

### Table 10F.28 — Form 10-7, Section E: Empanelled professional (facilities under Clause 10.6.1(c) and (d))

| Field | Entry |
|---|---|
| I have inspected the facilities listed and confirm Section C. Name, empanelment number, signature, date | _____ |

### Table 10F.29 — Form 10-7, Section F: For the Authority

| Field | Entry |
|---|---|
| Date received; on time (by 31 March) yes / no | _____ |
| Entered in the facility register (Clause 10.17), date | _____ |
| Follow-up action, if any (Clause 10.15) | _____ |

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## Form 10-8 — Asset Handover Certificate

Supports Clause 10.14 of Chapter 10.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Signed by the developer and the ULB when drains, open space facilities, regional facilities or other stormwater assets built by a developer are handed over.

### Table 10F.30 — Form 10-8, Section A: Asset and parties

| No. | Field | Entry |
|---|---|---|
| A1 | Developer: name and address | _____ |
| A2 | ULB | _____ |
| A3 | Layout or project, approval reference | _____ |
| A4 | Assets handed over (FAC_ID, type, length or volume), with a plan | _____ |

### Table 10F.31 — Form 10-8, Section B: Conditions of handover (Clause 10.14.1)

| No. | Condition | Met (yes / no) | Reference or date |
|---|---|---|---|
| B1 | As-built certificate (Form 10-5) accepted | _____ | _____ |
| B2 | Facility cleaned; pipes and culverts inspected internally (CCTV or manual entry), record handed over | _____ | _____ |
| B3 | Land, or an easement over it, transferred to the ULB | _____ | _____ |
| B4 | O&M plan, drawings, GIS data (Annex 10B) and warranties handed over | _____ | _____ |

### Table 10F.32 — Form 10-8, Section C: Defects liability and register

| No. | Field | Entry | Clause |
|---|---|---|---|
| C1 | Defects liability period: from _____ to _____ (includes at least one full monsoon season, from 1 April to 31 October, after handover) | _____ | 10.14.2 |
| C2 | Developer responsible during the period for defects and routine maintenance | _____ | 10.14.2 |
| C3 | Security deposit held by the ULB, ₹, and release date | _____ | 10.14.2 |
| C4 | Entered in the ULB GIS drainage asset register and the facility register: date | _____ | 10.14.3 |

### Table 10F.33 — Form 10-8, Section D: Signatures

| Party | Name and designation | Signature | Date |
|---|---|---|---|
| Developer | _____ | _____ | _____ |
| Certifying professional | _____ | _____ | _____ |
| ULB | _____ | _____ | _____ |

ANNEXES TO CHAPTER 11

# Basin and City Stormwater Master Plans

These annexes support Chapter 11. They give a terms of reference template for a Basin Stormwater Master Plan (BSMP), the layout of the basin list and boundary layer, the layout and method for depth–damage curves, the standard for publishing BSMP data and models, and the annual implementation report form. Annexes 11B and 11C need data that are not yet available; they say so and give the rule to use in the meantime. The template and the form are a model and a draft form for consideration by a competent authority, and are not in force.

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## Annex 11A — BSMP terms of reference template

Supports Clauses 11.1 to 11.12 of Chapter 11.

> *Model text for consideration by a competent authority. Not in force.* The Lead Authority adapts this template for each basin. Items in "[ ]" are for the Lead Authority to complete. Clause references are to this Manual, which the consultant shall follow in full.

### 11A.1 Background and purpose

1. The [Lead Authority] intends to prepare a Basin Stormwater Master Plan for the [name] basin under Chapter 11 of the Sikkim Stormwater Design Manual.
2. The BSMP shall (Clause 11.1.2):
    - (a) map flood hazard for the basin under existing and future conditions;
    - (b) set the level of service for each part of the drainage system;
    - (c) identify, cost and rank the works, storage and land needed to reach that level of service;
    - (d) identify land to be reserved in the statutory land-use plan for regional storage, pokhari and tank restoration and major flow paths;
    - (e) set the basin inputs for site design: regional facilities, the fee-in-lieu unit rate, and any basin release rate stricter than Chapter 4; and
    - (f) recommend catchments for notification as flood-sensitive.
3. The BSMP may make the site criteria of Chapters 4 to 8 stricter for the basin. It shall not relax them, except through the regional detention and fee-in-lieu routes of Clauses 4.13 and 4.5.6 (Clause 11.1.3).

### 11A.2 Client, partners and study area

1. **Client:** [Lead Authority] (Clause 11.4.1).
2. **Partners:** WRD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, a development authority or UDD, SSDMA] (Clause 11.4.1).
3. **Study area:** the whole of the [name] basin, draining to [outfall], as delineated under Clause 11.3, including the parts outside the client's limits (Clause 11.3.1). The provisional boundary is in [Annex 11B / attached map]. The consultant shall confirm it in Task 2.

4. **Links to other basins:** [for example the receiving jhora, khola, river, reservoir or pokhari corridor]. Diversions between basins by canal, drain or surplus course shall be mapped and represented in the model (Clause 11.3.2).

## 11A.3 Team

1. The study shall be led by an engineer empanelled as a Stormwater Design Professional with the basin modelling endorsement of Annex 10E (Clause 11.4.3).
2. The team shall include at least: [a hydrologist; a hydraulic modeller; a coastal or tidal specialist where the basin has a tidal outfall; a GIS and survey lead; a planner; a cost engineer; a community engagement lead]. The client sets the minimum qualifications and experience of each.

## 11A.4 Tasks

**Task 1 — Inception.** Review existing studies, data and projects in the basin. Prepare a data inventory against Table 11.1, a gap list, a survey plan, a consultation plan, and the work programme. Deliver the inception report.

**Task 2 — Data and surveys.** Assemble, survey where missing, and quality-check every item of Table 11.1 (Clause 11.5.1):

- (a) terrain: DEM from LiDAR or photogrammetry with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum, with the accuracy test reported;
- (b) drain network: every public drain, culvert and outfall, with invert levels, sizes, condition and silt depth; private drains above 600 mm;
- (c) waterbodies: every tank, pokhari, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels and encroachment, in the fields of Annex 7A;
- (d) rivers and canals: cross-sections at no more than 200 m spacing and at every structure;
- (e) outfalls, rivers, kholas, jhoras, reservoirs and pokharis: outfall invert levels, on a named datum, against the river bed surveyed after October 2023, the flood mark of October 2023 surveyed at the outfall and the high flood level of the receiving river at the nearest CWC level-monitoring site, with any conflict between published values stated; for ungauged kholas and jhoras, the Rani Khola and the Roro Chu among them, surveyed flood marks and the 1% AEP level with its sediment and debris; for outfalls to hydropower reservoirs and their release reaches, the maximum water level, full reservoir level, spillway capacity and release records from the operator; pokharis at their surveyed spill levels; the GLOF corridors, the stability zones and the landslide, sinking and debris-flow areas above the basin; and flap gates, debris racks, debris basins, silt traps, check dams and pumping stations on the outfalls, with their capacities and operating rules;
- (f) rainfall and water levels: all available records (IMD, including its observatories at Gangtok (42299; rainfall from 1958) and Tadong (22209; 1978–2007 in its *Extremes*) and the district gauges reported by the Meteorological Centre Gangtok (types and record lengths [TBC]); the ordinary gauges at Singhik and Dikchu used for the CWC Flood Estimation Report for subzone 2(a), whose record lengths are not confirmed [TBC]; the automatic weather station at Lachen used by Sattar et al. (2025) and the India-WRIS rainfall station at Lachen; the river gauges of CWC on the Teesta, the Rangit, the Rongni Chu and the Dik Chu; the hydro-meteorological gauges of NHPC and the other hydropower operators, at Teesta-V, Dikchu and Chuzachen among them [TBC]; and any gauges or sensors kept by the Gangtok Municipal Corporation, GSCDL, SSDMA or WRD [TBC]), including the 9 June 1997 (Gangtok's 223.8 mm in 24 hours, in a June whose 1,281.3 mm is the station's highest monthly total, IMD, with the Gangtok landslides of that month, for which a single unofficial source gives 38 deaths, as reported), 25 September 2005 (212.5 mm at Tadong, its record, and 141.0 mm at Gangtok on the same day, IMD, at stations 4–5 km apart; no flood record of the day was found [TBC]) and 12–13 June 2024 (the rain and landslides of Mangan district, with 6 deaths reported at first and 9 in a later account, the Sangkalang bridge lost and tourists stranded at Lachung, and about 250 mm over the State in 1–13 June, all as reported; no IMD station rainfall for the event was found [TBC]) events;
- (g) flood evidence: surveyed flood marks and mapped extents of past events, including public reports, photographs and residents' records;

- (h) land use: existing land use and imperviousness; future land use from the statutory master plan;
- (i) soils and groundwater: HSG map (Annex 3A or Clause 3.7.2), seasonal high groundwater, aquifer and recharge zones; and
- (j) sewer interaction: known cross-connections, dry-weather flow in drains, solid-waste hotspots.

Confirm the basin boundary and the inter-basin diversions (Clause 11.3.2). Deliver the data report and the data in the formats of Annex 11D.

**Task 3 — Model build.** Build a coupled 1D–2D hydraulic model of the minor system, the major (overland) system, rivers, canals and tanks, and the outfalls (Clause 11.7.1; Figure 11.2). Use the methods of Chapter 3 and the tidal and river boundaries of Chapter 5. Run the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs, with areal reduction under Clause 2.7.3 (Clause 11.7.2). Where the basin has tank cascades, run continuous simulation under Clause 3.13 with the full IMD gridded daily record where available, and at least 30 years, disaggregated by the temporal patterns of Annex 2D. The two-step approach of Clause 3.13.5 may be used: starting tank levels and antecedent conditions from the continuous run are passed to the design-storm runs (Clause 11.7.3).

**Task 4 — Calibration and validation.** Calibrate and validate the model under Clause 3.15, using at least two of the 9 June 1997 (Gangtok's 223.8 mm in 24 hours, in a June whose 1,281.3 mm is the station's highest monthly total, IMD, with the Gangtok landslides of that month, for which a single unofficial source gives 38 deaths, as reported), 25 September 2005 (212.5 mm at Tadong, its record, and 141.0 mm at Gangtok on the same day, IMD, at stations 4–5 km apart; no flood record of the day was found [TBC]) and 12–13 June 2024 (the rain and landslides of Mangan district, with 6 deaths reported at first and 9 in a later account, the Sangkalang bridge lost and tourists stranded at Lachung, and about 250 mm over the State in 1–13 June, all as reported; no IMD station rainfall for the event was found [TBC]) events where data exist (Clause 11.7.5). Report the performance measures of Clause 3.15.4 and the reasonableness check of Clause 3.15.6.

**Task 5 — Scenarios and hazard maps.** Model the scenarios of Clause 11.7.4: (a) existing; (b) future, uncontrolled; (c) future, controlled; (d) future, with plan; and (e) climate, applied to (a) and (d). Produce flood hazard maps of extent, depth, velocity and hazard class (H1–H6, Chapter 6) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan (Clause 11.8.4(a)).

**Task 6 — Level-of-service assessment.** Compare scenarios (a), (c) and (d) with the levels of service of Table 11.2 and any stricter levels the client adopts (Clause 11.6.1). Map every shortfall.

**Task 7 — Options.** Develop options in the order of Clause 11.8.1: protect and restore storage; regional retention and detention, sited by modelling; conveyance; outfall works; property-level protection; non-structural measures. Assess each option for the criteria of Clause 11.8.2: reduction in flood risk (buildings and people flooded, and expected annual damage using Annex 11C); capital and 30-year maintenance cost; land required; effect on the springs (dhara) on which most rural households and many town households depend, about 80% of rural Sikkim by one account (as reported), and their recharge areas above the intakes, which this Manual keeps free of paving and of infiltrated road runoff (the spring rule of Clause 8.8.1), the stability of hill slopes, where water put into colluvium, fill or slide debris raises the pore pressure and the stability zones of 2021 already treat "Wet", "Dripping" and "Flowing" ground as signs of instability, recharge on the tested river-terrace gravels of sub-area SK-A and the stable benches of stability zone 1, the only ground where it is allowed (Clause 4.11, recharge rule), and the quality of the springs, jhoras, rivers and pokharis that the runoff reaches; effect on downstream basins and the receiving jhora, khola, river, reservoir or pokhari; and who benefits.

**Task 8 — Basin inputs for site design.** Where scenario (c) does not meet the level of service, propose basin release rates (m³/s/ha) by AEP and sub-catchment (Clause 11.8.3). Recommend catchments for notification as flood-sensitive, with the evidence of Clause 4.5.4.1. Identify regional facility sites, with storage volumes, land needs and the sites they serve, and compute the fee-in-lieu unit rate, including land, construction and 10 years of maintenance (Clauses 4.13.3, 11.8.4(c), (d)).

**Task 9 — Capital Improvement Programme.** Rank the works by risk reduction per rupee, with cost, phasing and responsible agency (Clause 11.8.4(e)).

**Task 10 — Maintenance and monitoring.** Prepare the pre-monsoon maintenance programme: desilting, gate and pump testing, and tank operating rules (Clause 11.8.4(f); Chapters 7 and 10). Specify monitoring needs: new rain gauges, level sensors and flood-mark survey points (Clause 11.8.4(g); Clause 10.16.1).

**Task 11 — Land-use integration.** Prepare the material for the statutory land-use plan required by Clause 11.9.1: sites to be reserved; the 1% AEP hazard map with the Chapter 7 setbacks; land in hazard classes H5–H6 in the 1% AEP event; and open space locations that can form part of flow paths or regional storage.

**Task 12 — Consultation.** Publish the draft BSMP for public comment for at least 60 days, with public meetings in each affected local body (Clause 11.10.1). Keep a log of comments and responses.

**Task 13 — Final BSMP and publication.** Revise the BSMP after consultation. Prepare the package for approval by the State Stormwater Technical Committee, including the model for review (Clause 11.11.1). Publish the data, models, maps and CIP under Annex 11D (Clause 11.10.2).

### 11A.5 Deliverables

**Table 11A.1 — Deliverables**

| No. | Deliverable | Task | Due (months from start) |
|---|---|---|---|
| D1 | Inception report, data inventory and survey plan | 1 | [ ] |
| D2 | Data report and data sets (Annex 11D) | 2 | [ ] |
| D3 | Model build report and model files | 3 | [ ] |
| D4 | Calibration and validation report | 4 | [ ] |
| D5 | Scenario results, hazard maps and level-of-service assessment | 5, 6 | [ ] |
| D6 | Options report, with basin inputs for site design | 7, 8 | [ ] |
| D7 | Draft BSMP with draft CIP, for consultation | 9–12 | [ ] |
| D8 | Final BSMP, consultation log, approval package and open-data release | 13 | [ ] |

### 11A.6 Ownership and publication

All data, models, maps and reports produced under these terms are owned by the Lead Authority and shall be published under Annex 11D. The consultant shall not use any software licence, data licence or format that prevents publication, or that prevents a third party from re-running the model with the stated software version.

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## Annex 11B — Basin lists and boundaries for Tier A bodies

Supports Clauses 11.3 and 11.4 of Chapter 11.

**To be prepared.** This annex will contain the list of basins for every Tier A body, with a GIS layer of basin boundaries delineated under Clause 11.3.2. It needs the list of Tier A bodies (Annex 1A), a DEM of the accuracy of Clause 11.5.1, flown again over the Teesta, Rangit and Rongni Chu valley floors and the slide-prone slopes after any large flood or landslide, the drain network of every drain-owning body (the Gangtok Municipal Corporation and the other urban local bodies, GSCDL, the Roads and Bridges Department (PWD), NHIDCL and BRO, WRD, PHED and RMDD), a drain and jhora register giving every reach of every drain and jhora (झोरा; natural watercourse or ravine stream) its owner, its land status (municipal, Forest Department, private or road reserve) and its outfall, the river banks of the scheduled rivers, the treatment plants and sewer zones of Gangtok, the rivers and river works of WRD, the hydropower reservoirs with their levels, spillways, gates and release rules on a stated datum, the pokharis (पोखरी; ponds, lakes or tanks) with their spill levels, the springs (dhara, धारा) and their recharge areas above the town and village intakes, the stability zones of the Mines and Geology Department, the GLOF corridors and the flood and aggradation line of October 2023, and the landslide, sinking and debris-flow areas (other likely sources: Survey of India, CWC, CGWB, the Science and Technology Department's glacial-lake studies, SSDMA and the District Disaster Management Authorities, UDD's master-plan work and the land records of the Land Revenue and Disaster Management Department). Annex 11C would draw its damage data from the assessments of that Department and SSDMA, which made the post-disaster needs assessment of 2023 with NDMA, and from the District Collectors, and its replacement costs from the Roads and Bridges Department's schedule of rates, whose current title and edition were not found [TBC]. No basin map of any Sikkim town was found. Until the annex is published, the basins of Gangtok (the Rani Khola and the Roro Chu with their jhoras), the Teesta valley floor from Chungthang to Melli, Jorethang and Majitar on the Rangit, Ranipool and Singtam on the Rongni Chu, Mangan, Lachen and Chaten, the hydropower reservoirs and release reaches, the NH-10 corridor, Namchi and Soreng named in Clause 11.3.3 are at least those named there; other Tier A bodies define their basins in their first BSMP (Clause 11.3.3); in sub-areas SK-B1 and SK-C and on the Teesta valley floor the hazard screening of Clause 11.3.3 comes first; and the interim arrangements of Clause 11.12 apply in every basin without an approved BSMP.

Table 11B.1 — Basins named in Clause 11.3.3 (provisional)

| Tier A body or area | Basin | Note from Chapter 11 |
|---|---|---|
| Gangtok (Gangtok Municipal Corporation, with UDD) | Catchments of the jhoras that drain to the Rani Khola and the Roro Chu, with Tadong and Ranipool | Delineated by jhora, not ward; free outfalls checked to the next confluence (Clause 5.8.5(a)); sewer zones and treatment-plant outfalls in the 1D network; surveyed flood marks and 1% AEP level with debris as boundary |
| Teesta valley floor (Chungthang, Dikchu, Singtam, Rangpo, Melli, Toong Naga) | Catchments draining to the Teesta in the October 2023 corridor | Post-2023 bed and flood mark surveyed; CWC Khanitar and Melli levels (conflict stated); outfall-closed for the 72-hour storm (Clause 5.8.5(b)); GLOF corridor mapped as its own layer, hazard first |
| Jorethang and Majitar | Catchments draining to the Rangit | CWC Majitar high flood level (279.29 m, 1985) re-surveyed; Jorethang, Tashiding and Rangit-III release reaches |
| Ranipool and Singtam | Catchments draining to the Rongni Chu | CWC Singtam high flood level (356.09 m); Teesta level at the confluence |
| Mangan | Catchments of the town and the North Sikkim road | Slides of June 2024 mapped; debris-flow and jhora gullies as hazards |
| Lachen, Chaten and the catchments below high-risk glacial lakes (sub-area SK-C) | Catchments of the Lachen Chu and Lachung Chu settlements and camps | Hazard screening first; site-specific hydrology (Clause 2.3.6(i)) |
| Hydropower reservoirs and release reaches | Catchments draining to the reservoirs and the reaches below the dams | Operator levels and largest recorded releases on a named datum [TBC] (Clause 5.8.5(c)) |

| Tier A body or area | Basin | Note from Chapter 11 |
|---|---|---|
| NH-10 corridor | Catchments of the road and its settlements along the Teesta | Submergence and subsidence reaches mapped |
| Namchi (Namchi Municipal Council, with UDD) | Catchments of the ridge town and its jhoras | Free outfalls checked downstream; sewage in the drains in the 1D network |
| Soreng | Catchments of the town | Septic effluent in open drains in the 1D network |
| Other Tier A bodies and urban local bodies | To be defined in the first BSMP | Clause 11.3.3 |

**Table 11B.2 — Attributes of the basin boundary layer (layout)**

| Field | Type | Content |
|---|---|---|
| BASIN_ID | Text | Basin identifier |
| NAME_EN, NAME_NE | Text | Basin name in English and Nepali |
| TIER_A | Text | Tier A body or bodies in the basin |
| OUTFALL | Text | Outfall to the sea, river or major waterbody (Clause 11.2) |
| AREA_KM2 | Real | Basin area, km² |
| LEAD_AUTH | Text | Lead Authority (Clause 11.4.1) |
| PARTNERS | Text | Partners, including WRD where it applies |
| LINKS | Text | Diversions to and from other basins (Clause 11.3.2) |
| BSMP_STAT | Text | None / in preparation / draft published / approved |
| BSMP_DATE | Date | Date of approval of the current BSMP |
| REVIEW_DUE | Date | Date of the next review (Clause 11.11.2) |

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## Annex 11C — Depth–damage curves for Sikkim building types

Supports Clause 11.8.2 of Chapter 11.

**To be prepared.** This annex will contain depth–damage curves for the main building types of Sikkim towns, for structure and contents, for use in computing expected annual damage under Clause 11.8.2. It needs a building-type classification and building stock data (Census housing tables, property-tax records, Lead Authority GIS), damage surveys and claims from the 9 June 1997 (Gangtok's 223.8 mm in 24 hours, in a June whose 1,281.3 mm is the station's highest monthly total, IMD, with the Gangtok landslides of that month, for which a single unofficial source gives 38 deaths, as reported), 25 September 2005 (212.5 mm at Tadong, its record, and 141.0 mm at Gangtok on the same day, IMD, at stations 4–5 km apart; no flood record of the day was found [TBC]) and 12–13 June 2024 (the rain and landslides of Mangan district, with 6 deaths reported at first and 9 in a later account, the Sangkalang bridge lost and tourists stranded at Lachung, and about 250 mm over the State in 1–13 June, all as reported; no IMD station rainfall for the event was found [TBC]) floods (Land Revenue and Disaster Management Department and SSDMA damage assessments, insurers), and replacement costs (Roads and Bridges Department schedules of rates). Until it is published, each BSMP shall state the depth–damage relations it uses and their source, and shall report the reduction in buildings and people flooded for every option (Clause 11.8.2), which does not depend on the curves.

**Table 11C.1 — Depth–damage curve (layout, one table per building type)**

| Depth of water above floor level (m) | 0 | 0.25 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 |
|---|---|---|---|---|---|---|---|
| Structure damage (% of replacement cost) | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| Contents damage (% of contents value) | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| Building type, source and year of costs | _____ | | | | | | |

### 11C.1 Use in option assessment

Expected annual damage (EAD) is computed for each scenario from the damages at the modelled AEPs. With damages D_1, D_2, … at annual exceedance probabilities P_1 > P_2 > …, using at least the 50%, 10%, 1% and 0.2% AEP results of Clause 11.7.2:

> $EAD \approx \Sigma \tfrac{1}{2} \times (D_i + D_{(i+1)}) \times (P_i - P_{(i+1)})$

The reduction in EAD between scenario (c) and scenario (d), or between options, is the risk-reduction benefit used to rank works per rupee (Clause 11.8.4(e)). The BSMP shall state how damages beyond the 0.2% AEP and below the 50% AEP were treated.

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## Annex 11D — BSMP data and model publication standard

Supports Clauses 11.5.1 and 11.10 of Chapter 11, and Clause 10.17 of Chapter 10.

### 11D.1 What is published, and when

**Table 11D.1 — Items to be published**

| Item | Format | At draft (Clause 11.10.1) | At approval (Clause 11.10.2) |
|---|---|---|---|
| BSMP report, with the level-of-service assessment and options | Searchable PDF | Yes | Yes, final |
| Flood hazard maps: extent, depth, velocity, hazard class, for each AEP and scenario of Clause 11.8.4(a) | GeoTIFF rasters; extents also as GeoPackage polygons | Yes | Yes |
| Capital Improvement Programme | CSV and PDF | Draft | Yes |
| Basin release rates, recommended flood-sensitive catchments, regional facility sites, fee-in-lieu unit rate | GeoPackage and CSV | Yes | Yes |
| Data of Table 11.1 (terrain, drains, waterbodies, cross-sections, river, reservoir and pokhari levels, post-2023 river beds, GLOF corridors, slope and debris hazards and outfall structures, rainfall and levels, flood evidence, land use, soils and groundwater, sewer interaction) | GeoTIFF (terrain); GeoPackage (features); CSV (tables and time series) | Summary | Yes, except security-sensitive asset details |
| Model files: native, runnable, with all boundary-condition, rainfall and control files, the software name and version, and a run log | Native format, zipped | No | Yes |
| Calibration and validation report | Searchable PDF | Yes | Yes |
| Consultation log of comments and responses | PDF or CSV | — | Yes |

## 11D.2 Formats and references

- (a) Raster data shall be GeoTIFF, preferably cloud-optimised, with the cell size stated. Vector data shall be GeoPackage. Tables and time series shall be CSV in UTF-8, with a header row and units in the column names.
- (b) Horizontal and vertical references shall be as in Annex 10B.1(b) and (c). The vertical datum and its relationship to the Chapter 5 river datums of the CWC level-monitoring sites on the Teesta, the Rangit and the Rongni Chu, Khanitar, Melli, Singtam and Majitar among them (not stated in any source found [TBC]), of the reservoir levels of NHPC and the other hydropower operators (not found [TBC]), and of the flood marks of October 2023 and the post-2023 river beds surveyed at the outfalls and on ungauged kholas, jhoras and pokharis shall be stated in every data set that carries levels.
- (c) Times shall be in Indian Standard Time, written as ISO 8601 (yyyy-mm-ddThh:mm+05:30). Units shall be SI.
- (d) Hazard map files shall be named `<basin>_<scenario>_<AEP>_<variable>.tif`, where scenario is a to e of Clause 11.7.4, AEP is written as 50, 10, 1 or 0p2, and variable is depth, velocity, hazard or extent; for example `rani-khola_d_1_depth.tif`.
- (e) Waterbody data shall use the fields of Annex 7A. Facility and outfall data shall use the fields of Annex 10B.

## 11D.3 Metadata

Every published data set shall carry: title; description; Lead Authority; source and method; date of capture; accuracy (for the DEM, the measured vertical RMSE); horizontal and vertical reference; scenario and AEP, where relevant; BSMP version; licence; and a contact.

## 11D.4 Withholding and personal data

- (a) Security-sensitive details of critical assets may be withheld, with the reason recorded and published (Clauses 10.17.3, 11.10.2). The flood hazard maps and the model shall still be published; only the sensitive attributes are removed.
- (b) Personal data shall not be published (Clause 10.17.3). Flood evidence collected from residents shall be published without names or contact details unless the person consents.

### 11D.5 Licence, viewer and versions

- (a) Published data and models shall be released under the Government Open Data Licence – India or an equivalent open licence (Clause 10.17.4).
- (b) The hazard maps, regional facility sites and CIP shall also be shown on a public map viewer (Clause 11.10.2).
- (c) Each approved BSMP shall carry a version number and date. Superseded versions shall stay available, marked as superseded, so that designs approved under them can be checked.
- (d) The published model package shall allow a third party with the stated software version to reproduce the published results. Designers may use its boundary conditions for site designs in the basin (Clause 11.10, Commentary).

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## Form 11-1 — Annual implementation report

Supports Clause 11.11.3 of Chapter 11, with Clauses 4.5.6.3 and 4.13.4 of Chapter 4.

*Draft form — Sikkim Stormwater Design Manual, Draft v1.0.* Published by the Lead Authority for each basin with an approved BSMP before each monsoon season, by **31 March** (Clause 11.11.3).

### Table 11F.1 — Form 11-1, Section A: Basin and plan

| No. | Field | Entry |
|---|---|---|
| A1 | Basin; Lead Authority; partners | _____ |
| A2 | BSMP version and date of approval | _____ |
| A3 | Reporting year (1 April to 31 March) | _____ |
| A4 | Date of publication (by 31 March) and web address | _____ |

### Table 11F.2 — Form 11-1, Section B: CIP progress

| CIP rank | Work | Agency | Cost in CIP (₹) | Spent this year (₹) | Spent to date (₹) | Status | Expected completion |
|---|---|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

### Table 11F.3 — Form 11-1, Section C: Fee-in-lieu ledger (Clauses 4.5.6.3(c) and 4.13.4)

| Regional facility or tank | Volume credited to sites (m³) | Volume delivered (m³) | Fees received (₹) | Fees spent (₹) | Fees held, with year received |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| Basin total: volume owed and delivered | _____ | _____ | _____ | _____ | _____ |

### Table 11F.4 — Form 11-1, Section D: Maintenance completed (Clause 11.8.4(f))

| No. | Item | Planned | Done | Date completed |
|---|---|---|---|---|
| D1 | Desilting of drains and canals (length, km; volume, m³) | _____ | _____ | _____ |
| D2 | Tank and pokhari desilting and restoration (tanks, number; storage restored, m³) | _____ | _____ | _____ |
| D3 | Gate tests (number of gates) | _____ | _____ | _____ |
| D4 | Pump station duty tests (number of stations) | _____ | _____ | _____ |
| D5 | Tank operating rules reviewed with the custodian (number) | _____ | _____ | _____ |
| D6 | Monitoring added: rain gauges, level sensors, flood-mark points (Clause 11.8.4(g)) | _____ | _____ | _____ |

### Table 11F.5 — Form 11-1, Section E: Flooding against the levels of service

| Event (dates) | Rainfall compared with the design depths (Clause 10.16.2(a)) | Level-of-service element (Table 11.2) | Location | Met (yes / no) | Event report reference (Clause 10.16.2) |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |

### Table 11F.6 — Form 11-1, Section F: Review triggers and sign-off

| No. | Field | Entry |
|---|---|---|
| F1 | Event exceeding the 1% AEP design depth in the basin this year (yes / no). If yes, review due within 2 years (Clause 11.11.2) | _____ |
| F2 | Statutory land-use plan revised this year (yes / no) (Clause 11.11.2) | _____ |
| F3 | Next 10-year review due (date) | _____ |
| F4 | Officer of the Lead Authority: name, designation, signature, date | _____ |