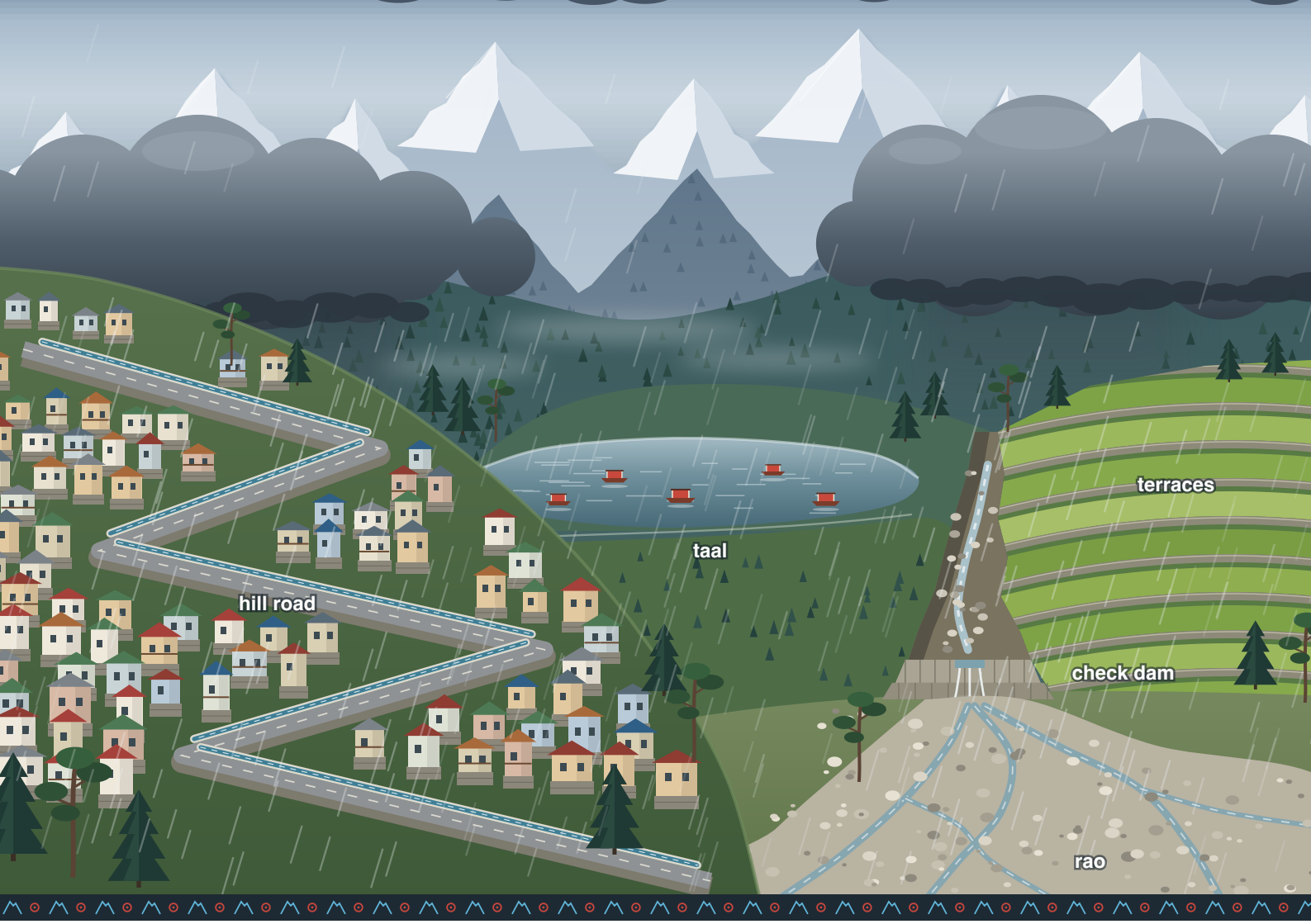
UTTARAKHAND

Stormwater Design Manual

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



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Prepared by

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About this draft

Status. This is Draft v1.0 of the *Uttarakhand Stormwater Design Manual*. It was prepared by Neer as a proposed stormwater design standard for Uttarakhand.

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Uttarakhand or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Housing Department (Awas Vibhag) or its Town and Country Planning Department (T&CP), the Urban Development Department or its Directorate (UDD), the Irrigation Department, the Mussoorie Dehradun Development Authority (MDDA), the Haridwar Roorkee Development Authority (HRDA), the Uttarakhand Housing and Urban Development Authority (UHUDA), any district-level development authority, the Dehradun Municipal Corporation (DMC) or any other Municipal Corporation (Nagar Nigam), Nagar Palika Parishad, Nagar Panchayat or other local body, or any other agency. Where it names a body, such as the Revenue Department, the Public Works Department (PWD), Uttarakhand Peyjal Nigam, Uttarakhand Jal Sansthan, the Uttarakhand Urban Sector Development Agency (UUSDA), Dehradun Smart City Limited (DSCL), the Lake Development Authority at Nainital, the Uttarakhand Environment Protection and Pollution Control Board (UKPCB), the Uttarakhand State Wetland Authority, the Spring and River Rejuvenation Authority (SARRA), the Uttarakhand State Disaster Management Authority (USDMA), the Uttarakhand Landslide Mitigation and Management Centre (ULMMC), the State Mission for Clean Ganga, a District Magistrate acting as Flood Zoning Authority, a district administration, a dam or barrage operator such as THDC India Limited (THDC) or Uttarakhand Jal Vidyut Nigam (UJVN), or a body of the Union, such as the Central Water Commission (CWC), the Central Ground Water Board (CGWB), the India Meteorological Department (IMD) or the National Mission for Clean Ganga (NMCG), it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. The Uttarakhand Building Construction and Development Bye-laws/Regulations, 2011 (Amendment 2015) as amended, the Unified Zoning Regulations, 2025, the master plans and their approval conditions, notifications under the Uttarakhand Flood Plain Zoning Act, 2012, the Government Orders on the banks of the Ganga, drainage schemes, orders of courts and tribunals and approval conditions in force continue to apply.

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

- Uttarakhand was part of Uttar Pradesh until 9 November 2000, and was called Uttaranchal until 2007; Acts adapted in its first years keep that name. Older sources, including the CWC flood estimation reports for zone 7 (1994) and subzone 1(e) (1984), the National Institute of Hydrology's water balance of Nainital lake (1998–99) and IMD's station lists, name its districts as districts of "Uttar Pradesh" or "U.P.". The district map has also changed: Saharanpur district included Hardwar until 1988; Nainital included today's Udham Singh Nagar until 1995; Garhwal is now Pauri Garhwal; Almora included Bageshwar and Champawat; and Chamoli included part of Rudraprayag. IMD and CWC sources, and the rainfall data in this Manual, use the districts of their time, and a clause that names a district must be checked against the current list;
- **Haridwar** is written **Hardwar** in IMD's tables and many older sources, and IMD's gauge of the 1880 record is Hardwar (Hydro); **Dehradun** is also Dehra Dun; **Joshimath** was renamed **Jyotirmath** in 2023, and its IMD and CWC stations and most sources, including those on its subsidence, keep the old name; **Mukteshwar** is Mukteswar on IMD's observatory, **Lansdowne** Landsdown, **Kichha** Kitchha, **Banbasa** Bambasa, **Ukhimath** Okhimath, **Devprayag** Deoprayag, **Kotdwara** Kotdwar, **Munsiari** Munsiyari, the **bhabar** bhabhar and the **terai** tarai. The **Sarda** is also the Sharda and, on the Nepal border, the Mahakali or Kali; the **Gaula** is also the Gola; and the **Kosi** in this Manual is the river of Almora and Ramnagar in Kumaon, not the larger river of that name further east;

- **Raipur** in this Manual is the IMD raingauge and the area of that name on the eastern edge of Dehradun, towards Maldevta, where 487.5 mm fell on 2 August 1959; it is not Raipur, the capital of Chhattisgarh. **Rajpur**, the raingauge at the foot of the Mussoorie hills north of the city (440.4 mm on 25 August 1954), is a different station. Dehradun also has an IMD observatory (42111), with records from 1901, and self-recording raingauges whose short-duration maxima are printed in the CWC report for zone 7. This Manual names the station each figure comes from;
- CWC's **zone 7** ("Western Himalayas", report No. WH/22/1994, titled "J & K Kumaon Hills" in CWC's list of subzones) and **subzone 1(e)** ("Upper Indo-Ganga Plains", 1984) are the two hydrometeorological regions of the CWC flood estimation reports that cover the State. Their boundary runs along the Siwalik front: Dehradun, Doiwala, Rishikesh, Mussoorie and the hills are in zone 7; Haridwar, Roorkee, Kotdwara and the bhabar and terai of Kumaon, with Haldwani, Kashipur and Rudrapur, are in 1(e); Kathgodam is on the line. Neither report names Uttarakhand, which did not exist when they were written. They are not the three rainfall zones (UK-Z1 to UK-Z3) and six hydrologic sub-areas (UK-A to UK-F) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7, nor the prohibited and restricted areas of the Flood Plain Zoning Act;
- where a shared clause names the State's main city or its municipal corporation, this Manual names **Dehradun**, the seat of the State Government, and the **Dehradun Municipal Corporation (DMC)**, Nagar Nigam Dehradun. **MDDA** is the Mussoorie Dehradun Development Authority, into which Rishikesh was merged in 2019; **HRDA** is the Haridwar Roorkee Development Authority; and **UHUDA**, the Uttarakhand Housing and Urban Development Authority, is the State-level authority to which the funds, assets and liabilities of the former regulated areas were transferred. District-level development authorities, such as that of Haldwani–Kathgodam, were constituted in 2016–17;
- the State has five belts, broadly from south to north. The **Ganga alluvium** of southern Haridwar district; the **terai**, 8–25 km wide, where the water that sank into the fans above emerges along a spring line, with water within 1–7 m of the ground and more than 2,000 artesian wells; the **bhabar**, 4–20 km wide, a belt of coalesced boulder fans at the foot of the hills where the streams sink and the water table lies 40–75 m down, and the State's main recharge zone; the **Siwalik** hills; and, behind them, the **Doon** (Dun), the valley between the Siwalik and the Mussoorie ridge, floored by the **Doon Gravels**, a deep fill of boulders and pebbles in a sandy and silty matrix. North of these rise the Lesser and Great Himalaya, whose **outer ridge** (Mussoorie, Nainital, Lansdowne) takes the monsoon head-on and whose **inner valleys** (Tehri, Srinagar, Uttarkashi, Pithoragarh) lie in its rain shadow. **Garhwal** and **Kumaon** are the State's two divisions, west and east. The names describe regions, not administrative units, except where a district bears the same name;
- the hills have their own names for water, from the hill dialects of Garhwali and Kumaoni. A **taal** (ताल) is a lake or tank that holds rainwater, as in Nainital, Bhimtal, Sattal and Naukuchiatal; this Manual uses it as its general term for lakes and ponds, and *talab* (तालाब) in the plains. A **khal** (खाल) is a small rain-fed pond or recharge depression on a hill, often in the saddle between two crests; the word also means a saddle in place names, such as Dwarikhal, and in Dehradun court records *khala* is a seasonal storm channel, so this Manual always glosses it. A **naula** (नौला) is a covered, stepped tank that collects water from a spring, and a **dhara** (धारा) a spring spout; the bye-laws call both "underground water sources", and *dhara* also means a section of an Act. A **gadhera** (गधेरा) is a small hill stream that flows in the rains, and a **gad** (गाड़) a hill river or torrent, as in Kheer Gad. In the Doon a **rao** (राव; also *rau*) is a seasonal torrent with a bed of boulders, such as the Bindal Rao, the Sitla Rao and the Rawli Rao; in the hill dictionaries *rau* is a pool in a stream, and the Doon sense comes from use, not from a dictionary; and
- many levels and flows in the sources are not in metric or not on a stated datum. The levels of the **Naini lake** are read in feet on the PWD gauge at Tallital, and must be converted to metres above mean sea level before use; flows at barrages are often given in **cusecs** (cubic feet a second; 1 cusec = 0.0283 m³/s), as at the Gaula barrage at Kathgodam, designed for 115,000 cusecs (about 3,250 m³/s), which passed 123,000 cusecs in 1993. CWC's levels for its sites in the State were read only in transcriptions by SANDRP, which also give two values for some sites: the highest flood level of the Ganga at Haridwar, 296.30 m, is dated 19 September 2010 in one transcription and 17 June 2013 in another, and that of the Kosi at the Ramnagar barrage in October 2021 is given as 220.75 m and as 220.95 m. No source read states the datum of these levels, and they are quoted as reported [TBC].

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 **Uttarakhand Building Construction and Development Bye-laws/Regulations, 2011** (the **Bye-laws 2011**) are Uttarakhand's own building rules, made by the Housing Department under s.57 of the **Uttar Pradesh Urban Planning and Development Act, 1973**, which the State inherited from Uttar Pradesh in 2000 and amended in 2013; the notifications render the Act's name in three ways. The rules in force are the Bye-laws 2011 (Amendment 2015), amended piecemeal since; the amendments of 27 September 2022, 13 March 2023 and 10 January and 13 June 2024 were read, and only the filling-station rule of 10 January 2024 touches water. A comprehensive "Amendment 2017" exists only as a draft, on which MDDA invited suggestions until February 2018. Each development authority adopts the bye-laws and each amendment through its board. The text read for this Manual is a compilation of the bye-laws with their amendments of 2015 to 2019, which MDDA's website labels a draft; Uttar Pradesh's own building bye-laws do not apply in Uttarakhand;
- a **Municipal Corporation** (Nagar Nigam) is constituted under the Uttar Pradesh Municipal Corporation Act, 1959 as adapted by the Uttaranchal (Uttar Pradesh Municipal Corporation Act, 1959) Adaptation and Modification Order, 2002, and a **Nagar Palika Parishad** or **Nagar Panchayat** under the Uttar Pradesh Municipalities Act, 1916, with its Uttaranchal Amendment of 2002. Their Uttarakhand texts, and their chapters on drains, were not read for this Manual [TBC]. All three are urban local bodies (ULBs) under **UDD**. The CAG counted 91 ULBs in 2021, eight of them Municipal Corporations; there are now 11, taken to be Dehradun, Haridwar, Haldwani, Rudrapur, Kashipur, Roorkee, Rishikesh, Kotdwara, Srinagar, Pithoragarh and Almora [TBC]. The Uttarakhand Special Provisions for Urban Local Bodies and Authorities Act, 2018 bars the eviction of settlements that existed before 11 March 2016, and was reported extended by an amendment of 2025;
- the **Housing Department** issues the bye-laws and the **Unified Zoning Regulations, 2025** (UZR; notification No. 568 of 20 November 2025, under s.8(2) of the 1973 Act), which **T&CP** prepared, and oversees the development authorities and UHUDA; the development authority, or the ULB outside its area, grants building permission;
- the **Irrigation Department** holds the rivers and the flood works and is the nodal agency for floodplain zoning under the **Uttarakhand Flood Plain Zoning Act, 2012** (Uttarakhand Act No. 07 of 2013). The Act is applied river by river: the Irrigation Department maps the 25-year and 100-year flood lines, the **Flood Zoning Authority**, usually the District Magistrate, notifies them, and land inside the 25-year line becomes a prohibited area and land between the two lines a restricted area. The Irrigation Department is also preparing drainage master plans for Haldwani and other towns of Kumaon, as reported, and is named in this Manual as the State groundwater agency, because the Uttarakhand Ground Water (Regulation and Control of Development and Management) Act, 2016 was repealed in 2017 and no groundwater law is in force;
- the **PWD** keeps the State's roads and their roadside and hill-road drains; **Uttarakhand Peyjal Nigam** builds sewers, treatment plants and the interception and diversion (I&D) of drains, and **Uttarakhand Jal Sansthan** runs them; **UUSDA** carries out the urban projects funded by the Asian Development Bank (ADB), including the storm drains of Dehradun; and **DSCL** is the company of the Smart Cities Mission in Dehradun;
- **USDMA** is the State's disaster management authority, and **ULMMC** its centre for landslides; no founding instrument of ULMMC was found. The **Uttarakhand State Wetland Authority** was constituted by a letter of 16 October 2019; the national atlas lists 192 wetlands in the State, and no wetland notified under the Wetlands (Conservation and Management) Rules, 2017 was found. **SARRA**, for springs and rivers, was reported constituted in May 2025; no order constituting it was found. The **Lake Development Authority** at Nainital acts against unauthorised building around the lake; its instruments were not read; and
- a **tehsil** is the revenue subdivision of a district, under a Tahsildar. River beds outside municipal limits are recorded as forest land, as the High Court noted in 2022.

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;
- DMC is the Dehradun Municipal Corporation. DM is the District Magistrate, who is also the Collector and, under the Flood Plain Zoning Act, usually the Flood Zoning Authority; disaster management is written in full;
- HFL is the highest flood level recorded at a gauge, as CWC uses it. It is not a design level, and sources sometimes give different values for the same gauge. At several CWC sites in the State the transcribed HFL is below the warning level, and such rows are not used without CWC's site sheet. WL and DL are CWC's warning and danger levels;
- FRL (full reservoir level) and MWL (maximum water level) are used for reservoirs and barrage ponds, such as Tehri (FRL 830 m, MWL 835 m); the "maximum fixed level" of a lake is the bye-laws' term;
- FPZ is the Flood Plain Zoning Act, 2012, or a zone notified under it; the "25-year line" and the "100-year line" are the limits of its prohibited and restricted areas; and
- SWD is a storm water drain.

The sense is clear from the context. Hindi, Garhwali and Kumaoni terms used in the text, such as *taal*, *khal*, *naula*, *dhara*, *gadhera*, *gad* and *rao*, and also *gul* (गूल, an irrigation channel dug along the contour), *simar* (सिमार, a marshy tract fed by groundwater), *sera* (सेरा, irrigated fields on a valley floor), *chal-khal* (the traditional practice of building small rain-fed ponds on the hills), *nala* (नाला, a natural drain or large storm drain), *nali* (नाली, a small street drain) and *talab* (तालाब, a pond or tank in the plains), are explained where they first appear.

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

Uttarakhand's towns flood, and fail, for three reasons. Dehradun showed the first on 25 July 1966, when its observatory recorded 487.0 mm in a day, far more than the 100-year day on the national maps, on a valley whose drains are designed for a 2-year storm where any storm is stated; Joshimath showed the second in the winter of 2022–23, when the town subsided and an expert committee named inadequate drainage and sewerage among the causes, as reported; and the Rispana shows the third, a river of Dehradun whose bed is lined with houses and whose drains carry sewage, and which only in May 2025 had its floodplain notified.

1. **The outer Himalaya meets the monsoon head-on, with days far above the national maps and bursts of an hour on steep catchments, where drains fail by debris and blockage before they fail by capacity.** The Bay depressions that bring the monsoon reach the State weakened, about 1,300 km from the coast, but where they and the western disturbances meet the first ridges of the Himalaya the rain is among the heaviest in north India. The days recorded on those ridges exceed the 100-year values that the CWC flood estimation reports map for them: Hardwar (Hydro) recorded 495.3 mm on 18 September 1880, the State's record, against about 280–320 mm on the map; Raipur, on the edge of Dehradun, 487.5 mm on 2 August 1959 and the Dehradun observatory 487.0 mm on 25 July 1966, against about 320–360 mm; and Rajpur 440.4 mm in 1954, all within about 10 km of one another. On 18–19 October 2021, after the monsoon had withdrawn, Pantnagar recorded 403.9 mm, Nainital 401 mm and Mukteshwar 340.8 mm in a day, against previous records of 228, 313.7 and 254.5 mm, as reported; the Gaula bridge at Haldwani partly collapsed and the Naini lake overflowed. Short bursts are as severe: Dehradun's self-recording gauge recorded 98 mm in one hour on 14 June 1970 and 143 mm in three hours, and Uttarkashi 100 mm in one hour in 1979. On 16 September 2025 IMD's centre at Dehradun recorded 26 cm at Sahastradhara in the 24 hours to 08:30, and the press reported 264 mm with 54 mm in one hour; IMD said the storm was not a cloudburst. In Dehradun district 13 bridges, 10 culverts and 21 roads were lost and at least 30 people died, as reported, and 83 of the structures that intercept the drains of the Rispana and the Bindal were damaged. On slopes of 10–60% a street drain fills in minutes, and it fills with stones, gravel and debris as well as water: a drain or culvert that is blocked by boulders or buried by a slip fails long before its capacity is reached. The only design basis found for any drain in the State is that of the drains built in Dehradun with ADB funding: "a storm frequency of once in 2 years" for roadside drains and "once in 5 years" for primary and secondary channels, with no allowance for climate change. In the high valleys the largest disasters were not floods that a drain could carry: the Kedarnath flood of June 2013 followed 325 mm in 24 hours at Chorabari glacier and the breach of the lake below it; the Raini flood of 7 February 2021 was a rock and ice avalanche of about 27 million m³ with no rain; and the debris flow that buried Dharali on 5 August 2025 came when the gauge at Harsil recorded 0.8 cm. Such events set where towns may build, not how their drains are sized.
2. **Hill towns built on colluvium and old slides, where water put into the ground can move the ground.** Nainital's slopes are colluvium and old slide debris, and after about 33 inches of rain in three days a landslip on 18 September 1880 killed about 151 people, as reported; the drains built after it still carry the town's runoff to the lake. Below the lake the Balia Nala, its outlet, slides because the perched groundwater in its slopes is recharged by the drains and wastewater of the catchment, which raises the pressure of the water in the soil and lowers its strength. At Joshimath, a town built on moraine, studies quoted after the subsidence of 2022–23 named "internal erosion caused by the subsurface drainage, which may be due to infiltration of rainwater/melting of ice/waste water discharge" and said it "can be minimized by controlling infiltration of water"; a committee had asked in 1976 for its open drains and soak pits to be closed, as reported, and about 1,403 of 2,152 houses were reported affected. The bye-laws forbid building on slopes steeper than 30° (26.5° in Nainital) or within 250 m of a site prone to landslides, and require a site plan on a slope to divert the water that comes from uphill away from the foundations, but no rule restricts soak pits or recharge pits on slopes, and the rainwater harvesting rule rewards a recharge pit on any plot of more than 400 m² by cutting the storage required to one-third. The plains habit of recharging everywhere must therefore be reversed on the slopes. It holds on the Doon Gravels, whose hydraulic conductivity is 13–583 m a day, and on the bhabar, whose water table lies 40–75 m down, as deep as 173.71 m at Bhotia Parao near Haldwani: these are the State's recharge zones, and the bhabar feeds the artesian aquifers

of the terai, whose zone of free-flowing wells has receded by about 5–7 km in the east as the bhabar has been cleared and built over. Haldwani, Kashipur and Bahadrabad and Bhagwanpur in Haridwar district are the State's semi-critical blocks. In the hills, the springs that supply 70–87% of the water in some blocks are failing: the working springs of the Almora region are reported to have fallen from 360 to 60 over 150 years, and the National Institute of Hydrology (NIH) estimated that about half the subsurface recharge of the Naini lake enters through the 2 ha bed of the Sukhatal, on which the High Court stopped construction in 2022.

3. **Rivers and raos encroached and laden with sewage, a floodplain law notified on only some reaches, and no design storm.** Dehradun's rivers, the Rispana, the Bindal, the Song, the Suswa and the Tons, are seasonal, boulder-laden and ungauged, and they are also the city's trunk storm drains and, until intercepted, its sewers. In 2022 the High Court, in *Urmila Thapa*, recorded 37.93 ha of encroachment on river beds in Dehradun tehsil and 57.4 ha in Vikasnagar; in 2025 the National Green Tribunal (NGT) recorded 89 encroachments on the Rispana in the Municipal Corporation's area and 413 in MDDA's; and in 2026 NMCG counted 330 structures in the Rispana's 5-year flood zone. Of the 208 drains that reach the Rispana, 187 have been intercepted and diverted to treatment plants, but the floods of September 2025 damaged 83 of the interception structures; statewide, CPCB counted 70 of 200 monitored drains as untapped in 2025, and listed the Rispana, the Bindal Rao, the Rambha at Rishikesh and the Kalyani at Rudrapur as "rivers reported as drains", as quoted. The Flood Plain Zoning Act gives the State a working floodplain law, but it has been finally notified on 614.6 km of five rivers of the Ganga system in the hills and on the Rispana (5 May 2025), and the Asan was reported approved in June 2025; the studies of the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani are done but not notified, and an amendment of 2024 allows a notified floodplain to be reduced where "riverbank development" can protect the land behind it. Of the drains themselves, no State or municipal standard states a design storm, and the 2-year and 5-year rule of one project in Dehradun is the only basis in use.

Behind all three lie the State's lakes, springs and reservoirs, which set the level at the outfall. The Naini lake is a closed basin: every drain of Nainital discharges to it, and it discharges through five sluice gates at Tallital, installed in 1888 and worked by rules of the Hill Slide Committee of 1927 that limit their opening to protect the Balia ravine below; the maximum lake level is 12.5 ft on the PWD gauge (12 ft in the press), and the sluices are sealed on 15 October. In October 2021 the lake reached a record of about 12.2 ft and overflowed, as reported. Upstream the Bhagirathi is held by the Tehri dam (FRL 830 m, MWL 835 m), and below the hills the Ganga by the barrages at Pashulok and Bhimgoda, the Yamuna by the Dakpathar barrage and the Asan by its barrage, whose wetland, 444.4 ha, became the State's first Ramsar site on 21 July 2020. The Unified Zoning Regulations of 2025 put every river and waterbody in the revenue records, including ponds, lakes, nalas and streams, in a conservation zone with no new construction within 30 m of river and lake banks, but no wetland in the State has been notified, and no statute protects a spring.

Design for Uttarakhand therefore has to cover a monsoon that reaches Dehradun about 20 June and Roorkee about 28 June and withdraws about 25–27 September, with the State clear by about 1 October under IMD's new normals, but whose largest storms in Kumaon came in October (9 October 1956 and 18–19 October 2021); about 78% of the year's rain falls from June to September and 9% in winter, from western disturbances, which have brought days of 192.0 mm at Mukhim (20 February 1979) and 210.0 mm at Naitwar (10 February 1986), and snow in January. The State's normal is 1,326.1 mm a year, but the gauges range from 2,588.1 mm at Askote, 2,464.5 mm at Nainital and 2,238.3 mm at Dehradun on the outer ridge to 925.5 mm at Joshimath and 494.7 mm at Srinagar in the rain shadow. Underground, the State draws about half of its extractable groundwater (53.54% in 2024), and none of its assessed units is critical, but the hard-rock hills, 85% of its area, are not assessed at all; in the samples of 2024, nitrate exceeded 45 mg/L in 17.39%, and arsenic exceeded 10 ppb in 3.86%, in Almora, Haridwar and Udham Singh Nagar, which limits what may be recharged.

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

- hold frequent rainfall on site, in the ground where the ground can take it and in tanks where a slope cannot;
- 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 rao, gadhera, river, taal or reservoir is high, when a barrage or dam upstream is releasing, or when a drain is choked with debris.

The Manual also sets how public drains, hill roads and their drains, raos, gadheras, rivers, taals, reservoirs and springs, outfalls and basin-wide master plans are designed, and how drains in steep catchments are protected against debris and sediment, 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 Uttarakhand's south-west monsoon from late June to the end of September, with its storms against the outer ridge, its late storms in October and its western disturbances in winter; to the Ganga and its headwaters, the Bhagirathi, the Alaknanda and the Mandakini, under the Tehri and Koteshwar dams and the barrages at Pashulok and Bhimgoda; to the Yamuna, the Tons and the Asan under the Dakpathar and Asan barrages; to the raos of the Doon, the Song, the Suswa, the Rispana and the Bindal; to the Gaula, the Kosi, the Ramganga and the Sarda in Kumaon, under the barrages at Kathgodam, Ramnagar and Banbasa; to the Doon Gravels, the boulder fans of the bhabar, the wet terai, the Ganga alluvium, the Siwalik and the colluvium, slide debris and moraine of the hills; to the taals of Kumaon, the naulas and dharas and the khals; and to towns whose roads and stepped houses lie across the natural lines of drainage on the slopes.

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 two CWC *Flood Estimation Reports* that divide the State at the Siwalik front, as the interim source: the report for zone 7, Western Himalayas (1994), for the Doon and the hills, and the report for subzone 1(e), Upper Indo-Ganga Plains (1984), for Haridwar–Roorkee and the bhabar and terai of Kumaon and Garhwal. The zone 7 report rests on only six gauged catchments, about 1% of the zone, of which one, the Suswa, is in the State; it warns against using its relations without checking them, and does not apply them to snow-fed catchments, which this Manual leaves to site-specific study with a screening for debris flows and glacial lake outbursts. Its ratio of the 1-hour to the 24-hour rain, 0.425, is the highest in the series: it fits the bursts recorded in the Doon and the inner valleys, where this Manual uses it, but gives more than twice the largest hour recorded at Nainital, so on the outer-ridge hill stations this Manual applies the ratios of the 1(e) report to the zone 7 maps. It does check the design day against the largest reliable days recorded nearby, which exceed the maps in the Doon and at Haridwar. IMD's national set of rainfall intensity curves (Das et al., 2022) has a panel for Dehradun, but it repeats the generic curve printed for many other cities and is not Dehradun data; an equation for the northern region gives Dehradun a 2-year day of about 63 mm, against 152 mm from the station's own record, and is not used; and frequency analysis of gridded rainfall by NIH, Roorkee, is used for comparison only in the plains, since in the high valleys it gives 1-hour falls of a tenth of the day.
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 Uttar Pradesh Urban Planning and Development Act, 1973 as applicable in Uttarakhand; the Bye-laws 2011 (Amendment 2015) as amended, applied by the development authorities, UHUDA and the ULBs; the Unified Zoning Regulations, 2025; the Uttarakhand Flood Plain Zoning Act, 2012 and the notifications under it; the Housing Department's Government Order of 29 November 2017 on the banks of the Ganga in the hills, as revised on 1 June 2023; the Uttar Pradesh Municipal Corporation Act, 1959 and the Uttar Pradesh Municipalities Act, 1916, as adapted; the Doon Valley notification of 1989 and the Bhagirathi eco-sensitive zone of 2012 under the Environment (Protection) Act, 1986; the Wetlands (Conservation and Management) Rules, 2017; the Ganga Authorities Order of 2016; and the orders of the High Court of Uttarakhand and the NGT on rivers, lakes, encroachment and sewage. This Manual follows them or, where disclosed, makes them stricter. The bye-laws were read in a compilation of their amendments of 2015 to 2019, not in their gazetted text, and the printed setbacks of bye-law 4.4 are read as single distances; four amendments of 2022–2024 were read, others only by

title, and none of them adds a rule on detention, drainage design or flood-prone land. The amendment of 2024 to the Flood Plain Zoning Act was seen only as quoted, the Rules approved by the cabinet on 12 October 2026 were not found, and the final notification for the Rispana was not read. The Municipal Acts were not read in their Uttarakhand form, and the Doon Valley and Bhagirathi notifications were not opened. The Ground Water Act of 2016, repealed in 2017, is not relied on. Every rule cited must be checked against the current text.

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 Uttarakhand 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.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. IMD's 2022 national set of rainfall intensity curves has one panel for the State, Dehradun, and it repeats the curve printed for many other cities. The two CWC reports that cover the State date from 1984 (subzone 1(e)) and 1994 (zone 7); they take the 1-hour rain as 0.34 (1(e)) and 0.425 (zone 7) of the 24-hour rain, which gives a 50-year hour of about 95 mm at Haridwar, 119–136 mm at Dehradun, 136–150 mm at Haldwani and more than 187 mm at Nainital, where the largest hour on the self-recording gauge was 79 mm; the largest hour on Dehradun's self-recording gauge is 98 mm (1970) and Uttarkashi's 100 mm (1979). At the other end their maps are exceeded at gauges: Dehradun recorded 487.0 mm in a day where the map gives a 100-year day of about 320–360 mm, Hardwar 495.3 mm against about 280–320 mm, and Pantnagar 403.9 mm against a 50-year day of about 280–320 mm. The reanalysis grids of NIH-DHAARA err both ways: they give a 50-year day of about 400 mm at Kashipur and Rudrapur, above the maps' 280–320 mm, and a 50-year hour of 24 mm at Joshimath and 32 mm at Kedarnath, where Uttarkashi has recorded 100 mm.

Uttarakhand has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of UDD, the Housing Department, the Irrigation Department, DMC or any other Municipal Corporation that fixes a return period or a design rainfall for city storm drains. The storm drains built in Dehradun with ADB funding, at least 117 km, were designed for a 2-year storm in roadside drains and a 5-year storm in primary and secondary channels, with a minimum drain of 250 × 250 mm, velocities of 0.6–3.0 m/s and outfall inverts above the highest flood level of the receiving water; their designs "do not include an allowance for climate change", and the project's own climate risk assessment recommends drains that carry "10-20% more flow". The CAG found in 2025 that Dehradun's Smart City drainage work made no provision for storm water reuse, for which the Smart City plan had provided. The Irrigation Department is preparing drainage master plans for Haldwani, at a reported ₹1,003 crore, and for other towns of Kumaon; no design storm for them has been published. These are projects, not a State standard. This Manual is

offered as a technical companion to the bye-laws, the Unified Zoning Regulations, the Flood Plain Zoning Act and the Municipal Acts: it supplies the design storm, detention, slope, water-level and buffer values that they leave open. It has not been adopted by UDD, the Housing Department or any other body. In particular:

- **The bye-laws require setbacks and rainwater harvesting, but not detention.** Bye-law 6.5 makes rainwater harvesting mandatory where the ground coverage is 125 m² or more, except in waterlogged areas, with storage of 2.0 m³ up to 250 m² of coverage, 3.5 m³ up to 400 m² and 0.5 m³ more for every further 50 m²; on plots of more than 400 m² that provide recharge, one-third of that storage suffices. The storage holds about 8–16 mm of rain on the covered area. Bye-law 4.4(V)(b), which requires a site plan on a slope to divert the water coming from uphill away from the foundations, is the only clause on the runoff of a site. No rule requires on-site detention, limits peak runoff, sets "zero runoff" or deals with permeable paving, and the Ground Water Act of 2016, which let an authority order rainwater harvesting, was repealed in 2017;
- **The slope rules stop building, not infiltration.** Bye-law 4.4(IV) forbids building where the local slope exceeds 30° (26.5° in the Nainital municipal area) or landslides are likely to be severe and continuous, and requires a contour plan at 2 m intervals; the hills allow a single basement, only on plots of at least 2,000 m² with 18 m of frontage. No rule restricts soak pits, recharge pits or infiltration trenches on slopes, on slide debris or above a cut or retaining wall, and the storage discount of bye-law 6.5 for recharge applies on any site;
- **The setbacks are fixed distances, and two readings of the Ganga line conflict.** Bye-law 4.4(III) leaves 30 m from the bank of a river, 10 m from a spring and 30 m from a lake or the maximum fixed level of a natural reservoir free of any construction, and keeps building at least 5 m from the bank of a nala; the first two are printed "30.0–30.0" and "10.0–10.0" metres and are read as single distances [TBC]. The Unified Zoning Regulations repeat the 30 m. On the Ganga in the hills a Government Order of 2017, revised in 2023, prohibits building within 100 m of the middle of the river or the 25-year flood, whichever is more, and regulates the next 200 m, and yields to the Irrigation Department's floodplain notifications where they exist; for the reach from Haridwar downstream, the NGT's judgment of 2017 made 100 m from the edge of the river a no-construction zone until the floodplain is demarcated. No rule sizes a buffer along a gadhera or a rao by the flood it carries;
- **The floodplain law covers only some reaches.** Final notifications under the Flood Plain Zoning Act cover 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini, and the Rispana; the Asan was reported approved in 2025, and the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani wait on studies already done. The Act's 25-year prohibited and 100-year restricted lines are drawn by the Irrigation Department with HEC-RAS and marked on revenue maps; NMCG asked in 2025 for the 5-year line as well. In a restricted area the draft notification for Rishikesh (2020) required a plinth at least 1.00 m above the highest flood level; elsewhere the bye-laws require a plinth of only 0.45 m above the ground, and no rule bars basements in flood-prone land. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7); it does not replace any line that the State notifies or a court draws, and where such a line binds and is wider, it governs; and
- **No document sets the river, rao or lake level for which an outfall is designed.** CWC's levels for the Ganga at Haridwar (warning 293.0 m, danger 294.0 m, HFL 296.30 m) and Rishikesh and the Song at Satyanarayan were found only in transcriptions, with two dates for Haridwar's highest flood; Dehradun's raos are ungauged; and the level of the Naini lake is read on a gauge in feet whose datum was not found. Danger levels and highest flood levels are flood-warning levels and records, not design levels.

So each agency and each local body interprets the central manual its own way. DMC and the other Municipal Corporations, the Nagar Palika Parishads and Nagar Panchayats, MDDA, HRDA, UHUDA and the district development authorities, the Irrigation Department, the PWD, Peyjal Nigam and Jal Sansthan, UUSDA, DSCL, road agencies, their consultants and funding agencies fill the gaps differently. Two drains on the same road, built by different agencies, can be sized for different storms from different rainfall sources: the CAG found the drains of Dehradun's Paltan Bazaar divided between DSCL and the PWD. No rule divides the raos from municipal drains: in Dehradun a rao's bed is forest or revenue land, its flood zone is the Irrigation Department's, the interception of its drains is Peyjal Nigam's and the drains that reach it are the Municipal Corporation's. 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 three rainfall zones and six hydrologic sub-areas, with a checked station analysis to govern where one exists, the ratios of each CWC report where the records support them, and a check of the design day against the largest reliable days recorded nearby, such as Dehradun's 487.0 mm and Raipur's 487.5 mm; and, in the snow-fed catchments of the high Himalaya, site-specific hydrology with a screening for debris flows and glacial lake outbursts (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites (Chapter 4);
- a required tailwater check for outfalls to raos, rivers, taals and reservoirs, against a design river or lake level: CWC's levels where they exist, the maximum water level of a reservoir or barrage pond, the sluice rules of the Naini lake, and, on the ungauged raos and gadheras, surveyed flood marks and a 1% AEP study that allows for debris (Chapter 5);
- a design flood line, and corridors and setbacks along raos, gadheras, nalas and rivers and around taals and springs, proposed by this Manual for use where the Flood Plain Zoning Act has not drawn one, with the bye-laws' 30 m and 5 m lines wherever those are wider (Chapter 7);
- recharge first on the Doon Gravels and the bhabar, none in the terai where the water table rises within 1 m of the ground, and no deliberate infiltration on slopes steeper than 10°, on landslide or creep zones, on colluvium, slide debris or moraine, or above a cut slope or retaining wall, unless a geotechnical certificate allows it; protection of the recharge areas of springs and of the Sukhatal; and treatment where drains carry sewage (Chapter 8);
- debris racks and traps, allowances for sediment and blockage, energy dissipation in steep drains, and hill-road drainage that never discharges onto an unprotected slope (Chapters 6 and 9), with debris cleared before the monsoon and again by 15 October in the hill towns, and standby kept to 31 October for the late storms (Chapter 10); and
- basin-wide master plans, so that the agencies that share a basin plan together (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). A Municipal Corporation, a development authority, UHUDA or UDD 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); Government of Uttarakhand, Housing Department, Building Construction and Development Bye-laws/Regulations, 2011 (Amendment 2015–2019), compilation hosted by MDDA ("Draft Compiled ByeLaws Part I"), bye-laws 2.3, 2.41, 4.4, 5.1, 5.6, 6.4, 6.5 and Appendix-1; amendment notifications of 27 September 2022 (e-file 33107), 13 March 2023 (e-file 27020), 10 January 2024 (No. 180884) and 13 June 2024 (e-file 64586); draft Bye-laws/Regulations, 2011 (Amendment 2017), hosted by MDDA; Unified Zoning Regulations, notification No. 568/E.No. 92710 of 20 November 2025, chapter 11; Government Order No. 1995/V-2-2017-58(३TT0)/2014 of 29 November 2017 and letter of 1 June 2023 (e-file 46063) on the banks of the Ganga; Uttarakhand Flood Plain Zoning Act, 2012 (Uttarakhand Act No. 07 of 2013); Irrigation Department notification No. 1875/II(2)-2020-06(18)/2020 of 7 October 2020 (Ganga at Rishikesh, s.8) and notification No. 888/II(2)/2025 of 3 October 2025; Irrigation Department compliance report, Peyjal Nigam affidavit (December 2025) and NGT order of 18 August 2025 in NGT O.A. 417/2022 (Niranjan Bagchi v. State of Uttarakhand); NMCG and Nagar Nigam Dehradun affidavits (April 2026) in the same case; applicant's submission of 12 March 2026 in NGT O.A. 200/2014 (M.C. Mehta), quoting CPCB; High Court of Uttarakhand, Urmila Thapa v. State, WPPIL 58/2019 (August 2022), Ravi Shankar Joshi v. State, WPPIL 178/2013 (22 November 2019), Rajeshwari Yadav Gupta v. State, WPMS 739/2026 (1 April 2026), and reports of the Sukhatal order (2022); Uttarakhand Ground Water (Regulation and Control of Development and Management) (Repeal) Act, 2017 (Act No. 11 of 2017); Uttarakhand State Wetland Authority, Current Status Report of Wetlands in Uttarakhand (17 October 2025); CAG, Performance Audit on the Implementation of the 74th Constitutional Amendment Act (Uttarakhand, 2022), Chapter 1; CAG, Performance Audit of the Smart Cities Mission (Dehradun, 2025), Chapters 2 and 5; CAG Report No. 39 of 2017, Chapter 8; ADB, Uttarakhand Integrated and Resilient Urban Development Project (38272-044), Climate Risk and Vulnerability Assessment (October 2021) and resettlement plans (July and October 2022); CWC, Flood Estimation Report for Western Himalayas – Zone 7 (WH/22/1994) and Flood Estimation Report for Upper Indo-Ganga Plains

subzone 1(e) (1984), plates read by eye; CWC levels as transcribed by SANDRP (2022 and event posts of 2013, 2021 and 2023); IMD, Climate of Uttarakhand (Climatological Summaries of States Series No. 21); IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); IMD, Pai et al. (2020), new normal dates of onset and withdrawal of the south-west monsoon, Table 2; IMD Meteorological Centre Dehradun, Monsoon 2025 report and station extremes; IMD press release of 19 October 2021; Das et al. (2022), MAUSAM 73(4); Ram Babu et al. (2006); NIH-DHAARA (accessed 10 November 2026); NIH, Water Balance of Lake Nainital (CS(AR)-6/98-99); NITI Aayog, Inventory and Revival of Springs in the Himalayas (2018); CGWB, Dynamic Ground Water Resources of Uttarakhand 2024, district brochures for Dehradun, Nainital, Udham Singh Nagar and Hardwar, and Water Level Bulletin (January 2025); UJVN and Irrigation Department salient features of the Dakpathar, Asan and Gaula barrages; THDC, Tehri progress report (February 2025); Dobhal et al. (2013), Current Science 105(2); Shugar et al. (2021), Science 373; reports of the floods of 2013, 2021, 2023 and 2025, of the subsidence of Joshimath (2023), of the Balia Nala and the Nainital landslip of 1880, of the Irrigation Department's drainage master plans for Kumaon (2026) and of the floodplain notifications of the Asan (2025) and the Rules (2026) (press and secondary sources).

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.

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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
ADB	Asian Development Bank
AEP	Annual exceedance probability
AMC	Antecedent moisture condition
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
ARF	Areal reduction factor
AWS	Automatic weather station
BSMP	Basin Stormwater Master Plan
Bye-laws 2011	The Uttarakhand Building Construction and Development Bye-laws/Regulations, 2011 (Amendment 2015), as amended
CAG	Comptroller and Auditor General of India
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
CN	Curve number (SCS/NRCS method)
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CWC	Central Water Commission

Abbreviation	Meaning
DL / WL	Danger level / warning level (CWC)
DM	District Magistrate (the Collector)
DMC	Dehradun Municipal Corporation (Nagar Nigam Dehradun)
DPR	Detailed project report
DSCL	Dehradun Smart City Limited
DWF	Dry-weather flow
EIA	Environmental impact assessment
ESC	Erosion and sediment control
ESZ	Eco-sensitive zone (under the Environment (Protection) Act, 1986)
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FPZ	Flood plain zoning (the Uttarakhand Flood Plain Zoning Act, 2012, or a zone notified under it)
FRL / MWL	Full reservoir level / maximum water level
FZA	Flood Zoning Authority (under the Flood Plain Zoning Act)
GLOF	Glacial lake outburst flood
GWRA	Ground water resource assessment (CGWB)
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Uttarakhand)
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HRDA	Haridwar Roorkee Development Authority
HSG	Hydrologic soil group
I&D	Interception and diversion (of drains to sewers or treatment plants)
IDF	Intensity–duration–frequency
IMD	India Meteorological Department
IRC	Indian Roads Congress
MDDA	Mussoorie Dehradun Development Authority
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
NDMA	National Disaster Management Authority
NGT	National Green Tribunal
NIH	National Institute of Hydrology, Roorkee
NMCG	National Mission for Clean Ganga
NOC	No-objection certificate

Abbreviation	Meaning
PSD	Permissible site discharge
PWD	Public Works Department, Uttarakhand
RRV	Required retention volume
RWH	Rainwater harvesting
SANDRP	South Asia Network on Dams, Rivers and People
SARRA	Spring and River Rejuvenation Authority, Uttarakhand
SLA	Sea-level allowance (coastal term; not applicable in Uttarakhand)
SoI	Survey of India
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
SW monsoon / JJAS	South-west monsoon, June–September
SWD	Storm water drain
T&CP	Town and Country Planning Department, Uttarakhand
THDC	THDC India Limited (operator of the Tehri and Koteshwar dams)
UDD	Urban Development Department (and Directorate), Uttarakhand
UHUDA	Uttarakhand Housing and Urban Development Authority
UKID	Uttarakhand Irrigation Department (this Manual's shorthand)
UJVN	Uttarakhand Jal Vidyut Nigam Limited (operator of the Dakpathar and Asan barrages)
UKPCB	Uttarakhand Environment Protection and Pollution Control Board
ULB	Urban local body (a Municipal Corporation, Nagar Palika Parishad or Nagar Panchayat)
ULMMC	Uttarakhand Landslide Mitigation and Management Centre
USDMA	Uttarakhand State Disaster Management Authority
UTM	Universal Transverse Mercator
UUSDA	Uttarakhand Urban Sector Development Agency
UZR	Unified Zoning Regulations, 2025 (Uttarakhand)
WQv	Water quality volume
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 Uttarakhand. 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 south-west monsoon storms of July–September, brought by depressions and lows from the Bay of Bengal and forced up against the outer Himalaya, at times with a western disturbance, as in September 1880 and October 2021, which fall on thin hill soils, springs and terai water tables already raised by weeks of rain, on reservoirs and taals at their full levels and on rivers and raos already in flood, as well as for short-duration intensities;
- (d) to design outfalls for the stage of the rivers and raos into which the towns drain, the Ganga at Rishikesh and Haridwar, the Rispana, the Bindal, the Song and the Suswa in the Doon, the Solani at Roorkee, the Gaula at Haldwani, the Kosi at Ramnagar, the Kalyani at Rudrapur, the Sarda at Banbasa and the Alaknanda and the Bhagirathi at the valley towns, which rise within hours and carry boulders and debris; the levels of the reservoirs and barrage ponds of Tehri, Koteshwar, Dakpathar, Asan, Pashulok, Bhimgoda and the Gaula barrage; and the levels of Naini lake and the other taals, held by their sluices, including the case where the outfall is closed;
- (e) to protect tanks (taals), 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 bye-laws made by the Government under section 57 of the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, and adopted by the board of each development authority (the Uttarakhand Building Construction and Development Bye-laws 2011), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> Commentary. Uttarakhand's floods come from four sources, often together. The first is the heavy storm of the monsoon, or of a western disturbance meeting it, forced up against the outer Himalaya. On 17–18 September 1880 Hardwar recorded 495.3 mm in a day, still the State's highest, and Roorkee 284.7 mm, and the rain of those days, about 33 inches in three days at Nainital, brought down the landslip of 18 September 1880 that buried part of the town (IMD; as reported). The Doon's gauges recorded 440.4 mm at Rajpur in 1954, 487.5 mm at Raipur in 1959 and 487.0 mm at the Dehradun observatory on 25 July 1966, far above the 100-year depths of the CWC plates (IMD). On 17 June 2013 Dehradun recorded 370.2 mm, its highest June day, while 325 mm fell in 24 hours at the Chorabari glacier camp above Kedarnath (IMD; Dobhal et al., 2013). On 18–19 October 2021, after the normal withdrawal of the monsoon, Pantnagar recorded 403.9 mm, Nainital 401 mm and Mukteshwar 340.8 mm,

each the highest day at its gauge, and at least 54 people died (IMD; as reported). The second is the rivers and the raos. The Ganga at Haridwar rose to 296.30 m, its highest level, in September 2010 or June 2013 (the CWC records differ), the Alaknanda set its highest levels at Srinagar and Rudraprayag on 17 June 2013, and in October 2021 the Gaula at Kathgodam, the Kosi at Ramnagar and the Sarda at Banbasa set new highest levels and the Gaula bridge at Haldwani partly collapsed (CWC data as transcribed by SANDRP; as reported). The raos of the Doon are ungauged and rise within an hour: on 15–16 September 2025, when Sahastradhara recorded 264 mm in 24 hours with 54 mm in one hour, 13 bridges, 10 culverts and 21 roads were lost around Dehradun, at least 30 people died, and 83 of the structures that intercept sewage from the drains of the Rispana were damaged (as reported; Peyjal Nigam, affidavit before the NGT). The third, found in no plains State of the series, is debris, outbursts and unstable ground. The moraine-dammed Chorabari lake emptied in 5–10 minutes on 17 June 2013 and the Mandakini destroyed much of Kedarnath, with more than 5,700 people presumed dead by the State (Dobhal et al., 2013; as reported); on 7 February 2021 about 27 million m³ of rock and ice from Ronti peak became a debris flow down the Rishiganga and the Dhauliganga, with more than 200 dead or missing and no rain at all (Shugar et al., 2021); in the winter of 2022–23 the ground of Joshimath subsided, and the experts' committee named inadequate drainage and sewerage and blocked natural water paths among the primary causes (as reported); and on 5 August 2025 a debris flow down the Kheer Ganga buried Dharali when the nearest gauge recorded 8 mm (as reported). The fourth is the town drainage that fails in a fall that is not extreme: the command centre of Dehradun Smart City was flooded after bursts on 25 August 2021 and 8 August 2023 (CAG, performance audit of the Smart Cities Mission, 2025), and Rudrapur was flooded by the Kalyani in 2021 and again in August 2023 (as reported).

Missing design makes all four worse. The only design storm found for a town's drains in the State is that of the ADB-funded drainage of Dehradun, a 2-yr storm for roadside drains and a 5-yr storm for main channels, with no allowance for climate change (ADB, 2021); the drainage master plans that the Irrigation Department is preparing for Haldwani and the towns of Kumaon state no design storm (as reported). The Bye-laws 2011 control rainwater storage and the siting of buildings on slopes, not runoff, and they have no rule against soak pits on unstable slopes, although the committee on Joshimath's subsidence asked as long ago as 1976 that soak pits there be closed (as reported). Objectives (b) to (e) address the storage, outfall and building-level failures, which a drain-sizing manual alone cannot fix; the third source is answered by the siting, screening and debris rules of Chapters 2, 6 and 7, because no drain is sized to carry a debris flow.

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 Uttarakhand Building Construction and Development Bye-laws 2011 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.

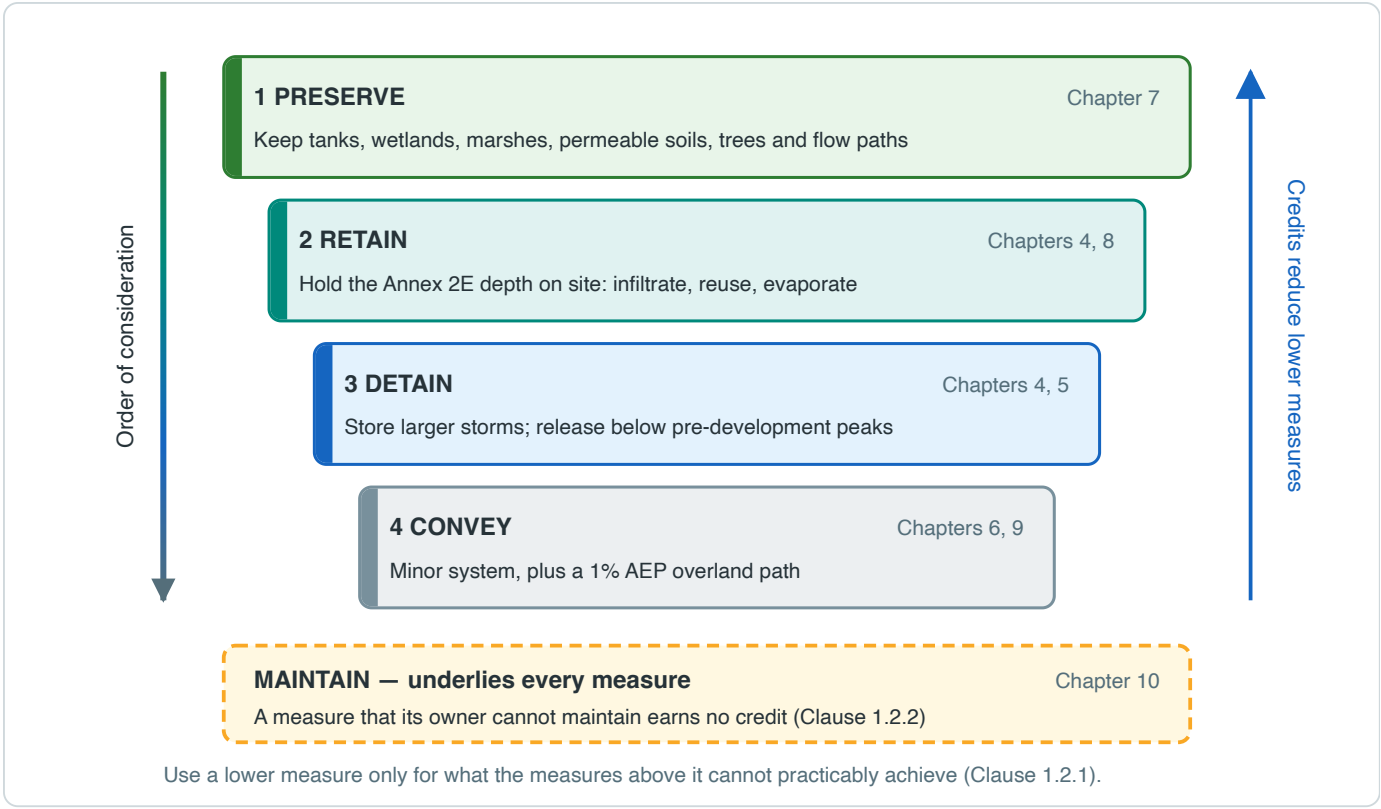

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

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 Uttarakhand, the top two layers have a particular meaning. Much of the State's natural storage and recharge lies in its taals (Naini lake, Bhimtal, Naukuchiatal and Sattal), in the recharge areas that feed them, in its springs (naula, a covered spring tank, and dhara, a spring spout), in the khals (small rain-fed ponds) of the hill saddles, in the beds and floodplains of its raos and gadheras, in the bouldery bhabar along the foot of the hills, where the water table lies 40–75 m down and the rivers lose water to the gravels, and in the Asan wetland, the State's only Ramsar site (444.4 ha, designated on 21 July 2020) (CGWB; State Wetland Authority). About half of the subsurface recharge of Naini lake is estimated to enter through the Sukhatal, a basin of about 2 ha (NIH, as cited by NITI Aayog), springs supply 70–87% of the water in some hill blocks, and the working springs of Almora are reported to have fallen from 360 to 60 over 150 years (NITI Aayog, 2018). The law protects some of this. The Bye-laws 2011 bar construction within 30 m of a river bank, 10 m of an underground water source (a spring), 5 m of a nala and 30 m of every lake (bye-law 4.4(III)); the Unified Zoning Regulations of 2025 put rivers, lakes, ponds, nalas and streams in a Conservation Use Zone with no new construction within 30 m of river and lake banks; the Flood Plain Zoning Act protects the notified reaches of the rivers; river beds outside municipal limits are forest land (High Court, *Urmila Thapa*, 2022); and the High Court has stopped construction on the bed of the Sukhatal (2022, as reported). In the hills the second layer changes. Retention on a slope is storage and reuse, not infiltration: water put into colluvium, slide debris or moraine raises the pressure in the slope, as the Balia Nala slides below Naini lake and the subsidence of Joshimath show, so this Manual bars deliberate infiltration on natural slopes of more than 10°, on

mapped landslide or creep zones, on colluvium, slide debris or moraine and close upslope of a cut or retaining wall, unless a geotechnical certificate allows it (Clause 4.11, hill infiltration rule, set by this Manual). Infiltration remains the first choice on the Doon Gravels and the bhabar, which are the recharge zones of the State, and is not credited on terai land where the seasonal water table is within about 1 m. Losing that storage and those springs cannot be offset by pipes, and in the hills drains that put water into a slope can make it fail.

1.3 Legal basis and status

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

- (a) an amendment to the Uttarakhand Building Construction and Development Bye-laws 2011 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 Uttarakhand the building rules are the Uttarakhand Building Construction and Development Bye-laws/Regulations 2011 (Amendment 2015), made by the Housing Department (Awas Vibhag) under section 57 of the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, and amended piecemeal since by notifications under the same section; each development authority adopts each amendment through its board and may propose local modifications to the Government (notification of 10 January 2024). The amendments read for this Manual, of 27 September 2022 (setbacks for single residences), 13 March 2023 (mobile towers), 10 January 2024 (filling stations) and 13 June 2024 (housing for the economically weaker sections), touch water only in the third, which keeps filling stations 50 m from rivers, waterbodies, springs and the floodplain and 5 m from a nala. A comprehensive "Amendment 2017" hosted by MDDA, which invited suggestions until February 2018, exists only as a draft, and later notifications still amend the 2011 (Amendment 2015) text; this Manual cites a compilation of the amendments of 2015–2019, whose agreement with the gazetted text is to be confirmed [TBC]. The bye-laws bar construction within 30 m of a river bank, 10 m of an underground water source and 30 m of every lake, and beyond at least 5 m from a nala (4.4(III), printed as "30.0–30.0 m" and "10.0–10.0 m", read here as single distances pending confirmation [TBC]); bar building on natural slopes of more than 30°, more than 26.5° in the Nainital municipal area, and at sites of severe and continuous landslides, and require a contour plan at 2 m intervals (4.4(IV)); require the site plan on a slope to show the landslide-prone areas near it and to divert the natural flow of water coming from uphill away from the foundations (4.4(V)(b)); set a plinth of at least 0.45 m above ground (2.41); allow only one basement in the hills, on plots of at least 2,000 m² with a frontage of at least 18 m (5.6); and require a sewer no-objection certificate or a treatment plant for premises of more than 1,000 m² (6.4(III)). Bye-law 4.4(V)(b) is the only clause on site runoff. The bye-laws set no design storm, return period, release rate or detention volume, and no "zero runoff" rule. The route of Clause 1.3.1(a)

therefore runs through a Housing Department notification under section 57, adopted by the board of each development authority. This Manual is a draft; neither the Government nor any authority has adopted it. 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.

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 Mussoorie Dehradun Development Authority (MDDA), the Haridwar Roorkee Development Authority (HRDA) or a district development authority constituted under the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, in its development area; the Uttarakhand Housing and Urban Development Authority (UHUDA), or the authority to which a regulated area has been transferred, in that area; or, where it grants building permission, the Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat concerned (the division of these powers, and the bodies that grant permission outside development areas, are to be confirmed [TBC]), 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 Uttarakhand Building Construction and Development Bye-laws 2011 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).
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).

Term	Meaning in this Manual
Flood-sensitive catchment	The catchments of the Rispana, the Bindal, the Song, the Suswa and the Tons (Tamsa) and of their khalas within the development area of MDDA; the low-lying land of Haridwar, Jwalapur and Kankhal that drains to the Ganga below the Bhimgoda barrage; the land of Haldwani–Kathgodam that drains to the Gaula and to the Rakasia and Kalasia nalas; the land of Rudrapur, Kichha and Pantnagar that drains to the Kalyani and the Kichha across the terai; the whole catchment of Naini lake, with the Sukhatal basin and the land along the Balia Nala below the Tallital sluices; the land of Rishikesh, Muni-ki-Reti and Dhalwala that drains to the Ganga above the Virbhadra (Pashulok) barrage or to the Chandrabhaga; valley-floor towns on river terraces below the fans of gadheras, such as Srinagar, Rudraprayag and Uttarkashi; and the land within, or draining directly into, the prohibited or restricted zone of a river reach finally notified under the Uttarakhand Flood Plain Zoning Act 2012, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (taal), 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 Uttarakhand Building Construction and Development Bye-laws 2011 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 Uttarakhand Gazette.

> **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).

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 Uttarakhand Building Construction and Development Bye-laws 2011;
- (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 Uttarakhand, 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 bye-law 6.5 of the Bye-laws 2011 to every permitted construction, of any land use, with a ground coverage of **125 m²** or more, except in areas with a waterlogging problem, as storage of at least 2.0 m³ for a coverage of up to 250 m², 3.5 m³ up to 400 m² and 0.5 m³ more for every further 50 m² or part, reduced to one-third on plots of more than 400 m² where groundwater recharge is provided by bore well, recharge pit, well or trench, and confirmed on the building plan before approval (the Uttarakhand Ground Water (Regulation and Control of Development and Management) Act, 2016, whose section 20 provided for rainwater harvesting, was repealed in 2017 and gives no mandate), 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.

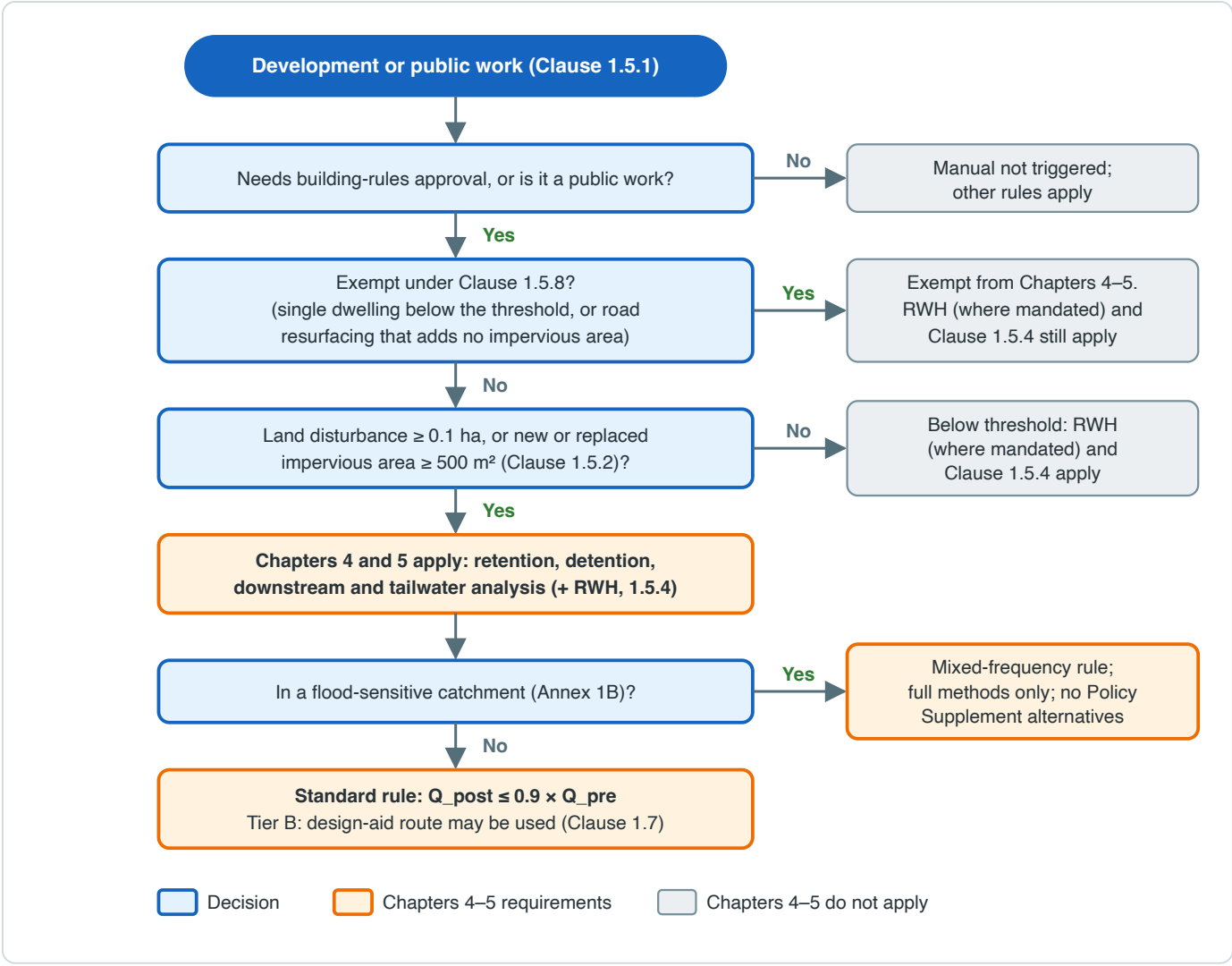

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Uttarakhand plots are small and the cumulative effect of many small plots is what fills Dehradun's drains. For small buildings in Uttarakhand, bye-law 6.5 of the Bye-laws 2011 requires rainwater storage only where the ground coverage is 125 m² or more, and not in waterlogged areas: 2.0 m³ up to 250 m² of coverage, 3.5 m³ up to 400 m² and 0.5 m³ for each further 50 m², reduced to one-third on plots of more than 400 m² that provide recharge. That is about 8–16 mm of rain over the covered area, and 10 mm at the margin; it is a supply measure, and none of it limits what leaves the plot. A plot below 125 m² of coverage has no rule at all. On a slope the only runoff clause, bye-law 4.4(V)(b), diverts the water coming from uphill away from the foundations, which protects the building but sends the water on to the next plot or the road. The plinth of at least 0.45 m (bye-law 2.41) is measured from the ground, not from any flood level,

although the plinth inspection that the bye-laws already require is the natural point to check it. Clause 1.5.4(b) applies to every building whatever its size for this reason. A small building on a hill slope is also where a soak pit or recharge pit can do most harm; the Bye-laws 2011 do not forbid one, and an Authority may make the hill infiltration rule of Clause 4.11 a condition of every building permit in its hill 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.

1.6 Tiered adoption

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

- (a) Dehradun Municipal Corporation (DMC);
- (b) every Approving Authority within the development area of MDDA, the Mussoorie Dehradun Development Authority, under the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, as that area is notified from time to time, including Dehradun, Mussoorie and Rishikesh, which was merged into it in 2019, and including MDDA itself and the Nagar Nigams, Nagar Palika Parishads and Nagar Panchayats in that area; and
- (c) every other Nagar Nigam constituted under the Uttar Pradesh Municipal Corporation Act, 1959, as adapted in Uttarakhand, as constituted from time to time, among them Haridwar, Roorkee, Kotdwar, Srinagar, Haldwani, Rudrapur, Kashipur, Almora and Pithoragarh, and HRDA, UHUDA and every district development authority where it grants permission within the planning area of a Nagar Nigam.

1.6.2 **Tier B authorities.** All other Nagar Palika Parishads and Nagar Panchayats 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 T&CP 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 development area of MDDA, HRDA or a district development authority constituted under the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, 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.** Dehradun Municipal Corporation, with its engineering wing and a city whose drains and khalas discharge to the Rispana, the Bindal and the other raos of the Doon, 208 of them to the Rispana alone (Peyjal Nigam, affidavit before the NGT, 2025), and a small hill 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 Dehradun.

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.

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
Uttarakhand Building Construction and Development Bye-laws/Regulations 2011 (Amendment 2015), made by the Housing Department under section 57 of the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, and adopted by the board of each development authority; amendments read: 27 September 2022, 13 March 2023, 10 January 2024 (No. 180884) and 13 June 2024; a compilation of 2015–2019 read, its gazetted text to be confirmed [TBC]; the "Amendment 2017" exists only as a draft	Continue. Bye-law 4.4(III) bars construction within 30 m of a river bank and 10 m of an underground water source (a spring), both printed as ranges ("30.0–30.0" and "10.0–10.0" m) and read here as single distances [TBC], within at least 5 m of a nala, and within 30 m of the bank of every lake, including the Nainital lake special area, or of the maximum fixed level of a natural reservoir, whichever is more; bye-law 4.4(IV) bars building on natural slopes of more than 30° (26.5° in the Nainital municipal area) and at sites of severe and continuous landslides, and requires a contour plan at 2 m intervals; bye-law 4.4(V) requires the site plan in the hills to show nearby landslide-prone areas and, on a slope, to divert the natural flow of water from uphill away from the foundations; bye-law 2.41 sets a plinth of at least 0.45 m above ground; bye-law 5.6 allows a single basement in the hills, on plots of at least 2,000 m² with a frontage of at least 18 m, and requires a certificate on the effect of excavation on stability and the water table; bye-law 6.4(III) requires a sewer no-objection certificate or a treatment plant above 1,000 m²; and Appendix 1 (Nainital) asks that drainage be improved so that no water accumulates and saturates the ground near the footings. The amendment of 10 January 2024 keeps filling stations 50 m from rivers, waterbodies, springs and the floodplain and 5 m from a nala. The bye-laws set no design storm, release rate, detention volume or "zero runoff" rule, and no rule on infiltration on slopes. The design criteria of Chapters 2–6, the hill rules of Chapters 4, 6 and 8 and the hydraulic corridor and setbacks 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 bye-laws, a master plan or a statute are stricter, they govern (Clause 1.3.3).
Rainwater harvesting: Bye-laws 2011, bye-law 6.5; Uttarakhand Ground Water (Regulation and Control of Development and Management) Act, 2016 (Act 12 of 2016), repealed by Act 11 of 2017	Continue unchanged. Bye-law 6.5 requires rainwater storage on every permitted construction with a ground coverage of 125 m² or more, except in waterlogged areas: 2.0 m³ up to 250 m², 3.5 m³ up to 400 m² and 0.5 m³ for each further 50 m² or part, reduced to one-third on plots of more than 400 m² where recharge is provided; the provision is confirmed on the plan before approval, and drainage and storage structures do not count as ground coverage. The storage is about 8–16 mm of rain over the covered area. The Ground Water Act of 2016, whose section 20 provided for rainwater harvesting, was repealed in 2017 "at once", so no groundwater statute is in force in the State. This Manual counts bye-law storage against its retention requirement only as reuse or verified infiltration (Clauses 4.4.3 and 4.11), and in the hills only as storage, under the hill infiltration rule of Clause 4.11.

Instrument	Relationship
Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand (2013); Uttarakhand Unified Zoning Regulations, Housing Department notification No. 568/E.No. 92710 of 20 November 2025, under section 8(2)	Continue. MDDA (Dehradun, Mussoorie and, since 2019, Rishikesh), HRDA and the district development authorities constituted in 2016–17 prepare master plans and grant permission in their development areas, and UHUDA holds the former regulated areas. The Unified Zoning Regulations, to be part of every master plan prepared in the State, put rivers recorded in the revenue records and all existing waterbodies, "including ponds, lakes, nalas and streams", in a Conservation Use Zone with a green buffer under the prevailing bye-law, in which no construction is allowed, and allow no new construction within 30 m of river and lake banks (chapter 11, E-1). Master plans would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11).
Uttaranchal (Uttar Pradesh Municipal Corporation Act, 1959) Adaptation and Modification Order, 2002, and the Uttar Pradesh Municipalities Act, 1916 (Uttaranchal Amendment), 2002, as amended; Uttarakhand Special Provisions for Urban Local Bodies and Authorities Act, 2018	Continue. The Nagar Nigams run on the adapted Act of 1959 and the Nagar Palika Parishads and Nagar Panchayats on the adapted Act of 1916 (CAG, 2022); in the Uttar Pradesh text the Municipal Commissioner maintains and repairs all Corporation drains, but the drainage chapters of the adapted texts and of the amendments of 2007–2025 were not read for this Manual [TBC]. The Act of 2018 bars the eviction of settlements that existed before 11 March 2016, a cut-off extended by an amendment of 2025 (as cited by the High Court); the High Court has held that moving families from the dry bed of the Rispana, where a flash flood endangers them, is rehabilitation and not eviction (*Rajeshwari Yadav Gupta*, WPMS 739/2026, 1 April 2026).
Uttarakhand Flood Plain Zoning Act, 2012 (Uttarakhand Act No. 07 of 2013), as amended in 2024; final notifications under it; Uttarakhand Floodplain Zoning Rules, 2026 (approved by the cabinet on 12 October 2026; text not found [TBC])	Continue, and govern where a reach is notified. The Collector or another authority is the Flood Zoning Authority (s.3), the Irrigation Department maps the 25-year (prohibited) and 100-year (restricted) zones with HEC-RAS, marks them on the revenue (shajra) maps and sets pillars, and no activity is allowed in either zone without the Authority's permission, deemed granted after 90 days (s.12(3)). Final notifications cover 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini (Irrigation Department, 2024) and the Rispana (5 May 2025, as cited by the NGT); the cabinet approved the Asan's in June 2025 (as reported); the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani have been studied but not notified. In the restricted zone of the Ganga at Rishikesh the notice of intent of 7 October 2020 (No. 1875/II(2)-2020-06(18)/2020) allows rebuilding only with a plinth at least 1.00 m above the high flood level. The amendment of 2024, seen only as quoted, extends the period for notification to 24 months and lets a final notification be amended where "riverbank development" can protect land and buildings, which would shrink notified floodplain storage [TBC]. Where no line is notified, the hydraulic corridor of Chapter 7, with a Zone 1 of at least 15 m, and the bye-law lines of 30 m and 5 m apply, whichever is wider, as this Manual's proposal.
Housing Department G.O. No. 1995/V-2-2017-58(आ0)/2014 of 29 November 2017 on the banks of the Ganga in the hills, and letter of 1 June 2023; NGT, *M.C. Mehta*, OA 200/2014, judgment of 13 July 2017; High Court, *Lalit Miglani*, WPPIL 140/2015, 2 December 2016	Apply where they bind. Upstream from Rishikesh the G.O. makes the prohibited zone 100 m from the middle of the river or the area of floods up to the 25-year frequency, whichever is more, and the next 200 m a regulatory zone; since 2023 the Irrigation Department's floodplain notifications govern where they exist. Downstream, from Haridwar to Unnao, the NGT designated 100 m "from the edge of the river" as a no-development zone until the floodplain is demarcated. The State's order reads the Tribunal as measuring from the middle of the river and the judgment measures from the edge; this Manual cites each for its reach and does not merge them [TBC].
Doon Valley notification, S.O. 102(E) of 1 February 1989 under the Environment (Protection) Act, 1986, amended by S.O. 94(E) of 6 January 2020; Bhagirathi Eco-Sensitive Zone, notified on 18 December 2012 (S.O. 2930(E) in MoEF's documents), with its Zonal Master Plan of 2020	Apply where they bind. The Doon Valley notification regulates industry, mining and changes of land use in the valley, and the High Court has relied on it for the khalas and storm-water drains of Rajpur (*Urmila Thapa*); the Bhagirathi zone covers 4,179.59 km² from Gaumukh to Uttarkashi, including Dharali. Their drainage, river-bank and slope clauses were not read for this Manual [TBC].
Nainital: Bye-laws 2011, bye-laws 4.4(III)(iii), 4.4(IV)(iv) and 5.1 and Appendix 1; Lake Development Authority, Nainital; High Court, *Ajay Singh Rawat*, WPPIL 31/2012, and the Sukhatal orders of 2022	Apply where they bind. In the Nainital municipal area building is allowed only on slopes of 0–26.5°, only two storeys and 7.5 m, and no construction within 30 m of the lake; the High Court has stopped construction on the Sukhatal lakebed (2022, as reported). Its order of 2016 barring construction within 2 km of the major lakes was stayed by the Supreme Court in 2018 and is not cited as in force. The instruments of the Lake Development Authority were not read [TBC].

Instrument	Relationship
Wetlands (Conservation and Management) Rules, 2017; Uttarakhand State Wetland Authority (letter No. 757(1)/X-3-18-09(01)2004 of 16 October 2019); Asan Conservation Reserve (Ramsar site, 21 July 2020)	Continue. The Rules' restrictions apply to wetlands once notified; of the 192 wetlands of the national atlas in the State, 149 had been ground-truthed by October 2025 and none was found notified (State Wetland Authority, 2025).
River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016; Namami Gange interception and diversion works; orders of the NGT on the Rispana (*Niranjan Bagchi*, OA 417/2022) and of the High Court on the river beds of the Doon (*Urmila Thapa*, WPPIL 58/2019) and the Gaula (*Ravi Shankar Joshi*, WPPIL 178/2013)	Apply where they bind. The NGT has directed the removal of encroachments from the Rispana's floodplain, subject to NMCG's review under clause 6(3) of the Order; the High Court recorded that river beds outside municipal limits are classified as forest land and made the Municipal Commissioner personally responsible for removing encroachments within them. Sewage in storm drains is dealt with in Chapter 8.
Disaster Management Act, 2005; USDMA; the Uttarakhand Landslide Mitigation and Management Centre (ULMMC); the flood control rooms of the Irrigation Department	Continue. No urban flood plan or standard operating procedure of USDMA was read for this Manual [TBC]; the dates by which drains are to be cleaned before the monsoon (15 June) and USDMA's monsoon period (5 June–15 September) were found only in press reports, and the works calendar of Chapter 10 sets this Manual's dates.
IRC:SP:48, Hill Road Manual (1998), and the practice of the Public Works Department on hill-road drainage	Apply to the drainage of hill roads, cross-referenced from Chapter 6, where they do not conflict with it; the drainage clauses of IRC:SP:48 were not read for this Manual [TBC].
Design criteria of the ADB-funded Uttarakhand Integrated and Resilient Urban Development Project for the drains of Dehradun (climate risk assessment, 2021)	Superseded for works designed under this Manual. They size roadside drains for a 2-yr storm and primary and secondary channels for a 5-yr storm, with no climate allowance; Table 2.1 and Chapter 6 apply instead.
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 Uttarakhand 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 SW monsoon, because RWH sumps are usually full or the ground saturated by the time a July to September monsoon burst or cloudburst against the outer Himalaya, or a late-season storm such as that of October 2021 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.

Uttarakhand is spending on its town drains. The ADB-funded Uttarakhand Integrated and Resilient Urban Development Project is building at least 117 km of storm drains in Dehradun, with outfalls to the Bindal and the nalas of the city (ADB, 2022); Dehradun Smart City Ltd has an integrated drainage work of about ₹17 crore (CAG, 2025); the Irrigation Department is preparing drainage master plans for Haldwani, of about ₹1,003 crore, and for the other towns of Kumaon, about ₹3,394 crore in all (as reported); and the interception of the drains of the

Rispana and the Bindal under Namami Gange was completed in 2021–2025 (Peyjal Nigam, affidavit before the NGT). Only the ADB drains have a stated design storm, 2 and 5 years; the Smart City's drainage DPR left out the storm-water reuse it had provided for (CAG, 2025); and none of the master plans found states a design storm. 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 already holds many of the tools, more than any plains State of the series. It keeps buildings 30 m from rivers and lakes, 10 m from springs and 5 m from nalas, keeps them off slopes of more than 30° and away from landslides, and asks every hill site plan to divert the water from uphill away from its foundations (Bye-laws 2011, 4.4); it puts rivers, ponds, lakes, nalas and streams in a Conservation Use Zone in every master plan (Unified Zoning Regulations, 2025); it draws 25-year and 100-year flood lines river by river under the Flood Plain Zoning Act, the only working floodplain-zoning law found in the series; it adds the Ganga hill order of 2017; and the High Court and the NGT have acted on the river beds of the Doon, the Rispana, the Gaula and the Sukhatal. What it lacks is a design standard. None of these instruments says how large a drain must be, which storm it must carry, how much water a hill site may put into its slope, how a gadhera's flood level is to be fixed where no line is notified, or how much storage a paved plot removes; and the floodplain lines cover only the reaches notified. This Manual's checks are framed as part of the building permission of the development authorities and the local bodies, and of the permission of the Flood Zoning Authority where a line is notified, not as a separate no-objection certificate. This Manual is offered as a technical companion to these instruments, to the orders of the High Court and the NGT, and to the drainage works of the towns: it supplies the design storm, detention, hill-site drainage, infiltration and buffer numbers they do not set, as a proposal for the Government and the authorities to consider. Neither the Housing Department, the Urban Development Department, the Irrigation Department nor any other body has adopted it.

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
Housing Department (Awas Vibhag)	Makes the Bye-laws 2011 and their amendments under section 57 of the 1973 Act, and the Unified Zoning Regulations under section 8(2); oversees UHUDA, MDDA, HRDA and the district development authorities. Would prepare the amendment of Clause 1.3.1(a) and ask each development authority's board to adopt it.
Urban Development Department and Directorate	Administers the Nagar Nigams, Nagar Palika Parishads and Nagar Panchayats and oversees UUSDA and Dehradun Smart City Ltd (CAG, 2022). Would issue the model ULB bye-law of Clause 1.3.1(b), apply this Manual to the drainage works it funds, and, with T&CP, give regional support to Tier B authorities (Table 1.1) and maintain the empanelled reviewer list (Clause 10.7).
State Stormwater Technical Committee (Clause 1.3.2)	Would adopt higher standards, issue Annexes, tables and the compliance calculator, concur with Tier A alternatives, decide variances referred to it and review the Manual (Clause 1.12).
Town and Country Planning Department (T&CP)	Prepared the Unified Zoning Regulations of 2025 and advises on master plans. Would show flood-sensitive catchments, drainage reserves and regional facility sites in master plans (Chapter 11).
Uttarakhand Housing and Urban Development Authority (UHUDA)	The State-level development authority, holding the former regulated areas. Would apply this Manual to the areas and schemes it controls.

Agency	Role under this Manual
MDDA (Mussoorie Dehradun Development Authority), the Haridwar Roorkee Development Authority (HRDA) and the district development authorities	Prepare master plans and grant building and layout permission in their development areas under the Bye-laws 2011, which their boards adopt; MDDA has removed encroachments from the Rispana's floodplain under the NGT's orders. Would require the drainage report of Chapter 10 with each application, check the hill rules at the plinth inspection, and hand over drains and storage to the local body under Clause 10.14.
Dehradun Municipal Corporation (DMC) and the other Nagar Nigams (Haridwar, Roorkee, Rishikesh, Kotdwar, Srinagar, Haldwani, Rudrapur, Kashipur, Almora and Pithoragarh, as reported [TBC]); Nagar Palika Parishads and Nagar Panchayats	Hold, clean and maintain the public drains, nalas and khalas of their areas under the Municipal Acts as adapted (texts not read [TBC]); keep the river beds within municipal limits free of encroachment (High Court, *Urmila Thapa*). Would apply this Manual to their works, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15).
Uttarakhand Urban Sector Development Agency (UUSDA) and Dehradun Smart City Ltd (DSCL)	Build drains under the ADB-funded programme and the Smart Cities Mission for the Urban Development Department and hand them to the local body. Would design them to this Manual from the dates of Clause 1.11.
Irrigation Department	The nodal agency for floodplain zoning: maps the 25- and 100-year zones and proposes their notification; builds and maintains flood-protection works, barrages and canals; runs the flood control rooms; and is preparing the drainage master plans of Haldwani and the Kumaon towns. Would supply river and barrage levels for Chapter 5, approve the site-specific hydrology of Clause 2.3.6(i), and apply this Manual to its drainage master plans.
Public Works Department (PWD)	Builds and maintains State roads and hill roads with their side drains, catch-water drains, scuppers and cross-drainage, and some road drains in Dehradun's Smart City area (CAG, 2025). Would apply Chapter 6 and the hill-road rules to them; national highways are for NHAI, NHIDCL or MoRTH, and border roads for BRO.
Uttarakhand Peyjal Nigam and Uttarakhand Jal Sansthan	The Peyjal Nigam builds sewers, treatment plants and the interception and diversion of drains (187 of the 208 drains of the Rispana intercepted), and gives the sewerage no-objection certificate in restricted floodplain zones; the Jal Sansthan operates water supply and sewerage. Would design interceptors and their storm bypasses to Chapter 8 and protect them against floods.
Uttarakhand State Disaster Management Authority (USDMA) and the Uttarakhand Landslide Mitigation and Management Centre (ULMMC)	Prepare for and respond to floods, cloudbursts and landslides; run early warning. Would supply the hazard and landslide maps used in the screening of Clause 2.3.6(i) and the hill rules, and lead post-event reviews with the Authority (Clause 10.16).
Uttarakhand Environment Protection and Pollution Control Board (UEPPCB)	Monitors drains and rivers and reports to the NGT. Would receive the records of sewage found in storm drains under Chapter 8.
Uttarakhand State Wetland Authority, with the Forest Department	Inventories and protects wetlands, including the Asan Conservation Reserve; the Forest Department holds river beds outside municipal limits. Their consent is needed before a wetland or forest river bed is used for storage or an outfall (Chapter 7).
Spring and River Rejuvenation Authority (SARRA)	Reported constituted in 2025 to revive springs and rivers (constitution order not found [TBC]). Would be consulted on spring-shed and recharge areas protected under Chapters 7 and 8.
Lake Development Authority, Nainital	Acts against unauthorised construction around the lakes of Nainital (as reported). Would be consulted on every development in the catchment of Naini lake and on the custody of its sluices with the Irrigation Department [TBC].
Revenue Department and the District Magistrates	The District Magistrate is the Flood Zoning Authority under the Flood Plain Zoning Act, and the revenue records show the rivers, nalas and ponds that the Unified Zoning Regulations protect. Would record drainage reserves in the land records.
THDC India Ltd and UJVN Ltd	Operate Tehri and Koteshwar (THDC) and the Dakpathar, Asan and other barrages (UJVN). Would supply reservoir and pond levels and release rules for Chapter 5.

Agency	Role under this Manual
Central Water Commission (CWC), a body of the Union	Publishes the Flood Estimation Reports for zone 7 and subzone 1(e) used in Chapters 2 and 3, the river levels at its sites and its monitoring of glacial lakes. Would supply river stage records and forecasts for Chapter 5.
Central Ground Water Board (CGWB), a body of the Union	Assesses the groundwater of the State (53.54% stage of extraction in 2024, four units semi-critical). Would supply groundwater levels and quality with the Irrigation Department.
National Institute of Hydrology (NIH), Roorkee	Runs NIH-DHAARA (Chapter 2) and has studied the water balance of Naini lake.
IMD (Meteorological Centre Dehradun), and road and rail owners (PWD, NHAI, NHIDCL, BRO, Indian Railways)	IMD's stations supply the rainfall records of Chapter 2. Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. Stormwater in Uttarakhand is split between the Housing Department, the development authorities and UHUDA, through the Bye-laws 2011, the Unified Zoning Regulations, master plans and building permission; the Urban Development Department and the Nagar Nigams and other local bodies, through the drains vested in them; UUSDA and Dehradun Smart City Ltd, which build drains for them; the Irrigation Department, through the rivers, raos, barrages, canals and floodplain zoning, and now the drainage master plans of the Kumaon towns; the PWD, through the drains of the roads, which in the hills are the minor drainage system; the Peyjal Nigam and the Jal Sansthan, through the interception of drains for sewage; the Forest Department, which holds the river beds outside the towns; and the High Court and the NGT, which have set lines and ordered removals along the raos. Dehradun shows why the split matters. Its raos, the Rispana, the Bindal, the Song, the Suswa and the Tons, work as trunk storm drains and, until they were intercepted, as sewers; their beds are forest or revenue land, their flood zones are the Irrigation Department's, their interceptors are the Peyjal Nigam's, and the drains and khalas that feed them are the Nagar Nigam's or MDDA's. The Uttar Pradesh Municipal Corporation Act of 1959, as adapted, is understood to vest public drains in the Nagar Nigam, as the Uttar Pradesh text does (adapted text not read [TBC]), but no rule or order found divides the raos and gadheras from the municipal drains, or the road drains of the hill towns from the town drains, between the bodies concerned [TBC]. Until such a rule is made, this Manual assigns the drainage elements as in Table 1.5, as Chapter 6 does for the drains themselves, and recommends that each town keep a register of its drains and raos with an owner for each reach. The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Rivers, raos and gadheras with their beds, banks and floodplains (such as the Rispana, the Bindal, the Song, the Suswa, the Tons and the Asan in the Doon, the Gaula, the Kosi and the Ganga), flood-protection works, the demarcation of floodplains under the Flood Plain Zoning Act, and the barrages and canals of the Irrigation Department	The Irrigation Department; river-bed land outside municipal limits is forest land, held by the Forest Department (High Court, *Urmila Thapa*), and within municipal limits the local body keeps the bed free of encroachment
Natural nalas, khalas and public drains within the limits of a local body, other than those assigned to the Irrigation Department	The Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat (in Dehradun, DMC)
Drains built under the ADB-funded programmes or by Dehradun Smart City Ltd, until handed over in writing	UUSDA or DSCL, and the local body after handover
Drains and storage within a scheme of MDDA, HRDA, a district development authority, UHUDA or a colony developer, until handed over in writing	The body that built the scheme
Road drains, catch-water drains above cuts, scuppers and cross-drainage of State roads and hill roads	The PWD; on national highways, NHAI, NHIDCL or MoRTH; on border roads, BRO

Element	Assigned to
Sewers, interceptors, the interception and diversion of nalas and raos, and sewage treatment plants	The Peyjal Nigam, which builds them, and the Jal Sansthan, which operates them
Naini lake, its sluices at Tallital and the Balia Nala below them	The Lake Development Authority with the Irrigation Department, whose custody of the sluices is to be confirmed [TBC]; the drains of Nainital to the Nagar Palika Parishad, Nainital [TBC]
Reservoirs and barrages of the hydropower projects	THDC India Ltd (Tehri, Koteshwar); UJVN Ltd (the Dakpathar and Asan barrages and others)
Springs (naula, dhara) used for supply, and their rejuvenation	The Jal Sansthan, the local body or the panchayat that uses them; rejuvenation by SARRA (constitution order not found [TBC])
Wetlands and Ramsar sites, including the Asan Conservation Reserve	The Uttarakhand State Wetland Authority, with the Forest Department

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.

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. Uttarakhand has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to a river or rao in flood, to a reservoir or barrage pond such as Tehri, Dakpathar or Asan, or to Naini lake or another taal held by its sluices, 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 gadhera or down a hill slope.

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 Uttarakhand the High Court has had to order the removal of encroachments from the river beds and khalas of the Doon, where a survey found 37.93 ha of river bed encroached in Dehradun tehsil and 57.4 ha in Vikasnagar (*Urmila Thapa*, WPPIL 58/2019, 2022), the NGT has had to direct the removal of encroachments from the floodplain of the Rispana, in whose 1-in-5-year flood zone the State has counted 330 structures (OA 417/2022), and the High Court has had to stop construction on the bed of the Sukhatal, which feeds Naini lake (2022, as reported).

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).

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.

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Nagar Nigams and of the development areas of the Mussoorie Dehradun Development Authority, the Haridwar Roorkee Development Authority and the district development authorities
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model Bye-laws 2011 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 Uttarakhand. Where a Nagar Nigam, Nagar Palika Parishad, Nagar Panchayat, MDDA, HRDA or another development authority has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Uttarakhand trace to the rainfall input, not the hydraulics. Uttarakhand shows how. The only design storm found for a town's drains in the State is that of the ADB-funded drainage of Dehradun: a 2-yr storm for roadside drains and a 5-yr storm for primary and secondary channels, with no allowance for climate change, although the same project's climate risk assessment notes that the drains "may remove around half the floodwater in larger events" (ADB, 2021). No State or municipal drainage standard was found, and the drainage master plans now being prepared for Haldwani and the Kumaon towns state no design storm (as reported). The published sources that seem to fill the gap do not. The Dehradun panel of IMD Das et al. (2022) repeats the paper's generic curve; the northern-zone equation of Ram Babu et al. (2006) gives a 2-year 24-hour depth of about 63 mm at Dehradun, against 152 mm from the station's own annual maxima; and NIH-DHAARA's reanalysis-based depths are too high in the bhabar and terai and break down at 1 hour in the high valleys, where they give 24 mm at Joshimath against the 100 mm recorded in an hour at Uttarkashi (Clause 2.3.6). The rainfall figures that circulate after a flood are often conflicting: Sahastradhara's fall of 15–16 September 2025 is reported as 264 mm and as 192 mm, Nainital's of 19 October 2021 as 401 mm by IMD and 535 mm for an automatic station, and Nainital's highest day as 313.7 mm by IMD and 50.9 cm by the CWC zone-7 report (IMD; CWC; as reported). The CWC Flood Estimation Reports are the only regional sub-daily source, and the two that cover the State give 1-hour ratios of 0.34 in the plains and 0.425 in the hills. 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.
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.
SW monsoon season (JJAS)	June–September, with about 78% of the State's annual rainfall falling in these months and nearly 53% in July and August (IMD, normals of 1961–2010). The State's normal is 1,326.1 mm, from 965.9 mm in Almora and 1,071.1 mm in Udham Singh Nagar, through 1,202.9 mm in Hardwar and 1,521.2 mm in Nainital, to 1,632.1 mm in Dehradun and 1,775.4 mm in Pithoragarh, and at single gauges from about 500 mm at Srinagar in the rain shadow to more than 2,400 mm at Rajpur and Nainital on the outer ridge (IMD). The monsoon is brought by depressions and lows from the Bay of Bengal, weakened by the 1,300 km from the coast and forced up against the hills, with western disturbances interacting with it (IMD). The normal date of onset is 20 June at Dehradun and 28 June at Roorkee, and of withdrawal 27 September at Dehradun and 25 September at Roorkee (IMD, new normals of 2020); IMD gives the State as clear by 1 October and the Meteorological Centre Dehradun by 30 September. The antecedent moisture rule of Clause 2.11.4 refers to this season; the pre-monsoon deadline of 31 May is set ahead of the earliest onset (Chapter 10). Directions to clean drains before 15 June and a monsoon period of 5 June to 15 September for USDMA were found only in press reports.
Storms outside the season	Large falls come before, after and outside the monsoon, and **October is the main late-season threat**. The storm of 9 October 1956 gave Nainital 300.7 mm, Roorkee 231.7 mm, Deoprayag 215.9 mm, Mussoorie 198.1 mm and Tehri 172.5 mm, and that of 18–19 October 2021 the highest days on record at Pantnagar (403.9 mm), Nainital (401 mm) and Mukteshwar (340.8 mm), three weeks after the normal withdrawal; Kashipur's highest day, 315.0 mm, fell on 2 October 1954 and Ramnagar's, 291.0 mm, on 14 October 1985 (IMD; as reported). In June, before the monsoon is established everywhere, Ranikhet recorded 350.5 mm (16 June 1970), Joshimath 300.0 mm (21 June 1973) and Dehradun 370.2 mm (17 June 2013), and the Dehradun recording gauge 98 mm in one hour (14 June 1970); before the monsoon, Nainital recorded 208.3 mm on 31 May 1956 (IMD; CWC). In winter, about 9% of the annual rain falls with western disturbances, January brings the heaviest snowfall, and days of 100–200 mm are on record in the hills: Mukhim 192.0 mm (20 February 1979), Naitwar 210.0 mm (10 February 1986), Tehri 194.8 mm (12 December 1957) and Ghangaria 136.0 mm (25 December 1985) (IMD); rain on snow and snowmelt add to them, and inlets in towns above about 1,500 m are blocked by snow and ice (Chapter 10). Design statistics use annual maxima from all months, and no works deadline or operating rule shall assume that heavy rain is confined to June–September; the works calendar of Chapter 10 keeps standby to 31 October 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 Uttarakhand this clause

is suspended until Annex 2A is published: Clause 2.3.6 sets the interim source.

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 1(e) (Upper Indo-Ganga Plains), below the Siwalik front (Haridwar–Roorkee and the bhabar–terai), or zone 7 (Western Himalayas), in the Doon and the hills, other than their snow-fed catchments, as applicable.

Where the design value is lower than the CWC 1(e) or zone 7 (Western Himalayas) 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.

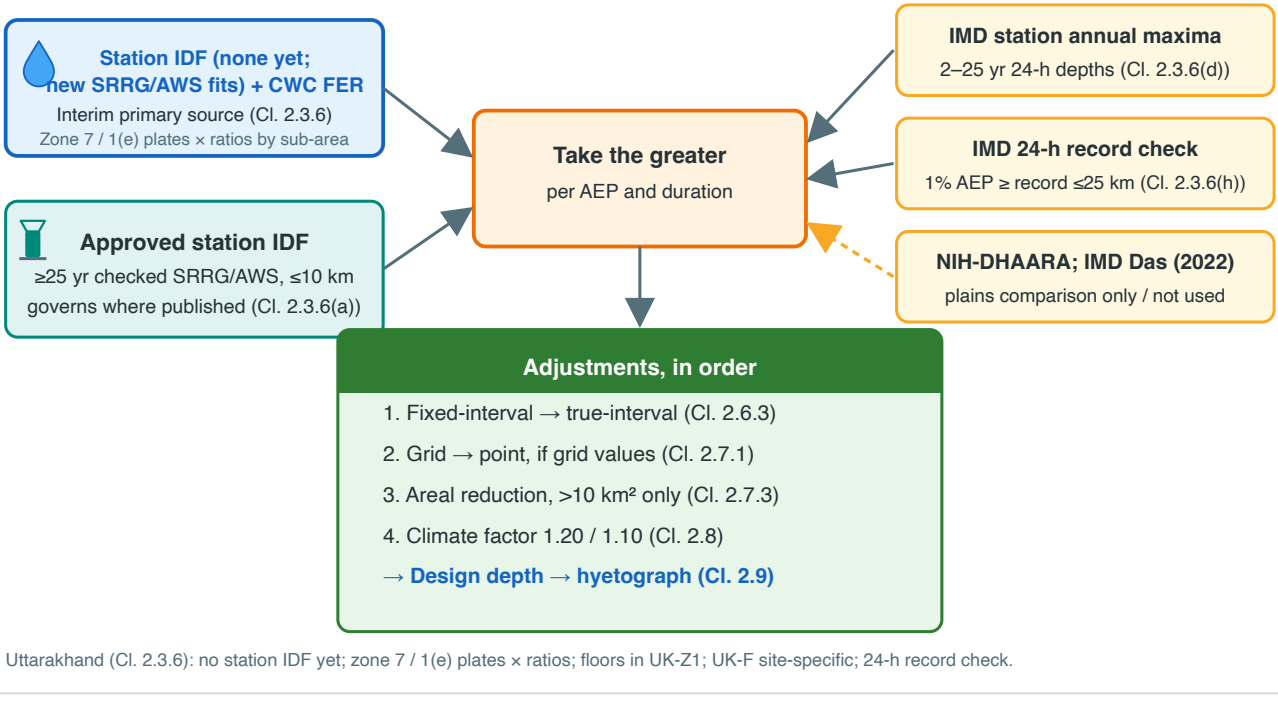


Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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 Uttarakhand.** 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 Uttarakhand, 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 (g); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e) and (h), and the CWC floor of Clause 2.3.3 still applies. 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 Uttarakhand Clause 2.3.2(a) is read with 25 years in place of 30 (set by this Manual, so that the recording gauges of the State's main towns can qualify once analysed), and the gauge shall not be separated from the site by a ridge (set by this Manual, because the outer ridge and the inner valleys receive very different rain within a few kilometres). No IDF has yet been published in Annex 2B, and no station IDF with verified constants was found for any town in the State: the Dehradun constants of Ram Babu et al. (1979) and the frequency tables of the analysis of 99 years of Dehradun rainfall by the Central Soil and Water Conservation Research and Training Institute (1968) were not obtained [TBC], the Dehradun panel of IMD Das et al. (2022) is the paper's generic curve (n), and the northern-zone equation of Ram Babu et al. (2006) is a generalised formula (o). The first data request of this Manual is for the recording-gauge and automatic weather station records of the IMD stations of the main towns, to be fitted under this paragraph: Dehra Dun, 42111 (daily record 1901–2012), and the two recording gauges at Dehradun used by the CWC zone-7 report, for the Doon; Roorkee, 42140 (1901–2012), for Haridwar and Roorkee; Mukteswar, 42147 (1901–2012), for Mukteshwar, Almora and Bhimtal; Tehri New, 42114 (1956–2012), for Tehri and New Tehri; the observatory at Pantnagar, which is not in IMD's table of station extremes, for Rudrapur and Kichha; Nainital, 42146 (1953–1980), and its two recording gauges, for Nainital; and the automatic weather stations of the Meteorological Centre Dehradun, among them Sahastradhara ITI, Maldevta and Jolly Grant (IMD); the years of recording-gauge data held at each are to be confirmed [TBC].

- (b) **Report, zone and sub-area.** Two CWC reports cover the State, split at the Siwalik front: the report for zone 7, Western Himalayas (WH/22/1994), covers the Doon and the hills, which it calls part of "Uttar Pradesh" because it was written before the State was formed; the report for subzone 1(e), Upper Indo-Ganga Plains (1984), covers the plains below the front. Subzone 1(f) does not reach the State. The site's report is that whose area contains it, by the boundary drawn on the reports' plates, which runs along the Siwalik front, south of Dehradun near the Suswa bridge (Br. 139) and just north of Kotdwara, and meets the Kumaon hills at Kathgodam. Zone 7 therefore covers sub-areas UK-A, UK-D, UK-E and UK-F of Annex 2A, including **Dehradun**, Doiwala, **Rishikesh**, **Mussoorie**, Vikasnagar, **Nainital**, Bhimtal, Almora, Ranikhet, Mukteshwar, **Pithoragarh**, Champawat, Lohaghat, Bageshwar, **Tehri** and New Tehri, **Srinagar**, Pauri, Rudraprayag, Gopeshwar, **Uttarkashi**, **Joshimath (Jyotirmath)** and Lansdowne; 1(e) covers sub-areas UK-B and UK-C, including **Haridwar**, **Roorkee**, Laksar, Manglaur, Bhagwanpur, **Kotdwara**, **Haldwani**, south of Kathgodam, **Kashipur**, Jaspur, Bazpur, **Rudrapur**, Kichha, Gadarpur, Sitarganj, **Khatima** and Tanakpur–Banbasa. Within 5 km of the line between the two reports, and at Kathgodam, Kotdwara, Ramnagar, Rishikesh and the northern wards of Haridwar (Har-ki-Pauri and Bhupatwala) whatever the distance, the 24-hour depths are read from the plates of both reports and the higher is used, and at each duration the higher of the products under (f) and (g) for the two sub-areas concerned (set by this Manual). 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 are a guide: the plate boundary governs, and is to be confirmed on the reports' index maps [TBC]. The rainfall zone and sub-area of the site are those of Annex 2A; they fix the ratios of (f), the floors of (g) and the rule of (i).

- (c) **24-hour depth, 2% and 1% AEP (50- and 100-yr).** The 24-hour point value at the site read from the 50- and 100-year isopluvial plates of the report for its zone (Plates 9 and 10 of zone 7; Plates 9 and 10 of 1(e)), 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 (40 mm); and where the plate cannot be read at the site, the highest contour legible within 25 km of the site is used until the plate has been read for it [TBC] (all set by this Manual). Plates are read by the coordinates of the site, not by the

town labels; the zone-7 plates are drawn on a skewed projection and the scan available is poor, so each reading is recorded on Form 2-1 with the contours on either side. For orientation only, read by eye to about one contour on scans re-rendered for this Manual, the 50-year plates give about 280–320 mm at Dehradun, at Rishikesh, at the edge of the plate, and at Kotdwara, Kashipur and Rudrapur; about 280 mm at Haridwar and Roorkee; about 320 mm at Khatima and Tanakpur, where no contour is labelled near the towns [TBC]; 320–360 mm at Ramnagar; 240–280 mm at Mussoorie, Mukteshwar and Uttarkashi; about 200–240 mm at Tehri; **400–440 mm at Haldwani and Kathgodam**, with a spot of more than 450 mm just north-west of them; and **more than 440 mm at Nainital**, at the centre of a closed cell, which the rule above takes as 480 mm. At Almora, Pithoragarh, Srinagar and Joshimath the graticule of the zone-7 plates cannot be read on the scan [TBC]. The 100-year values are about one contour (40 mm) higher: about 320–360 mm at Dehradun, 280–320 mm at Haridwar and Roorkee, where Plate 10 of 1(e) prints a spot value of 311 mm, about 320 mm at Kotdwara, Kashipur and Rudrapur, and 440–480 mm at Kathgodam, with a spot of 490 mm north-west of it. The worked example of the zone-7 report, the Banu Khad in Himachal Pradesh, reads 32.0 cm at 50 years. 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).

- (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, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3; in zone 7 the 4% AEP depth is not less than the 25-year plate value (Plate 8) read as in (c) (set by this Manual). The station is, for example, Dehra Dun, 42111, for the Doon, for which a Gumbel fit to the annual maxima of 1901–2020 gives 152, 196, 226 and 263 mm at 2, 5, 10 and 25 years before the fixed-interval factor (ADB, 2021; to be repeated on the IMD series checked under (a)); Roorkee, 42140, for Haridwar and Roorkee; Mukteswar, 42147, for Mukteshwar, Almora and Bhimtal, and as a check for Nainital, whose observatory record, 42146 (1953–1980), is too short; Tehri New, 42114, for Tehri and New Tehri; Mussoorie, 42112 (1901–1992), for Mussoorie and Landour, with Dehra Dun as a check; and Joshimath, 42116 (1958–2008), for Joshimath. Haldwani, Kashipur, Rudrapur, Khatima, Kotdwara, Rishikesh, Srinagar, Pithoragarh and Uttarkashi have no IMD observatory of 30 or more years in IMD's table of station extremes; for them the station is a district rain gauge of 30 or more years of data supplied by IMD, such as Haldwani (35 years of data in IMD's district table), Kashipur (34), Khatima (33), Rudrapur/Kichha (33) and Narendranagar (33) for Rishikesh, or the nearest IMD station with 30 or more years of record, from the candidates in Annex 2A [TBC]. A day of record excluded under (h) is left out of the series, and the fit with it is reported beside the fit without it on Form 2-1 (set by this Manual).

- (e) **48- and 72-hour depths.** The Gumbel estimate from the annual maximum 2-day and 3-day rainfall series of the same station, with the fixed-interval factors of Clause 2.6.3, and not less than the 24-hour depth for the same AEP, as checked under (h).

- (f) **Durations of 1 to 24 hours.** The 24-hour depth of (c) or (d), before the check of (h), multiplied at every AEP by the ratios in Table 2B.1 for the site's sub-area (all set by this Manual):

    - in sub-areas **UK-A** (Doon valley) and **UK-E** (Inner valleys and middle mountains), and in the local catchments of UK-F that (i) allows, the ratios of zone 7: 0.425 at 1 hour, 0.600 at 3 hours, 0.725 at 6 hours, 0.790 at 9 hours, 0.845 at 12 hours, 0.895 at 15 hours and 0.935 at 18 hours, derived from the 10-year depths of the nine recording gauges of the zone with eight years or more of data, among them those at Dehradun, Nainital and Tehri (CWC, zone 7);
    - in sub-areas **UK-B** (Haridwar–Roorkee plains) and **UK-C** (Bhabar–terai), the 50-year ratios of 1(e): 0.34 at 1 hour, 0.475 at 2 hours, 0.56 at 3 hours, 0.607 at 4 hours, 0.647 at 5 hours, 0.68 at 6 hours, 0.77 at 9 hours, 0.84 at 12 hours, 0.89 at 15 hours and 0.93 at 18 hours, then raised under (g); and
    - in sub-area **UK-D** (Outer-ridge hill stations), the ratios of 1(e) applied to the 24-hour depth of the zone-7 plates, without the floors of (g).

  The zone-7 ratios are the highest of any report in the series; the report found them comparable at return periods beyond 5 years, and they are applied at every AEP. In UK-A they give about 119–136 mm in 1 hour and 168–192 mm in 3 hours at 50 years at Dehradun, against the 98 mm in 1 hour and 143 mm in 3 hours recorded by the Dehradun recording gauge on 14 June 1970; in UK-E they give about 102–119 mm in 1 hour at Uttarkashi, against

the 100 mm recorded there on 12 July 1979 (CWC, zone 7, Annex 4.4). They are consistent with the hours of record. In UK-D the 24-hour depths are orographic: the outer ridge catches long monsoon rain whose daily totals are very large, while its hours are not larger in proportion. There the zone-7 ratio would give more than 187 mm in 1 hour at Nainital, against the 79 mm measured by its recording gauge on 3 July 1972 (CWC) and the 50–100 mm/h recorded for about an hour at seven stations in the storm of 18 October 2021 (Thapliyal & Singh, 2023); the 1(e) ratio gives about 150–165 mm, still about twice the recorded hour, and is used as a conservative interim value. Between the tabulated durations the ratio is interpolated on logarithmic axes; the 2-hour ratio of zone 7, which the report does not give, is interpolated in the same way. The 24-hour depth itself is that of (c) or (d) as checked under (h).

- (g) **Short storms.** In sub-areas UK-B and UK-C (zone UK-Z1), for the 10-yr and rarer storms, the 1-hour and 3-hour depths shall be not less than the greater of (i) 0.35 times (1 hour) and 0.57 times (3 hours) the 24-hour depth of (c) or (d) for the same AEP, before the check of (h), and (ii) the following values; the 2-hour depth shall be not less than the value interpolated on logarithmic axes between the 1- and 3-hour values for the same AEP (all set by this Manual):

Sub-area	Duration	10% (10)	4% (25)	2% (50)	1% (100)
UK-B Haridwar–Roorkee plains	1-hour depth not less than (mm)	70	80	90	100
UK-B Haridwar–Roorkee plains	3-hour depth not less than (mm)	110	135	150	165
UK-C Bhabar–terai (Haldwani–Kashipur–Rudrapur–Kotdwara)	1-hour depth not less than (mm)	80	95	105	115
UK-C Bhabar–terai (Haldwani–Kashipur–Rudrapur–Kotdwara)	3-hour depth not less than (mm)	130	155	175	195

The ratio floor and the values are those that the Uttar Pradesh edition of this Manual sets for the same 1(e) plain across the State boundary: for its western plain, which adjoins Haridwar, in UK-B, and for its terai and Rohilkhand, which adjoin Udham Singh Nagar, in UK-C. They rest on the only published station fit in that plain and on the 2-year ratios of three of its stations, all above the subzone ratios (Kathuria, Kaur & Mehra, 1987). No hourly record of the plains of Uttarakhand was found for this Manual [TBC], but the evidence found points the same way, and so supports carrying the floors across the boundary rather than leaving the 1(e) ratios bare. NIH-DHAARA, whose 1-hour values run low in the hills and in the other States of the series, gives 50-year 1-hour depths of about 75 mm at Haridwar and 89 mm at Roorkee, close to the values of (ii) for UK-B, and 96–109 mm at Haldwani, Rudrapur and Kashipur, at or above those for UK-C (NIH-DHAARA, queried 10 Nov 2026); rates of 50–100 mm/h were recorded for about an hour at seven stations in Udham Singh Nagar, Champawat, Nainital and Pauri on 18 October 2021 (Thapliyal & Singh, 2023); and the 24-hour plate values of UK-C, about 280–440 mm, are among the highest of the 1(e) plain, which is why its values are those of the terai side and not of the western plain. Where the 24-hour depth is large, as at Haldwani, the ratio floor of (i) governs and the values of (ii) do not bind; they bind where a station's Gumbel estimate at 10 or 25 years is low. No floor is set in UK-A, UK-D, UK-E or UK-F: in UK-A and UK-E the zone-7 ratios already give depths at or above the hours of record, and in UK-D the depths of (f) are about twice them. The floors are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to them, and the climate factor of Clause 2.8 is. The floors are interim, to be revisited when Annex 2B publishes frequency analyses of the recording-gauge and automatic weather station records of the stations of (a), beginning with Dehradun, Roorkee, Pantnagar and Nainital: if any shows 1- or 3-hour depths above those of (f) and (g) for a sub-area, a floor shall be set or raised for it; if together they show depths well below them, a reduction may be proposed to the State Stormwater Technical Committee. The depths of (f) and (g) are present-day, true-interval values once the fixed-interval factor has been applied to the 24-hour depth; the climate factor of Clause 2.8 is then applied.

- (h) **24-hour record check.** The 1% AEP (100-yr) 24-hour depth of (c) or (d) shall be not less than the highest qualifying 24-hour rainfall recorded by IMD at any station or district rain gauge within 25 km of the site, where that record is higher; the record is used as printed, without the fixed-interval factor, and is treated as a 1% AEP depth; the 2% AEP (50-yr) 24-hour depth is then not less than the 1% AEP depth so raised less one contour interval of the plates, 40 mm (all set by this Manual). A record qualifies only when it is printed by IMD (in *Extremes of Temperature and Rainfall for Indian Stations*, the *Climate of Uttarakhand*, 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, or IMD has confirmed that the gauge that made it stood where the present gauge stands and was read in the same way; it falls in a month in which a fall of that size is plausible for the station; and it is not contradicted by another IMD table for the same gauge. A record that fails any test is excluded until IMD confirms what it lacks (set by this Manual). The test of date is added in Uttarakhand because several of the State's highest days were recorded in the 1870s–1890s at canal and district gauges whose sites and practice then are not documented in the sources found, and IMD's tables disagree about some of them (commentary). The records that qualify and raise the 100-year depth above the plates, read as in (c), are **487.0 mm at Dehradun (Obsy) on 25 July 1966** (50 years of data), against about 320–360 mm, which governs within 25 km of the observatory, in Dehradun city, Rajpur, Raipur, Maldevta, Sahastradhara, Doiwala, Selaqui, Prem Nagar and Mussoorie, where it exceeds **440.4 mm at Rajpur on 25 August 1954** (25 years); **396.0 mm at Narendranagar on 27 July 1999** (33 years), for Rishikesh, Muni-ki-Reti and Dhalwala; **405.6 mm at Khatima on 15 September 1972** (33 years), for Khatima, Banbasa and Tanakpur; **450.0 mm at Askote (Obsy) on 5 September 1982** (26 years), for Pithoragarh town and Dharchula, each about 23 km from it (gauge coordinates to be confirmed [TBC]); **475.0 mm at Berinag on 6 September 1965** (23 years), for Berinag and Chaukori; **413.0 mm at Haldwani on 11 July 1970** (35 years), which is below the plate at Haldwani but raises Pantnagar, about 22 km away; and **340 mm at Mukteshwar on 19 October 2021** (34 cm in IMD's press release of that day; the observatory's record runs from 1901), for Mukteshwar and Almora, and for Bhimtal and Bhowali where the plates give less (IMD). No qualifying record raises Haridwar, Roorkee, Kotdwara, Kashipur, Rudrapur, Nainital, Tehri, Srinagar or Uttarkashi. Excluded pending confirmation [TBC]: **495.3 mm at Hardwar (Hydro) on 18 September 1880**, the State's highest day, and the other records made before 1901, among them Mussoorie's 439.4 mm of 19 August 1890, for an observatory whose highest day in IMD's table of station extremes is 317.0 mm (5 August 1964), Roorkee's 284.7 mm of 17 September 1880, against the 266.7 mm of 1888 given for the Roorkee observatory in the same table, Kotdwara's 349.0 mm (1892), Champawat's 389.9 mm (1897), Kathgodam's 306.6 mm (1897) and Kilpuri's 330.2 mm (1885), each admitted once IMD confirms its gauge; **487.5 mm at Raipur (Dehradun) on 2 August 1959**, the State's second highest day, from a gauge with 16 years of data in IMD's district table, and **403.9 mm at Pantnagar on 19 October 2021** (40 cm in the press release), from an observatory with 16 years of data in the same table, each admitted once IMD confirms at least 20 years of daily record at its gauge; Ranikhet's 350.5 mm (16 June 1970), whose years of data are not printed; the 264 mm at the Sahastradhara automatic weather station on 16 September 2025 (26 cm in IMD's report; 192 mm in another), a station of a few years; and the 419 mm reported at Rishikesh in August 2023, which no IMD table found prints. Excluded until IMD confirms the value itself [TBC]: Nainital's 50.9 cm of 22 September 1958 and Bazpur's 40.6 cm of 1954 in the annex of the zone-7 report, which IMD's own tables contradict (313.7 mm on 15 September 1957; 298.5 mm on 21 July 1954); the three different maxima printed for Mukhim; and the 535 mm reported for an automatic station at Nainital on 19 October 2021 (as reported). Nainital's 401 mm of that day (40 cm, IMD) is below its plate value and does not raise it. Until Annex 2A is published, the designer lists on Form 2-1 every IMD record within 25 km of the site, with the tests it passes or fails. The check raises the 24-hour depth and, through (e), the 48- and 72-hour depths, in every sub-area, and in UK-F as a minimum for the study of (i). It does not raise the depths of (f) and (g) for 1 to 18 hours, because the records are daily totals of long monsoon storms against the outer Himalaya, no hourly record of any of them exists, and multiplying them by the zone-7 ratios would give about 207 mm in 1 hour at Dehradun, about twice the largest hourly fall recorded in the State. The check is made because the long-record gauges of the Doon and of Pithoragarh district, and the terai gauges since the plates were drawn, have recorded far more than the plates' 100-year depth, so that the plates cannot be relied on in the tail on which floors, storage and spillways depend (commentary).

- (i) **Snow-fed catchments and sub-area UK-F.** The zone-7 report states that its relations are not to be used for design floods in the snow-fed area of the zone, and that its recommendations are to be applied with caution where catchments are covered by snow and glaciers (CWC, zone 7). In sub-area UK-F (High Himalaya and snow-fed), and in any catchment elsewhere with permanent snow or a glacier within it, the design rainfall and design flood are site-specific: the method, data and values are agreed with the Authority and the Irrigation Department and recorded on Form 2-1, and are not less than the values of (c) to (h) for the rain falling on the part of the catchment below the snow [TBC]. For a local catchment wholly below the snow and without a glacier, such as the slopes of a town in UK-F, (c) to (h) apply as in UK-E. No design in UK-F, and no design in any sub-area for a site with a glacier, a glacial lake or a mapped debris-flow fan in the catchment above it, is complete without a debris-flow and glacial lake outburst flood (GLOF) screening recorded in the drainage report: it identifies the glacial lakes, moraine dams, landslide dams and debris-flow fans upstream, from the glacial lake monitoring of CWC and the hazard and landslide maps of USDMA and ULMMC where they exist [TBC], and states whether the site lies on their flow path; where it does, the siting, setback and floor-level rules of Chapters 6 and 7 govern, because no drain is sized to carry a debris flow (all set by this Manual). The disasters of the State's high valleys have been outbursts and debris flows more than rainfall: on 17 June 2013 the moraine-dammed Chorabari lake above Kedarnath emptied in 5–10 minutes after 325 mm of rain in 24 hours at the glacier camp (Dobhal et al., 2013); on 7 February 2021 about 27 million m³ of rock and ice fell from Ronti peak and became the debris flow of the Rishiganga and the Dhauliganga, with no rain at all (Shugar et al., 2021); and on 5 August 2025 a debris flow down the Kheer Ganga buried Dharali while the gauge at Harsil recorded 8 mm (as reported).

- (j) **Cloudbursts.** IMD calls a fall of 100 mm or more in one hour at a station a cloudburst (as quoted; no IMD primary document was found for this Manual [TBC]). No design rule is drawn from the term. No gauge in the State was found in a primary source to have recorded more than 100 mm in an hour: the 100 mm of the Uttarkashi recording gauge (12 July 1979) equals the threshold and the 98 mm at Dehradun (14 June 1970) is just below it (CWC), while the falls reported as cloudbursts at Kedarnath (2013), Sahastradhara (54 mm in an hour on 16 September 2025, which IMD said was not a cloudburst) and Dharali (2025) did not reach it at the gauges (Dobhal et al., 2013; as reported). The 1-hour design depths of (f) at 50 and 100 years, about 120–155 mm at Dehradun and 85–135 mm in the inner valleys before the climate factor, are of the same order, so a burst of that size is within the range for which the major system of Chapter 6 is checked. What a burst does in a steep hill catchment that a design storm does not represent is to bring down boulders, slope debris and trees in its first minutes. In such catchments 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 storms of the hills are front-loaded: the zone-7 report puts 73% of a 3-hour storm, and 52% of a 6-hour storm, in its first hour (CWC, zone 7, Annex 4.1).

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

- (m) **NIH-DHAARA.** In sub-areas UK-B and UK-C its present-day values at the site are reported on Form 2-1 beside the interim values, for comparison only; there its 24-hour depths are high, about 400 mm at 50 years at Haldwani, Kashipur and Rudrapur against plate values of 280–320 mm at Kashipur and Rudrapur, and 358 mm at Haridwar against about 280 mm (commentary). In UK-A, UK-D, UK-E and UK-F it is not used or reported, because its hill cells break down at short durations: its 50-year 1-hour depths are 24 mm at Joshimath and 32 mm at Kedarnath, 0.09 and 0.12 of its 24-hour depths there, against the 100 mm in an hour recorded at Uttarkashi (NIH-DHAARA, queried 10 Nov 2026; CWC). Its ratios of the t-hour to the 24-hour depth are tabulated in Annex 2B for comparison and are not design ratios. Its projected depths are not used under Clause 2.8.4; the ratio of its projected to its present-day depths may be reported as a check on the climate factors of Table 2.2, which apply.

- (n) **IMD Das et al. (2022).** The paper has a panel for Dehradun (Fig. 4(vi)), but the panel repeats the generic curve that the paper prints for eleven other cities on the same page; it is not Dehradun data. Its 1-hour intensity of about 101 mm/h at 50 years is close to the 98 mm recorded at Dehradun in 1970, and its 24-hour intensity at 100 years, about 15 mm/h or 360 mm in a day, is in the range of the Doon's records; these coincidences do not make it a station curve. The cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available, and the paper is not used as a value, a check or a floor.

- (o) **Earlier design values.** The figures found for the State are not a design source. The drains of Dehradun built under the ADB-funded Uttarakhand Integrated and Resilient Urban Development Project are designed for "a storm frequency of once in 2 years" for roadside drains and "once in 5 years" for primary and secondary channels, with a minimum drain of 250 × 250 mm, velocities of 0.6–3.0 m/s and outfall inverts above the high flood level of the receiving water, and "do not include an allowance for climate change"; the project's climate risk assessment fits a Gumbel distribution to the daily maxima of Dehradun for 1901–2020 (152, 291 and 319 mm at 2, 50 and 100 years), notes that the drains "may remove around half the floodwater in larger events" and recommends that they carry "10-20% more flow" (ADB, 2021). It is the only stated design basis for a town's drains found in the State; no State or municipal drainage standard was found. Road drains follow IRC:SP:42-2014 (10-year drains and 25- or 50-year culverts on national and State highways; Chapter 6). The Irrigation Department maps floodplains for the 25- and 100-year floods under the Flood Plain Zoning Act, the State has treated the Rispana's 1-in-5-year flood zone as its active floodplain, and NMCG asks for the 5-, 25- and 100-year extents (NGT, OA 417/2022). The northern-zone IDF equation of Ram Babu et al. (2006) gives a 2-year 24-hour depth of about 63 mm at Dehradun, against 152 mm from the station's annual maxima; it is a generalised formula under Clause 2.3.4(a) and is not used. The return periods of Table 2.1 and the depths of this clause apply instead, in the Doon as elsewhere: the ADB 2-year and 5-year criteria are cited as the history of practice.

- (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 Uttarakhand the platform does not yet meet that purpose. Its present-day values there come from IMDAA reanalysis (about 12 km), not from gauges, and they fail in a pattern of their own. In the plains its 50-year 24-hour depths are high: about 400 mm at Haldwani, Kashipur and Rudrapur, against plate values of 400–440 mm at Haldwani but 280–320 mm at Kashipur and Rudrapur, and 358 mm at Haridwar, against about 280 mm. On the outer ridge they are close to the plates (Nainital 426 mm, Dehradun 339 mm). In the high valleys they break down at short durations: the 50-year 1-hour depths are 24 mm at Joshimath and 32 mm at Kedarnath, 0.09 and 0.12 of the 24-hour depths, against the zone-7 ratio of 0.425 and the 100 mm in one hour recorded at Uttarkashi in 1979 (NIH-DHAARA, queried 10 Nov 2026; CWC). A source that errs by these margins cannot be adopted, so Clause 2.3.6 uses the two CWC reports and the long IMD station records until Annex 2A has been done, uses NIH-DHAARA for comparison in the plains only, and does not use it in the hills. Uttarakhand is the first mountain State of the series, and three things set its interim source apart. First, it is split between a hill report and a plains report whose short-duration ratios differ sharply, 0.425 at 1 hour in zone 7 and 0.34 in 1(e). The zone-7 ratio is the highest of any report in the series and rests on nine recording gauges, most of them in the hills; the report's unit hydrograph rests on only six catchments, about 1% of the zone, of which one, the Suswa, is in the State, and the report warns that its relations are not to be used without checking them by other methods, and not at all in snow-fed areas (CWC, zone 7). The ratio is consistent with the hours of record in the Doon and the inner valleys, but on the outer ridge it gives more than twice the largest recorded hour, because there the daily totals are swollen by orographic monsoon rain; that is why Clause 2.3.6(f) uses the plains ratios on the outer-ridge plate. The single-storm maxima of the recording gauges point the same way: the 1-hour maximum is 0.30 of the 24-hour maximum at Dehradun and 0.33 at Nainital, but 0.55 at Tehri and 0.81 at Uttarkashi, where a short burst made most of a small day's rain (CWC, zone

7, Annex 4.4; maxima of different storms at Dehradun). Second, the 24-hour records far exceed the plates. Three gauges of the Doon within about 10 km of one another have recorded more than 440 mm in a day, Raipur (Dehradun) 487.5 mm in 1959, the Dehradun observatory 487.0 mm in 1966 and Rajpur 440.4 mm in 1954, against a 100-year plate value of about 320–360 mm and a Gumbel 100-year value of 319 mm from the observatory's annual maxima (IMD; ADB, 2021); either the fit is too light in its tail or these storms are much rarer than 100 years, and in either case a recorded day is a depth the design must at least carry. Clause 2.3.6(h) answers that with a check rather than a new statistic. A record that is the highest of more than 100 years at one gauge, as the observatory's is, has an empirical return period of the order of 100 years, and for a shorter record the check is conservative. Its test of record length keeps a gauge of a few years from setting the depth of a whole town, which is why Raipur's 487.5 mm and Pantnagar's 403.9 mm wait for IMD to confirm their records. Its test of date keeps out the falls of the 1870s–1890s, among them the State's highest day, 495.3 mm at Hardwar (Hydro) on 18 September 1880: the storm is not in doubt, for Roorkee recorded 284.7 mm the day before and Nainital's great landslip followed it (IMD; as reported), but a single reading 146 years old, at a canal gauge whose site and practice then are not documented, would raise Haridwar's 100-year depth by about 60%, and IMD's tables disagree about other gauges of that period. Its radius of 25 km matches the spread of the Doon's records, all within about 10 km of the observatory. The check stops at 24 hours, because a record day says nothing about its peak hour. Third, the hazards of the hills are not all rainfall: the outbursts and debris flows of Kedarnath (2013), Raini (2021) and Dharali (2025) are represented by no design storm, which is why Clause 2.3.6(i) sets a screening and not a depth. The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the zone of each town, the ratios of the outer ridge, the floors in the plains, the record check, the snow-fed and debris-flow rules 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, on a poor scan drawn on a skewed projection, and the zone-7 graticule cannot be read at Almora, Pithoragarh, Srinagar and Joshimath [TBC]. The zone-7 report's worked example prints a time to peak of 2.5 hours where its own equations give about 3.05 hours, and a loss rate of 0.20 cm/h where its paragraph 3.5 recommends 0.5 cm/h (Chapter 3). Nainital's highest day is 313.7 mm in IMD's tables and 50.9 cm in the annex of the zone-7 report, and Mukhim has three different maxima; the record lengths of the Raipur and Pantnagar gauges, and the history of the 19th-century gauges, are to be obtained from IMD (Clause 2.3.6(h)). No storm-drain DPR for any town of the State with its design rainfall analysis was found for this Manual, other than the ADB criteria for Dehradun [TBC], so the design basis of the drainage master plans that the Irrigation Department is preparing for Haldwani and the Kumaon towns could not be compared with this clause.

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: Dehradun, Haridwar, Haldwani, Rudrapur and Roorkee 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

Element	Design AEP (return period)	Check event	Chapter
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.

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. Uttarakhand's worst floods have come when days of rain fill the soils, springs and reservoirs and raise the rivers. The storm of 16–18 September 1880 brought about 33 inches of rain in three days to Nainital, ending in the landslip of 18 September, and 495.3 mm in a day to Hardwar (IMD; as reported). In June 2013 Dehradun recorded 1,094.8 mm in the month and 370.2 mm on the 17th, and the Tehri reservoir rose from 750.00 m to 775.05 m in three days, from 16 to 18 June, while it held back an inflow of about 7,500 m³/s (IMD; THDC, as cited). The storm of 17–19 October 2021 fell for three days over Kumaon and filled Naini lake to a record 12.2 ft on its gauge, and the Kosi, the Gaula and the Sarda set new highest levels (as reported). Dehradun has recorded 1,637.8 mm in August 1885 and 1,256.7 mm in July 1973 (IMD), and the monsoon of 2025 brought 1,974.6 mm to Dehradun district, 37% above normal, before the storm of 15–16 September (IMD, Meteorological Centre Dehradun). The raos and gadheras rise within an hour of a burst, but the landslides, the debris that blocks their culverts and the rivers that hold their 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.

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 Uttarakhand recording gauges. They shall not be lower than the ratios of the CWC Flood Estimation Report for the zone or subzone (zone 7 Western Himalayas in the hills and the Doon; subzone 1(e) in the plains), except as Clause 2.3.6 provides for the outer-ridge hill stations. The IMD Das et al. (2022) Dehradun panel repeats a generic curve and is not used.

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 SW 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.

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 1(e) or zone 7 (Western Himalayas): 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 IMDAA cell at Dehradun gives a 100-year 24-hour depth of about 379 mm, while the Dehradun observatory recorded 487.0 mm on 25 July 1966 and Raipur, a few kilometres away, 487.5 mm on 2 August 1959; at Haridwar the cell gives about 401 mm, while the plate value is about 280–320 mm (NIH-DHAARA, queried 10 Nov 2026; IMD; CWC). Single storms are patchy at a scale that no cell of about 12 km can show, least of all in the

hills: on 15–16 September 2025 Sahastradhara recorded 264 mm and Maldevta, a few kilometres away, about 150 mm (IMD, as reported), and the annual normals of the gauges run from about 500 mm at Srinagar in the rain shadow to more than 2,400 mm at Rajpur and Nainital on the outer ridge (IMD). 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.

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. It is at or below published projections for India: Ali and Mishra (2018) project 3-hourly 100-year maxima rising by about 20% at 1.5 °C and 25% at 2.0 °C of warming. No design uplift factor has been adopted in Uttarakhand: the ADB-funded drains of Dehradun "do not include an allowance for climate change", while the project's own climate risk assessment projects heavy daily rainfall to rise by 10% (RCP4.5) to 16% (RCP8.5) by 2036–65 and by 15% to 25% by 2066–95, and recommends that the drains carry "10-20% more flow" (ADB, 2021). The interim factors of Table 2.2 sit within that range. The trend in observed heavy-rain days at Dehradun, Pantnagar, Tehri and Mukteshwar over 1983–2023 is weak and not significant (Singh & Thapliyal, 2026, abstract), but recent extremes have not fallen: Narendranagar recorded its highest day, 396.0 mm, in 1999, Pantnagar, Nainital and Mukteshwar theirs in October 2021, and new highest levels have been set since 2010 on the Ganga at Haridwar, the Alaknanda, the Gaula, the Kosi and the Sarda, all after the CWC plates of 1984 and 1994 were drawn (IMD; as reported). The State Action Plan on Climate Change of 2014 was not read for this Manual [TBC]. NIH-DHAARA offers a CMIP6 projection but no historical run of the same model, so no ratio of future to present depths can be formed; under Clause 2.3.6(m) it would serve only as a check. The factors of Table 2.2 are therefore interim values, not Uttarakhand estimates.

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 (SW 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.

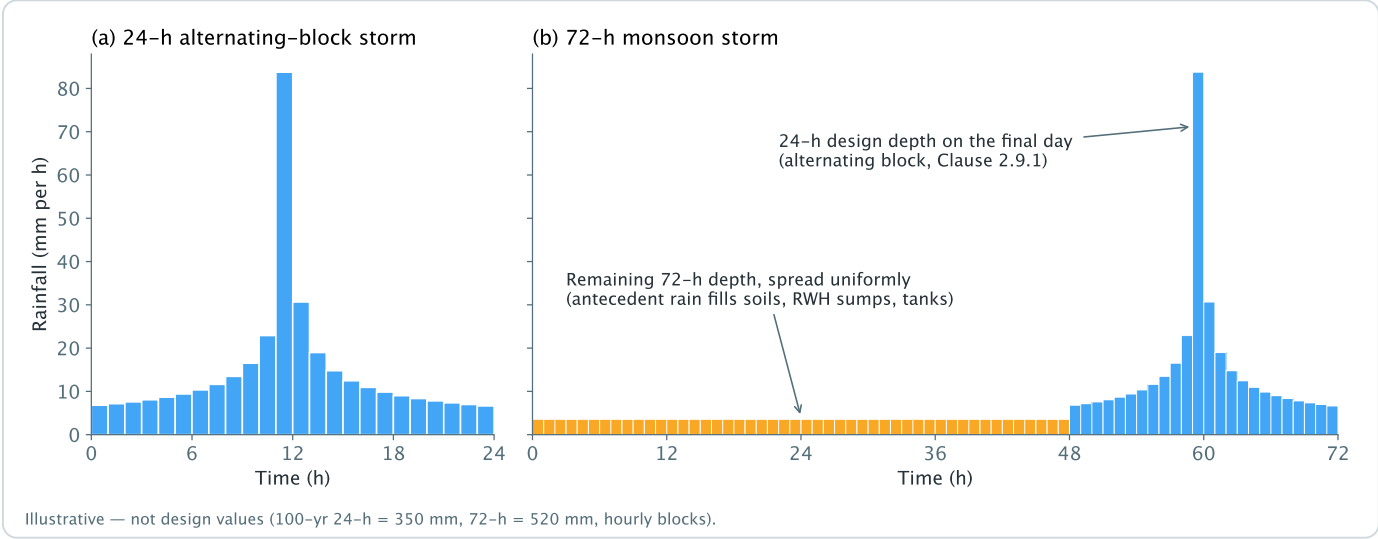


Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour SW monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Uttarakhand 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 Uttarakhand: by the time the largest falls arrive in July–September, or with a western disturbance in October, the thin soils of the hill slopes are saturated and the springs are flowing, the terai water table is within a metre or two of the surface, Naini lake is near the top of its gauge, the reservoirs and barrage ponds of Tehri, Dakpathar and Asan are full, and the Ganga and its tributaries are already high. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Uttarakhand records.

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.

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 the Doon raos at Dehradun, of the Ganga at Haridwar and Rishikesh, of the Gaula at Haldwani, of the Kalyani terai at Rudrapur–Kichha and of Naini lake, the valley-floor towns below debris fans and the notified floodplain reaches, 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 July to 30 September at a site in sub-area UK-A (Doon valley), UK-D (Outer-ridge hill stations), UK-E (Inner valleys and middle mountains) or UK-F (High Himalaya and snow-fed) of Annex 2A, or on terai land below the spring line in sub-area UK-B or UK-C. Use AMC III for every design storm at any time of year in a catchment that drains to a reservoir or barrage pond, to Naini lake or Bhimtal, or to a river reach whose CWC site stands at or above its warning level in the coincident case of Chapter 5. 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 SW monsoon extremes arrive after weeks of rain. In Uttarakhand the ground and the receiving waters, more than the season alone, decide how wet a catchment is. The hill slopes have thin, skeletal soils over rock, colluvium and slide debris that hold little water and saturate early; it rains on 14–18 days a month in July and August (Dehradun about 15–16, Rudraprayag 18.1, Pithoragarh 18.3), and the springs that run from the slopes show that they drain slowly (IMD; CGWB). In the terai the water table stands 1–7 m below the surface and more than 2,000 wells have flowed under artesian pressure (CGWB). In the bhabar and on the Doon Gravels, by contrast, the water table lies 40–75 m down and the gravels take water fast (hydraulic conductivity 13–583 m/day in the Doon Gravels and 25–250 m/day in the bhabar; CGWB), but the raos that cross them gather their water from the steep slopes above. This Manual therefore uses AMC III from 1 July to 30 September in the hill sub-areas, UK-A, UK-D, UK-E and UK-F, and on terai land; at any time of year where the outfall is a reservoir or barrage pond, Naini lake or Bhimtal, or a river at or above its CWC warning level, because those receiving waters are high only when the catchment is wet; and elsewhere only 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). 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 colony draining to the Rispana in Dehradun 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.

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.

Uttarakhand has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the river, rao, gadhera, reservoir, barrage pond or taal into which a town drains. 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 levels are those of Clause 5.8.5(a). The CWC sites with published levels found are on the Ganga and its main tributaries: warning, danger and highest flood levels of 293.0 m, 294.0 m and 296.30 m for the Ganga at Haridwar, whose highest level is dated 19 September 2010 in one CWC record and 17 June 2013 in another, the 2013 peak being given elsewhere as about 295.75 m; 339.5 m, 340.5 m and 341.72 m (5 September 1995) at Rishikesh; 337.2 m, 338.2 m and 338.49 m (28 June 2019) for the Song at Satyanarayan, below Dehradun; 260.5 m and 261.5 m for the Solani at Roorkee, whose highest level is 260.58 m (14 October 2021); and 535.0 m, 536.0 m and 537.9 m (17 June 2013) for the Alaknanda at Srinagar. The Bhagirathi at Uttarkashi has a highest level of 1,124.13 m (1978) and the Alaknanda at Joshimath of 1,388.65 m (7 February 2021). In October 2021 the Gaula at Kathgodam reached 498.93 m, the Sarda at Banbasa 224.9 m, against a maximum water level of 223.3 m at the barrage, and the Kosi at the Ramnagar barrage a level given as 220.75 m by one source and 220.95 m by another (all CWC data as transcribed by SANDRP, or as reported; none was read in a CWC bulletin for this Manual). Tehri has a full reservoir level of 830 m and a maximum water level of 835 m (THDC). Naini lake has no CWC site: its outlet is five sluice gates at Tallital (1888), operated under the rules of the Hill Slide Committee (1927) to a maximum of 12.5 ft on the PWD gauge (NIH; 12 ft in the press), and the sluices are sealed on 15 October; the lake rose to a reported 12.2 ft and overflowed on 19 October 2021 (as reported). The raos of the Doon, the Rispana, the Bindal, the Song, the Suswa and the Tons, and the gadheras of the hill towns are ungauged; they rise within an hour of a burst and carry boulders, so their levels are known only from surveyed flood marks. These levels are set by rain over catchments upstream, by snowmelt and by the operation of gates, so storage and outfalls are checked for the outfall-closed condition with the local storm falling before, during or after the river 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], other than the criterion of the ADB-funded drainage of Dehradun that the outfall invert be above the high flood level of the receiving water, and Chapter 5 sets the interim rule. Every level is stated on a named datum, as Chapter 5 requires; no source found states the datum of the levels quoted here [TBC].

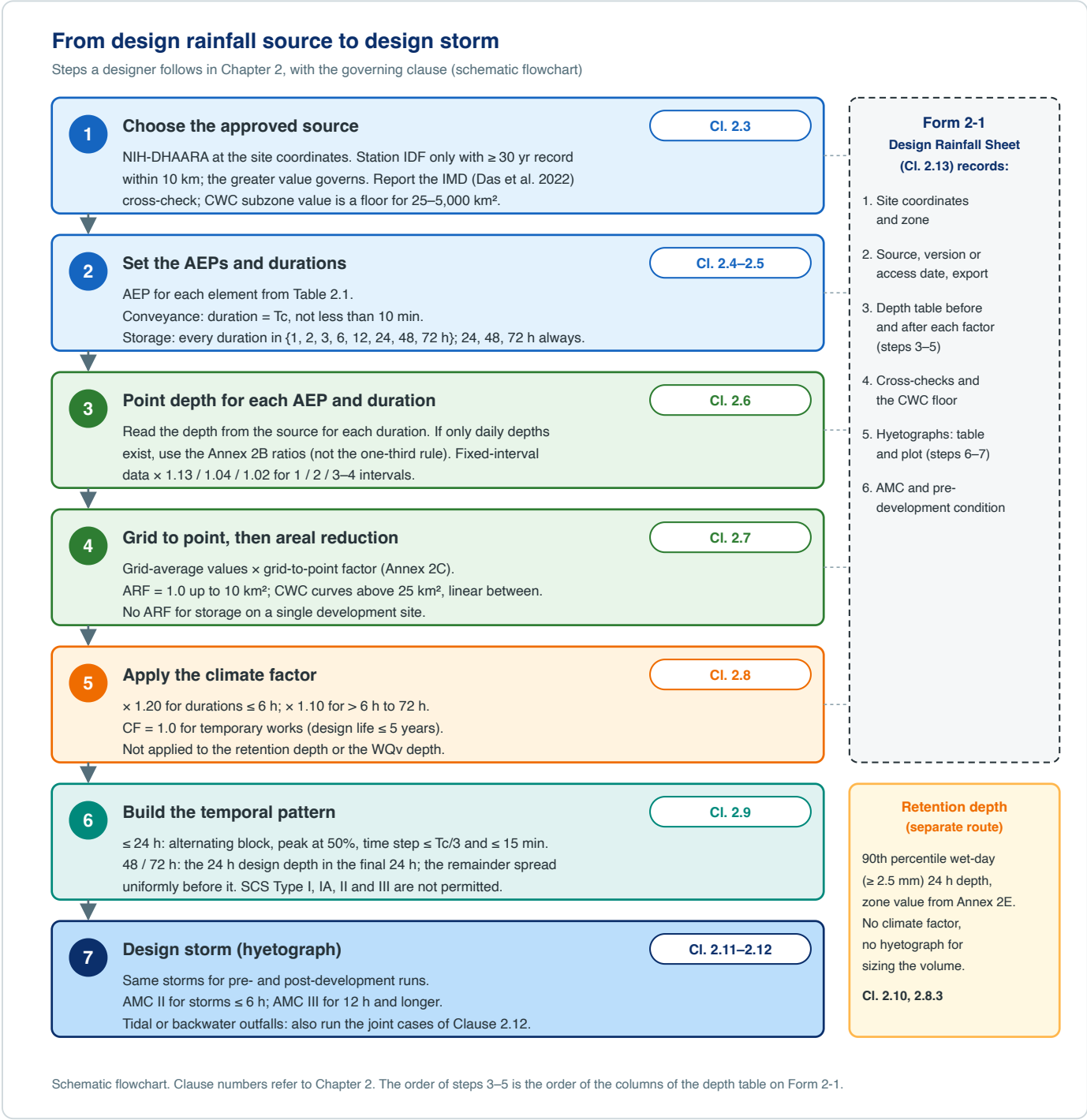
> Commentary. Uttarakhand has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the level of the rivers, raos, reservoirs and taals that receive the town drains. The coincidence is on record. On 17 June 2013 Dehradun recorded 370.2 mm while the Alaknanda rose to its highest levels at Srinagar and Rudraprayag and the Ganga to about 295.75 m at Haridwar (IMD; CWC data as transcribed by SANDRP). On 18–19 October 2021 Nainital and Pantnagar recorded about 400 mm while Naini lake rose to a record 12.2 ft and overflowed, the Gaula at Kathgodam reached 498.93 m and the Sarda at Banbasa 224.9 m, above the barrage's maximum water level of 223.3 m (IMD; as reported). On 14 August 2023 Dehradun recorded 175.1 mm while the Ganga at Rishikesh stood at 341.3 m, above its danger level of 340.5 m (IMD; as reported). In the Doon the raos themselves are the receiving waters: they rise within an hour of a burst on the Mussoorie ridge, while the storm is still falling on the town below. These levels are set by rain over catchments upstream, by snowmelt and by the operation of gates, so they give no warning of a local storm that falls while they are high. The levels quoted by different sources differ: the highest level of the Ganga at Haridwar, 296.30 m, is dated 19 September 2010 in one CWC record and 17 June 2013 in another, and the Kosi at the Ramnagar barrage is given as 220.75 m and 220.95 m for the same flood, which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Uttarakhand, which has no coast, the counterpart of surge is the stage of the rivers, raos, reservoirs and taals that receive the town drains, raised by the same monsoon systems and western disturbances that bring the heaviest rain to the towns: on 17 June 2013 Dehradun recorded 370.2 mm while the Alaknanda set its highest levels at Srinagar and Rudraprayag, and on 18–19 October 2021 Nainital and Pantnagar recorded about 400 mm while the Gaula, the Kosi and the Sarda set new highest levels and Naini lake overflowed, all as reported), they cannot be treated as independent. Case (b) is a simple joint-probability surrogate until a statistical joint analysis is adopted.

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.



Schematic flowchart. Clause numbers refer to Chapter 2. The order of steps 3–5 is the order of the columns of the depth table on Form 2-1.

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.

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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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	Uttarakhand temporal patterns (Huff curves)
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 (taal) 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 (taals) in which the surplus of one tank feeds the next.

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 Doon Gravels, the bhabar boulder fans, the terai, the Ganga alluvium, Siwalik rock, and the colluvium, slide debris, moraine and rock of the hills, 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).

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 1(e) or zone 7 (Western Himalayas)	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 (taal) 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

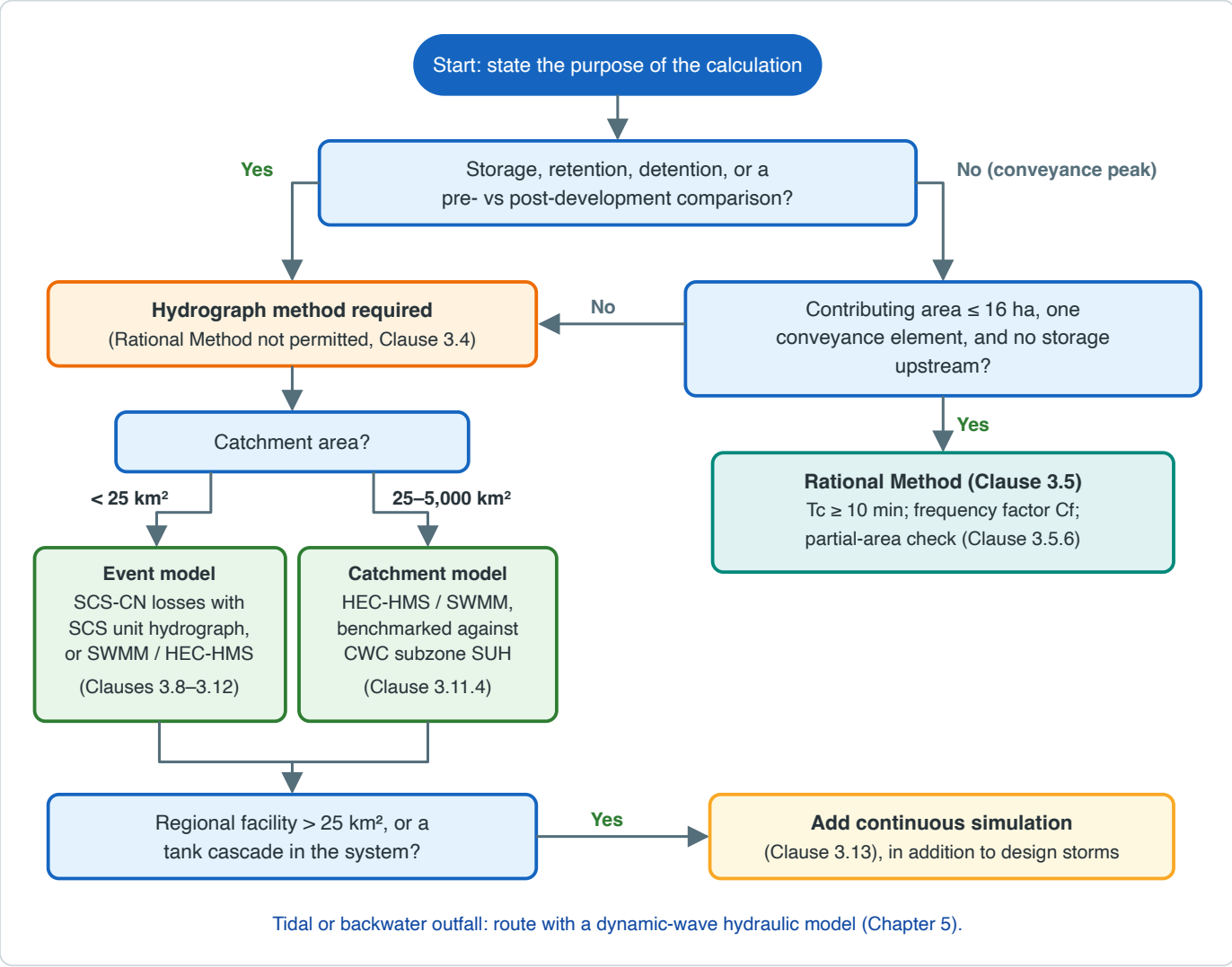

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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 Irrigation Department.

> 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.

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

Surface or land use	C	Source
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
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 Uttarakhand'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.

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.

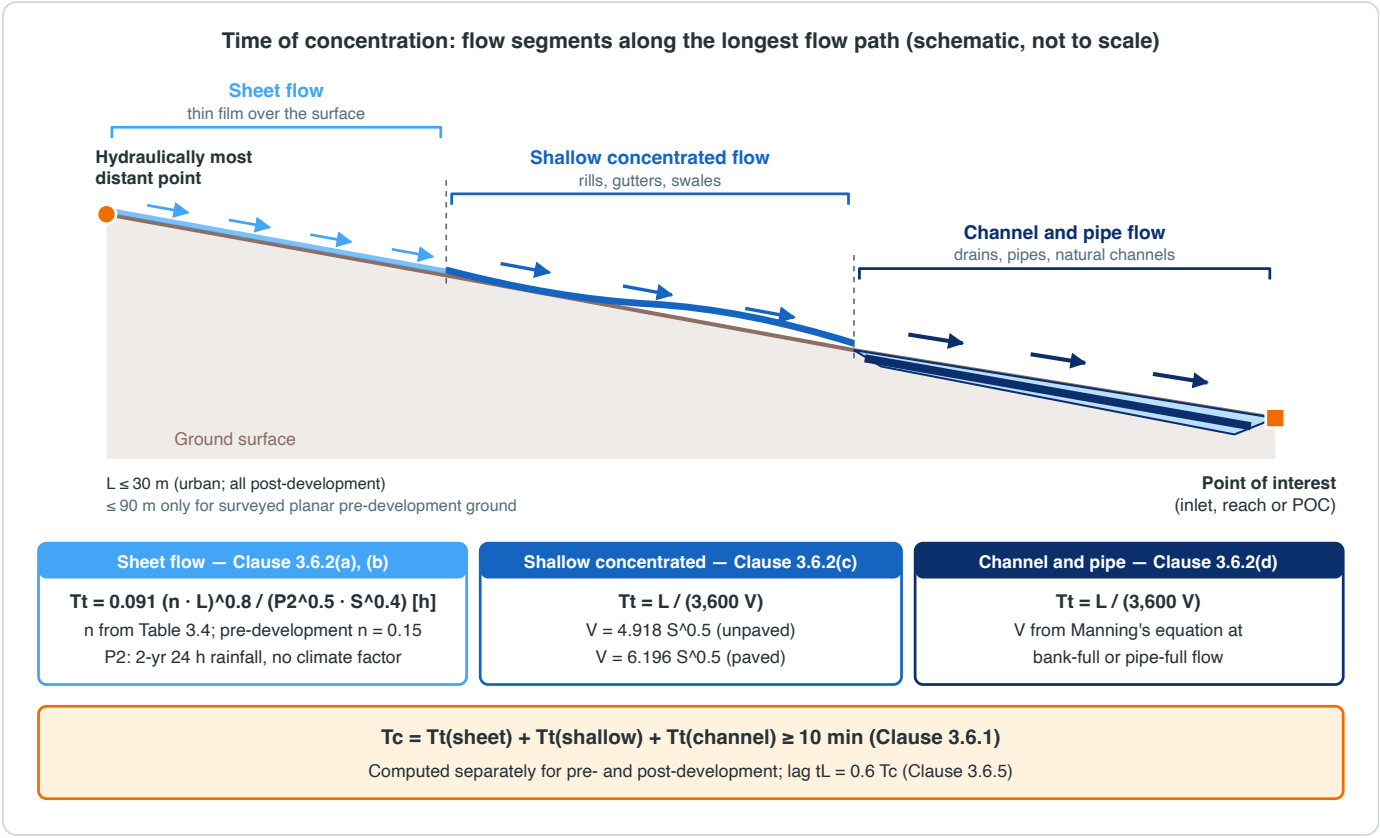

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986),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

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 Uttarakhand Agriculture Department (soil survey) [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 Uttarakhand: the Doon Gravels of the Doon valley and the boulder fans of the bhabar, HSG A, and HSG B where a fine-loamy or silty cover lies over the gravels or the ground is compacted urban ground; the terai below the spring line, HSG C, and HSG D for every design storm wherever the seasonal high water table is within about 1 m of the surface, wells flow under artesian pressure (auto-flow) or the land is waterlogged; the Ganga alluvium of southern Haridwar, Laksar and Khanpur, HSG B on sandy floodplain soils and HSG C on silty ones; the regolith of the Siwalik sandstone and conglomerate, HSG C, and HSG D on mudstone or claystone; hill colluvium, slide debris and moraine, HSG D for design, with no infiltration credit on slopes, whatever group the material itself would take; exposed rock (quartzite, phyllite, slate, limestone, schist and the like), HSG D; and urban fill, HSG C, and HSG D where it is clayey or compacted. 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 on a hill site is governed by the hill infiltration rule of Clause 4.11, 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 at the edges of the belts, where one site can span two groups: at the foot of the Doon fans and of the bhabar, where the boulder gravels pass under a fine-loamy cover and then into the terai at the spring line; in the terai, where a sand lens that tests as HSG A or B lies over clay with the water table a metre or two below the surface; on the Siwalik front, where sandstone and mudstone alternate; and on hill sites, where a test pit in colluvium can show a high rate that is in fact water entering a slope that cannot take it (Clause 4.11). No HSG map or table for Uttarakhand, and no measured infiltration rate for any site in the State, was found during research for this Manual [TBC]: a 2024 study ran double-ring tests at three sites in Dehradun, but its values were not seen. About 85% of the State is mountainous and underlain by hard rock, and about 15% by the semi-consolidated and unconsolidated deposits of the bhabar and the terai (CGWB, *Dynamic Ground Water Resources of Uttarakhand 2024*). The interim groups follow that geology. The Doon Gravels are "boulders and pebbles embedded in sandy and silty matrix", "highly porous", with field permeabilities of 5.86–104 m/day and hydraulic conductivities of 13–583 m/day (CGWB, Dehradun district brochure, 2011); the bhabar is a belt of "coalesced piedmont fans" 4–20 km wide, about 21 km in the Haldwani–Kichha section, with hydraulic conductivities of 25–250 m/day and water 40–75 m below ground (173.71 m at Bhotia Parao, Haldwani) (CGWB, Nainital district brochure, 2010), whose porosity allows the "major part of the precipitation to infiltrate, within a very short span" (CGWB, Udham Singh Nagar brochure). These are aquifer values, not surface infiltration rates, but they support HSG A where the gravel reaches the surface. The terai is 8–25 km wide, of sand, silt and clay in which "clay beds predominate", with water 1–7 m below ground and more than 2,000 artesian wells with heads up to 8.69 m above ground (CGWB, Udham Singh Nagar brochure; NAQUIM, 2016), so it is HSG C, and D wherever it is wet. In the hills, the soils on steep slopes are "skeletal … with low available water capacity" (CGWB, Nainital brochure), and the colluvium and debris that cover them would take water fast as a material; but water put into a slope raises the pore pressure in it. At the Balia Nala below Nainital, water recharging the perched aquifer from the catchment drains and from buildings reduced the cohesion of the soil (Arabian Journal of Geosciences, 2022); at Joshimath, an IIT Roorkee report found internal erosion by subsurface drainage, which "can be minimized by controlling infiltration of water", and the Mishra Committee of 1976 had asked for soak pits to be closed (both as reported). That is why colluvium, slide debris and moraine are designed as HSG D: the group decides the runoff, and on a slope none of the water is to be put back into the ground. A single group D for the whole State would be conservative for peak flows, but it would deny recharge on the Doon Gravels and the bhabar, where four semi-critical groundwater blocks lie (Clause 4.11) and where the bhabar recharges the terai aquifers whose auto-flow zone is retreating (NAQUIM, 2016). The only regional measures of losses are the design loss rates of the CWC reports, 0.5 cm/h (5 mm/h) in zone 7 and 0.30 cm/h (3.0 mm/h) in subzone 1(e) (Annex 3E). They are φ-indices fitted to the floods of whole rural catchments, those of zone 7 to six catchments in Punjab, Himachal Pradesh and the Doon; they shall be used only in rural SUH runs under Clause 3.11.4, 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 1 m water-table threshold for the terai, the treatment of colluvium, slide debris and moraine and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Uttarakhand. Steep ground matters as much as soil in the hills and on the Siwalik and outer-ridge slopes, where runoff from rock and skeletal soil reaches a channel within minutes; the following rules are set by this Manual. (a) On hill streets and khalas with slopes of 10–60%, Kirpich and similar formulae give times of concentration of 1–5 minutes; Tc shall be found by the segment method of Clause 3.6.2 and shall not be taken below the 10-minute minimum of Clause 3.6.1, which matches the shortest design duration of Chapter 2, and the Kirpich formula, derived from small Tennessee 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, scree, 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) A catchment that runs from a hill flank onto a fan or the plain, such as the Rispana and Bindal from the Mussoorie ridge onto the Doon fans, or the Gaula and the bhabar streams from the Siwalik and outer ridge onto the bhabar,

shall be split at the break of slope, and the hill sub-area modelled on its own, so that a long, flatter lower reach does not average away the fast response of the hill; channel losses into the gravels of a rao or bhabar bed shall not be credited in design, because the bed is saturated by the time of the design storm. (d) 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 Chapters 6 and 9.

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 July to 30 September at a site in sub-area UK-A (Doon valley), UK-D (Outer-ridge hill stations), UK-E (Inner valleys and middle mountains) or UK-F (High Himalaya and snow-fed) of Annex 2A, or on terai land below the spring line in sub-area UK-B or UK-C; AMC III for every design storm at any time of year in a catchment that drains to a reservoir or barrage pond, to Naini lake or Bhimtal, or to a river reach whose CWC site stands at or 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. 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.

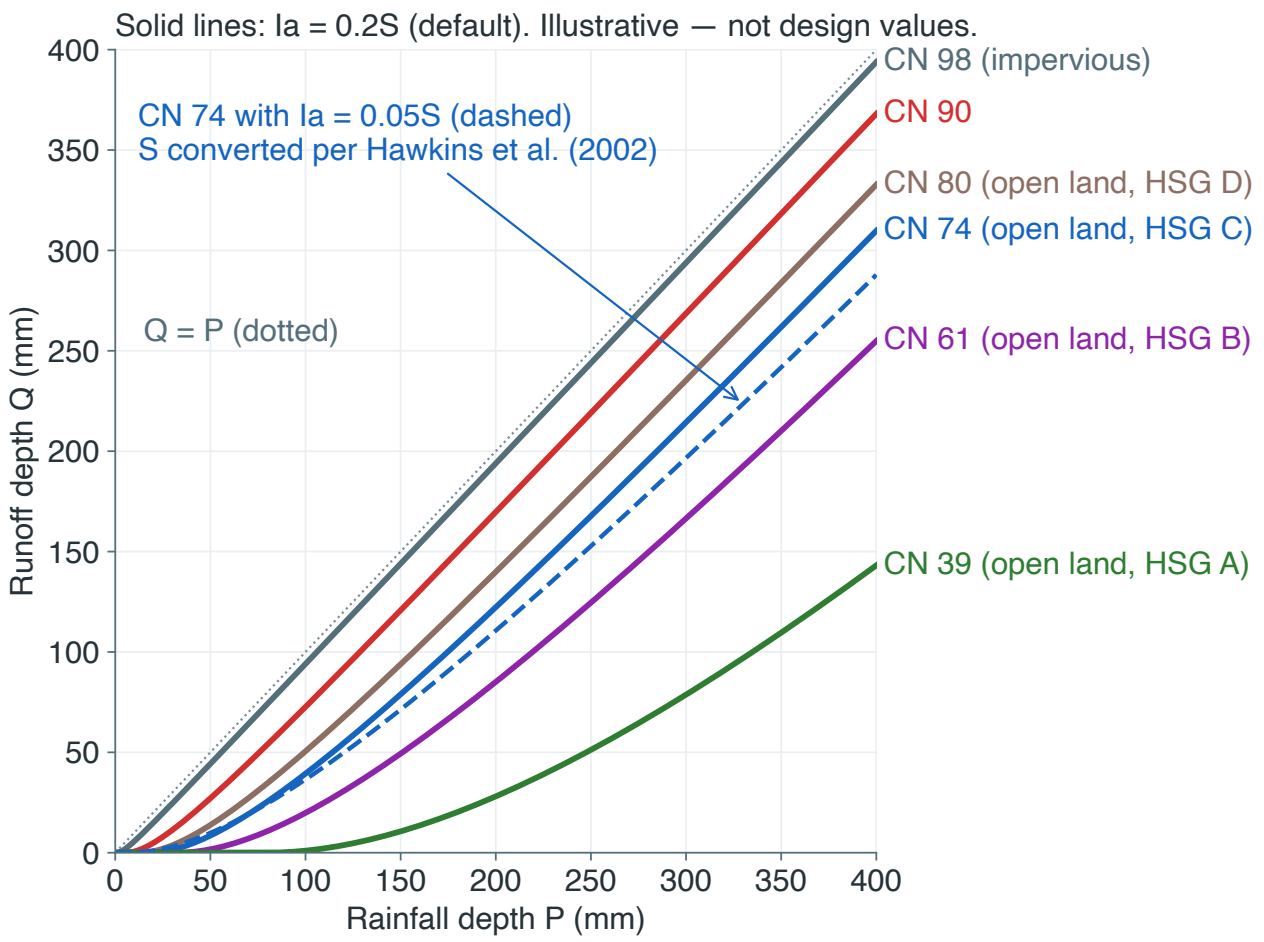

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion 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 Uttarakhand. 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.

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 SW 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 SW monsoon season (June–September), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or Irrigation Department 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, taal, 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 two belts of Uttarakhand are wet in the monsoon, while the rest of the State is not. The terai, below the spring line that separates it from the bhabar, has water 2.09–7.08 m below ground before the monsoon and 1.73–6.89 m after it, with more than 2,000 artesian wells in the Kashipur, Bazpur, Gadarpur, Rudrapur and Sitarganj blocks whose free-flowing heads reach 8.69 m above ground (CGWB, Udham Singh Nagar brochure); the whole of Bazpur and almost 80% of the Kashipur block were artesian in 2016, although the auto-flow zone has receded westward by about 5–7 km in the east as the bhabar has been cleared and shallow tube wells have multiplied (NAQUIM, Udham Singh Nagar, 2016). In Haridwar district the terai lies south of the bhabar of Bhagwanpur and Bahadrabad, with "flowing wells … common" in the lower piedmont plain, a first aquifer at 4–8 m below ground and shallow water levels from about 1.68 m (NAQUIM, Haridwar; CGWB, Hardwar brochure, 2009). The second wet belt is the floodplains and low terraces of the rivers, where the water table follows the river, and the taal margins. The Doon Gravels and the bhabar are the opposite case: water stands 2.29–71 m below ground in the Doon before the monsoon and 2.52 to more than 100 m after it, deepest near the hills (CGWB, Dehradun brochure, 2011), and 40–75 m below ground in the bhabar, with perched water within 10 m in places (CGWB, Nainital brochure, 2010). In the hills groundwater occurs as perched bodies in weathered veneers and colluvium (CGWB, Dehradun brochure), and of the 225 wells measured in January 2025 the shallowest stood 0.52 m below ground at Joshimath and 28.44% stood within 5 m (CGWB, Water Level Bulletin, January 2025). No monsoon water-table depths for individual sites in Rudrapur, Kashipur, Kichha or Haridwar, and no map of the seasonal high water table of the terai, were obtained [TBC]; Annex 3A is to supply them. Clause 3.10.4 reflects the State's receiving waters, which are rivers held up by barrages and reservoirs, ungauged raos, and taals with gated outlets. Haridwar drains to the Ganga, whose CWC warning and danger levels at Haridwar (Dudhia Band) are 293.0 m and 294.0 m, with a highest level of 296.30 m dated 19 September 2010 in one CWC record and 17 June 2013 in another; Rishikesh to the Ganga above the Virbhadra (Pashulok) barrage (warning 339.5 m, danger 340.5 m, highest 341.72 m on 5 September 1995); the east of Dehradun and Doiwala to the Song at Satyanarayan (337.2 m, 338.2 m and 338.49 m on 28 June 2019); and Roorkee to the Solani (warning 260.5 m, danger 261.5 m, highest 260.58 m on 14 October 2021, below its danger level) (all CWC, as transcribed by SANDRP). The Rispana, the Bindal, the Suswa and the Tons in Dehradun have no CWC site. Nainital drains wholly to Naini lake, a closed basin of 4.7 km² whose outlet is five sluice gates at Tallital (NIH, *Water Balance of Lake Nainital*); a site there drains to a water surface, not to a channel, and Clause 3.10.4(b) applies to the land below the lake's maximum level.

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 (m^3/s); A is the area (km^2); Q is the runoff depth (mm), equal to 1 mm for the unit hydrograph; t_p is the time to peak (h); and Δt is the computation interval (h).

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

- (a) Δt 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 km^2 in CWC subzone 1(e) (Upper Indo-Ganga Plains), below the Siwalik front (Haridwar–Roorkee and the bhabar–terai), or zone 7 (Western Himalayas), in the Doon and the hills, other than their snow-fed catchments:

- (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 T_c interval are from NEH Part 630, Ch. 16 (USDA NRCS, 2007). The interval follows from the unit hydrograph geometry: with $t_p = \Delta t/2 + 0.6\ T_c$ and $T_c + \Delta t = 1.7\ t_p$, $\Delta t = 0.133\ T_c$. The SI constant 0.208 is the direct conversion of 484 (cfs, mi^2, 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 1984 and 1994; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the reports of 1984 and 1994 (the only Uttarakhand catchment behind the zone 7 relationships, the Suswa at railway bridge 139 on the Laksar–Dehradun line, was gauged in 1966–67), 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 ($PRF' \approx 0.122$) 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.

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 taals, reservoirs and barrage ponds at their full or maximum level in 3.12.5 because Uttarakhand's heaviest rain falls in the middle and late monsoon and in October, on waterbodies that have taken the earlier rains and are held up for supply, power or safety, not drawn down for drainage. About 78% of the State's annual rain falls in June to September (IMD, *Climate of Uttarakhand*), and its largest storms have come in every month from June to October: 370.2 mm at Dehradun on 17 June 2013, 487.0 mm at Dehradun on 25 July 1966, 487.5 mm at Raipur (Dehradun) on 2 August 1959, 495.3 mm at Hardwar on 18 September 1880, and 403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October 2021 (IMD). The starting levels are as follows.

- **Naini lake.** The lake is regulated through five sluice gates at Tallital, installed in 1888, under rules of the Hill Slide Committee of 1927 that limit the opening to 6 inches while the gauge is below 9 ft and to 12 inches while it is below 9.5 ft, to protect the Balia ravine below the outlet; the maximum lake level is 12.5 ft on the PWD gauge at Tallital, and the sluices are finally sealed on 15 October (NIH, *Water Balance of Lake Nainital*). The press usually gives the maximum as 12 ft, and the lake reached a record 12.2 ft and overflowed on 19 October 2021 (as reported). Operation of the gates is reported to have passed from the

PWD to the Irrigation Department in 2018 (as reported), and the custodian of the rules today, the Lake Development Authority or the Irrigation Department, is to be confirmed [TBC]. The lake shall be started at its maximum gauge level of 12.5 ft on the PWD gauge, converted to metres above mean sea level, whose datum has not been found [TBC], for every design storm from 1 July to 15 October, with the sluices modelled under the 1927 rules, and at the same level with the sluices sealed after 15 October.

- **Bhimtal and the other Kumaon taals.** Bhimtal (47.8 ha, catchment 17.12 km²) and Naukuchiatal have no published operating rule or level record (as reported) [TBC]; they shall be started at their spill or outlet crest level.
- **Reservoirs and barrage ponds.** These are started at their maximum water level, or, where none is published, at the full or maximum pond level plus 0.5 m, as for a gated reservoir in Chapter 5: the Tehri reservoir at its maximum water level of 835 m (full reservoir level 830 m, first reached on 24 September 2021; THDC); the Dakpathar barrage on the Yamuna at its maximum pond level of 456.40 m, or 456.50 m in its 200-year flood (UJVN O&M manual, 2021); the Asan barrage at 401.50 m (UJVN O&M manual, 2021); the Gaula barrage at Kathgodam at its high pond level of 513.250 m; and the Baur and Haripura reservoirs at their full reservoir level of 242.32 m (795 ft) plus 0.5 m (Irrigation Department salient-feature sheets).
- **Khals and village tanks.** The small rain-fed ponds of the hill ridges and the talabs of the plains are started full from July.

A gated reservoir or barrage is modelled with its gate rule from its operator (THDC, UJVN or the Irrigation Department), 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 July to 15 October in Clause 3.13.5(a) is set by this Manual. It starts after the monsoon has covered the State, which it reaches at Dehradun by 20 June and at Roorkee by 28 June (IMD, Pai et al., 2020), so that a late onset or a dry June does not lower the starting level. It ends on 15 October, after the normal withdrawal of about 25–27 September (IMD, Pai et al., 2020) and the complete withdrawal by 1 October (IMD, *Climate of Uttarakhand*), because October storms are the main late-season threat: on 9 October 1956 Nainital recorded 300.7 mm and Roorkee 231.7 mm (IMD), and the storm of 17–19 October 2021 set the October records of Kumaon. The date also matches the sealing of the Naini lake sluices. Pumps, gates and debris screens stay on standby until 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 July to 15 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.

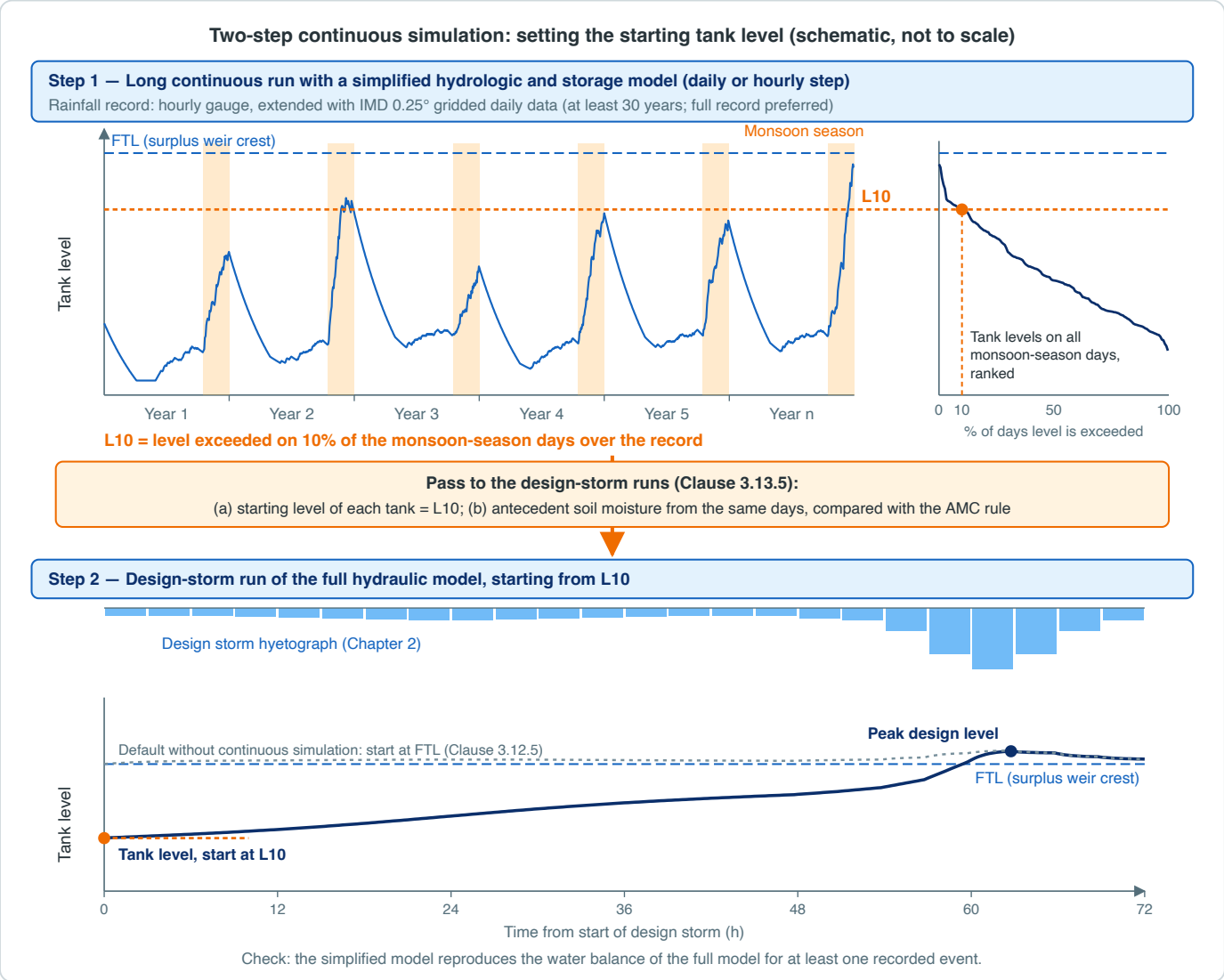

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 July to 15 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place 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 Uttarakhand. 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 south-west monsoon 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 September 2021, when the Tehri reservoir reached its full reservoir level of 830 m for the first time, on 24 September (THDC), and October 2021, when Naini lake rose to a record 12.2 ft on its gauge and overflowed on 19 October (as reported).

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.

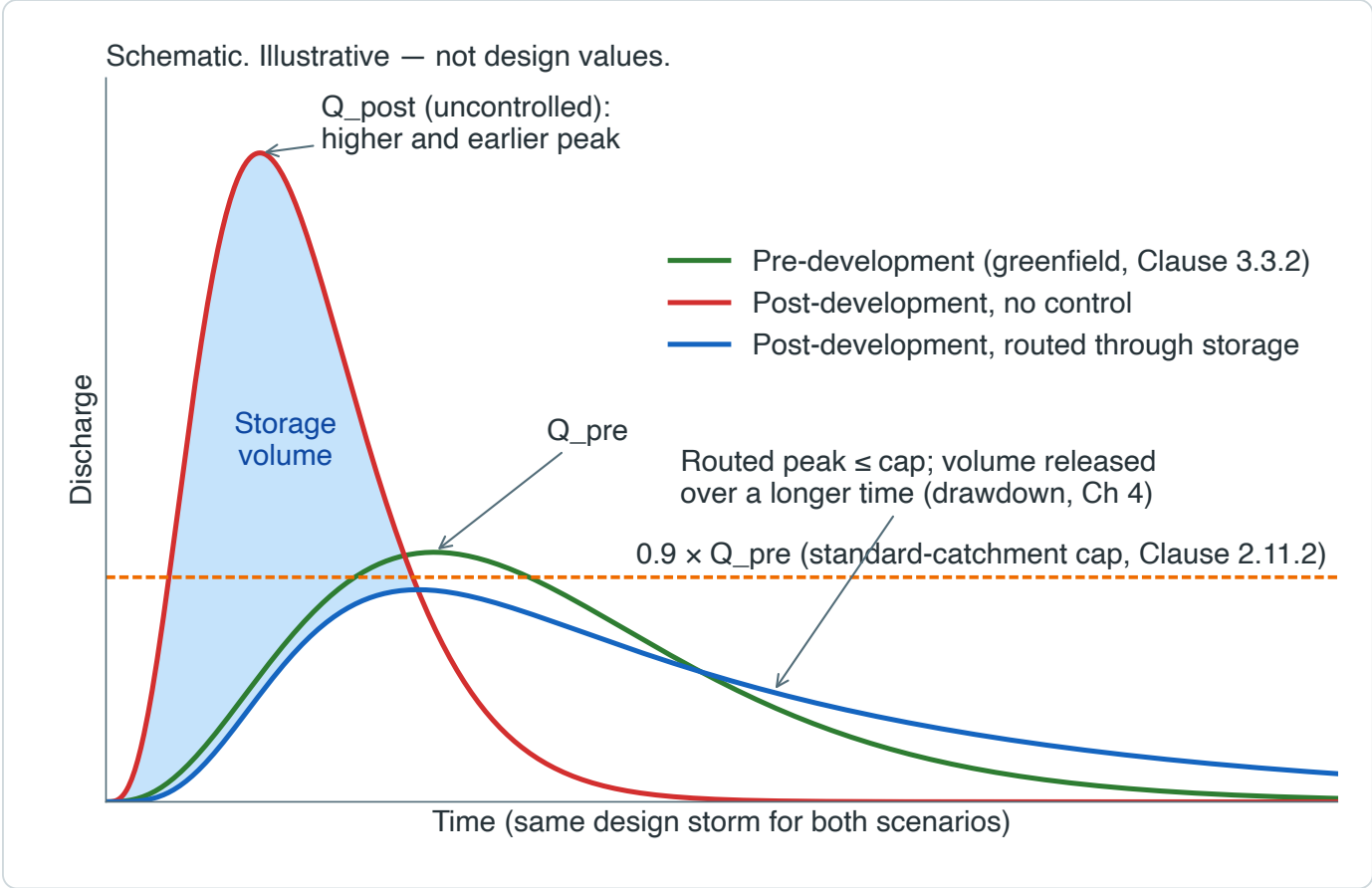

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro 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) ≤ 0.9 × Q_pre(T) for the 50%, 10% and 1% AEP (Clause 2.11.2);
- (b) flood-sensitive catchments: Q_post(1% AEP) ≤ Q_pre(10% AEP), and Q_post(50% AEP) ≤ 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 Ia = 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 Uttarakhand 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.

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 (Irrigation Department gauging sites, DMC or USDMA 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 SW monsoon or cyclone event (for example the Dehradun storm of 16–17 June 2013 (370.2 mm in 24 hours at Dehradun on 17 June, IMD), the Kumaon storm of 17–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, IMD), the Dehradun storm of 13–14 August 2023 (175.1 mm at Dehradun on 14 August, IMD), or the Doon storm of 15–16 September 2025 (264 mm in 24 hours and 54 mm in one hour at Sahastradhara, as reported), 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.

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.

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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Annexes and forms

Annex / Form	Content
3A	Uttarakhand soil series to HSG lookup; seasonal high water table map
3B	Uttarakhand CN calibration and supplementary land covers (terraced fields, oak and chir pine forest, slide scars and debris fans, bare rock and scree, boulder-bed raos, terai paddy, taal and reservoir beds)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land

Annex / Form	Content
3E	CWC SUH parameters for subzone 1(e) and zone 7, 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 the building rules (rainwater storage under bye-law 6.5 of the Bye-laws 2011 on every permitted construction with a ground coverage of 125 m² or more, except in waterlogged areas, of at least 2.0 m³ for a coverage of up to 250 m², 3.5 m³ up to 400 m² and a further 0.5 m³ for each further 50 m² or part, reduced to one-third where groundwater recharge is provided on a plot of more than 400 m², and confirmed on the plan before approval; the rules are discussed in the Commentary to Clause 4.11) 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 Uttarakhand 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". The building rules are the Uttarakhand Building Construction and Development Bye-laws/Regulations 2011 (Amendment 2015), made by the Housing Department under section 57 of the Uttar Pradesh Urban Planning and Development Act 1973, as applicable to and amended in Uttarakhand, and adopted by the board of each development authority, which may propose local amendments to the Government (notification of 10 January 2024, para 4). They have been amended piecemeal since: of the amendments read, those of 27 September 2022 (setbacks of single residences), 13 March 2023 (mobile towers), 10 January 2024 (No. 180884) and 13 June 2024 (housing for the economically weaker sections), only that of 10 January 2024 touches water, keeping a filling station at least 50 m from rivers, waterbodies, springs and the flood plain and 5 m from a nala (cl. 7.14(III)(1)(i)). A comprehensive "Amendment 2017", hosted by MDDA, is a draft that invited suggestions until 24 February 2018; it was not seen notified, later notifications still amend the 2011 (Amendment 2015) text, and it is not cited in this Manual as in force. The text read is the Housing Department's compilation of 2015–2019; the 2015 notification and the amendments of 2016, 2019, 2021 and 7 January 2022 were not read [TBC]. The drainage provisions that can be found protect the building, the slope and the watercourse, not the catchment. Bye-law 4.4(III) fixes plot boundaries back from water:

at least 30 m from a river bank and 10 m from an underground water source (the bye-law's term for a spring), both left for dense plantation with no construction of any kind; at least 5 m from the bank of a nala, or the required setback if more; and 30 m from the bank or boundary of every lake in the State, including the Nainital lake special area, or from the maximum fixed level of a natural reservoir, whichever is more. The distances are printed "30.0–30.0" and "10.0–10.0" metres; this Manual reads them as single distances of 30 m and 10 m, and the printing is to be confirmed with the Housing Department [TBC]. Bye-law 4.4(IV) requires a contour plan at 2 m intervals with sections, and bars building where landslides are likely to be severe and continuous or where the local slope exceeds 30°, or 26.5° in the Nainital municipal area, with public utilities on steeper ground approved only at Government level on a geologist's certificate; the draft of 2017 would also bar building within 250 m of a place prone to landslides. Bye-law 4.4(V) requires the site plan in the hills to show nearby landslide-prone areas and, on a sloping site, "proposals to divert the natural flow of water coming from uphill away from the foundation" (4.4(V)(b)). That is the only clause of the bye-laws on site runoff. Appendix 1, for Nainital, adds that "the drainage condition should be improved such that no water accumulates and saturates the grounds close to the footing level" (cl. 14). The plinth shall be at least 0.45 m above ground, with no maximum (2.41); premises of more than 1,000 m² need a sewer-capacity no-objection or their own treatment plant before approval (6.4(III)); and rainwater storage is required under 6.5 (Commentary to Clause 4.11). None of these sets a design storm, a release rate, a storage volume or an overflow path. The Unified Zoning Regulations 2025 (No. 568, 20 November 2025) put the rivers, lakes, ponds, nalas and streams of the revenue record into a Conservation Use Zone of the master plans, with a green buffer under the bye-laws and no new construction within 30 m of the banks of rivers and lakes. The Uttarakhand Flood Plain Zoning Act 2012 (Act 07 of 2013) lets the Irrigation Department, through the Flood Zoning Authority, prohibit building on land within the 25-year flood line and restrict it within the 100-year line, river by river, marked on shajra maps and by pillars; these lines are final for 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini, and for the Rispana (5 May 2025), the Asan was approved by the cabinet in June 2025 (as reported), and the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani have been studied but not notified (Irrigation Department, status report in NGT OA 417/2022). The amendment of 2024, seen only as quoted, extends the time for a final notification to 24 months and allows a notified line to be amended where "riverbank development" can protect the land; Rules were approved by the cabinet on 12 October 2026, but no text was found [TBC]. The only flood-level building rule found is in the declaration of intent for the Ganga's right bank at Rishikesh, which allows reconstruction in the restricted zone with the plinth at least 1.00 m above the high flood level (No. 1875/II(2)-2020-06(18)/2020, 7 October 2020). On the Ganga in the hills, the Housing Department's order of 29 November 2017, revised on 1 June 2023, prohibits building within 100 m of the middle of the river or the 25-year flood area, whichever is wider, and regulates the next 200 m, while the NGT designated "100 meters from the edge of the river" as a no-development zone from Haridwar to Unnao until the floodplain is demarcated (OA 200/2014, 13 July 2017); the two are measured from different lines, and both are cited as written (Chapter 7). The Uttarakhand Ground Water Act 2016 was repealed in 2017 (Act 11 of 2017), so the State has no groundwater law in force. The Nagar Nigams are governed by the Uttar Pradesh Municipal Corporation Act 1959 as adapted by the Adaptation and Modification Order 2002, and the Nagar Palika Parishads and Nagar Panchayats by the Uttar Pradesh Municipalities Act 1916 as amended in 2002 (CAG, performance audit of the 74th Amendment, 2022); their chapters on drains were not read in their Uttarakhand form [TBC]. The Doon Valley notification of 1989 and the Bhagirathi eco-sensitive zone of 2012 regulate development in their areas, but their drainage clauses were not read [TBC]. No drainage design standard of the Housing or Urban Development Department, any development authority or any Nagar Nigam stating a return period was found. The only stated design basis is in a funded project: the national consultants of the ADB's Uttarakhand Integrated and Resilient Urban Development Project designed the roadside drains of Dehradun for a storm of "once in 2 years" and the primary and secondary channels for "once in 5 years", with a minimum drain of 250 × 250 mm, velocities of 0.6–3.0 m/s and the outfall invert "above 'high flood level' (HFL) of the receiving water body", and the ADB's climate risk assessment notes that they "do not include an allowance for climate change", recommends drains "to convey 10-20% more flow", and observes that "the drains may remove around half the floodwater in larger events" (ADB, UIRUDP climate risk assessment, October 2021). That basis records practice; it is superseded for design under this Manual by the design storms of Chapter 2 and the levels of service of Chapter 6. The Irrigation Department's drainage master plans for Haldwani and other Kumaon towns state no design storm (as reported), and the Smart City's drainage project in Dehradun made no provision for storm-water reuse (CAG, performance

audit of Smart Cities, 2025). Basements are regulated for the hills, not for flooding. In the hill area, "keeping in view the geological sensitivity", a single basement is allowed only on a plot with a frontage of at least 18 m and an area of at least 2,000 m², while the plains allow up to three on plots of 2,000 m² or more (5.6(iii)); the basement ceiling shall be at least 0.9 m above the surrounding ground (5.6(viii)), and a structural and soil certificate shall cover the effect of the excavation on nearby stability and on the water table (5.6(xi)); no Uttarakhand rule restricts basements in low-lying or flood-prone land, sets a level for a basement ramp or opening, or keeps surface water out of a basement. 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, on the terai, floodplain and taal-margin land of Clause 4.12.1 and in the restricted zone of a notified floodplain, it recommends that no basement be permitted where the 1% AEP flood level stands above the surrounding ground; and in the hills, a basement cut into a slope shall also carry the geotechnical certificate of the hill infiltration rule of Clause 4.11, with the water behind its walls drained to a lined drain and not to the ground. For a sloping site, this chapter also supplies what bye-law 4.4(V)(b) leaves open: the diversion of uphill runoff shall carry the flow of the catchment above the site in the design storms of Chapter 6, and shall discharge to a lined drain or a stable natural channel, never onto an unprotected slope. These are the Manual's proposals, not rules of the Bye-laws 2011. This chapter is written so that it can supply, as a technical companion to the Bye-laws 2011 and the Municipal Acts, the design storm, release rates and storage volumes that they leave open; it has not been adopted for either purpose. In practice many of the State's urban streams and nalas carry sewage: of the 208 drains that reach the Rispana in Dehradun, 187 have been intercepted and diverted, but the floods of 16–17 September 2025 damaged 83 of the interception structures (Peyjal Nigam, affidavit in NGT OA 417/2022); the CPCB counted 70 of 200 monitored drains in the State as untapped before the monsoon of 2025 (as quoted in a filing of March 2026 in NGT OA 200/2014); and the CAG found 47 of 111 nallas reaching the Ganga tapped in 2017 (Report 39 of 2017) (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 sewage. 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.

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.
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.

Term	Meaning in this Manual
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 development authority that grants building or layout permission under the Bye-laws 2011 in its development area, such as MDDA, the Haridwar–Roorkee Development Authority (HRDA) or a district development authority constituted under the Uttar Pradesh Urban Planning and Development Act 1973 as applicable in Uttarakhand; UHUDA or the authority of a regulated area; or, where it grants building or layout permission, the Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat concerned [TBC], as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Dehradun Municipal Corporation (DMC), every approving authority within the development area of MDDA, including MDDA itself and the Nagar Palika Parishads and Nagar Panchayats in that area; HRDA in its development area; and every other Nagar Nigam, with the development authority in whose area it lies. Tier B: Nagar Palika Parishads and Nagar Panchayats.

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, taals, 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.

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 (m³) = 10 × Q_R × 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 × P_R × Rv × A, with Rv = 0.05 + 0.009 × 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

> Uttarakhand, 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) **Dehradun's raos**: the catchments of the Rispana, the Bindal, the Song, the Suswa and the Tons (Tamsa) and of their khalas within the development area of MDDA, whose ungauged, boulder-laden flows rise within an hour of a burst on the Mussoorie ridge;
- (b) **Haridwar's low land on the Ganga**: the low-lying land of Haridwar, Jwalapur and Kankhal that drains to the Ganga and its channels below the Bhimgoda barrage, whose outfalls are held up when the river at Haridwar is above its CWC warning level;
- (c) **Haldwani on the Gaula**: the land of Haldwani–Kathgodam that drains to the Gaula and to the nalas that cross the town, among them the Rakasia and Kalasia nalas;
- (d) **Rudrapur–Kichha terai**: the land of Rudrapur, Kichha and Pantnagar that drains to the Kalyani and the Kichha across the terai, where the water table is high and the outfalls are flat;
- (e) **Nainital lake catchment**: the whole catchment of Naini lake, including the Sukhatal basin, which drains to a closed lake with a gated outlet, and the land along the Balia Nala below the Tallital sluices;
- (f) **Rishikesh on the Ganga**: the land of Rishikesh, Muni-ki-Reti and Dhalwala that drains to the Ganga above the Virbhadra (Pashulok) barrage, or to the Chandrabhaga;
- (g) **Valley-floor towns below debris fans**: the land of a town built on a river terrace or valley floor below the fan of a gadhera or nala, such as Srinagar, Rudraprayag and Uttarkashi;
- (h) **Notified floodplain reaches**: the land within, or draining directly into, the prohibited (25-year) or restricted (100-year) zone of a reach finally notified under the Uttarakhand Flood Plain Zoning Act 2012, which today are the 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini and the Rispana; and
- (i) 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 a river in flood or by a barrage or reservoir pond, such as the Ganga at Haridwar and Rishikesh, the Song at Satyanarayan, the Solani at Roorkee, the Gaula below Kathgodam, the Kosi at Ramnagar or the Sarda at Banbasa, or that discharges to Naini lake, Bhimtal or another taal held at its maximum level, for part of the SW monsoon (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and taal 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 Dehradun entry follows the raos. The Rispana and the Bindal rise on the Mussoorie ridge and cross the city to the Suswa and the Song; their catchments are given as 58.09 and 44.40 km² in one study and the Rispana as 53.45 km² in another (as reported), and none of the raos has a CWC site, so their levels are known only from surveyed marks. The record falls of the Doon are among the highest in north India: 487.5 mm at Raipur (Dehradun) on 2 August 1959, 487.0 mm at Dehradun on 25 July 1966 and 440.4 mm at Rajpur (IMD), 98 mm in one hour at Dehradun on 14 June 1970 (CWC zone 7 report), and 264 mm in 24 hours with 54 mm in one hour at Sahastradhara on 15–16 September 2025 (as reported), when 13 bridges and 10 culverts were lost and 83 sewage interception structures on the Rispana were damaged (Peyjal Nigam, affidavit before the NGT). The Smart City's command centre was flooded after the bursts of 25 August 2021 and 8 August 2023 (CAG, performance audit of Smart Cities, 2025). The High Court has acted against encroachment of the river beds and khalas of the Doon (*Urmila Thapa*, WPPIL 58/2019), the Rispana was the first Doon river finally notified under the Flood Plain Zoning Act (5 May 2025), and before the NGT the State counted 330 structures in the Rispana's 1-in-5-year active floodplain (OA 417/2022; letter of 3 January 2026). The drains of the city under the ADB-funded programme were designed for a 2-yr storm, and its primary and secondary channels for a 5-yr storm, with no allowance for climate change (ADB, UIRUDP climate risk assessment, 2021). The Haridwar entry follows the Ganga: its warning and danger levels at Haridwar are 293.0 m and 294.0 m, its highest level is 296.30 m (dated 19 September 2010 in one CWC record and 17 June 2013 in another), and it stood near 295.7 m in 2013 and 2023 (CWC, as transcribed by SANDRP); Hardwar holds the State's 24-hour record of 495.3 mm, on 18 September 1880 (IMD). The Haldwani entry follows the Gaula, whose barrage at Kathgodam passed 123,000 cusecs in 1993 against a design of 115,000 (Irrigation Department), whose bridge at Haldwani partly collapsed on 19 October 2021 (as reported), and whose level at Kathgodam reached 498.93 m on 20 October 2021 (as reported); the Irrigation Department's drainage master plan for the town, of about ₹1,003 crore, would line the Rakasia (10.25 km) and Kalasia (1.55 km) nalas and add pumping stations in low-lying areas, and states no design storm (as reported). The Rudrapur–Kichha entry follows the terai: Pantnagar recorded 403.9 mm in the 24 hours to 08:30 on 19 October 2021 (IMD), Rudrapur was flooded by the Kalyani then, and flooded again in August 2023, and about 25,000 ha of farmland in Udham Singh Nagar was under water in July 2024 (all as reported). The Nainital entry follows the lake: every drain of the town discharges to Naini lake, which rose to a record 12.2 ft on its gauge and overflowed on 19 October 2021, when Nainital recorded 401 mm (as reported; IMD), and whose outlet through the Balia ravine is limited by rules of 1927 to protect a slope that has slipped repeatedly (NIH, *Water Balance of Lake Nainital*). The town's British drain network was built after the landslip of 18 September 1880, which followed about 33 inches of rain in three days (as reported), and the High Court has acted on the lake in *Ajay Rawat* and on the Sukhatal in 2022. The Rishikesh entry follows the Ganga (danger level 340.5 m, highest level 341.72 m on 5 September 1995), which stood above its danger level at 341.3 m in August 2023 (as reported) and whose right-bank floodplain from the Dhalwala drain to Haripur Kalan has been put under a notice of intent under the Act (No. 1875/II(2)-2020-06(18)/2020, 7 October

2020). The valley-floor entry follows the 2013 flood, which set the highest levels of the Alaknanda at Srinagar (537.9 m) and Rudraprayag (634.85 m) on 17 June 2013, 1.9 m and 7.85 m above their danger levels, and the debris flows of Dharali (5 August 2025) and Maldevta (2022), which buried land below the fans of side streams (CWC, as transcribed by SANDRP; as reported). Haldwani's neighbours on the bhabar, Kotdwara, Ramnagar, Kashipur and Tanakpur–Banbasa, and Roorkee on the Solani are candidates for notification under Clause 4.5.4. 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 SW 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 taal 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 Irrigation Department 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 Paltan Bazaar and the old city of Dehradun, the lanes of Haridwar behind Har-ki-Pauri, the bazaars of Nainital and Mussoorie on the Mall, or the old bazaar of Haldwani, 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.

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 July to 30 September in sub-areas UK-A, UK-D, UK-E and UK-F and on terai land, at all times in catchments draining to a reservoir or barrage pond, Naini lake or Bhimtal, or a river at or 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
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 colony draining to the Rispana in Dehradun. 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

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)
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.

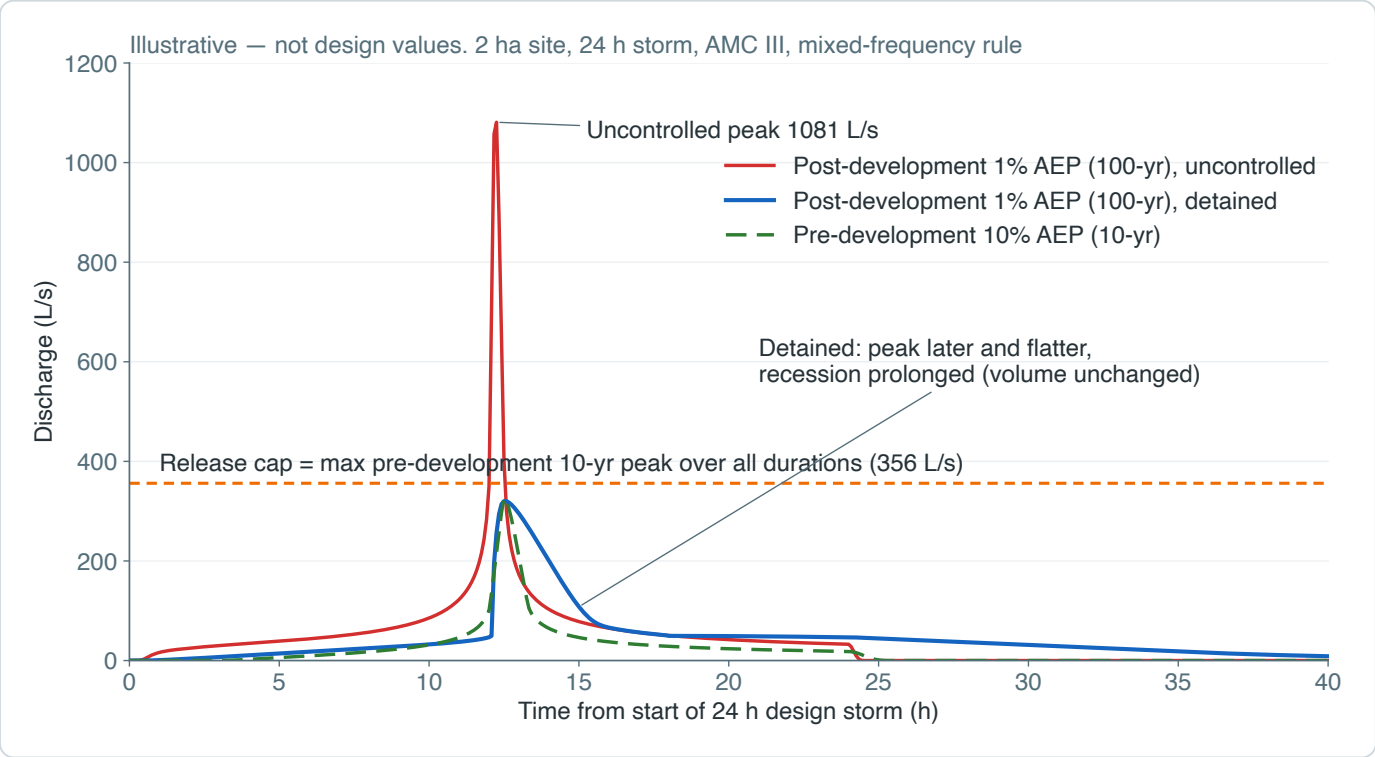


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA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

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 Uttarakhand storage must hold multi-day volumes. It is still short enough that a basin filled by one SW monsoon depression will have most of its volume back before the next, which in June 2013, when Dehradun recorded 1,094.8 mm in the month and 370.2 mm in the 24 hours of 17 June (IMD) followed within days.

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).

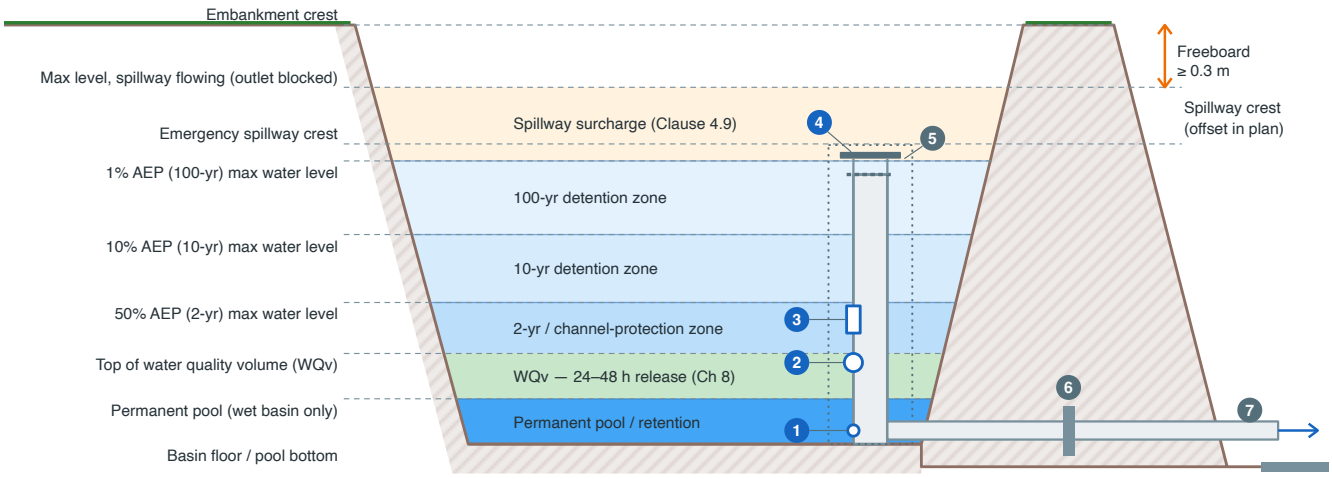
4.8.5 **Outlet barrels.** Outlet barrels through embankments shall:

- 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).

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.

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 the Bye-laws 2011, under which layouts keep parks and open space and plant 25–125 trees per hectare (the percentage of open space for a layout in the Uttarakhand text was not checked for this Manual [TBC]), and the Unified Zoning Regulations 2025, which allow parks and plantation in the green buffer of a Conservation Use Zone. In the Doon valley, on the bhabar and on the plains of Haridwar, Roorkee and the terai, 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 on the Doon Gravels and the bhabar it can also infiltrate under Clause 4.11. On a hill site the position is different. Ground on a natural slope of more than 10°, a terrace held up by a retaining wall, and land within twice the height of a cut or wall downslope of it are not to be used for ponding, because water held there soaks into the slope (hill infiltration rule, Clause 4.11). 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 Clause 4.11 covers; an excavated pond or basin on a slope is not accepted. Four kinds of land are not open space for this purpose. A taal, khal or naula on the land is preserved under step 1 of Clause 4.3.1 and modelled as a water surface (Clause 3.3.2(e)) that starts at its full level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows. The strips of bye-law 4.4(III), 30 m from a river or lake, 10 m from a spring and 5 m from a nala, are kept for dense plantation with no construction, and the 30 m buffer of the Unified Zoning Regulations 2025 is a Conservation Use Zone; land within the prohibited (25-year) or restricted (100-year) zone of a floodplain notified under the Flood Plain Zoning Act 2012 is flood land already. Land in the hydraulic corridor of a rao, gadhera, nala, taal or river under Chapter 7 is corridor or flood land: water reaches it first, so it is not counted as detention for the development beside it (Chapter 7). And a recharge area kept open on purpose, such as the Sukhatal basin above Naini lake, which the High Court has kept free of construction (2022, as reported) and through which about half of the lake's subsurface recharge is estimated to enter (NIH, as cited by NITI Aayog, 2018), or a mapped spring-recharge area under Clause 4.11, is not graded or paved for detention.

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 SW monsoon season.

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of bye-law 6.5 of the Bye-laws 2011, the guidelines of the Central Ground Water Authority where they apply, any condition of a building or development permission, or any rainwater harvesting rule or direction of an approving authority.

> Commentary. RWH in Uttarakhand rests on bye-law 6.5 of the Bye-laws 2011, "rainwater harvesting standards". Except in areas with a waterlogging problem, rainwater harvesting is mandatory for every permitted construction, of any land use, with a ground coverage of 125 m² or more (6.5(I)). The storage required is at least 2.0 m³ for a coverage of up to 250 m², 3.5 m³ for a coverage of up to 400 m², and a further 0.5 m³ for each further 50 m² of coverage or part of it (6.5(II)). On a plot of more than 400 m² where groundwater recharge is provided by a bore well, a recharge pit, a well or hand pump, or a trench, one-third of that storage is required (6.5(III)). The provision is to be confirmed on the building plan before approval, and drainage and storage works are not counted in the ground coverage (6.5(IV)); rainwater storage structures, including underground tanks, are among the works exempt from permission. Over the covered area, the storage of 6.5(II) is about 8–16 mm of rain: 2.0 m³ is 16 mm over 125 m² and 8 mm over 250 m², 3.5 m³ is about 9 mm over 400 m², and each further 0.5 m³ per 50 m² is 10 mm; with recharge on a plot of more than 400 m², the storage falls to about 3–5 mm. The MDDA-hosted draft "Amendment 2017" would apply the rule to plots of more than 100 m² and require recharge on plots of 500 m² or more (§§9.1 and 9.2), but it is a draft only (Commentary to Clause 4.1). The Uttarakhand Ground Water Act 2016, whose section 20 let the State order rainwater harvesting for recharge in notified areas, was repealed by Act 11 of 2017, so no groundwater law requires recharge. MDDA is reported to have ordered rainwater harvesting in residential projects to be improved within a week in June 2024, and to require recharge pits to be built because approved plans often show provisions that are not built (as reported). Bye-law 6.5 sets no drawdown, no infiltration test, no depth to the water table, no rule that a tank be empty before a storm, and no restriction on recharge on slopes, near springs or on wet ground; no rule against soak pits or recharge pits on slopes was found in any Uttarakhand instrument. This Manual credits these structures against its own retention requirement (Clause 4.4) as follows:
>
> - An RWH storage tank under 6.5(II) 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 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.
> - An RWH tank 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. The tank is then modelled under Clause 4.4.6 like any other retention practice. On hill sites, where infiltration is barred, this storage and reuse is the way retention is provided.
> - The bore wells, recharge pits, wells and trenches of 6.5(III) count as retention only where they meet Clause 4.11.4: 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. They are also subject to the hill infiltration rule below.
> - **Hill infiltration rule.** No deliberate infiltration practice (soakaway, soak pit, 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 a mapped landslide or creep zone, or within the landslide-prone setting of bye-law 4.4(IV)–(V); on colluvium, slide debris or moraine, whatever its slope; or upslope of a cut slope or

retaining wall within a distance of 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. On such sites roof runoff goes to the storage tanks of bye-law 6.5, with overflow to a lined drain that discharges through a sediment trap to a stable natural channel (or to the lake through a trap in a lake town), never onto an unprotected slope. 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.

- **Recharge first on the Doon Gravels and the bhabar.** The State's stage of groundwater extraction was 53.54% in the 2024 assessment, with 16 of 20 assessment units safe and 4 semi-critical (CGWB, *Dynamic Ground Water Resources of Uttarakhand 2024*); the semi-critical units in the assessments of 2020 and 2022 were Bahadrabad and Bhagwanpur in Haridwar, Haldwani in Nainital and Kashipur in Udham Singh Nagar, all on the bhabar and its fringe, and the names of the four units of 2024 were not found [TBC]. The bhabar recharges the terai aquifers, whose auto-flow zone has receded as the bhabar has been built over (NAQUIM, Udham Singh Nagar, 2016), and the Doon Gravels recharge the aquifers on which Dehradun draws. On the Doon Gravels and the bhabar fans, on ground to which the hill infiltration rule does not apply, retention shall be provided by recharge before reuse or detention wherever site tests allow, through a silt trap, a filter and a first-flush diverter ahead of the recharge structure, and with a hydrogeologist's check of the target zone.
- **No recharge credit on wet ground.** On terai land where the seasonal high water table is within 1 m of the surface, wells flow under artesian pressure (auto-flow) or the land is waterlogged, which bye-law 6.5(I) already exempts, on the floodplains and low terraces of the rivers, on the margins of the taals and reservoirs, and wherever the seasonal high water table is within the 1.0 m separation of Clause 4.4.3, no recharge or infiltration practice earns retention credit; storage and reuse, detention and conveyance govern there.
- **Springs and lake recharge areas.** Springs supply most of the water in many hill blocks, from about 70% in Chamoli to about 84–87% in some blocks (GBPNIHE, *Water at a glance: Uttarakhand*, 2019), and the number of working springs round Almora fell from 360 to 60 over 150 years (NITI Aayog, 2018). Within 10 m of a spring the bye-laws allow no construction (4.4(III)(i)), and the Unified Zoning Regulations 2025 place streams ("धाराएँ", a word that can also mean spring spouts) in the Conservation Use Zone. In the recharge area of a naula or dhara, where it has been mapped, and in a lake recharge area such as the Sukhatal basin above Naini lake, only clean roof runoff, passed through a filter, may be infiltrated; road and parking runoff shall not be infiltrated, the area shall not be paved, and no runoff that may be polluted shall be infiltrated upslope of a naula or dhara.
- **Nitrate, arsenic and uranium.** Nitrate above 45 mg/l was found in 17.39% of the 207 samples of the 2024 assessment, in Almora, Dehradun, Haridwar, Nainital and Udham Singh Nagar districts, arsenic above 10 ppb in samples from Almora, Haridwar and Udham Singh Nagar, and uranium above 30 ppb in one sample from Haridwar (CGWB, 2024). In these districts the hydrogeologist's check shall report the nitrate, arsenic and uranium of the target aquifer before a recharge bore or shaft is credited, and untreated runoff shall not be put into a bore or shaft there; retention is then provided by surface infiltration through a soil or filter layer, or by storage and reuse (Chapter 8).
- **Everywhere,** road and parking runoff shall be recharged only through a surface infiltration practice with a filter, such as a vegetated basin or trench, never directly into a bore or well, and runoff from a rao or nala that carries sewage, as the Rispana and the Bindal do in part, shall not be recharged at all.

In the hills, water put into the ground does not stay where it is put. At the Balia Nala below Nainital, recharge of the perched aquifer from the catchment drains and from buildings raised the pore pressure and reduced the cohesion of the slope (*Arabian Journal of Geosciences*, 2022); at Joshimath an IIT Roorkee report found internal erosion by subsurface drainage, which "can be minimized by controlling infiltration of water", and the Mishra Committee of 1976 had asked for soak pits to be closed (both as reported); and Nainital's British drain network was built after the landslip of 18 September 1880, which followed about 33 inches of rain in three days (as reported). On the terai a recharge pit sits in the water table in the monsoon, and in any town 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 hill infiltration rule, the recharge-first rule for the Doon Gravels and the bhabar, the bar on recharge credit on wet terai land, the spring and lake-recharge rules, the nitrate, arsenic and uranium checks and the pre-treatment and road-runoff rules are set by this Manual. No Uttarakhand source sets a slope or distance threshold for infiltration: the 10° limit is the upper bound of the lowest slope band (up to 10°) used for risk classes in the bye-law text hosted by MDDA, below the 26.5° and 30° limits on building, and the distance of twice the height of a cut or wall is set by this Manual as a precaution, pending guidance from ULMMC or a geotechnical study [TBC].

4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the terai below the spring line in Udham Singh Nagar, Haridwar and the south of Nainital district, where wells flow under artesian pressure and the water table stands 1–7 m below ground, the floodplains and low river terraces of the Ganga, the Solani, the Song, the Gaula, the Kosi, the Kichha, the Kalyani and the Sarda and of the rivers of the inner valleys, the margins of Naini lake, Bhimtal and the other taals, the margins of the Tehri, Dakpathar, Asan, Baur, Haripura and Tumaria reservoirs and barrage ponds, and hill sites with perched water, such as Joshimath, 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 SW monsoon, from:

- (a) site piezometer readings over at least one full June–November season; or
- (b) where (a) is not available, the higher of the CGWB or Irrigation Department record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, rao, gadhera, nala or taal.

For the flotation check of 4.12.3 at sites in the terai, the river terraces and floodplains, and the taal margins, 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.** Uttarakhand is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3, do not apply in the State, and saline groundwater was not found (no sample above the limit for electrical conductivity in the 2024 assessment; CGWB, *Dynamic Ground Water Resources of Uttarakhand 2024*), so the exposure provisions of 4.12.5 apply only where a test at the site shows it. Groundwater lies at three kinds of depth. On the Doon Gravels and the bhabar it is deep: 2.29–71 m below ground in the Doon before the monsoon (CGWB, Dehradun brochure, 2011) and 40–75 m in the bhabar, with perched water within 10 m in places (CGWB, Nainital brochure, 2010). On the terai it is shallow: 2.09–7.08 m below ground before the monsoon and 1.73–6.89 m after it, with more than 2,000 artesian wells whose free-flowing heads reach 8.69 m above ground (CGWB, Udham Singh Nagar brochure), and in Haridwar district "flowing wells" are common in the lower piedmont plain (CGWB, Hardwar brochure, 2009). In the hills it occurs as perched bodies in weathered rock and colluvium: of the 225 wells measured in January 2025, 28.44% stood within 5 m of the surface, the shallowest 0.52 m below ground at Joshimath (CGWB, Water Level Bulletin, January 2025). The terai, the floodplains and low terraces of the rivers, the margins of the taals and of the reservoirs and barrage ponds, and hill sites with perched water are the wet cases. 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 or barrage pond at its full level or a taal at its maximum 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, rao, gadhera, nala or taal where that is higher than the well record, and on the terai, the floodplains and low terraces and the taal margins it is taken as existing ground level for the flotation check unless piezometers show otherwise. Where an excavation reaches, or comes within 1 m of, the clay that confines an auto-flow aquifer of the terai, the tank shall also be checked for uplift with the groundwater at the artesian head measured in the nearest flowing well, which may stand above ground, and the excavation shall not be carried through the clay. 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 (hill infiltration rule, Clause 4.11). The June–November monitoring season of 4.12.1(a) is set by this Manual to cover the SW monsoon and the post-monsoon high that the CGWB measures in November: a reading taken in May or June understates the design level. No monsoon water-table depths for individual town sites in Rudrapur, Kashipur, Kichha or Haridwar, and no map of the seasonal high water table of the terai, were obtained [TBC]. The factor of 1.2, the 0.5 m allowance, the "ground level" default for the terai, the floodplains and the taal margins, and the artesian-head check have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Uttarakhand were found during research.

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 taal 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 SW monsoon. Storage below FTL that is held for irrigation or supply through June to September 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.
>
> Uttarakhand has no tank or lake Act, and no taal, lake or reservoir in its towns was found to be operated for flood control under a documented rule. The one taal with an operating rule, Naini lake, is regulated to protect a slope, not to store floods: its five sluice gates at Tallital, installed in 1888, are opened under rules of the Hill Slide Committee of 1927 that limit the opening while the lake is low, to protect the Balia ravine below the outlet, the lake is held up to 12.5 ft on the PWD gauge, and the sluices are sealed on 15 October (NIH, *Water Balance of Lake Nainital*); the lake rose to a record 12.2 ft and overflowed on 19 October 2021 (as reported). The bye-laws keep construction 30 m back from every lake (4.4(III)(iii)), the Unified Zoning Regulations 2025 place lakes and ponds in the Conservation Use Zone, and the High Court has stopped construction on the Sukhatal lakebed (2022, as reported). The State Wetland Authority, constituted on 16 October 2019, has 192 wetlands on the national atlas, 149 of them ground-truthed by October 2025, but none notified under the Wetlands Rules 2017 (State Wetland Authority, status report of 17 October 2025); the State's only Ramsar site is the Asan Conservation Reserve, 444.4 ha at the confluence of the Asan and the Yamuna above the Asan barrage, designated on 21 July 2020. The State's regional storage is of five kinds: the Kumaon taals, Naini lake, Bhimtal, Naukuchiatal and Sattal; the khals, small rain-fed ponds on the ridges of the hills; the reservoirs and barrages, Tehri and Koteshwar (THDC), the Dakpathar and Asan barrages (UJVN), the Bhimgoda and Virbhadra (Pashulok) barrages on the Ganga, and the Gaula barrage and the Baur, Haripura and Tumaria reservoirs of the Irrigation Department; the Asan wetland; and the river floodplains, which the Flood Plain Zoning Act now protects reach by reach. Four points follow:
>
> - A taal on the record may not be a working taal, and a taal in the hills is not a detention basin. No inventory of the taals, khals and ponds within the Nagar Nigams and Nagar Palika Parishads, with their beds, bunds and outlets, was found [TBC]. A taal is credited only after a survey shows its bed, bund or rim and outlet,

and only for the storage above its full level; Naini lake, held at its maximum level until 15 October with an outflow limited by the 1927 rules, offers none, so every site in its catchment provides its full detention on site. A recharge area such as the Sukhatal is not storage for detention (Commentary to Clause 4.11).

- The reservoirs and barrages are not spare capacity for a site. They are held for power, irrigation and supply through the monsoon, so their storage below full level is not credited (Clause 4.13.2(c)); their releases are set by their operators for the whole river; and storm water spilled to a reservoir or barrage pond, or to a river below one, can be relied on only with the written agreement of the operator, THDC, UJVN or the Irrigation Department, for a stated flow and level.
- A pond or check dam in the bed of a rao or gadhera is not regional detention unless it is designed for debris. The streams of the Doon and the hills carry boulders and sediment in every large storm, and a basin in their bed fills with debris in one event; 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 (Chapters 9 and 10). A regional facility on a hill slope is also subject to the hill infiltration rule of Clause 4.11.
- No rule dividing natural streams from municipal drains was found [TBC]. Until one is made, this Manual follows the working assignment of Chapter 1: rivers, raos and gadheras with their beds and floodplains, flood-protection works, barrages and canals as the Irrigation Department's; the nalas, khalas, drains and public ponds within the limits of a Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat as that body's; drains built under the ADB programme or by Dehradun Smart City Ltd as UUSDA's or DSCL's until handed over; road drains as PWD's; sewers and interception works as the Peyjal Nigam's and the Jal Sansthan's; Naini lake and its sluices as the custodian's under the Lake Development Authority and the Irrigation Department [TBC]; the hydropower reservoirs and barrages as THDC's and UJVN's; and the Asan wetland as within the remit of the State Wetland Authority and the Forest Department (Commentary to Clause 6.9). This is the Manual's working assignment, not a statutory one.

The first point is the basis of condition 4.13.2(c) in Uttarakhand. A taal gives flood storage only above its full level, unless a notified operating rule commits it to be lowered before the SW monsoon. 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
UK-Z1 Plains and foothills: UK-B Haridwar–Roorkee plains	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
UK-Z1 Plains and foothills: UK-C Bhabar–terai (Haldwani–Kashipur–Rudrapur–Kotdwara)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
UK-Z2 Doon and outer ridge: UK-A Doon valley (Dehradun–Rishikesh)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
UK-Z2 Doon and outer ridge: UK-D Outer-ridge hill stations (Nainital–Mussoorie)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
UK-Z3 Inner and high mountains: UK-E Inner valleys and middle mountains (Tehri–Srinagar–Almora–Pithoragarh)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
UK-Z3 Inner and high mountains: UK-F High Himalaya and snow-fed (Joshimath–Kedarnath–Dharchula)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(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 (m^3) 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):

$V_{100} = \max_d [\, 10 \times C_v \times P_{100}(d) \times A - 1.8 \times Q_{cap,10} \times d \,]$

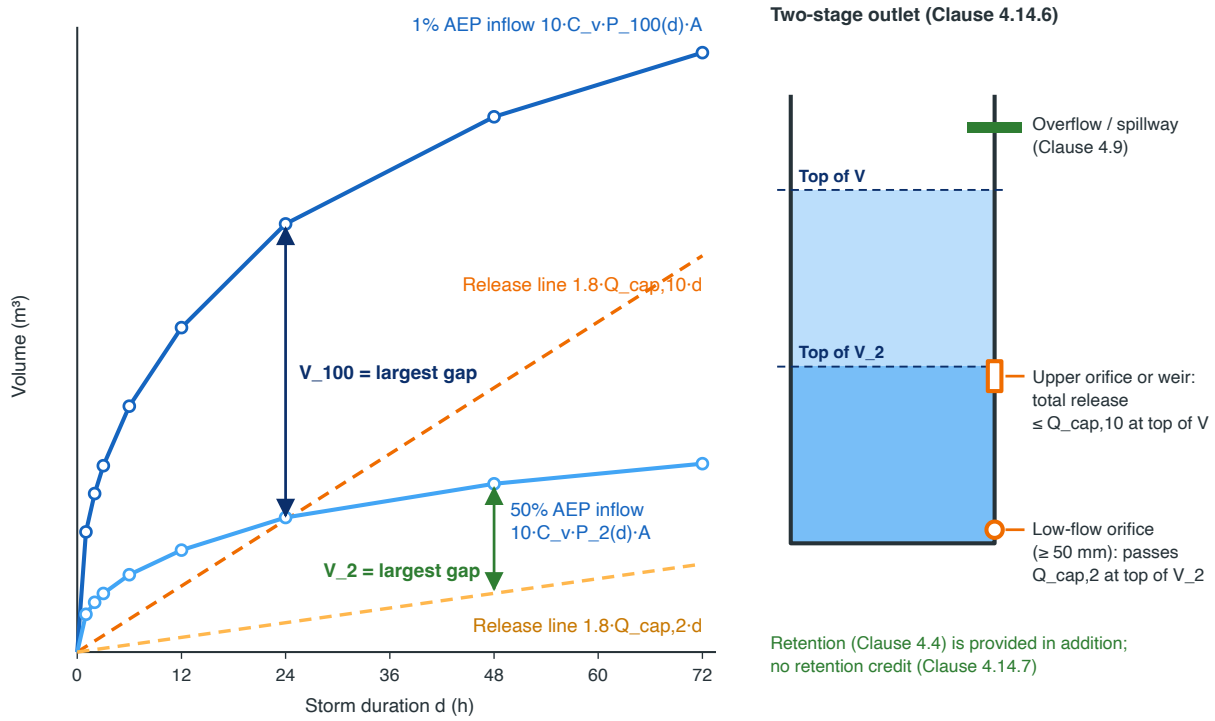
$V_2 = \max_d [\, 10 \times C_v \times P_2(d) \times A - 1.8 \times Q_{cap,2} \times d \,]$

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.

$Q_{cap,10} = 2.78 \times C_{10} \times i_{10} \times A$; $Q_{cap,2} = 2.78 \times C_2 \times i_2 \times A$; (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 $[\, 10 \times C_v \times P_T(d) \times A - 1.8 \times Q_{cap} \times d \,]$ (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 Doon valley, 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.

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 Hindi 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 Uttarakhand, the governing failure takes two forms. On the plains, in the Doon and in the lake towns, it is volume with no outlet when a river, barrage pond or taal downstream is high. Haridwar drains to the Ganga, whose CWC warning and danger levels at Haridwar are 293.0 m and 294.0 m and which reached 295.75 m on 17 June 2013 and 295.7 m on 14 August 2023 against a highest level of 296.30 m (CWC, as transcribed by SANDRP); Rishikesh drains to the Ganga above the Virbhadra barrage, which stood at 341.3 m on 14 August 2023, above its danger level of 340.5 m; Ramnagar drains to the Kosi, which rose to about 220.95 m at the Ramnagar barrage on 19 October 2021, about 4 m above its previous highest level (as reported; the CWC list gives 220.75 m); and the terai towns drain to the Kalyani, the Kichha and the Sarda, which at Banbasa reached 224.9 m on 19 October 2021, above its maximum water level of 223.3 m (as reported), on the day that Rudrapur was flooded by the Kalyani. Nainital drains wholly to Naini lake, whose outlet is limited by its sluice rules and which rose to a record 12.2 ft and overflowed on 19 October 2021 (as reported): when the lake is at its maximum level, every drain of the town discharges to a water surface that cannot fall. In the hills and on the Doon fans the outfall is closed in a different way: by debris. The raos and gadheras rise fast after a burst and carry boulders and sediment that bury outfalls, block culverts and choke the drains behind them; in the storm of 15–16 September 2025 in Dehradun, 13 bridges and 10 culverts were lost (as reported) and 83 sewage interception structures on the Rispana were damaged (Peyjal Nigam, affidavit before the NGT). No hourly record of how long a river, barrage pond or taal in Uttarakhand stays above a town's outfalls was obtained [TBC], the Rispana, the Bindal, the Suswa and the Tons in Dehradun have no CWC site, 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, 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 SW monsoon storms (Clause 4.6.3);
- prefer regional storage in the taal 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.

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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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 Uttarakhand.** Uttarakhand is landlocked and mountainous: it has no coast, no tide and no Coastal Regulation Zone, and a Bay of Bengal depression reaches it only as rainfall, often meeting a western disturbance over the hills, as in October 2021; that rainfall is dealt with in Chapter 2, not as a tidal or surge level. 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 Uttarakhand: 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 and boulders), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Uttarakhand the receiving water is one of five kinds: a river, reached directly, through a gate in a bank, flood wall or embankment or through a pumping station, such as the Ganga at Rishikesh and Haridwar, the Song, the Solani at Roorkee, the Gaula at Haldwani, the Kosi at Ramnagar, the Sarda at Banbasa and the Alaknanda and Bhagirathi at the valley towns, whose level rises and falls within hours in the mountains but is held up by barrages and long monsoon spells below them; a rao, gadhera or khala, such as the Rispana and the Bindal in Dehradun or the Rakasia and Kalasia nalas at Haldwani, ungauged, seasonal and laden with boulders, whose bed rises and falls in a single flood; a reservoir or barrage pond held at its full level, such as Tehri, the Dakpathar and Asan barrages, the Gaula barrage and the reservoirs of the terai; a lake whose only outlet is gated, Naini lake, whose sluices are worked under rules of 1927 and sealed on 15 October, and the other taals of the Nainital region; or a canal, such as the Upper Ganga Canal at Haridwar and Roorkee; 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 river, a rao or gadhera, a reservoir or barrage pond, a taal, a canal or a receiving drain, with the river lock of Clause 5.8.5(a) and the closures of Clause 5.8.5(b) to (e) in place of the tidal lock windows.

Commentary. The drains of Uttarakhand's towns fail in places that site design does not see, and in five different ways. The first is the river. Haridwar and Rishikesh drain to the Ganga, which stood at 295.75 m at Haridwar on 17 June 2013, within 0.6 m of its highest recorded level, and above its danger level at Rishikesh on 14 August 2023 (CWC data, as copied by SANDRP); Roorkee drains to the Solani, Haldwani to the Gaula, Ramnagar to the Kosi and Banbasa to the Sarda, all of which set their highest recorded levels in October 2021, the Solani on 14 October and the others on 19 and 20 October, the Kosi at Ramnagar 3.97 m above its previous highest level (CWC data, as copied by SANDRP); and the valley towns of Srinagar, Rudraprayag and Joshimath stand above rivers that rose to their highest recorded levels in the floods of June 2013 and February 2021. The second is the rao and the gadhera. Dehradun's raos, the Rispana, the Bindal, the Suswa, the Song and the Tons, carry the storm water of the city and, until it is intercepted, its sewage; none of them is gauged at a town; their beds have been built on, so that the High Court and the National Green Tribunal have ordered the encroachments removed (*Urmila Thapa*, WPPIL 58/2019; O.A. 417/2022); and in the floods of 15–16 September 2025 they carried away bridges and culverts and damaged 83 of the interception structures on the Rispana (Peyjal Nigam, affidavit in O.A. 417/2022). The third is the reservoir and the barrage pond: a pond held at its full level holds every drain that ends in it, and Tehri reached its full reservoir level, 830 m, for the first time on 24 September 2021 (THDC). The fourth is Naini lake, which receives every drain of Nainital and leaves only through five small sluices whose opening is limited to protect the ravine below; it rose to a record 12.2 ft on its gauge and overflowed on 19 October 2021 (as reported). The fifth is the canal: the Upper Ganga Canal runs through Haridwar and Roorkee, and its operation is reported to rest with another State (unverified [TBC]). The outfalls also belong to one body while the drains above them belong to others: the rivers, flood works and floodplain lines are the Irrigation Department's, the dams and barrages THDC's, UJVN Ltd's or the Irrigation Department's, Naini lake the Lake Development Authority's [TBC], and the drains the Nagar Nigams', the development authorities' and PWD's, and no rule divides them (Chapter 6, Clause 6.9). No document found during research sets a design level for any river, rao, reservoir, taal or canal outfall in the State; the only design basis found, for the drains built in Dehradun with ADB's assistance, sets the outfall invert above the high flood level of the receiving water without saying what that level is (ADB, 2021). A detention basin that meets every release rate in Chapter 4 still fails if the river it drains to stands above its outfall, if the rao has buried its outlet in gravel, or if the pond or lake is full. This chapter makes these failure modes part of the design. Uttarakhand has no tidal outfall, so Clause 5.1.4 says which of the chapter's coastal provisions fall away and what takes their place.

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.
Major drain	A channel listed as a major drain in the basin plan or Annex 5B, or any river, Irrigation Department canal, the Rispana, the Bindal, the Suswa, the Song, the Tons (Tamsa) and the Asan and their khalas in the Doon, the nalas of Rishikesh and Haridwar that run to the Ganga, among them the Chandrabhaga at Rishikesh, the Solani at Roorkee, the Rakasia and Kalasia nalas and the gadheras that run to the Gaula at Haldwani, the Kalyani at Rudrapur, the drains that feed Naini lake and the Balia Nala below it, the Upper Ganga Canal, any canal or gul that receives storm water, any drain built or held by a Nagar Nigam, a Nagar Palika Parishad, a Nagar Panchayat, MDDA, HRDA or another development authority, UUSDA, Dehradun Smart City Ltd or PWD with an internal width of 1.0 m or more, and every gadhera, khala or rao that drains 8 ha or more, or a tidal creek.

Term	Meaning in this Manual
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).

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, taal** 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 taal 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, DMC, USDMA or Irrigation Department; 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.

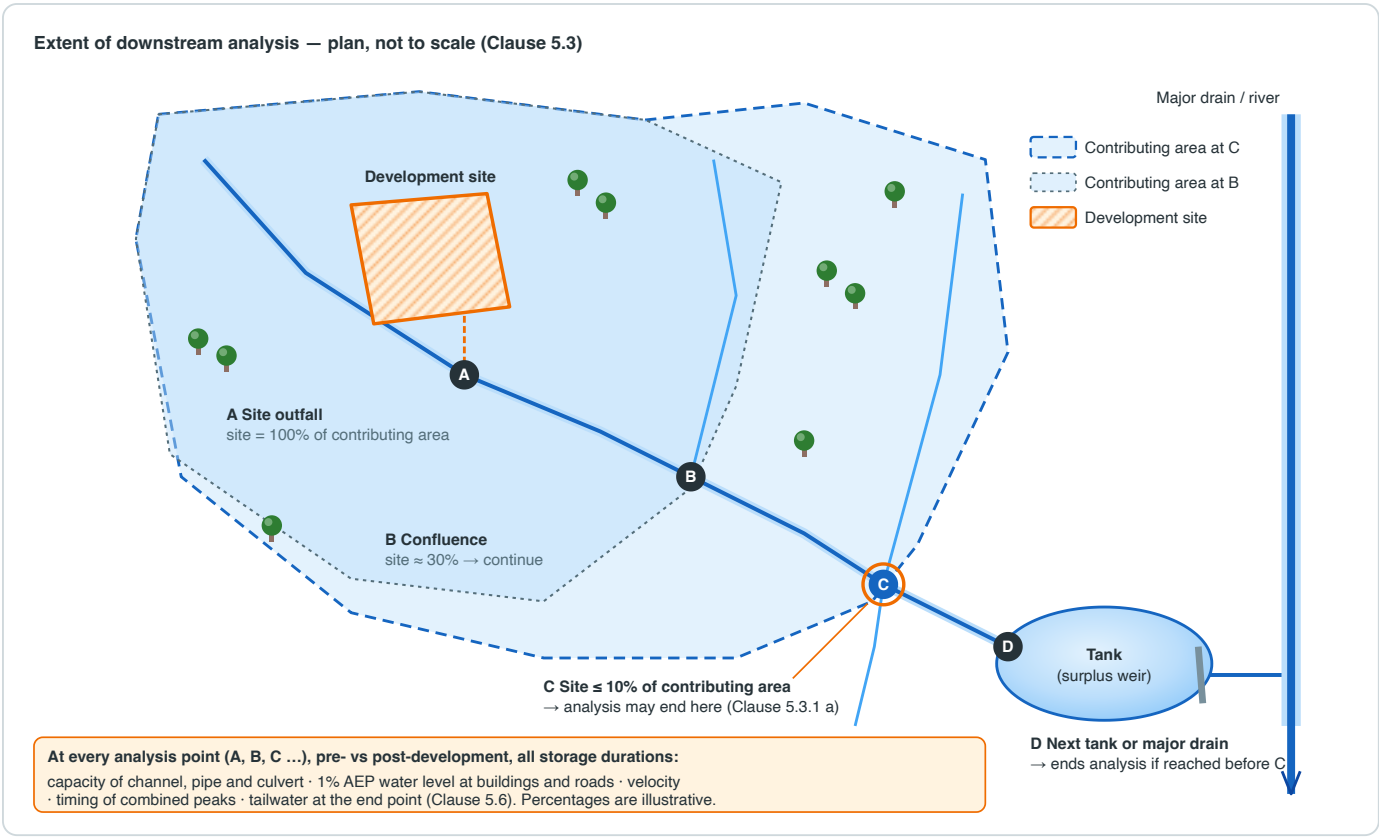


Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next taal or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Uttarakhand. In the Doon, where a colony's drain runs through a khala to the Rispana or the Bindal, the raos of Dehradun whose combined flow "ultimately meets the River Ganga" (ADB, resettlement plan, 2022), and on the plains of Haridwar and Roorkee, where the drains run to the Ganga at or below the Bhimgoda barrage, to the Solani, or beside and under the Upper Ganga Canal, 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.

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 river and plains towns of Uttarakhand, whose outfalls lie below rivers held up for days by monsoon spells and barrages: in August 2026 the Sarda carried more than one lakh cusec for three days, with about 70,000 cusec at Banbasa (as reported); on 14 August 2023 the Ganga at Rishikesh rose to 341.3 m, above

its danger level of 340.5 m, after 419 mm of rain at Rishikesh in two days (CWC data and IMD, as copied by SANDRP); and in July 2024 about 25,000 ha of farmland in the plains of Udham Singh Nagar was submerged (as reported). Detention that prolongs releases can lengthen that time even when it lowers the peak.

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.

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.

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 Uttarakhand, 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.

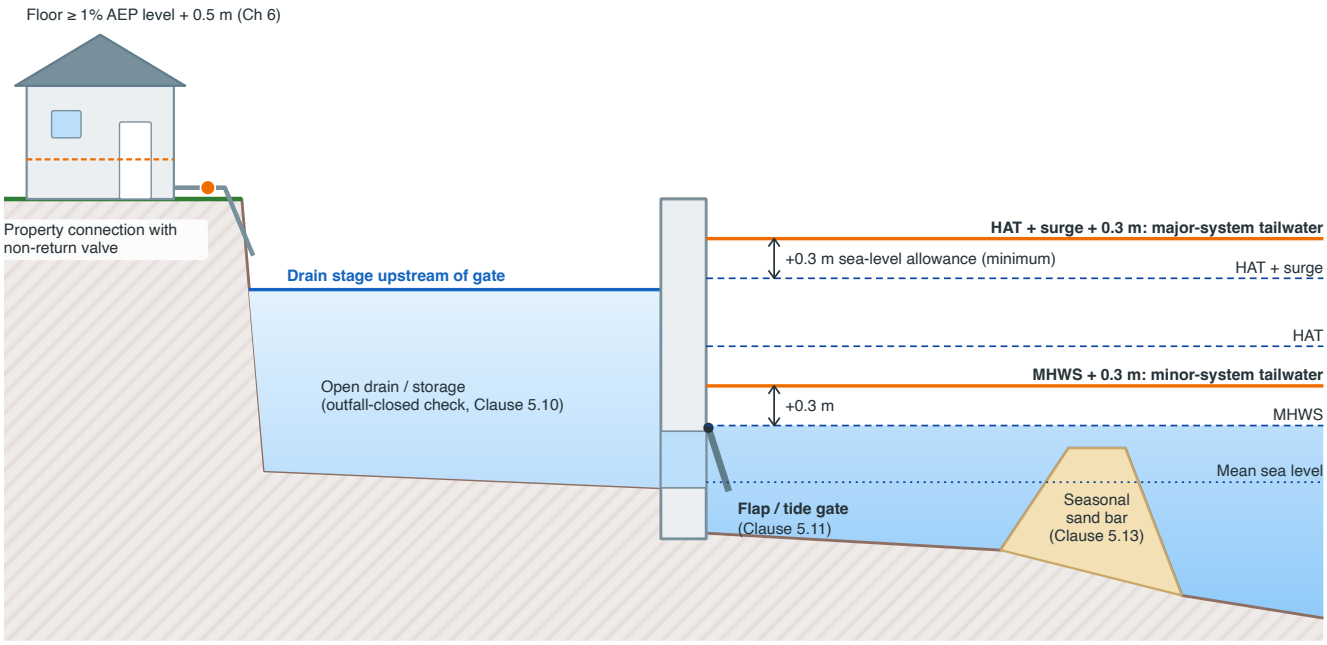
5.7.3 **Storm surge.**

- (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, MDDA 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.

Tidal outfall — schematic section, not to scale (Clauses 5.6–5.13)



Notes
Levels are diagrammatic. Datums from the current NHO / Survey of India tide tables, reduced to the project datum (Clause 5.7).
Joint case (Clause 2.12 b): 10-yr 48 h storm with the 1% AEP still-water level + 0.3 m. Riverine reaches: see Clause 5.8.
Outfall invert below the 1% still-water level → flap or tide gate required; property connections need non-return valves.

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; Uttarakhand has no coast, and the surge term does not arise in the State, which a Bay of Bengal depression reaches only as rainfall, often meeting a western disturbance over the hills, as in October 2021 (Chapter 2).
>
> 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 Uttarakhand, which has no coast, and Annex 5A is not prepared for the State (Clause 5.1.4).

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 **Ganga** at **Rishikesh**, **Muni-ki-Reti** and **Dhalwala** past the **Rishikesh** gauge and the **Pashulok (Virbhadra)** barrage, and at **Haridwar** above and below the **Bhimgoda** barrage and past the **Haridwar (Dudhia Band)** gauge, to the State border below **Laksar**, with the nalas of the towns that end in it, among them the **Chandrabhaga** at Rishikesh (Clauses 5.8.3 and 5.8.5(a) and (c));
- the **Song** at **Satyanarayan** below Dehradun and **Doiwala**, and the **Asan** at **Sabhawala** above the **Asan** barrage (Clauses 5.8.5(a) and (c));
- the **Solani** at **Roorkee**, **Dosni** and **Raysi** (Clause 5.8.5(a));
- the **Gaula** at **Kathgodam** and through **Haldwani** below the **Gaula** barrage, with the **Rakasia** and **Kalasia** nalas, and the **Kosi** at **Ramnagar** below the **Ramnagar** barrage (Clauses 5.8.3 and 5.8.5(a), (b) and (c));
- the **Sarda** at **Banbasa**, **Tanakpur** and **Khatima** below the **Banbasa** barrage (Clauses 5.8.3 and 5.8.5(a) and (c));
- the **Alaknanda** at **Joshimath**, **Rudraprayag** and **Srinagar**, the **Mandakini** at **Rudraprayag**, and the **Bhagirathi** at **Uttarkashi** and below the **Tehri** and **Koteshwar** dams (Clauses 5.8.3 and 5.8.5(a) and (c));
- the raos and khalas of the **Doon**, among them the **Rispana**, the **Bindal**, the **Suswa**, the **Song** above Satyanarayan and the **Tons (Tamsa)**, and the gadheras of the hill and valley towns (Clause 5.8.5(b));
- the **Tehri** and **Koteshwar** reservoirs, the ponds of the **Dakpathar**, **Asan**, **Pashulok**, **Bhimgoda**, **Gaula**, **Ramnagar** and **Banbasa** barrages, the **Kalagarh** reservoir, and the **Baur**, **Haripura** and **Tumaria** reservoirs and the **Dhela** and **Phika** barrages of the terai (Clause 5.8.5(c));
- **Naini lake** and the **Balia Nala** below its sluices, **Bhimtal**, **Naukuchiatal** and **Sattal** (Clause 5.8.5(d));
- the **Upper Ganga Canal** at Haridwar and Roorkee, any canal or gul of the **Irrigation Department**, and any drain or channel of another body that receives storm water (Clause 5.8.5(e)); and
- elsewhere: any river or Irrigation Department channel listed in Annex 5B.

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

- (a) Irrigation Department 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 Tehri and Koteshwar dams on the Bhagirathi above Rishikesh and Haridwar, the Pashulok (Virbhadra) barrage at Rishikesh and the Bhimgoda barrage at Haridwar on the Ganga, the Dakpathar barrage on the Yamuna and the Asan barrage, the Gaula barrage at Kathgodam above Haldwani, the Ramnagar barrage on the Kosi, the Banbasa barrage on the Sarda, the Kalagarh dam on the Ramganga, and the Baur, Haripura and Tumaria reservoirs and the Dhela and Phika barrages in the terai), 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 **River-locked outfalls, raos and gadheras, reservoirs, barrage ponds and dam releases, Naini lake and Bhimtal, canals and the drains of other bodies, and Irrigation Department consent.**

- (a) **River-locked outfalls.** For an outfall to a river directly, through a gate in a bank, a flood wall or an embankment, or through a pumping station, or into a drain that itself discharges in one of those ways, the designer shall identify the body that operates each gate and pumping station, and obtain the sill of each gate, the crest of the bank, wall or embankment, the installed pumping capacity and the operating levels, including the river level at which each gate is closed. Every level shall state its datum and its connection to the gauge datum of the nearest CWC or Irrigation Department gauge.
    - **Design river level.** The river level of Clause 5.8.2 at the outfall shall be, for the major-system cases (Clause 5.8.4(b)), the **1% AEP river level at the outfall**: the 100-year level of the Irrigation Department's floodplain study of the reach under the Uttarakhand Flood Plain Zoning Act 2012, where the study gives a level at the outfall, or a level from a hydraulic model under Clause 5.8.2(b), with the dam and barrage releases of item (c). The notifications under the Act mark the 25-year and 100-year lines on revenue (shajra) maps; no published flood level of a notified reach was found during research, and the levels of each study shall be obtained from the Irrigation Department [TBC]. The level shall in no case be less than the **highest recorded level** at the nearest CWC gauge on the same river, transferred to the outfall, nor less than the 10% AEP level of this item. The highest levels found during research (Table 5B.1), all from SANDRP's copies of CWC tables and posts, with no datum stated and none read in a CWC site sheet [TBC], are: the Ganga at Haridwar (Dudhia Band) **296.30 m**, which SANDRP dates 19 September 2010, after the river passed the 296.23 m of September 1978, while the CWC table that SANDRP copied dates it 17 June 2013, a flood whose peak SANDRP gives as 295.75 m; the date is in conflict, the level is not, and 296.30 m governs until CWC confirms the record [TBC]; the Ganga at Rishikesh **341.72 m** (5 September 1995; 341.45 m on 17 June 2013 and 341.3 m on 14 August 2023); the Song at Satyanarayan **338.49 m** (28 June 2019); the Solani at Roorkee **260.58 m** (14 October 2021), at Dosni **244.65 m** (29 July 2021) and at Raysi **232.24 m** (1 September 2018); the Gaula at Kathgodam **498.93 m** (20 October 2021); the Kosi at the Ramnagar barrage, **220.95 m** on 19 October 2021 in SANDRP's table of December 2021, 3.97 m above the 216.98 m of 1 June 2019, and 220.75 m for the same flood in the CWC list that SANDRP copied in 2022, a conflict in which the higher governs until CWC confirms the level [TBC]; the Sarda at Banbasa **224.9 m** (19 October 2021); the Asan at Sabhawala **450.85 m** (30 September 2019); the Alaknanda at Srinagar **537.9 m** and at Rudraprayag **634.85 m** (both 17 June 2013), and at Joshimath **1,388.65 m** (7 February 2021, the Rishiganga flood; 1,385.54 m on 28 June 2013 before it); and the Bhagirathi at Uttarkashi **1,124.13 m** (6 August 1978). Where a later flood has exceeded the listed level, the later level governs; four of these levels were set in October 2021. The recorded level shall be transferred along the river with the water-surface slope of the flood that set it, from the CWC and Irrigation Department gauge records, or from the model. Until either is available, the recorded level of the nearest gauge upstream applies unchanged at the outfall, except that where the outfall lies between two gauges on the same river, with no tributary joining between

them, the level may be interpolated linearly by river distance between the highest recorded levels of the two gauges; and on a mountain river, whose bed falls several metres in a kilometre, a profile of the flood marks of the same flood, surveyed between the gauge and the outfall and tied to a Survey of India benchmark, may be used in place of the unchanged level (set by this Manual).

- **Rivers and reaches with no gauge level.** No CWC level was found for the Ganga between Rishikesh and Haridwar other than at the two gauges, the Gaula below Kathgodam through Haldwani, the Kosi below the Ramnagar barrage, the Kalyani at Rudrapur, the Kichha, the Dhela at Kashipur, the Khoh at Kotdwar, the Asan below its barrage or the Mandakini, Alaknanda and Bhagirathi at the towns between the gauges [TBC]. On such a reach, and for an outfall upstream of every gauge on its reach, the river level shall be the higher of the level from a model under Clause 5.8.2(b) and the highest flood level surveyed at the outfall from flood marks, including those of June 2013, October 2021, August 2023 and September 2025, and from the records of the Irrigation Department, the local body or the Collector, with its source stated. Where a level is known only as a gauge reading, the designer shall tie the gauge zero to the project datum and a Survey of India benchmark by levelling. No outfall shall be designed on such a reach without one of these levels (set by this Manual).
- **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 a frequency analysis of the gauge record, and not less than the **danger level** at the nearest CWC gauge, transferred in the same way: **294.0 m** at Haridwar (warning 293.0 m); **340.5 m** at Rishikesh (339.5 m); **338.2 m** at Satyanarayan (337.2 m); **261.5 m** at Roorkee (260.5 m); **223.3 m** at Banbasa (warning 222.3 m in one row of the list and 222.96 m in another); **536.0 m** at Srinagar (535.0 m); **627 m** at Rudraprayag (626 m); **1,383 m** at Joshimath (1,382 m); and **1,123 m** at Uttarkashi (1,122 m), all from SANDRP's copy of the CWC list of 2022 [TBC]. At Roorkee the danger level is above the highest recorded level, so there the danger level is also the floor of the design river level; SANDRP warns that 18 of the sites that CWC upgraded to forecasting sites have a recorded highest level below the danger or even the warning level, and at those sites neither level shall be used without the CWC site sheet [TBC]. The gauges at Kathgodam, the Ramnagar barrage and Sabhawala are level-monitoring sites with no danger level; there, the 10% AEP case shall use the design river level of this item until a frequency analysis is accepted (all set by this Manual). The datum of every level is to be confirmed for each gauge [TBC].
- **Tailwater.** The tailwater at the outfall shall be the higher of that river level beyond the gate, bank, wall or embankment, 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, its storage as surveyed in its present condition, net of silt, boulders, encroachment, solid waste and weed, 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 (set by this Manual), with gravity discharge through the gate only while the river is lower than the level behind it. Pumps 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).
- **River lock.** Portable dewatering pumps brought in for an event, and capacity that has been sanctioned or proposed but not commissioned, shall not be counted. The outfall-closed check of Clause 5.10 applies with a single lock that lasts for as long as the river stays above the outfall invert, or above the level at which its gate is closed if that is lower, taken from the river model or from the stage record of the nearest CWC gauge in the flood that set the highest recorded level or in a comparable flood, with the releases of item (c), and not less than **72 hours**, or, on a river below a dam or barrage, the time for which the largest recorded release of the dams and barrages above stayed above the flow at which the outfall is closed, from the operator's records, if that is longer (set by this Manual). The lock covers the whole of the 48- and 72-hour storms of Clause 5.10.2, so that storage and pumping handle the full storm volume (Clause 5.9.4) and the drawdown of Clause 5.10.5 is met by pumping until the lock ends. An outfall to the pond of a barrage, such as the Ganga above Bhimgoda at Haridwar or above the Pashulok (Virbhadra) barrage at Rishikesh, whose invert is below the pond level of item (c), is closed for the whole storm. A shorter lock may be used only where the outfall invert is above the 1% AEP river level of this item, or where an analysis of the stage record of a CWC gauge under Clause 5.10.6, including the releases of the dams and barrages above, shows it and the Authority approves it.

    - **Gate failure and breach.** Floor levels and pumped outfalls behind a gate, flood wall or embankment shall also be checked for the failure of the gate and for a breach of the wall or embankment, with the land and drains behind it filled to the river level beyond it. Below a dam or barrage they shall also be checked for the release that results from a gate failing open.
- (b) **Raos, gadheras, khalas and other ungauged hill streams.** For an outfall to a rao, gadhera, khala, gad or other seasonal hill stream, such as the Rispana, the Bindal, the Suswa, the Song above Satyanarayan, the Tons (Tamsa) and the khalas that feed them in the Doon, the Chandrabhaga at Rishikesh, the Rakasia and Kalasia nalas and the gadheras that run to the Gaula at Haldwani, the Balia Nala below Naini lake, and the gadheras that come down to the valley towns of Srinagar, Rudraprayag and Uttarkashi, or into a drain that ends in one:
    - **No gauge.** None of these streams has a CWC gauge at a town, except the Song at Satyanarayan below the town of Dehradun, and none has a published flood level [TBC]. They are seasonal, steep and boulder-laden: they rise within an hour of a burst of rain, carry gravel, boulders and debris, and raise or scour their beds in a single flood.
    - **Design level.** The tailwater for the major-system and storage cases shall be the highest of: (i) the 1% AEP level at the outfall from a study of the stream, made with a hydrograph method of Chapter 3 for the whole catchment above the outfall, with the rainfall of its sub-area in Annex 2A, the AMC of Clause 3.8.4 and the bulking factor of Clause 6.3.6(b) on the peak flow, and routed through a hydraulic model (Clause 5.8.2(b)) of the channel as surveyed, with the crossings downstream blocked as Clause 6.3.6(c) requires; (ii) the 100-year level of the Irrigation Department's floodplain study, where the stream has been notified under the Flood Plain Zoning Act (the Rispana, final notification of 5 May 2025, as reported) or studied (the Suswa, the Song, the Baldi, the Asan and its tributaries, the Gaula and the Kosi) [TBC]; and (iii) 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 the floods of June 2013, October 2021, August 2023 and September 2025 or a later flood, and from the records of the Irrigation Department, the local body or the Collector, with its source stated. No outfall to such a stream shall be designed without items (i) and (iii) (set by this Manual).
    - **Bed level, scour and aggradation.** The designer shall survey the bed of the stream 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 Irrigation Department and 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, which for the Rispana the State and NMCG have taken as the land flooded once in 5 years (as reported). 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 stream.
    - **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 as long as the level of the stream, computed under item (i) for the coincident cases of Clause 5.8.4, stays above the invert, and, where no hydrograph of the stream has been computed, for the whole storm (Clause 5.9.4) (set by this Manual).
    - **Interceptors.** An interception and diversion structure on a rao or its drains (Clause 8.9) shall not raise the design level of this item or reduce the capacity of the drain; it shall stand above that level or be designed to be overtopped without damage.
- (c) **Reservoirs, barrage ponds and dam releases.** For an outfall to a reservoir or barrage pond, directly or through a drain or stream that ends in it, such as the Tehri and Koteshwar reservoirs on the Bhagirathi, the ponds of the Pashulok (Virbhadra) and Bhimgoda barrages on the Ganga, the Dakpathar barrage on the Yamuna and the Asan barrage, the Gaula barrage at Kathgodam, the Kosi barrage at Ramnagar, the Banbasa barrage on the Sarda, the Kalagarh dam on the Ramganga, and the Baur, Haripura and Tumaria reservoirs and the Dhela and Phika barrages in the terai:
    - **Consent.** Storm water shall not be discharged to a reservoir or barrage pond without the written consent of its custodian: THDC India Ltd for Tehri and Koteshwar; UJVN Ltd for the Dakpathar and Asan barrages; the Irrigation Department for the Gaula barrage and the reservoirs and barrages of the terai; and, for the

Bhimgoda, Pashulok, Ramnagar and Banbasa barrages and Kalagarh, the body that operates them, which was not confirmed during research (the canal flows at Bhimgoda are reported to be regulated by the Uttar Pradesh Irrigation Department, unverified) [TBC]. The pond of the Asan barrage lies in the Asan Conservation Reserve, a Ramsar site, where the permission of the State Wetland Authority and the Forest Department is also required (Chapter 7). An outfall that carries dry-weather flow is dealt with under Clause 8.9.

- **Design level.** The tailwater for the major-system and storage cases shall be the waterbody's **maximum water level (MWL)** as its custodian publishes it, or, where only the full reservoir level (FRL) or maximum pond level is published, **FRL plus the surcharge in its design flood**, computed from the rating of its spillway and gates with the gates operated only as the custodian's written rule provides. Where neither the MWL nor the surcharge has been published, or where the published MWL is not above the FRL, the tailwater is **FRL + 0.5 m** (set by this Manual) [TBC]. For a barrage pond, the tailwater is the higher of that level and the river level of item (a) at the barrage with its gates as operated. In every case it shall be not less than the highest level recorded at the waterbody. The minor-system tailwater is the FRL or maximum pond level, or the level at which the custodian's rule opens the gates if that is higher. The project's discharge shall be included in the level (Clauses 5.3.2 and 5.12.3).
- **The named reservoirs and barrages.** Until the custodian confirms the MWL or the design-flood level and its datum, the tailwaters are (set by this Manual) [TBC]: **Tehri**, FRL 830 m, MWL 835 m (THDC), **835.0 m**; **Dakpathar** barrage, maximum pond level 456.40 m and high flood level 456.50 m in the 200-year design flood (UJVN Ltd, operation and maintenance manual, 2021), **456.50 m**, to be revised when the upstream flood level for the revised design flood, which the dam-safety review left "yet to be determined", is published; **Asan** barrage, maximum pond level 401.50 m (UJVN Ltd, 2021), **402.00 m**; **Gaula** barrage, maximum pond level 510.750 m and high pond level 513.250 m (Irrigation Department), **513.25 m**; **Banbasa** barrage, FRL 222.96 m and MWL 223.3 m in the CWC list, but 224.9 m recorded at Banbasa on 19 October 2021, so **224.9 m**; **Kalagarh** dam, FRL 365.3 m and MWL 366.2 m (CWC list), **366.2 m**; and the **Baur** and **Haripura** reservoirs, FRL 242.32 m (795 ft; Irrigation Department), **242.82 m**. No level on a stated datum was found for Koteshwar (whose CWC gauge recorded 546.7 m on 15 August 2013), the Pashulok, Bhimgoda and Ramnagar barrages, the Tumaria reservoir or the Dhela and Phika barrages [TBC]; no outfall to any of them shall be designed without the custodian's FRL or pond level and spillway rating in writing, or, until the custodian gives them, the higher of a survey of the crest tied to a Survey of India benchmark and the river level of item (a) (set by this Manual).
- **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall shall be treated as closed for the whole storm (Clause 5.9.4), with storage and pumping handling the full storm volume, unless the custodian's stage record shows the waterbody below the invert at the start of comparable storms and the Authority accepts it. Every reservoir and barrage pond starts every design storm at its FRL or maximum pond level (Clause 7.7.3), and no lowering of a reservoir or pond before a storm and no early or additional gate opening shall be assumed unless the custodian's written operating rule and records show it.
- **Rivers below dams and barrages.** For an outfall to a river below a dam or barrage, such as the Bhagirathi and the Ganga below Tehri and Koteshwar, the Ganga below Pashulok at Rishikesh and below Bhimgoda at Haridwar, the Yamuna below Dakpathar, the Asan below its barrage, the Gaula below the Gaula barrage at Haldwani, the Kosi below Ramnagar, the Sarda below Banbasa, and the rivers of the terai below the Baur, Haripura and Tumaria reservoirs, in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) shall be run with the river at the level that results from the largest recorded release of the dams and barrages above, routed to the outfall, with the flow of the catchment below them as it occurred in the same event, and with the release placed before, during and after the site storm (set by this Manual), until the operator publishes an operating rule that bounds the release [TBC]. The largest recorded releases found are about 375,000 cusec at Bhimgoda in June 2021, 123,000 cusec at the Gaula barrage in 1993 against a design discharge of 115,000 cusec, and 12,742 m³/s at Dakpathar in 1973 (as reported; Irrigation Department; UJVN Ltd); the largest recorded release of each dam and barrage and its duration shall be obtained from its operator and stated [TBC]. A release, or a release rule, alone shall not be taken to bound the river level: the level shall also be checked for the largest recorded event at the nearest gauge, with the

local inflows as they occurred. No attenuation by the storage of Tehri or any other reservoir shall be credited to the river below unless the operator's written rule commits that storage to flood control for the event; and no dam or barrage gate shall be assumed to open earlier or wider than the operator's records show. The river level shall not be reduced on the ground that the flood comes from rain that falls outside the town, on snow or glacier melt, or in Nepal on the Kali (Sarda), or that the site storm is small.

- (d) **Naini lake and Bhimtal.** For an outfall to Naini lake, Bhimtal, Naukuchiatal, Sattal or another taal, directly or through a drain that ends in it:
    - **Consent.** Storm water shall not be discharged to a taal without the written consent of its custodian. The custodian of Naini lake and of its sluices was not confirmed during research [TBC]: the Lake Development Authority, Nainital, holds the lake area, and the operation of the sluice gates at Tallital is reported to have passed from PWD to the Irrigation Department in 2018 (as reported); the drains of the town are held by the Nagar Palika Parishad, Nainital [TBC]. Both the lake custodian and the Irrigation Department shall consent until the State names one custodian. The custodians of Bhimtal, Naukuchiatal and Sattal were not confirmed [TBC].
    - **Naini lake: design level.** The lake drains only through five sluice gates at Tallital, each 2.5 ft wide and 1.25 ft high, installed in 1888 and worked under rules framed by the Hill Slide Committee of 1927, which allow them to be opened no more than 6 inches while the gauge is below 9 ft and, as a rule, no more than 12 inches while it is below 9.5 ft, to protect the Balia ravine below, and which keep them open from their first opening in the monsoon until 15 October, when they are sealed (NIH, 1998–99). The maximum level of the lake is 12.5 ft on the PWD gauge at Tallital (NIH, 1998–99); press reports give 12 ft, and the lake rose to 12.2 ft and overflowed on 19 October 2021 (as reported). Until the custodian confirms a maximum level, the tailwater for the major-system and storage cases is the higher of **12.5 ft on the Tallital gauge** and the level to which the lake rose when it overflowed in October 2021, surveyed from flood marks; the minor-system tailwater is the gauge level at which the rules allow the sluices their full opening. The zero of the Tallital gauge has not been tied to mean sea level in any source found [TBC]: the designer shall level it to a Survey of India benchmark, convert every gauge level from feet on the gauge to metres on the project datum, and state the conversion on Form 5-1 (set by this Manual).
    - **Naini lake: closed outfall.** The lake starts every design storm from 1 July to 15 October at the tailwater of the previous item, and every design storm after 15 October with its sluices sealed and its level at the higher of that tailwater and its level on 15 October. An outfall whose invert is below that level shall be treated as closed for the whole storm (Clause 5.9.4). No opening of the sluices beyond the 1927 rules, and no lowering of the lake before a storm, shall be assumed unless the custodian's written rule and records show it. Pumping into the lake raises its level for every other outfall (Clause 5.12.3) and shall not be used without the custodian's consent.
    - **Drains to the lake.** Every drain that discharges to Naini lake or another taal shall pass a debris trap and a sediment trap (Clause 6.3.6(a) and Chapter 8) before it reaches the lake, sized for the bulked flow of Clause 6.3.6(b). No runoff shall be infiltrated on the slopes of the lake catchment except as Clause 4.11 allows, and the Sukhatal basin, which supplies a large part of the lake's subsurface inflow, shall not be built on or paved (Chapter 7).
    - **The Balia Nala.** No new discharge to the Balia Nala or its ravine below the Tallital sluices shall be made except through a lined channel or pipe with energy dissipation, with the consent of the Irrigation Department and a geotechnical certificate that the discharge will not destabilise the ravine (set by this Manual).
    - **Bhimtal and the other taals.** No level on a stated datum was found for Bhimtal, Naukuchiatal or Sattal [TBC]. Until the custodian gives one, the tailwater is the level at which the taal 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 the taal; the taal starts every design storm at its spill level, and an outfall below the tailwater is closed for the whole storm (set by this Manual).
- (e) **The Upper Ganga Canal, other canals and the drains of other bodies.** Storm water shall not be discharged to the Upper Ganga Canal, which leaves the Ganga at Bhimgoda and runs through Haridwar and Roorkee, or to any other irrigation or power canal or gul, without the written consent of the canal's operator (for the Upper Ganga Canal, reported to be the Uttar Pradesh Irrigation Department, unverified [TBC]; for its own canals, the Irrigation

Department), nor to a drain of another body, such as a drain of a Nagar Nigam or other urban local body, a development authority, UUSDA or Dehradun Smart City Ltd, PWD or NHAI, or an industrial estate, without the written consent of that body. A drain that crosses a canal shall cross by a cross-drainage work built with the canal operator's consent, and not discharge into it. 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, including the drains of other bodies, and with its downstream boundary at the river, reservoir or taal level of items (a) to (d); until a design water level is published for a channel, the computed level governs [TBC];
    - the channel shall be taken in its present condition, net of silt, boulders, encroachment, solid waste, weed and obstruction by crossing services and culverts, and with its narrowest section as surveyed, and with any weir that intercepts its dry-weather flow (Clause 8.9) at its crest level; a widening, lining, remodelling or diversion that has been proposed but not completed, such as the lining of the Rakasia and Kalasia nalas at Haldwani, shall not be counted, and a channel designed for a stated return period shall not be taken to carry more than its surveyed section carries; 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.

- (f) **Irrigation Department consent; floodplain, plan, wetland and court lines.** No outfall structure, gate, pumping station or drain shall be built in the bed, bank or floodplain of a river, rao or gadhera, or in a dam, barrage, reservoir, embankment, flood wall or canal of the Irrigation Department, without the consent of the Irrigation Department, or of THDC India Ltd or UJVN Ltd for their structures; the procedure for that consent was not found during research [TBC]. In the prohibited (25-year) or restricted (100-year) area of a reach notified under the Uttarakhand Flood Plain Zoning Act 2012 (614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini, and the Rispana; Chapter 7), any activity also needs the previous permission of the Flood Zoning Authority (s.12(3)); the lists of permitted works found in the notifications do not name drain outfalls, and whether an outfall is permitted in each area is to be confirmed with the Authority before design [TBC]. The designer shall also check the outfall against the lines that the building rules, the zoning regulations, the wetland rules and the courts have set, as they stand at the time of design (Chapter 7): the 30 m from a river bank, 30 m from the bank or maximum fixed level of a lake, 10 m from a spring and at least 5 m from a nala of bye-law 4.4(III) of the Bye-laws 2011; the 30 m from river and lake banks of the Unified Zoning Regulations 2025; on the Ganga in the hills, the prohibited zone (100 m from the middle of the river or the 25-year flood area, whichever is more) and the 200 m regulatory zone beyond it of the Housing Department's order of 29 November 2017 (revised 1 June 2023), which give way to the Irrigation Department's notified lines where they exist; below Haridwar, the 100 m from the edge of the river that the National Green Tribunal set as a no-development zone on the Ganga from Haridwar to Unnao until the floodplain is demarcated (O.A. 200/2014, judgment of 13 July 2017), which conflicts with the State's reading of 100 m from the middle of the river; the direction of the High Court in *Lalit Miglani* (2016) that drains opening into the Ganga be sealed, which this Manual reads as applying to sewage and dry-weather flow (Clause 8.9) and not to a storm-water outfall built under this chapter [TBC]; the Asan Conservation Reserve, a Ramsar site; the Sukhatal lakebed, on which the High Court stopped construction in 2022; and the orders on the beds of the Doon's raos and khalas (*Urmila Thapa*, WPPIL 58/2019; NGT O.A. 417/2022 on the Rispana). Whether a drain outfall is permitted within each line is to be confirmed with the authority concerned before design [TBC].

No pump, gate, sluice, barrage or dam operation that helps drainage, such as pumping a drain down before a storm, lowering a reservoir, barrage pond or taal before a storm, opening the Tallital sluices beyond their rules, closing a gate late or opening dam or barrage 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 waterbody or the river (Clause 5.12.3). Pumping shall not be used to move water into a taal, 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. Uttarakhand's rivers break that assumption, because their catchments are small and steep and the storms that fill them fall on the towns at the same time. On 17 June 2013 Dehradun recorded 370.2 mm in a day (IMD) in the same storm that sent the Alaknanda at Srinagar and Rudraprayag to their highest recorded levels and the Ganga at Haridwar to 295.75 m; on 18–19 October 2021, when Pantnagar recorded 403.9 mm and Nainital 401 mm in 24 hours, the Kosi at Ramnagar, the Gaula at Kathgodam and the Sarda at Banbasa all set new highest levels and Naini lake overflowed; and on 13–14 August 2023, when 419 mm fell at Rishikesh, the Ganga there rose above its danger level (IMD and CWC data, as reported and as copied by SANDRP). 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 dams and barrages above and beside the State's towns. Tehri, on the Bhagirathi, has a full reservoir level of 830 m, a maximum level in the design flood of 835 m and a spillway designed for a probable maximum flood of 15,540 m³/s, and first reached its full level on 24 September 2021 (THDC). In June 2013 it took a peak inflow of about 7,500 m³/s on 17 June while releasing no more than about 500 m³/s, its level rising from 750.00 m to 775.05 m in two days (THDC, as presented at CBIP); an expert panel later called that attenuation "a matter of chance, not design" (as reported): the reservoir stood some 80 m below its full level when the flood came. The Dakpathar barrage on the Yamuna passed 12,742 m³/s in 1973 and is designed for 14,420 m³/s, the 200-year flood, at a high flood level of 456.50 m (UJVN Ltd, 2021); the Asan barrage is designed for 4,500 m³/s (UJVN Ltd, 2021); the Gaula barrage at Kathgodam, designed for 115,000 cusec, passed 123,000 cusec in 1993, and its pond is reported to be silted with boulders (Irrigation Department; as reported); and the Bhimgoda barrage at Haridwar passed about 375,000 cusec in June 2021 (as reported). In August 2026 the Sarda carried more than one lakh cusec for three days, with about 70,000 cusec at Banbasa (as reported). No operating rule or release record for any of these dams and barrages, no rule curve for Tehri after 2013, and no hourly stage record for any gauge in the State was obtained during research [TBC]. Until they are, the largest recorded release applies, 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 copies of CWC data, because the CWC websites refused access during research; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Uttarakhand the tailwater at a town outfall is set not by the tide but by a river held high by a monsoon spell or a barrage, by a rao or gadhera whose level no one has recorded and whose bed moves, by a reservoir or barrage pond at its full level, by a lake whose outlet is gated, or by a canal, and no document found during research gives a design level for any of them. The only design basis found for town drains, that of the drains built in Dehradun with ADB's assistance, requires the outfall invert to stand above the high flood level of the receiving water but does not say what that level is (ADB, climate risk assessment, 2021). The State's municipal law was not read in its Uttarakhand form [TBC]. The Uttarakhand Flood Plain Zoning Act 2012 is the State's own instrument for flood lines, and the Irrigation Department has finally notified 614.6 km of five rivers of the Ganga system and the Rispana under it (Irrigation Department, status report filed in NGT O.A. 417/2022; Chapter 7), but the notifications mark lines on revenue maps and publish no levels.

The first is the river. Item (a) follows the interim river rule of the other plains editions of this Manual: the design level is the 1% AEP level, and never below the highest level recorded at the nearest CWC gauge. At Haridwar the record itself is not in doubt, 296.30 m, but its date is: SANDRP's account of the CWC data dates it 19 September 2010 and gives the peak of 17 June 2013 as 295.75 m, while the CWC table that SANDRP copied puts 296.30 m against 17 June 2013. Item (a) uses the level and states the conflict, because the date does not change the floor. At Ramnagar the conflict is in the level, 220.95 m or 220.75 m for the same flood, and the higher is used until CWC confirms it. The danger level is used as the floor of the 10% AEP level because the Ganga has crossed it in recent floods at both Haridwar and Rishikesh, so a level reached about once in ten years is unlikely to lie below it; at Roorkee the danger level stands above the recorded highest level, which SANDRP says is true of 18 of the sites that CWC has upgraded and is a reason to read every level in a CWC site sheet before final design [TBC]. The

rivers of the hills rise and fall within hours, which might seem to justify a shorter lock than in the plains. Item (a) keeps 72 hours for three reasons: no hourly stage record for any gauge in the State was obtained during research [TBC]; the storms that raise the rivers last for days, as on 16–18 June 2013 and 17–19 October 2021, and in August 2026 the Sarda carried more than one lakh cusec for three days (as reported); and on the plains the rivers are held up by barrages, the Ganga at Haridwar by Bhimgoda and at Rishikesh by Pashulok, so that an outfall into a barrage pond stays closed for as long as the pond is held, which item (a) treats as the whole storm. The lock covers the whole of the longest design storm of Clause 2.5.2, so that the site does not rely on the river falling during the storm. A designer who has the stage record of a CWC gauge can justify a shorter lock under Clause 5.10.6, and the mountain rivers are where that analysis is most likely to succeed. Item (a) counts only the permanent pumps less the largest one, for the same reason that Clause 5.12.2(b) requires a standby pump: pumping stations are proposed in the low-lying parts of Haldwani (as reported), and a station that loses a pump in the storm must still meet the check.

The second is the rao and the gadhera. Dehradun's raos are ungauged, and the Irrigation Department's floodplain study of the Rispana, modelled for the 25-year and 100-year floods with the CWC subzone unit hydrographs (affidavit of the State in NGT O.A. 417/2022), gives lines but no published level. Item (b) therefore requires the designer to make the study and to survey the flood marks, and takes the higher. A rao's bed is not fixed: it rises with the gravel and boulders of one flood and is scoured by the next, and the floods of September 2025 damaged 83 of the interception structures built in and beside the Rispana (Peyjal Nigam, affidavit in O.A. 417/2022). An outfall set at the present bed level is buried by the first and undermined by the second, so item (b) sets the invert at least 0.5 m above the highest bed level surveyed downstream, a margin set by this Manual for the aggradation that a gravel bed can show in a single flood, and takes the foundation below the computed scour. It keeps outfalls out of the active channel, which NMCG has asked the State to show for the Rispana as the 5-year flood zone (NGT order of 18 August 2025, as recorded).

The third is the reservoir and the barrage pond. A reservoir at its full level does not fall for the rest of the season but passes its inflow over its spillway, and its level rises above FRL by whatever head the flood needs. Item (c) therefore takes the MWL, as published for Tehri, or FRL plus the design-flood surcharge, and treats an outfall below it as closed for the whole storm, which is what Clause 5.9.4 already requires when the tailwater stays above the outfall. Where only a pond or full level is published, FRL + 0.5 m is set as the interim value: it is the freeboard that this Manual uses for floor levels (Clause 6.11.1), and it is a floor, not an estimate of the surcharge, which depends on the spillway and the flood [TBC]. For the Gaula barrage the published high pond level, 513.250 m, is used as its MWL, and for Dakpathar the 200-year high flood level, 456.50 m; at Banbasa the recorded 224.9 m of October 2021 is above the published MWL of 223.3 m, and the recorded level governs. Item (c) also runs the town storm with the river at the largest recorded release because the rain that fills a reservoir and the rain on the town below come from the same monsoon spell (see the Commentary to Clause 5.8.4). It credits no attenuation by Tehri, because the reservoir is held to a rule that THDC has not published and filled to its full level for the first time only in 2021, and because the panel that reviewed the flood of 2013 found its effect then to be "a matter of chance, not design" (as reported).

The fourth is Naini lake. The lake receives every drain of Nainital and leaves only through five sluices of 2.5 ft by 1.25 ft at Tallital, whose opening the rules of 1927 limit to protect the Balia ravine, and which are sealed on 15 October (NIH, 1998–99). A lake with a gated outlet of that size cannot be lowered in a storm, so item (d) starts every storm at the maximum level and treats an outfall below it as closed. The maximum level is 12.5 ft on the PWD gauge in the NIH study and 12 ft in press reports; item (d) uses the higher, with the level of October 2021 as a check, because the lake rose to 12.2 ft and overflowed on 19 October 2021 (as reported), four days after the date on which the sluices are sealed. That flood is also why item (d) starts every storm after 15 October with the sluices sealed. The gauge is read in feet from a zero that no source found ties to mean sea level, so item (d) requires the zero to be levelled before any outfall level is set [TBC]. The custodian of the lake and its sluices was not confirmed: the Lake Development Authority holds the lake area, and the operation of the sluices is reported to have passed from PWD to the Irrigation Department in 2018 [TBC]. Bhimtal and the other taals have no published level, so their spill level is used, as the plains editions of this Manual use the spill level of a talab.

The fifth is the canal and the drain of another body, and the sixth is the line within which an outfall may be built. The Upper Ganga Canal leaves the Ganga at Bhimgoda and runs through Haridwar and Roorkee to Uttar Pradesh; its flows are reported to be regulated by the Uttar Pradesh Irrigation Department (unverified [TBC]), so item (e) asks for the consent of the canal's operator, whoever it is. Items (c), (e) and (f) ask for the owner's consent and design level because a design that discharges to a channel, a reservoir or a lake cannot be checked without them. The lines of item (f) decide where an outfall can be built, not its level. On the Ganga they conflict: the Housing Department's order of 2017 reads the National Green Tribunal's direction as 100 m from the middle of the river, while the Tribunal's judgment of 13 July 2017 for the reach from Haridwar to Unnao says 100 m from the edge (Chapter 7). Item (f) states both and does not choose between them.

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.

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:

> $V_{inflow} \le V_{storage\ available} + V_{pumped} + V_{gravity\ (between\ locks)}$

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.

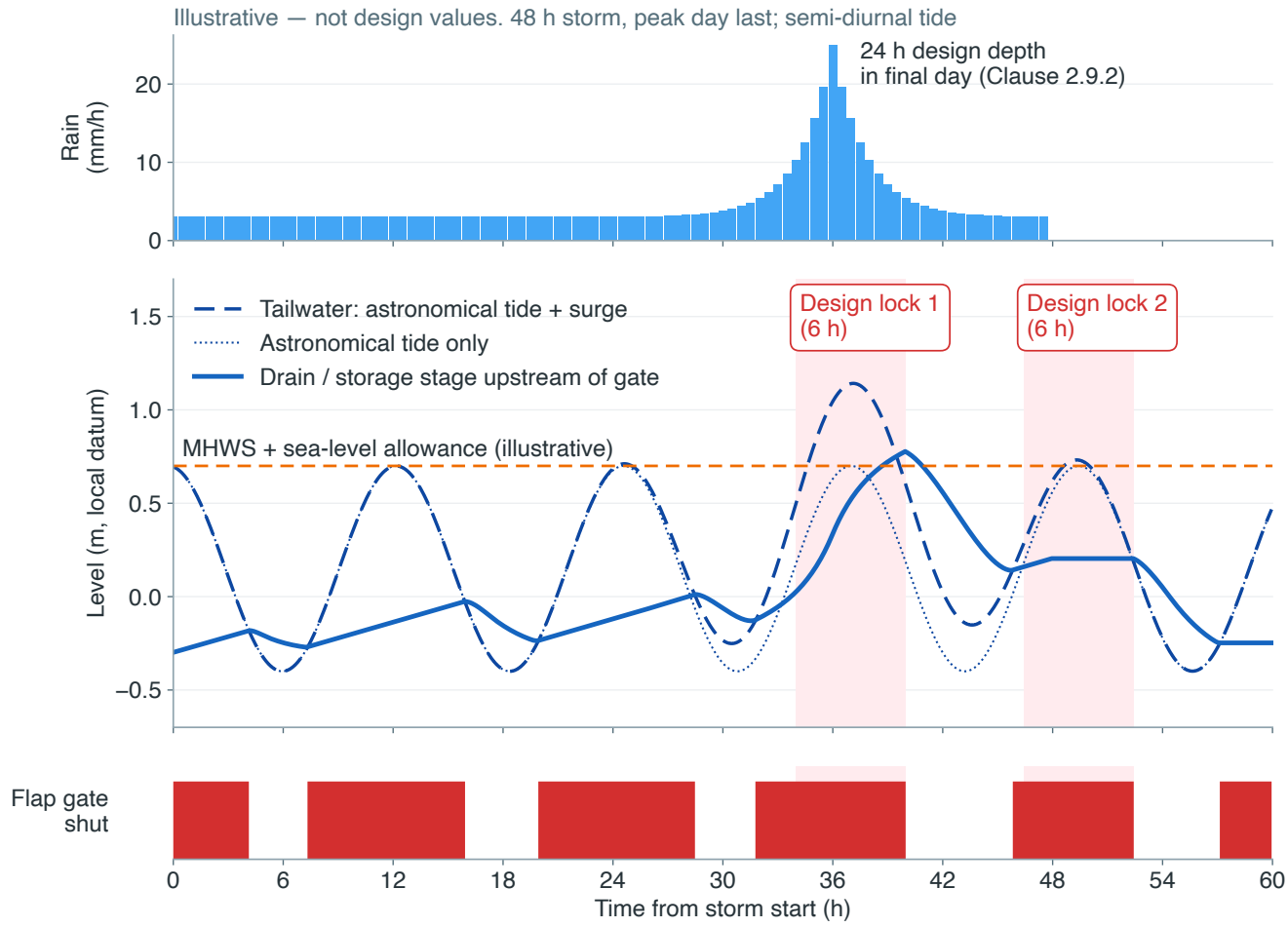


Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal 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 Uttarakhand requirement in this Manual. In Uttarakhand it applies where an outfall is shut not by the tide but by a river held high by a monsoon spell or by a barrage, by a rao that has risen over the outlet or buried it in gravel, by a reservoir or barrage pond at its full level, or by Naini lake, whose sluices are sealed on 15 October. In August 2026 the Sarda carried more than one lakh cusec for three days (as reported), and the storms of 16–18 June 2013 and 17–19 October 2021 each lasted for days. A river below a barrage stays high for as long as the barrage passes the flood, a pond or lake at its full level stays there for the rest of the monsoon, and a rao in flood can block an outlet with boulders, which is why Clause 5.8.5 replaces the two 6-hour windows described below with a single river lock of at least 72 hours and a closure for the whole storm at a pond, lake or rao outfall below its design level. 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.

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 **15 June** 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 Uttarakhand the outfalls do not cross a beach, but many of them end in a river whose level is set by a dam or barrage upstream, in a barrage pond, or in a lake whose only outlet is gated. In June 2013 Tehri took a peak inflow of about 7,500 m³/s while releasing about 500 m³/s (THDC, as presented), an attenuation that an expert panel called "a matter of chance, not design" (as

> reported); the Bhimgoda barrage at Haridwar passed about 375,000 cusec in June 2021 (as reported); and the five sluice gates at the Tallital end of Naini lake, installed in 1888, are worked under rules of 1927 that limit their opening to protect the Balia ravine below them, and are sealed on 15 October (NIH, 1998–99). A gate opened in a hurry raises the river below; a gate held shut raises the pond or the lake and every outfall that drains to it. The dams and barrages are held by THDC India Ltd (Tehri and Koteshwar), UJVN Ltd (Dakpathar and Asan) and the Irrigation Department (the Gaula barrage and the reservoirs of the terai), the canal flows at Bhimgoda are reported to be regulated by the Uttar Pradesh Irrigation Department (unverified [TBC]), the operation of the Tallital sluices is reported to have passed from PWD to the Irrigation Department in 2018 (as reported), and the drains that reach them belong to the Nagar Nigams, the Nagar Palika Parishads, the development authorities and PWD; no rule linking the operation of any of these gates to the levels of the drains was found during research [TBC], so a gate and the drains behind it can belong to different bodies. The 15 June inspection date is set ahead of the SW monsoon.

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 **15 June** 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.

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 Uttarakhand: Clause 5.1.4), and any other mouth listed in Annex 5B.

5.13.2 **Assumption at the start of the SW monsoon.** The mouth shall be assumed **closed** by a bar at the start of the June–September season, at the crest level of the most recent pre-monsoon survey. This applies unless the Irrigation 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 SW 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 Irrigation 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.** Uttarakhand 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 gravel, boulders and debris that hill streams leave at an outfall. The pond of the Gaula barrage is reported to be silted with boulders (as reported); in the floods of 15–16 September 2025 the raos of Dehradun damaged 83 of the interception structures on the Rispana (Peyjal Nigam, affidavit in NGT O.A. 417/2022); and the 1927 rules for the Tallital sluices of Naini lake exist to keep the Balia ravine below them from eroding (NIH, 1998–99). A flap gate held open or shut by gravel or debris, 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. Apart from the Tallital rules, no written gate-operation rule for the gates of any barrage or lake outlet in the State was found during research [TBC]. Clause 5.8.5 deals with both by setting outfalls above the 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.

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 Irrigation Department 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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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
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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) Uttarakhand 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.** Uttarakhand's drains were not designed against any State or municipal standard: none was found during research. The only design basis found is that of the drains built in Dehradun with ADB's assistance, at least 117 km of them, where "a storm frequency of once in 2 years" was used for roadside drains and "once in 5 years" for the primary and secondary channels, with a minimum size of 250 mm × 250 mm, velocities of 0.6 to 3.0 m/s, outfall inverts above the high flood level of the receiving water and no allowance for climate change, and where the assessment itself noted that the drains "may remove around half the floodwater in larger events" (ADB, climate risk assessment, 2021). The Irrigation Department, not the urban local bodies, is preparing drainage master plans for Haldwani (₹1,003.42 crore, including the lining of the Rakasia and Kalasia nalas and pumping stations in the low-lying areas) and other towns of Kumaon, whose design storm has not been published (as reported). The drains also work in a setting that the plains editions of this Manual do not meet. In the Doon and the hill towns they collect water from steep slopes that deliver gravel, stones and leaves with every storm and end in raos and gadheras whose beds move; Dehradun's command centre was flooded after the cloudbursts of 25 August 2021 and 8 August 2023 (CAG, 2025), and in the floods of 15–16 September 2025 the district lost 13 bridges, 10 culverts and 21 roads (as reported). The road drains of the hills are the drains of the land above them, and the Supreme Court's committee on the Char Dham roads found that "no slope drainage measures had been taken" (*Citizens for Green Doon*, judgment of 14 December 2021). The drains are also divided among owners: the Nagar Nigams and other urban local bodies, MDDA, HRDA and the district development authorities, UUSDA and Dehradun Smart City Ltd, PWD and NHAI, the Irrigation Department and the Peyjal Nigam all build or hold drains

and receiving waters, and no rule divides them (see the Commentary to Clause 6.9). 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.

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).

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 **Hill catchments: debris, sediment, steep drains and streets, hill roads and sloping sites.** This clause applies to every element of the minor and major systems that receives runoff from a hill catchment, which in this Manual means land in sub-area UK-A, UK-D, UK-E or UK-F of Annex 2A, any catchment whose natural ground slopes more than 10% on average, and any gadhera, khala, rao or other seasonal stream that comes down from the hills or runs across the Doon fans or the bhabar. Such elements shall meet Clauses 6.4 to 6.14 and, in addition (all set by this Manual):

- (a) **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, terraced or bare slope, or a slide scar), or from a gadhera, khala or rao 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. 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 May and, in the hill towns, again by 15 October (Chapter 10). The volume of a debris basin is to be set in Chapter 9 [TBC].
- (b) **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. A catchment that the screening of Clause 2.3.6(i) shows to be prone to debris flow, or that drains a mapped debris-flow fan, landslide or slide scar, is not designed by a bulking factor: no building, outfall, pumping station or storage shall be placed in the debris-flow path, and the drains are designed for the bulked flow only [TBC].
- (c) **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%.
- (d) **Sediment and minimum velocity.** Drains and pipes that receive flow from a hill catchment, or that run across the Doon Gravels or the bhabar fans, 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).
- (e) **Steep drains and energy dissipation.** 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 channel or a series of drop structures designed under Chapter 9 for the bulked flow of item (b), 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. No unlined drain shall be laid on a gradient on which the velocity exceeds the limit of Chapter 9 for its bed material.
- (f) **Steep streets.** 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. Where the 1% AEP flow cannot be kept within those limits on the

carriageway, the excess shall be carried in a lined side channel or stepped drain under item (e), 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.

- (g) **Hill roads as the minor system.** In the hill area of bye-law 2.3 of the Bye-laws 2011, the drainage of a road is the minor system for the land above it as well as for the road. Every road and street there shall have, as works of the road's owner:
    - (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 gadhera and khala, 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 (b) and (c);
    - (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, 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; and
    - (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.
- (h) **Sloping sites.** The diversion of uphill runoff away from foundations that bye-law 4.4(V)(b) requires on a sloping site shall be a lined drain sized for the minor design flow of Table 6.1 from the land above it, with the factors of items (b) and (c), and a 1% AEP flow path that does not pass through or against the building. It shall discharge to a public drain or a stable natural channel as item (g)(iv) requires, not onto the slope below. Roof and paved-area runoff on such a site follows the hill infiltration rule of Clause 4.11.

> **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 Dehradun 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 Uttarakhand, the first mountain State in this series, because the criteria of this chapter assume clear water on gentle ground. In the hills the water is not clear: the zone-7 rivers gauged for the CWC report fall 9.9 to 84 m in a kilometre (CWC, 1994), the pond of the Gaula barrage is reported to be silted with boulders (as reported), and in the floods of 15–16 September 2025 Dehradun district lost 13 bridges and 10 culverts (as reported). IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently: their side drains are "normally restricted to 60 cm" in width and lined because "rolling stones cause high friction", "culverts are required at closer intervals compared to those in plain areas", and "stepped chutes/baffles are to be provided where the longitudinal bed slope exceeds critical"; and the committee on the Char Dham roads recommended that "roadside drainage measures and protection against toe-erosion must be undertaken" (*Citizens for Green Doon*, Supreme Court, 2021). No Indian guidance on bulking factors, debris racks or debris basins was found during research [TBC], so each number in Clause 6.3.6 is an interim value with a stated reason. The 1 ha trigger for a debris rack reflects the time of concentration on hill slopes, a few minutes, so that even a small unbuilt slope delivers stones, gravel and leaves to an inlet in the first burst of a storm. 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 sediment than that behaves as a debris flow, which no drain can be sized for; the disasters of Kedarnath in 2013, Raini in 2021 and Dharali in 2025 were debris flows, and in three of the four such disasters of recent years, with Maldevta in 2022, no rain gauge captured the trigger. That is why item (b) keeps buildings and outfalls out of a debris-flow path rather than sizing a drain for it, and why the factor is to be replaced by a sediment study as soon as one is made [TBC]. The 3.0 m limit in item (c) doubles the core's 1.5 m because boulders block openings that leaves and plastic do not. The 1.0 m/s minimum in item (d) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm,

because hill drains carry gravel. On a 10% street, the hazard limit of 2.0 m/s is reached when sheet flow on a concrete surface is only about 30 mm deep, which is why item (f) takes the flow off steep carriageways. Item (h) gives a design standard to the only site-runoff clause of the bye-laws, the uphill diversion of bye-law 4.4(V)(b), and items (g)(iv) and (h) keep road and site runoff off unprotected slopes, because water discharged onto a slope raises its pore pressure: the investigations of the Balia Nala at Nainital and of Joshimath both name water entering the slope as a cause of its failure (Chapter 4, Clause 4.11).

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: Dehradun, Haridwar, Haldwani, Rudrapur and Roorkee core and other high-density areas	10% (10-yr)	1% (100-yr) overland path	This Manual (see Commentary)
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) the old city of Dehradun, including Paltan Bazaar; the old town of Haridwar behind Har-ki-Pauri; the old bazaar of Haldwani; the old towns of Roorkee and Rudrapur; and the bazaars of the hill stations, including the Mall Road and Tallital in Nainital and the Mall in Mussoorie: the older, densely built area within the Nagar Nigam's or Nagar

Palika Parishad's area that the applicable master plan under the 1973 planning Act identifies as the old city, core or central business district, with the boundary of each to be confirmed by the Nagar Nigam or Nagar Palika Parishad, the development authority and T&CP [TBC];

- (b) in every other Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat, the area that the applicable master plan identifies as the old town or the central business district, the main bazaar of a hill or Char Dham town, and the old village settlements that have been taken into the built-up area; 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.

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) · Sx^(5/3) · SL^(1/2) · 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

Road class	Minor design event (Table 6.1)	Check event and 1% AEP event
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
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.

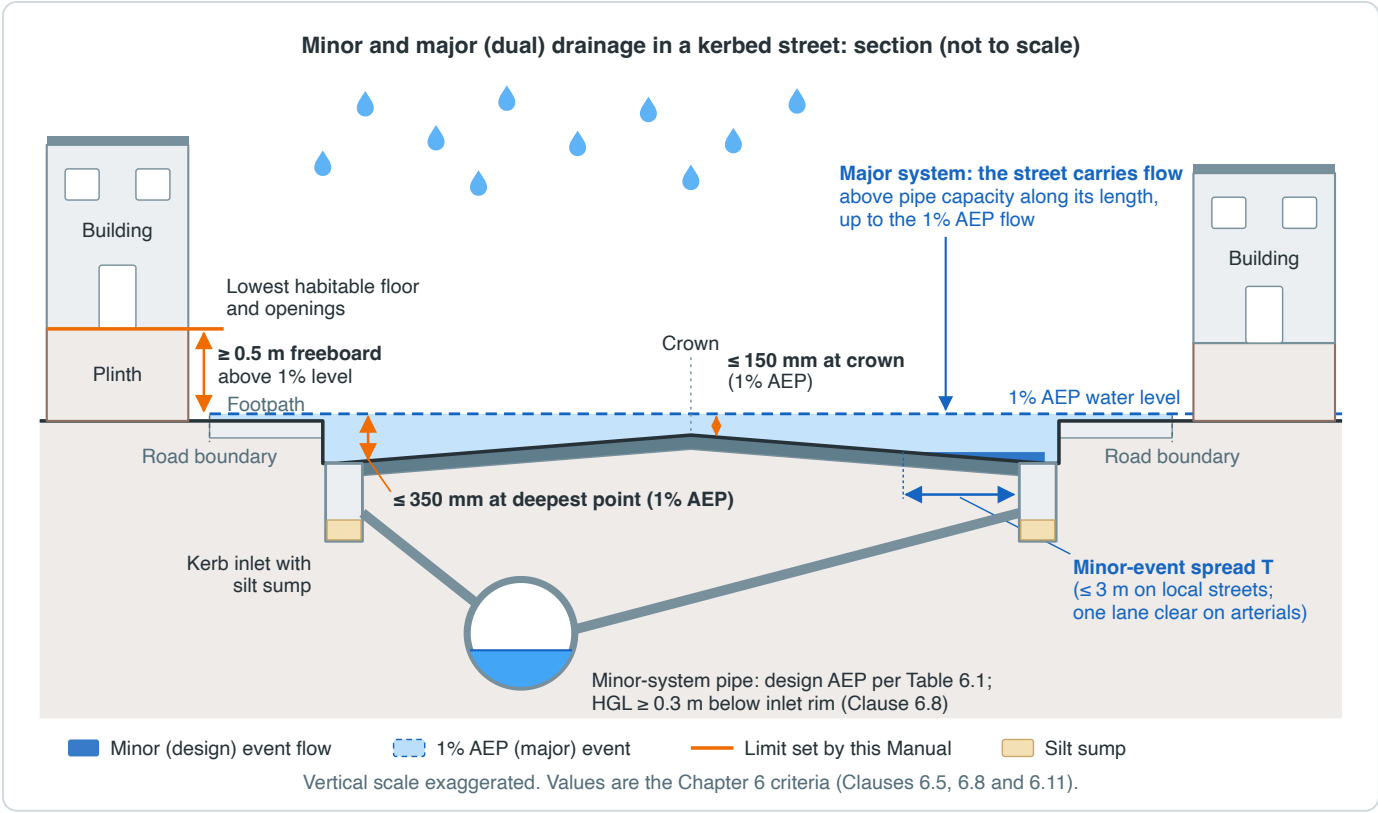


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

> **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 Uttarakhand 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.

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:

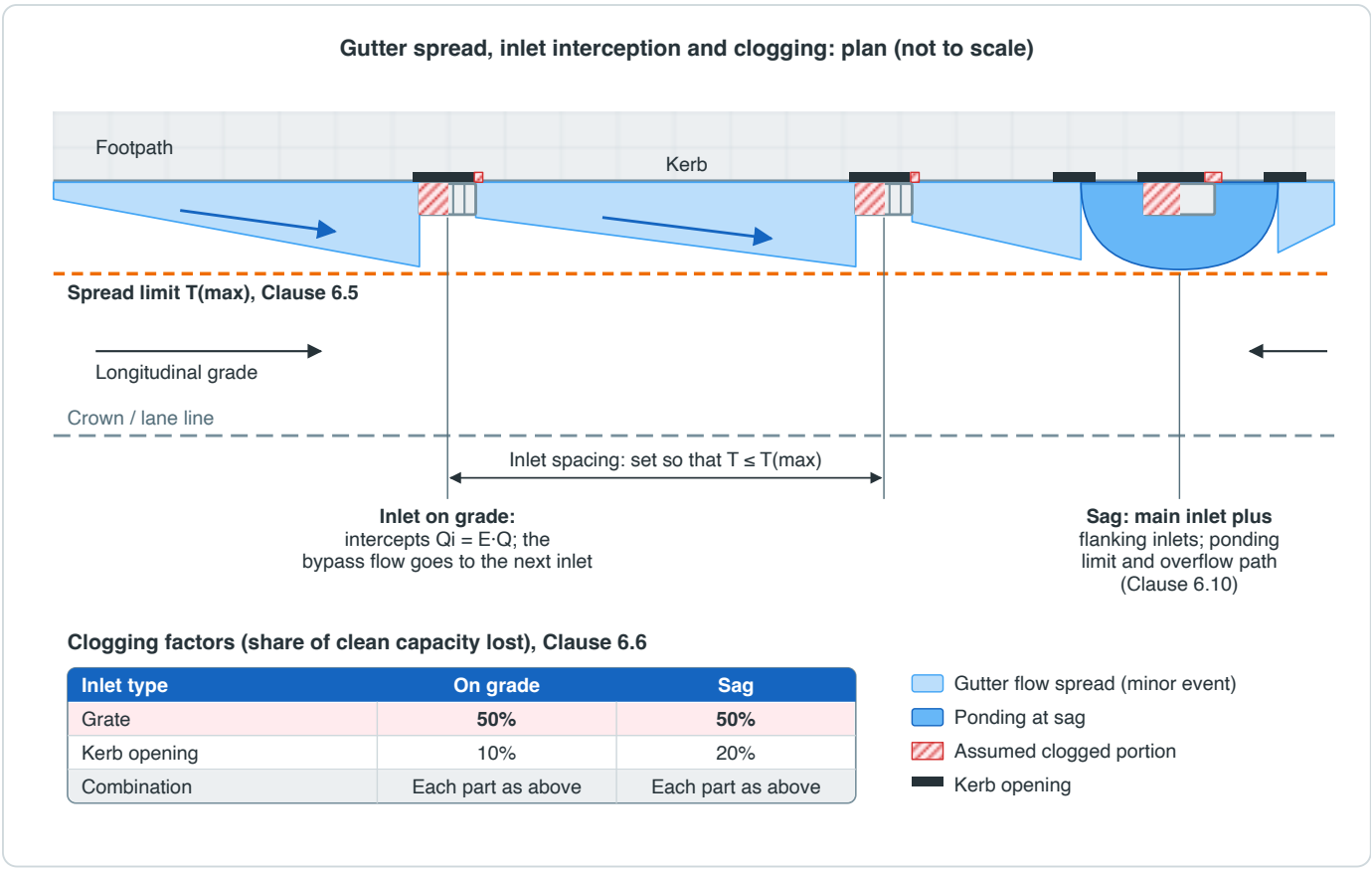
- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass 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.



Inlet type	On grade	Sag
Grate	**50%**	**50%**
Kerb opening	10%	20%
Combination	Each part as above	Each part as above

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 Uttarakhand 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. In Dehradun, the drains built with ADB's assistance include about 15 km of kerb-channel drains to IS 5758-1984 on minor roads less than 3 m wide, and roadside drains closed by precast covers (ADB, 2021 and 2022). 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 plains of Haridwar, Roorkee and Udham Singh Nagar are flat, which shortens the calculated spacing anyway; on the steep streets of the hill towns gutter flow runs fast and passes inlets by, which Clause 6.3.6(f) 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).

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 = (1/n) · R^(2/3) · S^(1/2); Q = A · 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 (m^2) and Q is the discharge (m^3/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
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 Mussoorie, Nainital, Almora, Pithoragarh, Pauri, New Tehri, Srinagar, Uttarkashi and Joshimath 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.

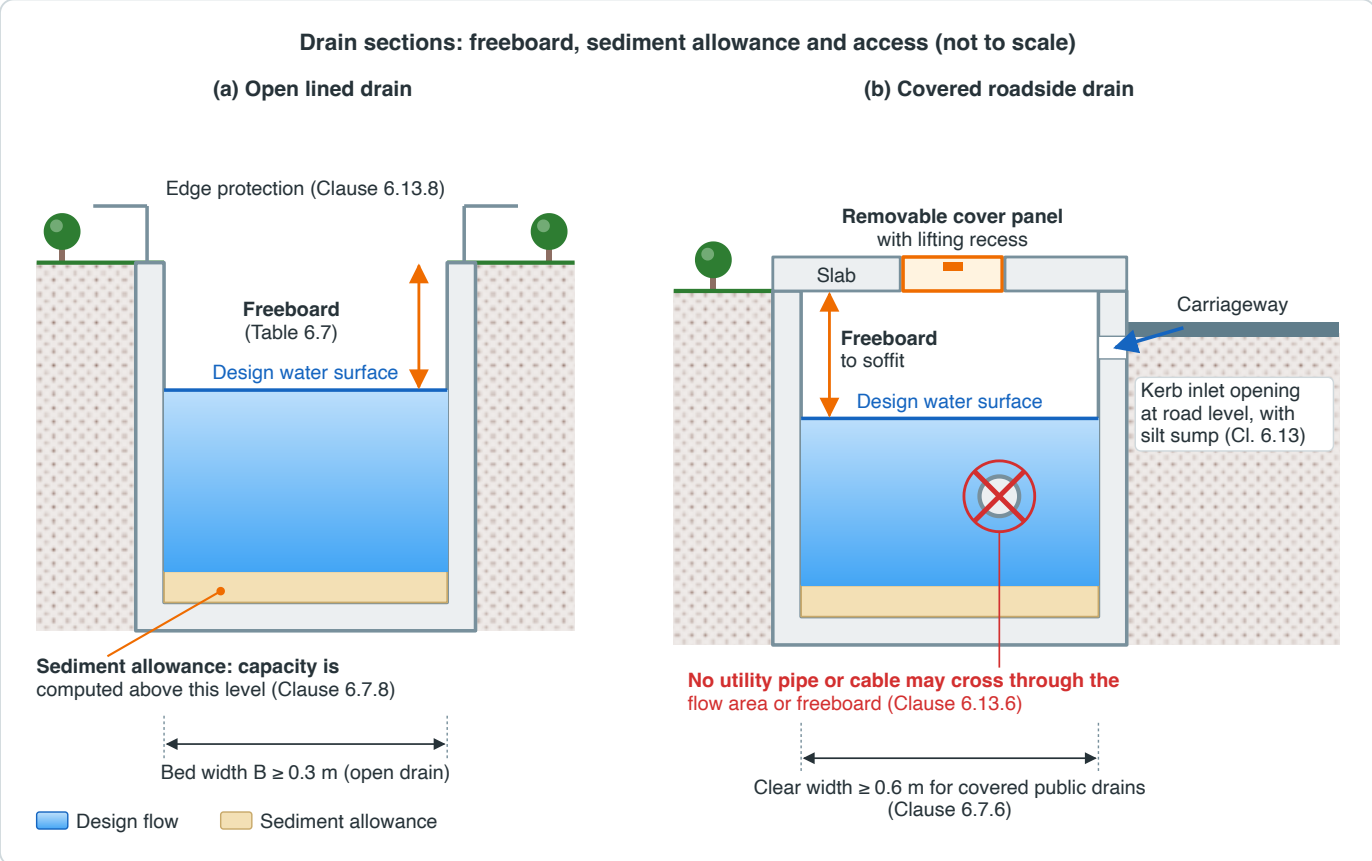


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

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 Uttarakhand 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 Dehradun storms of 25 August 2021 and 8 August 2023, which caused flash-flood-like conditions at the Smart City's command centre, in a city where the drains of Paltan Bazaar were divided between Dehradun Smart City Ltd and PWD and could not be built where power poles stood in their line (CAG, performance audit of the Smart Cities Mission, 2025), and after the floods of 15–16 September 2025, which carried away 13 bridges and 10 culverts in Dehradun district (as reported). 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. Dehradun'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.

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 Uttarakhand many town drains end in a rao, a river held high by a monsoon spell or a barrage, a barrage pond or Naini lake (Clause 5.8.5). Dehradun's khalas end in the Rispana and the Bindal, whose drains are intercepted by 187 interception and diversion structures on the Rispana alone (Peyjal Nigam, 2025), each of which, unless it is designed for the storm flow, raises the level in every drain above it (Clause 8.9); Haridwar's drains end in the Ganga at the Bhimgoda barrage or below it; and Nainital's drains end in a lake held at its maximum level until its sluices are sealed. The drains built in Dehradun with ADB's assistance set their outfall inverts above the high flood level of the receiving water (ADB, 2021), but no flood level of any rao was found during research. A drain whose HGL is started from a free outfall, or computed one length at a time without the river, rao, weir or lake 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.

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
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 an Irrigation Department channel, the reserve is transferred to the Irrigation 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.

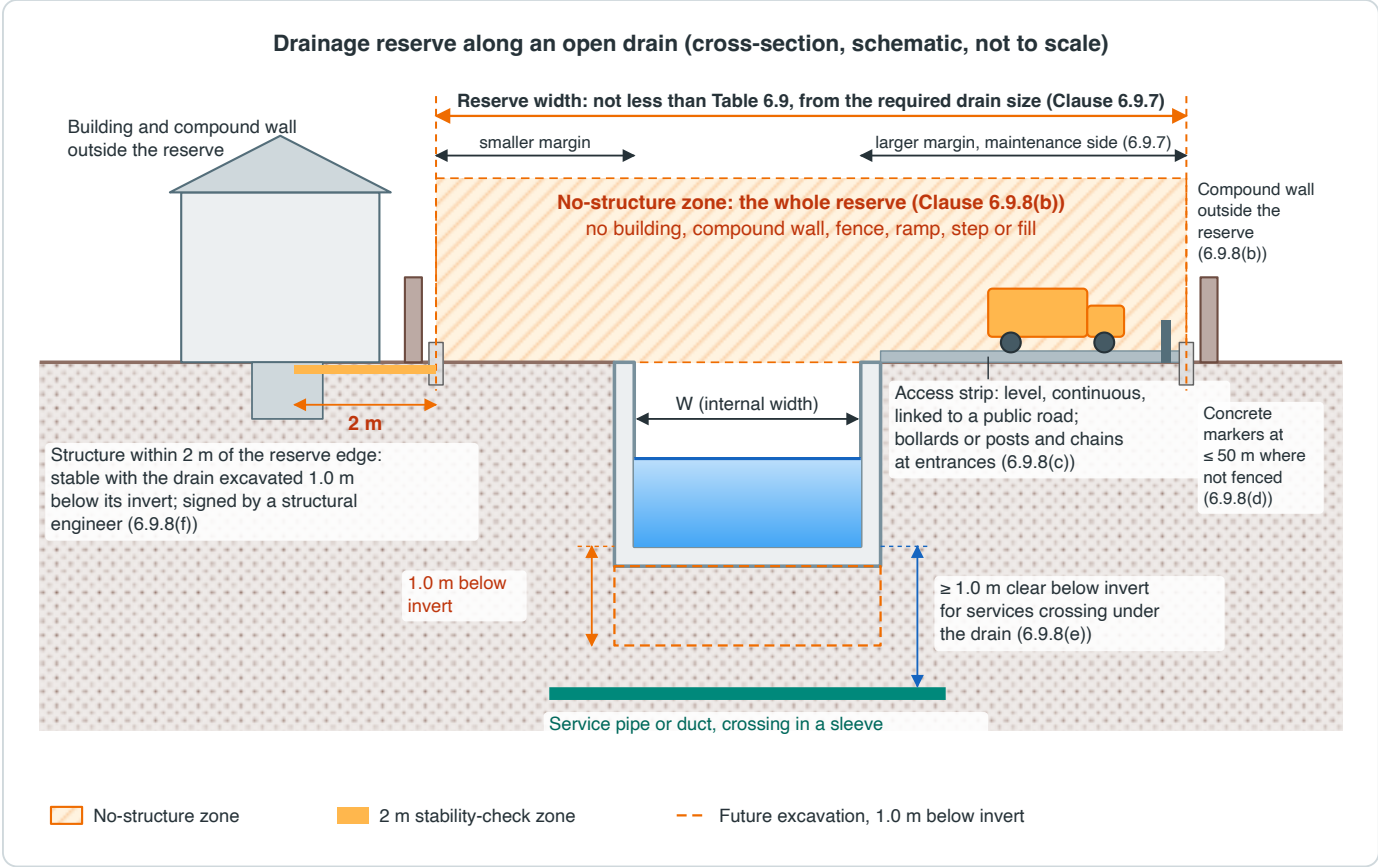


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Uttarakhand, 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. Uttarakhand, unlike most States in this series, has statutory distances from water, but no reserve width along a drain. Bye-law 4.4(III) of the Bye-laws 2011, made by the Housing Department under s.57 of the 1973 planning Act and adopted by the board of each development authority, fixes plot boundaries only beyond at least 30 m from a river bank and 10 m from an underground water source (a spring), both to be left for dense planting with no construction of any kind, beyond at least 5 m from the bank of a nala or the required setback, whichever is more, and beyond 30 m from the bank or boundary of every lake, including the Nainital lake special area, or from the maximum fixed level of a natural reservoir, whichever is more. The compiled text prints the first two distances as "30.0–30.0" and "10.0–10.0" metres; this Manual reads them as single distances of 30 m and 10 m, and the printing is to be confirmed against the gazetted text [TBC]. The Unified Zoning Regulations 2025 (No. 568 of 20 November 2025) put rivers and all waterbodies recorded in the revenue records, including ponds, lakes, nalas and streams, in a Conservation Use Zone of the master plans, with a green buffer and no new construction within 30 m of river and lake banks. Under the Uttarakhand Flood Plain Zoning Act 2012, the Irrigation Department maps the 25-year flood line, within which use is prohibited, and the 100-year line, within which it is restricted, and

marks them on revenue maps; they bind only where a reach has been finally notified: 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini, and the Rispana (5 May 2025, as reported), with the Asan approved by the cabinet in June 2025 (as reported) and the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani studied but not notified. An amendment of 2024 extends the time for notification to 24 months and lets a final notification be amended where "riverbank development" can protect the land behind it (seen only as quoted) [TBC]. On the Ganga in the hills, the Housing Department's order of 29 November 2017 (revised 1 June 2023) sets a prohibited zone of 100 m from the middle of the river or the 25-year flood area, whichever is more, and a regulatory zone of the next 200 m, and gives way to the Irrigation Department's notified lines where they exist; below Haridwar, the National Green Tribunal set 100 m from the edge of the river as a no-development zone until the floodplain is demarcated (O.A. 200/2014, judgment of 13 July 2017), a line that conflicts with the State's reading of 100 m from the middle; this Manual states both and does not choose between them. None of these defines the bank or the high flood level from which the distances are measured, and none gives a reserve width along a gadhera, khala or town drain that is not a river or a nala. For this Manual, as its own proposal and not as the meaning of the bye-laws, the bank of a channel is its top of bank, and the edge of a taal or lake is the higher of its maximum fixed level and its monsoon water line (Chapter 7, definitions after Clause 7.2); every gadhera, khala, rao and nala 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, piped or covered; and land recorded in the revenue records as a river, nala or waterbody is part of the channel or waterbody whatever its present use (set by this Manual). The beds of rivers outside municipal limits are forest land, and the High Court has ordered encroachments removed from the beds of the raos and khalas of the Doon (*Urmila Thapa*, WPPIL 58/2019). 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(b) (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along a river, rao, gadhera, khala or nala that drains 8 ha or more, the setbacks of Clause 7.4 measured from its top of bank, with a Zone 1 of at least 15 m; where a reach is notified under the Flood Plain Zoning Act, its prohibited and restricted zones govern; and where bye-law 4.4(III), the Unified Zoning Regulations, the Ganga orders, a master plan or a court sets a wider line, that line applies for as long as it binds (Chapter 7). The corridor is set by this Manual. It should be shown in the master plans made under the 1973 planning Act, among them those of Dehradun, Haridwar–Roorkee and Haldwani, as part of the Conservation Use Zone, and checked at plan approval, where the bye-laws already require a contour plan, the distances from water and, on a slope, the diversion of uphill runoff, rather than made a new NOC.

The reserve matters because the drains of Uttarakhand's towns are divided among owners, and no rule divides them. The Nagar Nigams hold the public drains of their areas under the Uttar Pradesh Municipal Corporation Act 1959 as adapted in 2002, and the Nagar Palika Parishads and Nagar Panchayats under the Uttar Pradesh Municipalities Act 1916 as amended in 2002 (CAG, 2022); the drain chapters of both, as they apply in Uttarakhand, were not read [TBC]. In Dehradun, drains have been built by UUSDA with ADB's assistance and by Dehradun Smart City Ltd, and the drains of Paltan Bazaar were divided between Dehradun Smart City Ltd and PWD (CAG, 2025); MDDA, HRDA and the district development authorities build schemes whose drains are later handed over; PWD holds the roads and their drains, and NHAI the national highways; the Irrigation Department holds the rivers and their floodplain lines, the flood works and its barrages and canals, and is now preparing the drainage master plans of Haldwani and other Kumaon towns (as reported); the Peyjal Nigam builds the sewers and the interception of drains, and the Jal Sansthan runs them; and THDC India Ltd and UJVN Ltd hold the dams and barrages of Tehri, Koteshwar, Dakpathar and Asan. No rule dividing the raos and natural nalas from the municipal drains was found during research. For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: rivers, raos and gadheras with their beds, banks and floodplains, among them the Rispana, the Bindal, the Song, the Suswa, the Tons, the Asan, the Gaula, the Kosi and the Ganga, the flood-protection works, the demarcation of floodplains under the Flood Plain Zoning Act, and the Irrigation Department's barrages and canals, to the **Irrigation Department**, with the Forest Department as owner of river-bed land outside municipal limits and the local body keeping the bed free of encroachment within them; the natural nalas, khalas and public drains within the limits of a Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat, other than those assigned to the Irrigation Department, to that body, in Dehradun to DMC; drains built under the ADB-assisted projects or by Dehradun Smart City Ltd to UUSDA or Dehradun Smart City Ltd until they are handed over in writing, and then to the local body; the drains and storages of a scheme of MDDA, HRDA, a district

development authority, UHUDA or a colony developer to the body that built it until they are handed over in writing; the road drains, catch-water drains, scuppers and cross-drainage of State roads and hill roads to **PWD**, of national highways to NHAI, NHIDCL or MoRTH, and of border roads to BRO; sewers, interceptors, the interception and diversion of nalas and raos, and treatment plants to the Peyjal Nigam for construction and the Jal Sansthan for operation (Clause 8.9); Naini lake, its Tallital sluices and the Balia Nala outlet to the Lake Development Authority, Nainital, with the Irrigation Department, and the drains of Nainital to the Nagar Palika Parishad, until the State confirms the custodian [TBC]; the hydropower reservoirs and barrages to THDC India Ltd (Tehri and Koteshwar) and UJVN Ltd (Dakpathar and Asan); springs used for supply to the Jal Sansthan, the local body or the gram panchayat, and their rejuvenation to the Spring and River Rejuvenation Authority, whose constitution order was not found [TBC]; and wetlands, including the Asan Conservation Reserve, to the State Wetland Authority with the Forest Department (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to the Irrigation Department is transferred to the Irrigation Department. Where a channel's status is disputed, the corridor follows the channel and not its name: the Rispana and the Bindal are rivers to the floodplain law, raos to the city and, in CPCB's words, "rivers reported as drains" (as quoted). No approved city drainage master plan with a design return period was found for any town in the State; the only design storms found for a city's drains are those of the drains built in Dehradun with ADB's assistance, 2 years for roadside drains and 5 years for primary and secondary channels (ADB, 2021), a project basis and not a State standard. 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(e) and Chapter 9 require lining on steep gradients. 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 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 Uttarakhand 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.

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: in the floods of 15–16 September 2025 Dehradun district lost 21 roads, 13 bridges and 10 culverts (as reported), and the Supreme Court's committee on the Char Dham roads found that "no slope drainage measures had been taken" (*Citizens for Green Doon*, 2021). Clause 6.10.5(d) links the 150 mm crown depth limit of Table 6.2 to the point at which traffic should stop.

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.

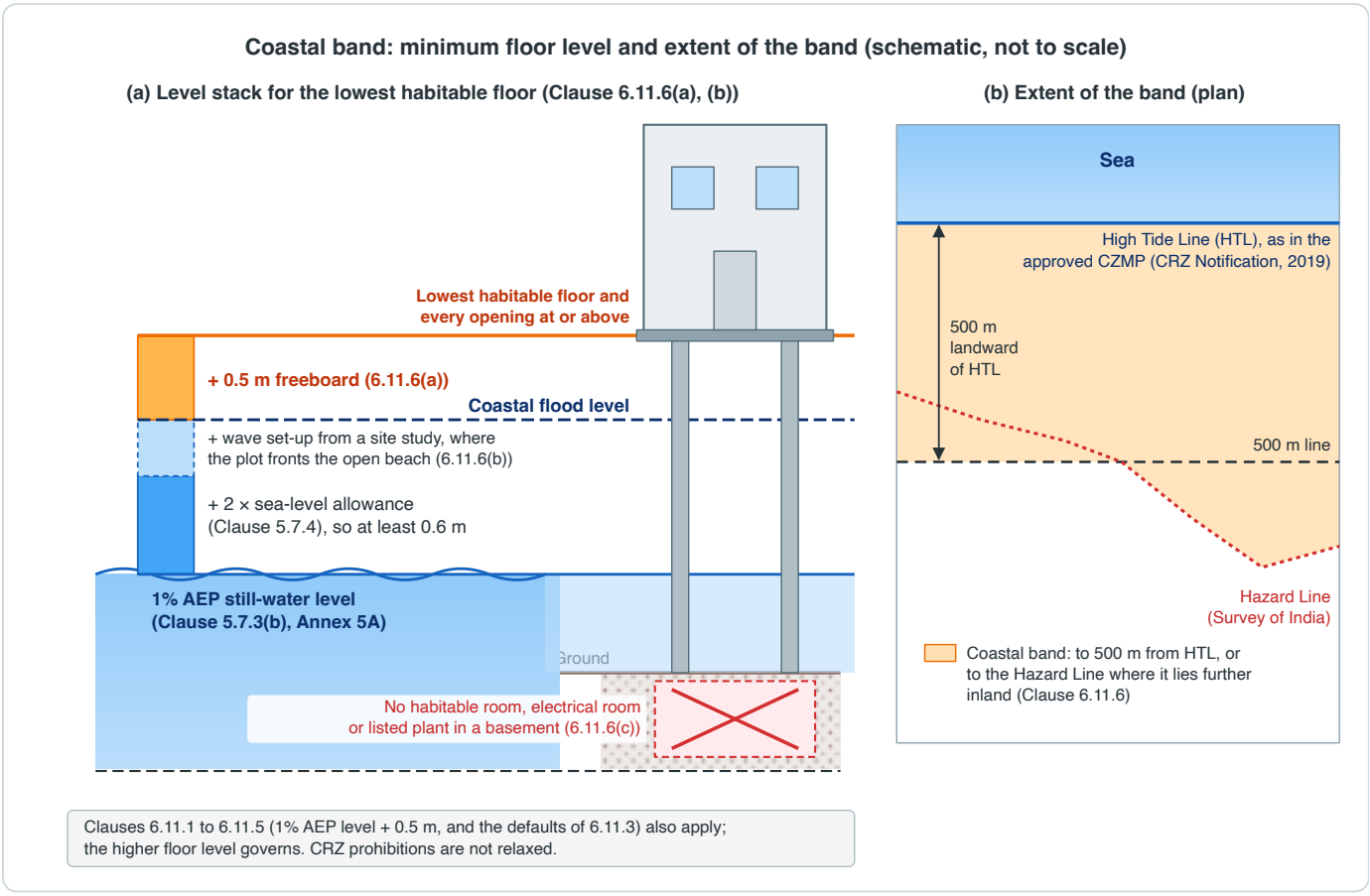


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Uttarakhand 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 Bye-laws 2011 set a plinth of at least 0.45 m above ground and no maximum (bye-law 2.41); allow only a single basement in the hill area, on plots of at least 2,000 m² with a frontage of at least 18 m, and up to three in the plains (bye-law 5.6); require the basement ceiling to stand at least 0.9 m above the surrounding ground and a structural and soil certificate that covers the water table; and bar no basement from low-lying or flood-prone land. The only flood-level building rule found is in the restricted area of a reach being notified under the Uttarakhand Flood Plain Zoning Act 2012, where the declaration of intent for the Ganga at Rishikesh allows reconstruction only with the plinth at least 1.00 m above the high flood level (Irrigation Department notification No. 1875 of 7 October 2020). 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 bye-laws. On a hillside the road crown is not always the right reference: a building below a road takes the road's runoff, so Clause 6.11.2(a) sets its floor and openings from the 1% AEP level of the flow path past it, with the uphill diversion of bye-law 4.4(V)(b) and Clause 6.3.6(h) in place, and a basement cut into a slope also needs the geotechnical certificate of the hill infiltration rule (Clause 4.11). The bye-laws require an inspection at plinth level, or before the basement slab is cast, which is the natural stage at which to check these levels (Chapter 10). Along the rivers, raos and gadheras, near the taals and springs, and in the notified floodplains, the lines of Chapter 7 also apply.

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.

6.13 Uttarakhand 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 south-west monsoon each year, as set out in Chapter 10.

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of Uttarakhand 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. NDMA (2010) recommends that pre-monsoon desilting be complete by 31 March. In Uttarakhand the south-west monsoon normally sets in at Dehradun on 20 June and at Roorkee on 28 June, and normally withdraws from Roorkee on 25 September and from Dehradun on 27 September (IMD, new normals), leaving the State by about 1 October. October is nevertheless the month of the largest floods in Kumaon: the storm of 9 October 1956 gave Nainital 300.7 mm and Roorkee 231.7 mm in a day, and that of 18–19 October 2021 gave Pantnagar 403.9 mm and Nainital 401 mm (IMD; as reported). The only directions found are press reports that drains and canals be cleaned before 15 June (2024) and a USDMA procedure that treats 5 June to 15 September as the monsoon period (as reported); no desilting order of the Urban Development Department or of a Nagar Nigam with a completion date was found during research [TBC]. So Clause 6.13.10 refers to the south-west monsoon, and Chapter 10 requires desilting and the clearance of debris from drains, racks, traps and culverts to be complete by 31 May; inlets, debris racks, culverts, flap gates and pumps to be certified ready and test-run by 15 June (Clauses 5.11.5 and 5.12.9), before the normal onset everywhere in the State; standby to continue until 31 October, because of the

October storms; a second clearance of debris racks, traps and culverts in the hill towns by 15 October, because every storm in the hills fills them; and inlets in towns above about 1,500 m to be kept clear of snow and ice from December to March. These dates are set by this Manual.

No rule of the Bye-laws 2011 on building over a drain was found, and the drain chapters of the Uttar Pradesh Municipal Corporation Act 1959 and the Uttar Pradesh Municipalities Act 1916, as adapted in Uttarakhand, were not read [TBC]. Natural drains, khalas and raos are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over: the High Court has ordered encroachments removed from the beds of the raos and khalas of the Doon and held the Municipal Commissioner personally responsible within municipal limits (*Urmila Thapa*, WPPIL 58/2019). 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 hill 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 stones without its access openings.

Clause 6.13.7 is not yet the practice. Of 208 drains running to the Rispana, 187 have been intercepted and diverted, and the floods of September 2025 damaged 83 of the interception structures (Peyjal Nigam, affidavit in NGT O.A. 417/2022); across the State, CPCB counted 70 untapped drains among 200 monitored (as quoted in a filing of March 2026 in NGT O.A. 200/2014); and the CAG found in 2017 that 47 of 111 nallas discharging to the Ganga had been tapped (CAG Report 39 of 2017). 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.

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.

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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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Uttarakhand 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, Taals (Lakes and Ponds) 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 (taal) 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 Uttarakhand, with no coast and no tidal water, means the Asan Conservation Reserve at the confluence of the Asan and the Yamuna, the State's only Ramsar site, any wetland notified under the 2017 Rules (none was found notified), the 192 wetlands of the national atlas that the Uttarakhand State Wetland Authority is ground-truthing, the taals of the Nainital lake region and their recharge flats, such as Sukhatal, the simar marshes and seeps of the hill slopes, and the floodplain wetlands and depressions of the rivers in Haridwar and Udham Singh Nagar;
- (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 Uttarakhand Flood Plain Zoning Act, 2012 (Act 07 of 2013), the Bye-laws 2011 (bye-law 4.4), the Unified Zoning Regulations 2025, the Uttar Pradesh Urban Planning and Development Act, 1973 as applicable in Uttarakhand, the Municipal Acts as adapted in Uttarakhand, the Wildlife (Protection) Act, 1972 (for the Asan Conservation Reserve), the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Uttarakhand has no Act for the protection of lakes, tanks, ponds or springs as such. Its waterbodies are protected instead by the building bye-laws, the zoning regulations, a floodplain zoning law, orders on the banks of the Ganga, the wetland rules and the courts. Bye-law 4.4(III) of the Bye-laws 2011, made by the Housing Department under s. 57 of the Uttar Pradesh Urban Planning and Development Act, 1973 as applicable in Uttarakhand and adopted by each development authority's board, fixes plot boundaries beyond set distances from rivers, springs, nalas and lakes, with no construction within them (Clause 7.4, Disclosure); bye-law 4.4(IV) forbids building where the local slope exceeds 30° (26.5° in the Nainital municipal area) or where landslides are likely to be severe and continuous; and bye-law 4.4(V)(b) requires the site plan of a sloping site to divert the natural flow of water from uphill away from the foundation, the bye-laws' only site-runoff clause. The Unified Zoning Regulations

2025 (Housing Department notification No. 568 of 20 November 2025) place the rivers and waterbodies in the Revenue records, "including ponds, lakes, nalas and streams", in a Conservation Use Zone of every master plan, with a green buffer and no new construction within 30 m of river and lake banks. The **Uttarakhand Flood Plain Zoning Act, 2012** (Act 07 of 2013) is applied river by river: the Irrigation Department, the nodal agency, models the 25-year and 100-year floods, the Collector or other authority appointed as Flood Zoning Authority declares the intent to demarcate the flood plain (s. 8), hears objections for sixty days (s. 10) and issues a final notification (s. 11), the lines are marked on the shajra (village) maps and by pillars, and no activity is then allowed within the **25-year line (prohibited area)** or the **100-year line (restricted area)** without the Authority's permission, deemed to be granted if not refused within ninety days (s. 12(3)). Final notifications cover 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini (Irrigation Department, status table filed before the National Green Tribunal, 2024), and the Rispana's was issued on 5 May 2025 (NGT order of 18 August 2025); the Asan's was approved by the cabinet in June 2025 (as reported); the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani have been studied but not notified (2024). An amendment of 2024, seen only as quoted, extends the time for the prohibition notification from eighteen to twenty-four months and lets a final notification be amended where "riverbank development" can protect land and buildings, and Rules under the Act are reported to have been approved by the cabinet on 12 October 2026, their text not found. On the Ganga in the hills a Housing Department order of 2017, revised in 2023, adds a prohibited zone and a 200 m regulatory zone, and the National Green Tribunal has set its own line below Haridwar (Clause 7.4, Disclosure). In the towns, drains and watercourses are understood to vest in the local body under the Uttar Pradesh Municipal Corporation Act, 1959 and the Uttar Pradesh Municipalities Act, 1916 as adapted in Uttarakhand, whose drain chapters were not read for this Manual [TBC]; outside municipal limits the High Court has held river-bed land to be forest land (*Urmila Thapa*, 2022). In this chapter **UKID** means the Uttarakhand Irrigation Department, the Irrigation Department of Chapter 1, which holds the State's barrages, dams, reservoirs and canals, operates the sluice gates of Naini lake (since 2018, as reported) and is the floodplain zoning agency.

This Manual treats every recorded waterbody as drainage infrastructure, as the Conservation Use Zone already does in the master plans. Three features set Uttarakhand apart. The first is the **taal** of the Kumaon lake region: Naini lake, Bhimtal, Naukuchiatal and Sattal are natural lakes in hill bowls, with a town or settlement on the slopes around them, so every drain of the town ends in the lake, and the lake empties through a controlled outlet into a steep and unstable gadhera; Naini lake also depends on a small recharge flat, Sukhatal, through which about half of its subsurface recharge was estimated by the National Institute of Hydrology to enter (as cited by NITI Aayog, 2018), and on which the High Court stopped construction in 2022 (as reported). The second is the **spring**: the naulas and dharas that supply much of the hill population's water (Clause 7.12, Commentary), whose recharge areas lie on the slopes being built over; the bye-law keeps 10 m from a spring, the zoning regulations protect "streams" (धाराएँ, a word that can also mean spring spouts) without naming springs as such, and a Spring and River Rejuvenation Authority (SARRA) was reported to be constituted in 2025, with no constitution order found. The third is the **rao and gadhera**, the seasonal boulder-laden torrents of the Doon and the hill towns, such as the Rispana and the Bindal, which are rivers in the floodplain law, trunk drains in the towns and, in places, sewers (Clause 8.9, Commentary). Small rain-fed ponds on the ridges and saddles, the khals and chals, and the hill irrigation channels, the guls, belong to the same system and are revived by village programmes (as reported). This chapter gives the design rules that protect the storage and conveyance of these waterbodies. It does not replace the floodplain zoning, building, zoning, municipal, forest and wetland procedures that record and protect them in law, or the directions of the High Court of Uttarakhand, the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river (such as the Ganga, the Alaknanda, the Bhagirathi, the Mandakini, the Yamuna, the Kali (Sarda), the Ramganga, the Kosi and the Gaula), rao, gad or gadhera (a seasonal hill stream or torrent, such as the Rispana, the Bindal, the Song, the Suswa and the Tons in the Doon, and the Balia Nala below Naini lake), natural drain, khala or nala, gul (a hill irrigation channel), canal, lake or taal (such as Naini lake, Bhimtal, Naukuchiatal and Sattal), recharge flat (such as Sukhatal), khal or chal (a small rain-fed hill pond), talab or pond of the plains, reservoir or barrage pond (such as Tehri, Koteshwar, Dakpathar, the Asan barrage, the Gaula barrage at Kathgodam, and the Baur, Haripura and Tumaria reservoirs of the terai), spring (naula or dhara) with its recharge area, simar (a seep or marshy tract), wetland (such as the Asan Conservation Reserve), glacial or moraine-dammed lake, supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (taal)	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 Irrigation 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 (gadhera, nala, gul 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, sluice 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.
Compensatory storage	Excavated storage that replaces flood storage lost to fill, under Clause 7.6.4.

Term	Meaning in this Manual
Flood cushion	Storage below FTL kept empty, under a documented operating rule, to absorb a flood (Clause 7.8).

Uttarakhand terms. The following terms are used in this chapter in addition to those above (see also Annex 7E):

Term	Meaning in this Manual
Taal (ताल)	A lake, pond or tank: "Pond, pool, tank, lake (= tālāb)" in Platts, and "वह नीची भूमि या लंबा चौड़ा गड्ढा जिसमें बरसात का पानी जमा रहता है" (low ground or a wide pit in which the rain-water collects) in the Shabdasagara (Annex 7E). In Uttarakhand the word names the natural lakes of the Kumaon lake region, Naini lake, Bhimtal, Naukuchiatal and Sattal, which lie in hill bowls and empty through an outlet; it is used here for any lake, tank or pond, and talab for the ponds of the plains. A taal with a controlled outlet is a tank under Clause 7.2: its outlet sluice, gate or regulator is its sluice, and its FTL is the level at which it spills over its outlet with the gates closed, found by survey.
Recorded taal	A taal, talab, khal, lake, reservoir, spring or wetland shown in the Revenue records or shajra maps, in a master plan's Conservation Use Zone under the Unified Zoning Regulations 2025 (which names "ponds, lakes, nalas and streams"), in the records of a Nagar Nigam, Nagar Palika Parishad, Nagar Panchayat or development authority, in the national wetland atlas or a list of the Uttarakhand State Wetland Authority, or in a list filed before the High Court of Uttarakhand or the National Green Tribunal. A recorded taal 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.
Maximum fixed level; boundary of a lake	Bye-law 4.4(III)(iii) of the Bye-laws 2011 measures its 30 m from the bank or boundary of a lake, or from "the maximum fixed level" of a natural reservoir, whichever gives more; the bye-law does not define that level. For this Manual, the maximum fixed level of a taal with a gauged outlet is the highest level its operating rule allows, such as the maximum of 12.5 ft on the PWD gauge at Tallital that the National Institute of Hydrology reports for Naini lake (12 ft in the press), stated to the datum of Clause 7.3.5; for any other taal it is the higher of its FTL and the outer edge of its water in the monsoon (July to September) shown by dated imagery or survey of recent years. The boundary of a taal under Clauses 7.3.3 and 7.13.1 is the largest of its Revenue record boundary, its surveyed FTL and that level, and setbacks are measured from it. This reading is set by this Manual; it is not a statutory interpretation.
Lake recharge flat	A flat, a dry lake bed or a depression in the catchment of a taal through which a large share of the taal's subsurface inflow enters the ground, such as Sukhatal for Naini lake, through which about half of the lake's subsurface recharge was estimated to enter (National Institute of Hydrology, as cited by NITI Aayog, 2018). A recharge flat is a waterbody for Clause 7.3 and lies within the taal's setback for this chapter. It is kept open and unpaved; no fill, debris, building, paving, lining or cementing of its bed is placed on it; and only roof water and runoff that has passed a filtering BMP may be led to it (Clause 8.8.1). This definition and rule are set by this Manual.
Spring (naula, dhara); spring recharge area	A spring is a place where groundwater comes out at the surface. A naula (नौला) is a covered, stepped tank closed on three sides that collects water from a subterranean spring, and a dhara (धारा) a spring spout (Rawat and Sah, 2009; Annex 7E); the bye-laws call a spring an underground water source (भूगर्भीय जल स्रोत). A spring, naula or dhara is a waterbody for Clause 7.3, and its setback under Clause 7.4 is measured from its outlet or the edge of its tank. Its recharge area is the area upslope from which it is fed, as a hydrogeologist maps it; within that area Clause 8.8.1 limits infiltration, no road runoff, sewage or septic effluent is led into the ground, and no drain is cut that would intercept the flow to the spring. This definition is set by this Manual.
Gadhera; gad; rao; khala	A gadhera (गधेरा) is a small seasonal hill stream that flows during the rains, and a gad (गाड़) a hill river or torrent (Annex 7E). Rao is the name of the seasonal torrents of the Doon, such as the Bindal Rao and the Sitla Rao, and khala the name of the seasonal storm channels of Dehradun that feed them, as in the High Court's record in *Urmila Thapa*. Every gadhera, gad, rao or khala 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 lined, piped or covered. A rao or gadhera carries boulders and debris in flood: its inlets and culverts take the debris racks, bulking and blockage of Clause 6.3.6, and its top of bank is the edge of its active boulder bed where that is wider than the edge of the 50% AEP flow. This definition is set by this Manual.
Khal; chal	A khal (खाल) is a small rain-fed pond on a ridge or in the saddle between two crests, used for irrigation and recharge (Rawat and Sah, 2009); the word also means "skin" and, in place names such as Dwarikhal, a saddle between hills (Annex 7E). Chal is used here only in "khal-chal", the traditional technique of small rain-fed hill ponds revived by village programmes (as reported). A khal is a waterbody for Clause 7.3 and a tank in a cascade for Clause 7.7.2, but its storage is never counted as design storage, because it is not surveyed, has no outlet and is usually full by the time of the peak storm. No new khal or other open pond for retention or recharge is dug on ground where Clause 8.8.1 bars infiltration.

Term	Meaning in this Manual
Gul	A gul (गूल) is a channel dug along the contour to carry water from a stream to fields (Platts; Rawat and Sah, 2009). A gul intercepts and carries runoff, so it is part of the drainage system; a gul that drains 8 ha or more is a natural channel under Clause 7.4.1(b), and no design under this Manual discharges to a gul unless its capacity and its outlet to a stable channel are shown.
Simar	A simar (सिमार) is a swampy or marshy tract fed by groundwater (CDIAL; Rawat and Sah, 2009). A simar is a wetland under Clause 7.12, and no drain under this Manual is designed to dry it.
Prohibited and restricted zones	The land within the 25-year flood line (prohibited area) and between that line and the 100-year flood line (restricted area) of a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012, marked on the shajra maps and by pillars. On such a reach Zone 1 is never narrower than the prohibited area, and Zone 2 never ends inside the restricted area; where the 1% AEP extent of this Manual, with the climate factor, is wider, it governs (Clause 7.4.5).
Glacial or moraine-dammed lake	A lake held by a glacier, moraine or landslide dam, such as the lake above Kedarnath that emptied on 17 June 2013 (as reported). It is a waterbody for Clause 7.3 and a hazard to be mapped under Chapter 5; it is **never** a design outfall or design storage, and no drain under this Manual discharges to it. This rule is set by this Manual.

7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with the Irrigation Department and the Revenue 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 Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat (for the drains and watercourses within a town, under the Uttar Pradesh Municipal Corporation Act, 1959 and the Uttar Pradesh Municipalities Act, 1916 as adapted in Uttarakhand, whose drain chapters were not read [TBC]), the Lake Development Authority, Nainital (for the lakes of the Nainital lake region, whose instruments were not read [TBC]), UKID (for flood works and floodplain zoning on the rivers, for the sluice gates of Naini lake, which it is reported to have operated since 2018, and for its barrages, dams, reservoirs and canals, such as the Gaula barrage and the Baur, Haripura and Tumaria reservoirs), UJVN Ltd (for the Dakpathar and Asan barrages), THDC India Ltd (for Tehri and Koteshwar), the Forest Department (for river beds outside municipal limits, which the High Court has held to be forest land, and for the Asan Conservation Reserve), the State Government through the Collector and the Tehsildar (for land recorded as water in the Revenue records), the Gram Panchayat (for the naulas, dharas, khals and guls of a village), Uttarakhand Jal Sansthan or Uttarakhand Peyjal Nigam (for a spring or stream tapped for a public water supply), a development authority (MDDA, HRDA or a district development authority) or a colony developer (for the drains and ponds of a scheme until they are handed over), the Uttarakhand State Wetland Authority (for a notified wetland), a private owner, or another body);
- (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) Revenue records and shajra (village) maps of the Revenue Department, in which rivers, nalas, taals, naulas, dharas and land covered by water are recorded, and on which the Irrigation Department marks the 25-year and 100-year flood lines of a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012, with its boundary pillars; the rivers and waterbodies in the Revenue records, "including ponds, lakes, nalas and streams", that the Unified Zoning Regulations 2025 place in the Conservation Use Zone of a master plan; the drains and watercourses in the records of a Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat; the river-bed land outside municipal limits that the High Court has held to be forest land, in the records of the Forest Department; the setbacks from rivers, springs, nalas and lakes and the 2 m contour plans shown on plans approved under bye-law 4.4 of the Bye-laws 2011; the boundary of the Asan Conservation Reserve (Ramsar site) and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017, and the wetlands of the national atlas that the Uttarakhand State Wetland Authority is ground-truthing; the inventories of springs and water sources of the Jal Sansthan, the Peyjal Nigam and SARRA (as reported); and the lists of encroachments in river beds and floodplains filed before the High Court of Uttarakhand (such as in *Urmila Thapa*) and the National Green Tribunal (such as for the Rispana);
- (b) UKID 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 UKID records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> **Commentary.** Uttarakhand is one of the few States that maps flood lines in law, but it does so river by river, and no 1% AEP flood map of any town's drains or raos was found. Under the Uttarakhand Flood Plain Zoning Act, 2012 the Irrigation Department, the nodal agency, analyses the floods, models the 25-year and 100-year lines with HEC-RAS, checks them on the ground, and after an interim and a final notification marks them on the shajra (village) maps and by pillars (compliance report in NGT O.A. 417/2022, 2024). Final notifications cover 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini, and the Rispana's was issued on 5 May 2025 (NGT order of 18 August 2025); studies of the Gaula, the Kosi, the Suswa, the Song, the Baldi, the Asan and the Solani were done but not notified in 2024, and 671 km more were under study. The lines are not complete for flood planning: the National Mission for Clean Ganga objected in 2025 that the Rispana reply did not show the extent of the 5-year, 25-year and 100-year floods, and the State later counted 330 structures in the Rispana's 1-in-5-year "active floodplain" (letter of 3 January 2026, recorded by NMCG before the Tribunal). The building process

asks for the ground but not the water: a 2 m contour plan and sections for every sloping site (bye-law 4.4(IV)(i)) and the landslide-prone areas near it (4.4(V)(a)), but no flood line; and the ADB-funded drains of Dehradun require only that each outfall invert be above the high flood level of the receiving nala or river, without a source for that level (resettlement plan, 2022). The raos of the Doon and the gadheras of the hill towns are ungauged. The river levels that are known, such as a highest flood level of 296.30 m for the Ganga at Haridwar (dated 2010 in one CWC source and 2013 in another) and of 498.93 m for the Gaula at Kathgodam (2021), are known only through transcriptions (as reported; Chapter 5). Clause 7.3.4 lets the Authority adopt flood maps once they are issued, and a final notification under the Act is such a map for the lines it shows; until then the Applicant must produce the 1% AEP extent for larger and flood-sensitive sites, and a notified 25-year or 100-year line is a minimum that the 1% AEP extent of this Manual, with the climate factor, may exceed but never reduce. Levels shall be stated to one datum (Clause 7.3.5), because no source read for this Manual states the datum of the CWC levels, of the Naini lake gauge or of the flood lines on the shajra maps. 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.

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 (wider lines bind in Uttarakhand and govern under Clause 7.4.5: bye-law 4.4(III) of the Bye-laws 2011 keeps 30 m from a river bank and from the bank or maximum fixed level of every lake, 10 m from a spring and at least 5 m from a nala free of construction, the Unified Zoning Regulations 2025 bar new construction within 30 m of river and lake banks, and on a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012 the 25-year prohibited zone is never narrower than Zone 1; this Manual's 15 m applies to every nala, gadhera, rao, khal, spring and other waterbody where nothing wider binds; 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 permission of the Flood Zoning Authority for any activity in the prohibited or restricted area of a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012 (s. 12(3)), the approval of the Irrigation Department for a work on or next to one of its rivers, embankments, barrages, reservoirs or canals, the conditions of the Housing Department order of 2017 (revised 2023) for the banks of the Ganga in the hills, the no-objection of the Peyjal Nigam on sewerage that a floodplain notification or that order requires, the views or permission of the Uttarakhand State Wetland Authority or the Forest Department for a work in or next to a notified wetland or the Asan Conservation Reserve, the consent of THDC India Ltd, UJVN Ltd or UKID for a work that drains to, or lies next to, one of their dams, barrages or reservoirs, or a

direction of the High Court of Uttarakhand or the National Green Tribunal (such as those on the Sukhatal lakebed and the Rispana floodplain listed in the Disclosure to Clause 7.4) 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. Uttarakhand, unlike most States in this series, has statutory distances from water. Bye-law 4.4(III) of the Bye-laws 2011 fixes plot boundaries only beyond "at least" 30 m from a river bank and 10 m from an underground water source (a spring), both kept for dense planting with no construction of any kind (printed "30.0–30.0" and "10.0–10.0" metres, read in this Manual as single distances), beyond at least 5 m from a nala or the required setback, whichever is more, and beyond 30 m from the bank or boundary of every lake, including the Nainital lake special area, or from the maximum fixed level of a natural reservoir, whichever is more; the Unified Zoning Regulations 2025 put rivers and waterbodies in the Conservation Use Zone with no new construction within 30 m of river and lake banks; and the Uttarakhand Flood Plain Zoning Act, 2012 bars or restricts use within the 25-year and 100-year flood lines of the reaches notified under it. The 15 m floor matters where the statutory line is narrower or absent: along nalas (5 m) and springs (10 m), and along the gadheras, raos, khalas and khals that the bye-law does not name as rivers or lakes, where it gives room for the debris that hill streams carry and for the machinery that clears it. 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 Uttarakhand flood maps are mostly coarser than US maps, the terai of Udham Singh Nagar and Haridwar, where Rudrapur, Kashipur

and Roorkee are growing, slopes at less than 1% (CGWB), and the only level land in a hill town is often a river terrace or a lake margin (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).

Uttarakhand's building rules are the Uttarakhand Building Construction and Development Bye-laws/Regulations, 2011 (Amendment 2015), made by the Housing Department under section 57 of the Uttar Pradesh Urban Planning and Development Act, 1973 as applicable in Uttarakhand, amended piecemeal since and adopted by the board of each development authority (notification of 10 January 2024, para 4); this Manual read them in the Housing Department's compilation of the amendments of 2015 to 2019, and a comprehensive "Amendment 2017" is found only as a draft. Unlike most States in this series, Uttarakhand has distances from water in its building rules. Bye-law 4.4(III) fixes the boundary of a plot only beyond: (i) at least 30 m from the bank of a river and 10 m from an underground water source (a spring), both to be left for dense planting with no construction of any kind, printed "30.0–30.0" and "10.0–10.0" metres, which this Manual reads as single distances of 30 m and 10 m until the gazetted text is checked; (ii) at least 5 m from the bank of a nala, or the setback otherwise required, whichever is more; and (iii) 30 m from the bank or boundary of every lake in Uttarakhand, including the Nainital lake special area, or from the maximum fixed level of a natural reservoir, whichever is more, within which no construction or development is allowed, community services and public infrastructure excepted in special circumstances. Bye-law 4.4(IV) bars building where the local slope exceeds 30° (26.5° in the Nainital municipal area) or where landslides are likely to be severe and continuous, and the amendment of 10 January 2024 keeps filling stations 50 m from rivers, waterbodies, springs and the flood plain and 5 m from a nala. The Unified Zoning Regulations 2025 (Housing Department notification No. 568 of 20 November 2025) place the rivers and waterbodies of the Revenue records, "including ponds, lakes, nalas and streams", in a Conservation Use Zone of every master plan, with a green buffer in which no construction is allowed and no new construction within 30 m of river and lake banks. On a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012, no activity may be undertaken within the 25-year line (prohibited area) or the 100-year line (restricted area) without the permission of the Flood Zoning Authority, deemed to be granted if it is not refused within ninety days (s. 12(3)); the Irrigation Department's draft notification for the Ganga at Rishikesh lists the works allowed in each zone and, where building is allowed in the restricted area, a plinth at least 1.00 m above the high flood level (No. 1875/II(2)-2020-06(18)/2020 of 7 October 2020). On the Ganga in the hills, a Housing Department order of 29 November 2017 fixes a prohibited zone of 100 m from the middle of the river or the area of floods up to the 25-year frequency, whichever is more, and a regulatory zone over the next 200 m, and since 1 June 2023 the Irrigation Department's floodplain notifications govern in the five hill districts where they exist; below Haridwar the National Green Tribunal designated 100 m "from the edge of the river" as a no-development zone until the floodplain is demarcated (*M.C. Mehta*, O.A. 200/2014, 13 July 2017). The rules leave gaps. The bye-law's nala line is 5 m, narrower than the room a rao or gadhera needs for its boulders and for the machinery that clears it; gadheras, khalas, guls and khals are not named; the bye-law does not say from which level a river's 30 m is measured; and none of the lines is tied to a flood level except the notified flood lines. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

Disclosure. Uttarakhand **has statutory setbacks from water**, and they are wider than this Manual's floor along rivers and lakes: bye-law 4.4(III) of the Bye-laws 2011 keeps **30 m from a river bank, 30 m from the bank or maximum fixed level of every lake, 10 m from a spring and at least 5 m from a nala** free of construction (the 30 m

and 10 m printed "30.0–30.0" and "10.0–10.0" metres, read as single distances [TBC]); the Unified Zoning Regulations 2025 bar new construction within **30 m of river and lake banks**; and on the reaches notified under the Uttarakhand Flood Plain Zoning Act, 2012 the **25-year line bounds a prohibited area and the 100-year line a restricted area**. 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 nalas, where the bye-law keeps 5 m; along springs, where it keeps 10 m; and along the gadheras, raos, khalas, guls and khals that it does not name. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, this Manual's reading of the "maximum fixed level", and the rules on recharge flats, spring recharge areas and glacial lakes (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. The setback is applied as **the larger of the corridor and any statutory, plan, court or Tribunal line**, so the Manual is **stricter than statute** along nalas, springs and unnamed streams, and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **Bye-law 4.4(III) (Bye-laws 2011, compilation of 2015–2019).** Rivers 30 m and springs 10 m, for dense planting with no construction of any kind; nalas at least 5 m or the required setback, whichever is more; every lake, including the Nainital lake special area, 30 m from its bank or boundary or from the maximum fixed level of a natural reservoir, whichever is more. Along a river or lake the 30 m is wider than Zone 1's floor and governs as Zone 1; along a spring the 10 m and along a nala the 5 m are narrower and never govern alone.
- **Unified Zoning Regulations 2025 (No. 568, 20 November 2025, chapter 11, E-1).** Rivers and waterbodies of the Revenue records, including ponds, lakes, nalas and streams, in the Conservation Use Zone of the master plan, with a green buffer free of construction and no new construction within 30 m of river and lake banks.
- **Uttarakhand Flood Plain Zoning Act, 2012 (Act 07 of 2013).** On a reach finally notified (614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini; the Rispana, 5 May 2025), no activity in the prohibited area (25-year line) or the restricted area (100-year line) without the Flood Zoning Authority's permission (s. 12(3)); the restricted-zone conditions are set in each notification, such as a plinth at least 1.00 m above the high flood level, 35% coverage, FAR 1.5 and 7.5 m height in the draft for the Ganga at Rishikesh (2020). An amendment of 2024, seen only as quoted, lets a final notification be amended where "riverbank development" can protect land and buildings; this Manual does not treat such an amendment as reducing the 1% AEP extent of Zone 2. The Asan's notification was approved by the cabinet in June 2025 and Rules under the Act on 12 October 2026 (both as reported; texts not found).
- **The Ganga in the hills and below Haridwar.** The Housing Department order of 29 November 2017 (revised 1 June 2023): a prohibited zone of 100 m from the middle of the river or the 25-year flood area, whichever is more, and a regulatory zone over the next 200 m, superseded by the Irrigation Department's notification where one exists. The National Green Tribunal's 100 m "from the edge of the river" from Haridwar to Unnao (13 July 2017). The two are measured from different lines; both are stated, and the wider governs.
- **Wetlands, Ramsar and forest land.** The Asan Conservation Reserve, the State's only Ramsar site (444.4 ha; designated 21 July 2020), to its boundary; any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was found notified); and river beds outside municipal limits, which the High Court has held to be forest land (*Urmila Thapa*, 2022).
- **Courts and custodians.** The High Court's order stopping construction on the Sukhatal lakebed (2022, as reported); the Irrigation Department's, UJVN's and THDC's lines at their works; the Lake Development Authority's controls in the Nainital lake region (instruments not read [TBC]).

This Manual sets 15 m as the floor because the bye-law gives the nalas, which carry most of the towns' storm water, only 5 m and the gadheras and khalas no width at all; because 15 m is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled; and because a rao or gadhera needs room for the boulders and debris it carries in flood and for the machinery that clears them. The reasons for the corridor are the record: the District Magistrate's survey counted 37.93 ha of encroachment in the river beds of Dehradun tehsil and 57.4 ha in Vikasnagar tehsil (*Urmila Thapa*, WPPIL 58/2019, 2022); the State counted 330 structures within the Rispana's 1-in-5-year flood zone (letter of 3 January 2026); and the floods of 16 and 17 September 2025 in Dehradun were reported to have carried away 13 bridges, 10 culverts and 21 roads in Dehradun district (as

reported) and damaged 83 interception structures on the Rispana and the Bindal (Clause 8.9, Commentary). Until a statute, rule, notification, master plan or court adopts it, the 15 m minimum is this Manual's recommended standard, and the statutory, plan, court and Tribunal lines above remain the only legal minimum. Approving authorities should state in each approval which was applied.

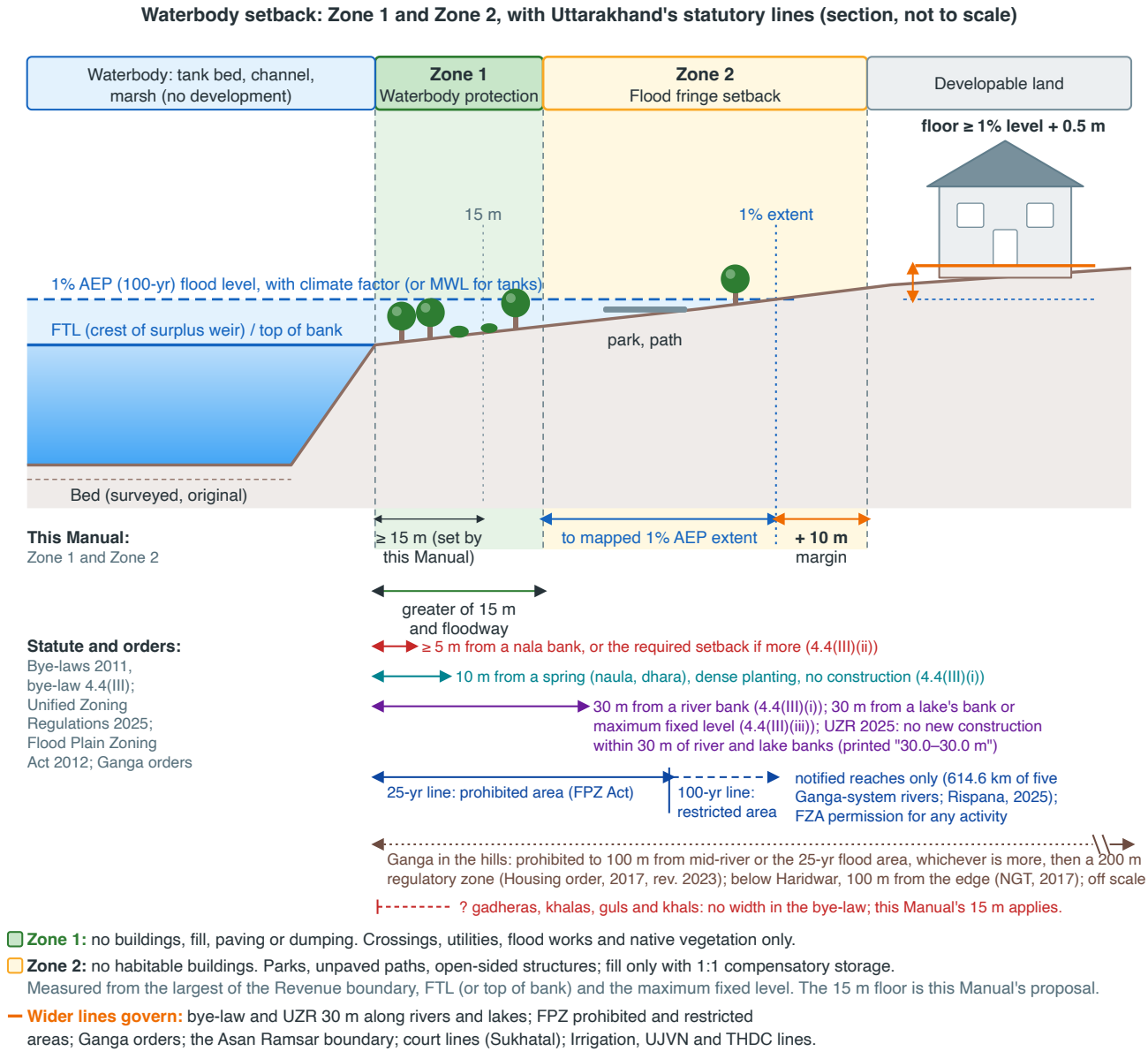

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 Uttarakhand Building Construction and Development Bye-laws 2011, 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 urban Uttarakhand 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.

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. The terai of Udham Singh Nagar and Haridwar, which slopes at less than 1% (CGWB), the Ganga floodplain below Haridwar, and the river terraces and lake margins on which the hill towns have built, are flat, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Uttarakhand the lake line of the building rules is already measured from a high level, not from the water's edge on the day of survey: bye-law 4.4(III)(iii) keeps 30 m from the bank or boundary of a lake or from the maximum fixed level of a natural reservoir, whichever gives more. The difference matters in the hill lakes, whose level swings widely through the year. Naini lake is held up to a maximum of 12.5 ft on the PWD gauge at Tallital (NIH; 12 ft in the press) and was reported at a record 12.2 ft when it overflowed on 19 October 2021, but it is drawn down through the dry months and was reported 18 ft below its normal level in 2017 and at a five-year low of 4.7 ft in 2025 (all as reported), so a line drawn from the shrunken summer edge would leave part of the lake's own bed open to building. On the plains, the floodplain wetlands of Haridwar and Udham Singh Nagar spread far beyond their dry-season pools in the monsoon. This Manual gives the bye-law's level a value for every taal: the maximum fixed level and the monsoon edge are part of its boundary (definitions after Clause 7.2), and the foreshore up to MWL is its 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 Dehradun along the Rispana and the Bindal, where the State counted 330 structures within the 1-in-5-year flood zone of the Rispana alone (letter of 3 January 2026, recorded by NMCG before the National Green Tribunal) and the Kathbangla basti stands on the dry river bed (High Court, 1 April 2026), of the riverside of Rishikesh, where the declaration of intent of October 2020 lists plots, by khasra number, within the 25-year flood limit of the Ganga, and of Rudrapur along the Kalyani, flooded in October 2021 (as reported) 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.

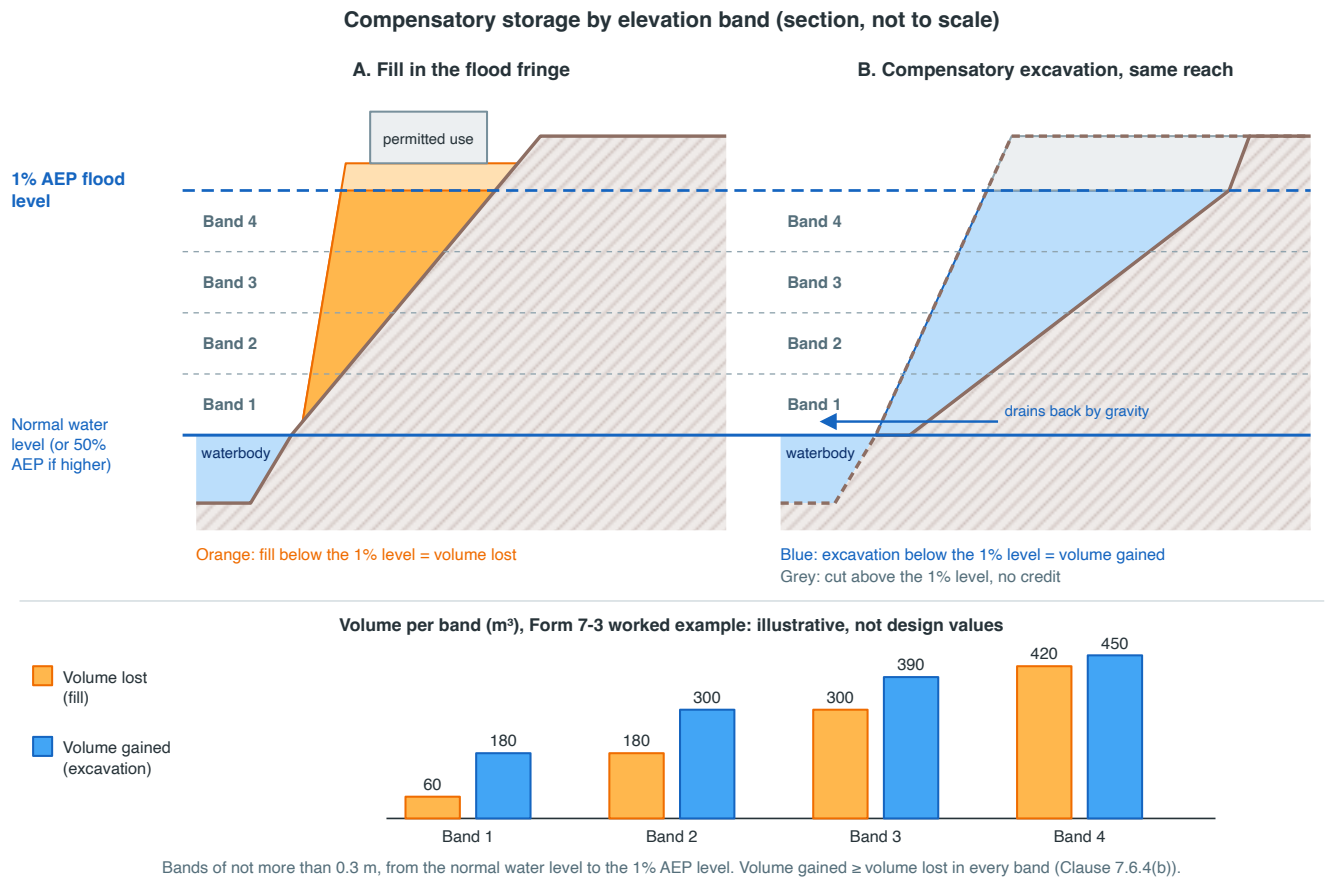

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation 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.

7.7 Tank cascades as design storage

Uttarakhand has no tank Act, and its storages range from khals a few metres across on the ridges to Tehri's reservoir behind a 260.5 m dam. The storages that matter for urban drainage are of five kinds. The first is the natural taal of the Kumaon lake region, in a hill bowl with a town or settlement on its slopes and a controlled outlet to a gadhera. Naini lake is the clearest case: about 1.4 km long and 0.45 km wide, with a surface of 0.46 km², a mean depth of 18.52 m, a volume of 8.58 Mm³ and a basin of 4.7 km² of which 0.75 km² is the Sukhatal sub-basin; it empties through five sluices at Tallital, installed in 1888, into the Balia Nala, which runs to the Gaula (National Institute of Hydrology, CS(AR)-6/98-

99). Bhimtal is reported at about 47.8 ha with a catchment of 17.12 km², and Naukuchiatal and Sattal are smaller (as reported; the depths conflict). These are the taals for which Figure 7.3 and Clause 7.8 matter most: every drain of the town ends in the lake, and the lake's release is limited by the stability of the ravine below it. The second is the khals and village ponds of the ridges and the talabs of the plains of Haridwar and Udham Singh Nagar, which hold 41 and 48 of the 192 wetlands of the national atlas (Uttarakhand State Wetland Authority, 2025); they are modelled as existing features but, in the hills, not counted as storage (definitions after Clause 7.2). The third is the reservoirs and barrage ponds: Tehri and Koteshwar (THDC India Ltd), the Dakpathar and Asan barrages (UJVN Ltd), and UKID's Gaula barrage at Kathgodam and the Baur, Haripura and Tumaria reservoirs of the terai; their releases enter a design as inflow and tailwater (Chapter 5), and they are not tanks for these clauses unless their storage is counted. The fourth is the recharge flats and springs, such as Sukhatal and the naulas and dharas of the hill towns, which are protected for their recharge and never counted as storage. The fifth is the glacial and moraine-dammed lakes of the high mountains, which are hazards (definitions after Clause 7.2). Clauses 7.7 and 7.8 apply to any of these whose storage is counted; any taal or reservoir whose storage is to be counted is subject to Clause 7.7.1 in full, with UKID, the Lake Development Authority, THDC, UJVN or other custodian, and the custodian of each taal 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.** UKID, 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 hill-town lake such as Naini lake, every drain that enters the lake from the slopes of its bowl, the lake itself with its gauge level and the operating rule of its sluice gates (Clause 7.8), the recharge flat that feeds it, such as Sukhatal, and the outlet channel and gadhera below the sluices, such as the Balia Nala to the Gaula, whose stability limits the release, 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 UKID'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. Uttarakhand's worst town floods have come when the lakes and reservoirs were already full. On 18 and 19 October 2021, after the monsoon had withdrawn, 401 mm fell at Nainital and 403.9 mm at Pantnagar in a day, Naini lake rose to a record 12.2 ft and overflowed, the approach of the Gaula bridge at Haldwani collapsed, and Rudrapur flooded along the Kalyani (all as reported); Tehri had reached its full reservoir level of 830 m on 24 September 2021 (THDC). The sluices of Naini lake are opened in steps through the monsoon and are sealed on 15 October each year (National Institute of Hydrology), so a storm in late October finds the lake at its highest and its outlet closed unless the custodian reopens it. No record of how long Naini lake, Bhimtal or the reservoirs of the terai stay at or above their spill level in a wet spell was obtained for this Manual. While a taal is full, it stores nothing more below FTL, the drains that flow into it discharge against its spill level, and its outflow adds to the flow in the gadhera below it, which itself discharges against the river. 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.

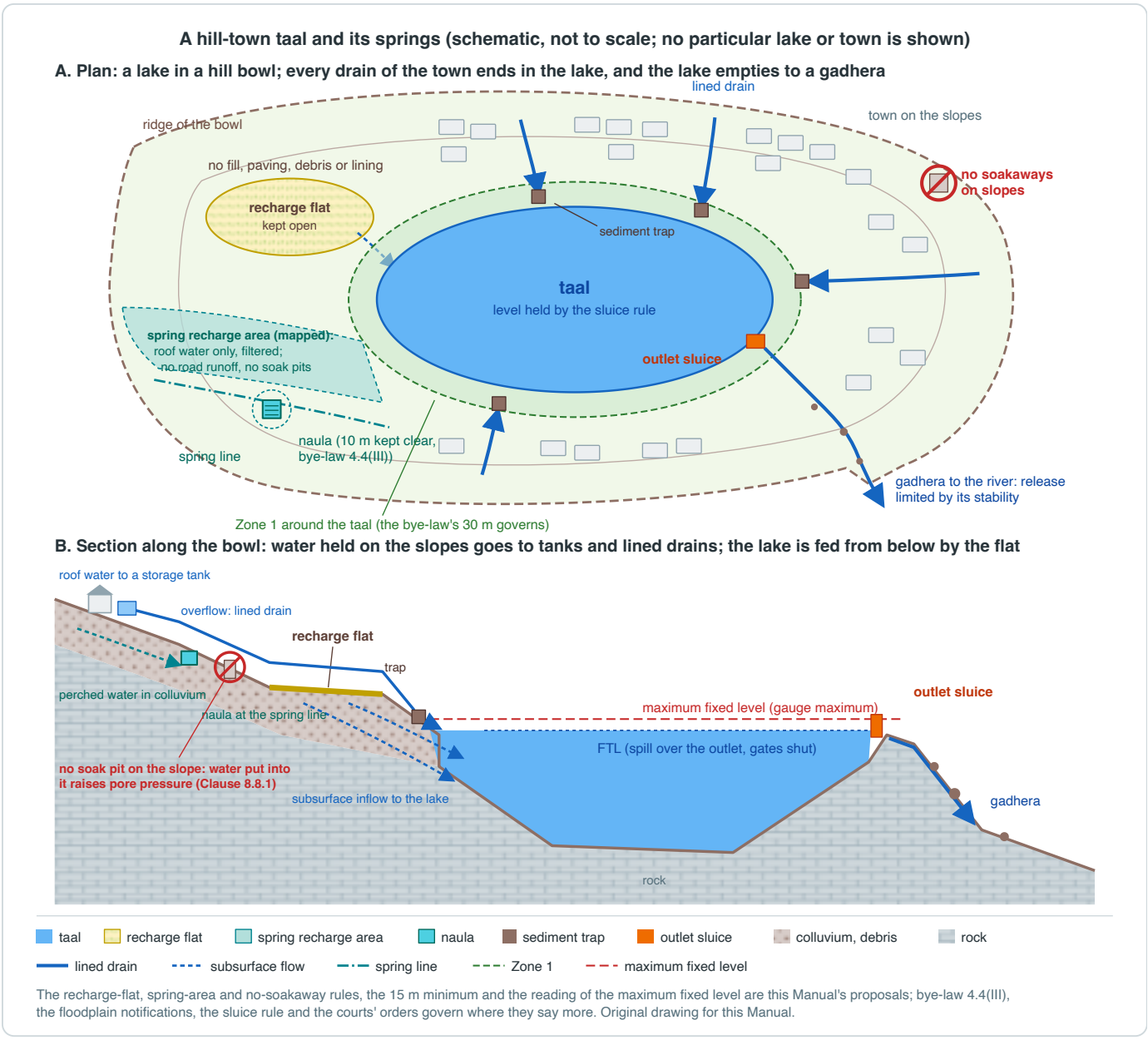

Figure 7.3 — A hill-town taal and its springs (schematic, not to scale; no particular lake, town or landmark is shown). A: in plan, the taal lies in a hill bowl with the town on the slopes around it, so every drain of the town ends in the lake; each drain is lined, and passes a sediment trap before it enters, because the lake is the end of the town's drainage and keeps every load of silt and debris it receives (Clauses 6.3.6, 7.9.7 and 8.10), and each drain discharges against the lake level (Clause 5.8.5(d)). A recharge flat on the floor of the bowl, of the kind that Sukhatal is for Naini lake, feeds the lake from below and is kept open, with no fill, paving, debris or lining. On the outer slope a naula takes water from the spring line; the bye-law keeps 10 m around it, and its recharge area upslope, as a hydrogeologist maps it, receives only filtered roof water, with no road runoff and no soak pits (Clause 8.8.1). Zone 1 around the taal is set by the bye-law's 30 m from its bank or maximum fixed level, which is wider than this Manual's 15 m floor. The lake empties through an outlet sluice into a gadhera that runs to the river, and the release is limited by the stability of the gadhera's banks, not by the lake's storage (Clause 7.8). No soakaway or recharge pit is placed on the slopes. B: in section, roof water goes to a storage tank whose overflow runs in a lined drain, through a trap, to the lake, because water put into the colluvium raises its pore pressure; the spring comes out where perched water in the colluvium meets the rock; and the lake is held between its FTL (the spill level over the outlet with the gates shut) and its maximum fixed level, from which its setback is measured (definitions after Clause 7.2). The recharge-flat, spring-area and no-soakaway rules, the 15 m minimum and the reading of the maximum fixed level are this Manual's proposals; bye-law 4.4(III), the floodplain notifications, the sluice rule and the courts' orders govern where they say more. Original drawing for this Manual.

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, USDMA 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 SW 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 SW 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 SW 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 UKID control, the operating rule shall be UKID's rule. This Manual does not authorise any other body to operate a UKID tank.

> Commentary. Uttarakhand has one taal with a written operating rule, and it is old. The five sluices of Naini lake at Tallital, each 2.5 ft wide and 1.25 ft high, were installed in 1888 on the recommendation of one of the committees on the safety of the hill slopes, and the Hill Slide Committee of 1927 set the rule still described for them: below 9 ft on the gauge the sluices are opened no more than 6 inches, and below 9.5 ft no more than 12 inches, "mainly to avoid any damage to the geotechnically sensitive Balia ravine"; once opened they are never fully closed until 15 October, when they are sealed; and the maximum lake level is 12.5 ft on the PWD gauge (National Institute of Hydrology, CS(AR)-6/98-99; the press gives 12 ft). The rule is a cushion in reverse: it limits the release, not the level, because the slopes of the Balia Nala below the lake are unstable, and landslides along it have been linked to the water that reaches them (Clause 8.8.1). Gate operation is reported to have passed from the PWD to the Irrigation Department in 2018, and the role of the Lake Development Authority in it was not found [TBC]. For the reservoirs, Tehri keeps a flood-control zone between its spillway crest at 815 m and its full reservoir level of 830 m, with a surcharge to 835 m (as described by THDC in a workshop paper), and in June 2013 it was reported to have held a peak inflow of about 7,000 m³/s while releasing about 500 m³/s, though how far that was by design is disputed (all as reported); no rule fixing dates, levels and release rates for Bhimtal, the barrages of the Doon or the reservoirs of the terai was found. Without an agreed rule with dates, levels, release rates and a named operator, storage in a taal or reservoir cannot be relied on, and a release made without warning to the colonies 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 usually refilled by the early monsoon rain gives no protection in a July to September monsoon burst or cloudburst against the outer Himalaya, or a late-season storm such as that of October 2021. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.

For Naini lake, Clause 7.8.1(d) is the governing condition: the maximum release is whatever the Balia Nala can take without sliding, and that limit, not the lake's storage, sets how much of a storm the lake can pass. A design that relies on the lake shall route the storm through it with the sluice rule in force and its gates at the opening the rule allows for the level, shall not assume a drawdown below the level the rule holds, and shall take the lake at its maximum fixed level, with the sluices sealed, for a storm after 15 October (Clause 7.7.3). Most taals have other users: the lake is the town's landscape and its trade, and a drawdown before a storm has costs to those who use it, which is why Clause 7.8.2(d) requires the custodian to accept it.

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 Uttarakhand Environment Protection and Pollution Control Board (UEPPCB) 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 May** each year (Chapter 10).

> Commentary. No statewide order of the Urban Development Department for the pre-monsoon cleaning of drains, raos or taals was found; directives that drains be cleaned before 15 June, and a monsoon period of 5 June to 15 September for the USDMA, were seen only in the press (as reported). In the hills the material to be removed is less silt than gravel, boulders and debris: the Gaula barrage at Kathgodam is reported silted with debris and

boulders upstream (as reported), and debris dumped on Sukhatal has reduced the recharge it gives to Naini lake (NITI Aayog, 2018). The date of 31 May in this Manual is set by this Manual, before the monsoon's normal onset (about 20 June at Dehradun and 28 June at Roorkee, IMD new normal dates, 2020); because the State's largest late floods have come in October (1956 and 2021), hill towns also clear debris a second time by 15 October (Chapter 10). Excavation to "increase capacity" is governed by Clause 7.9.3. In a taal it can cut the silt and clay that seal the bed; on a recharge flat it does the opposite of what is needed, and a plan to cement the base of Sukhatal has been dropped (NITI Aayog, 2018), and this Manual allows no recharge flat to be deepened, lined or cemented (definitions after Clause 7.2). The 31 May 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 Uttarakhand precedent.

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 Uttarakhand the drains of a town are understood to vest in its Nagar Nigam, Nagar Palika

Parishad or Nagar Panchayat under the Uttar Pradesh Municipal Corporation Act, 1959 and the Uttar Pradesh Municipalities Act, 1916 as adapted in Uttarakhand, whose drain chapters were not read for this Manual [TBC], while the raos and rivers lie with the Irrigation Department for flood works and floodplain zoning, and their beds outside municipal limits are forest land (High Court, *Urmila Thapa*, 2022). No rule or order dividing natural nalas, khalas and gadheras from municipal drains, or the local bodies' drains from the PWD's road drains, was found; Chapter 6 gives this Manual's working assignment. The building rules know the nala but give it only 5 m (bye-law 4.4(III)(ii)), and the gadhera, the khala and the gul not at all. The record shows the seasonal channels being lost: the petition in *Urmila Thapa* (WPPIL 58/2019) was about encroachment on the waterbodies and "khalas/storm water drains" of the Rajpur area of the Doon, and asked that the catchments of the khalas of the Rispana and the Bindal be declared no-construction zones; the High Court ordered removal of the encroachments in the river beds but set no width. In Nainital the drains are the town's defence against landslides: a network of drains was built on the slopes after the landslip of 18 September 1880, which killed about 151 people, though the sources disagree on its length and number of drains (as reported). Where drains are being rebuilt, they are being concentrated: the ADB-funded works in Dehradun lead new storm drains to 57 outfalls on the Harrawala, Nakraunda, Kaunwala and Natthanpur nalas (resettlement plan, July 2022); the Irrigation Department's drainage master plan for Haldwani is reported to line 10.25 km of the Rakasia nala and 1.55 km of the Kalasia nala, and those for six other Kumaon towns to aim at "100% connectivity of nalas" (as reported); and in Dehradun's Smart City works the drains of Paltan Bazaar were split between Dehradun Smart City Ltd and the PWD (CAG, 2025). Bye-law 4.4(III) keeps a building off the nala's first 5 m; it does not keep a nala, khala or gadhera at its recorded width once it has been lined, piped or covered, which is the failure Clauses 7.10.2 and 7.10.3 are written to prevent. Clause 7.10.3(b) prevents a crossing from narrowing a channel to its current, encroached width.

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 taal 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 Uttarakhand no shared form of storage is required by the building rules: the rainwater harvesting of bye-law 6.5 is plot-level storage of 2.0 m³ and more, and the rules have no detention, peak-flow or "zero runoff" rule. The drainage master plans that the Irrigation Department is preparing for Haldwani and other Kumaon towns are reported to rely on lined nalas and new pumping stations in the low-lying areas, not on storage (as reported), and the integrated drainage works of Dehradun Smart City made no provision for storm-water reuse

(CAG, 2025). The khal-chal ponds revived in the villages are for recharge and irrigation, not for urban detention. In the hill towns there is little flat land on which a regional pond could be built, and a regional facility there is more likely to be a tank or a lined detention structure than a pond. 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.

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 Uttarakhand State Wetland Authority;
- (b) the Asan Conservation Reserve at the confluence of the Asan and the Yamuna, the State's only Ramsar site (Site No. 2437; 444.4 ha; designated on 21 July 2020; a Conservation Reserve under section 36A of the Wildlife (Protection) Act, 1972 since 2005), to its boundary, and any wetland notified under the 2017 Rules;
- (c) the 192 wetlands of the national atlas that the Uttarakhand State Wetland Authority is ground-truthing, the taals of the Nainital lake region with their recharge flats, such as Sukhatal, the simar marshes and seeps of the hill slopes, and the marshy low land and depressions of the floodplains of the Ganga in Haridwar district and of the rivers of Udham Singh Nagar, within the 1% AEP extent of Clause 7.3.4 (the river channel itself is a waterbody under the rest of this chapter); and
- (d) any other marsh, wetland, taal, khal or simar that the Authority notifies, that the wetland authority lists, or that the High Court of Uttarakhand or the National Green Tribunal 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. Uttarakhand's wetlands are the concern of the **Uttarakhand State Wetland Authority**, constituted by letter No. 757(1)/X-3-18-09(01)2004 of 16 October 2019, with a State Level Technical Committee under the Principal Secretary, Environment, Forest and Climate Change, and a District Level Technical Committee in each district under the District Magistrate, with the Divisional Forest Officer as member secretary. Its status report of 17 October 2025 lists 192 wetlands in the national atlas of 2021 (100 natural, 9 reservoirs and 83 parts of rivers), 89 of them in forest areas, with 48 in Udham Singh Nagar, 41 in Haridwar, 30 in Pauri, 17 each in Chamoli and Nainital and 14 in Dehradun; ground-truthing was done for 149 and boundaries for 26, under the directions of the Supreme Court in W.P. 304/2018, and no wetland notified under rule 4 of the 2017 Rules was mentioned or found. The Asan Conservation Reserve, 444.4 ha at the confluence of the Asan and the Yamuna in Dehradun district, became a Conservation Reserve in 2005 and the State's first and only Ramsar site on 21 July 2020 (Site No. 2437); it is recorded for about 330 bird species and as a spawning ground of the golden mahseer (Wetland Authority note; Ramsar Information Sheet), and the floodplain notification of the Asan was approved in June 2025 (as reported). In the hills the wetlands that matter to drainage are small and not in the atlas: the recharge flats of the lakes, such as Sukhatal, on whose lakebed the High Court stopped construction in 2022 (as reported); and the simar, the marshy tracts fed by groundwater on the hill slopes (Rawat and Sah, 2009). A drain outfall, desilting, diversion or gate operation in or near the Asan Conservation Reserve, a notified wetland or a recharge flat therefore needs the views or permission of the Wetland Authority or the Forest Department where the Rules or the Wildlife (Protection) Act, 1972 reach it, as well as compliance with this chapter; for the taals, simars and floodplain wetlands they do not reach, this chapter, the bye-law setbacks and the Conservation Use Zone are the only controls. 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 Uttarakhand's raos, lakes and rivers through the drains (Clause 8.9, Commentary). The CPCB lists the Rispana, the Bindal Rao, the Rambha at Rishikesh and the Kalyani at Rudrapur among "rivers reported as drains", and counted 70 untapped drains in the State before the monsoon of 2025 (as quoted before the National Green Tribunal in March 2026); in Nainital the ADB-funded project is replacing about 9.6 km of trunk and outfall sewers and building a 17.5 MLD treatment plant (ADB, 2023), and the CAG reported in 2025 that 12 of 37 treatment plants it inspected under Namami Gange were discharging untreated sewage (as reported). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by many existing outfalls. In Uttarakhand they apply in full to every new outfall, and every existing outfall to a taal, rao, wetland or river that carries dry-weather flow comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed. In a lake town, every drain that enters the lake also passes a sediment trap first (Figure 7.3), because the lake is the end of the town's drainage and has no other way to lose the silt.

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. Uttarakhand's main controls on building in rivers, raos and lakes are the bye-law setbacks, the floodplain zoning law and the courts, and the courts have done most of the work. In *Urmila Thapa v. State of Uttarakhand* (WPPIL 58/2019, August 2022) the High Court recorded a survey of encroachment in the river beds of Dehradun district, 37.93 ha in Dehradun tehsil, 57.4 ha in Vikasnagar, 4.89 ha in Rishikesh and 5.62 ha in Doiwala, held that river-bed land outside municipal limits is forest land, ordered removal to begin at once, and made the Municipal Commissioner personally responsible within the city. On the Rispana, the National Green Tribunal recorded in 2025 the encroachments found by each body (89 by the Nagar Nigam, of which 20 dated from before 11 March 2016 and 69 had been removed; 413 by MDDA, of which 347 dated from before 2016 and 66 had been removed), and the State later counted 330 structures within the river's 1-in-5-year flood zone, 324 of them unauthorised (NGT O.A. 417/2022, order of 18 August 2025; NMCG affidavit, 2026). The cut-off date matters because the Uttarakhand Special Provisions for Urban Local Bodies and Authorities Act, 2018, as extended in 2025, defers the eviction of settlements that existed before 11 March 2016 (as recorded by the High Court); the Supreme Court held in abeyance in February 2025 the Tribunal's direction to remove the Rispana encroachments within a month (C.A. 1440/2025, as reported); and on 1 April 2026 the High Court dismissed petitions against the rehabilitation of the Kathbangla basti, whose residents were "living in dry river bed and are in danger if any flash flood … occurs" (*Rajeshwari Yadav Gupta*, WPMS 739/2026). In the Nainital lake region the High Court stopped construction on the Sukhatal lakebed in 2022, and a ban it laid in 2016 on construction within 2 km of the major lakes was stayed by the Supreme Court in 2018 (both as reported); the Lake Development Authority issues notices against unauthorised structures (as reported). The Gaula at Haldwani has its own record of mining and encroachment before the High Court (*Ravi Shankar Joshi*, WPPIL 178/2013). Floodplain zoning itself may yield: an amendment of 2024, seen only as quoted, lets a final notification be amended where "riverbank development" can protect land and buildings. 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.

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 SW monsoon (by 31 May) 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. Naini lake and the other Kumaon taals are natural lakes whose outlets are controlled by sluices, not by bunds, and khals and village ponds are too low to be specified dams, but each outlet works or bund shall be screened under Clause 7.14.1; the heights of the outlet works of Bhimtal, Naukuchiatal and Sattal were not found for this Manual. Tehri, at 260.5 m, is a specified dam under the Act, and the earth dams of the Baur, Haripura and Tumaria reservoirs in Udham Singh Nagar, of which the Baur dam is 9.5 km long (Irrigation Department salient features), are to be checked against it. Where the storage of a taal, khal 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. A glacial or moraine-dammed lake is never counted as storage, but where it lies upstream of a town, its breach path is mapped as a hazard (definitions after Clause 7.2; Chapter 5). 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 Uttarakhand the embankments and lakes that matter to the towns are the State's dams and barrages and the natural dams of the high mountains. In June 2013 the moraine-dammed lake above Kedarnath emptied within minutes on the morning of 17 June, in a disaster in which the State presumed more than 5,700 people dead (as reported); on 7 February 2021 a rock and ice avalanche at Raini became a debris flow that destroyed the Rishiganga project and damaged the Tapovan-Vishnugad project (Shugar et al., 2021); and on 5 August 2025 a debris flow buried Dharali in the Bhagirathi valley (as reported). Among the dams, Tehri's spillways were designed for a probable maximum flood of 15,540 m³/s (THDC), the Gaula barrage at Kathgodam was designed for 3,250 m³/s and passed about 123,000 cusec in 1993 (Irrigation Department salient features), and the Dakpathar barrage was given a waterway for the 1-in-50-year flood of 11,620 m³/s (UJVN, O&M manual, 2021). No breach map or emergency action plan for a taal, a barrage or a reservoir of the terai was read for this Manual, and no State disaster management plan for urban floods was read. A failed or overtopped bund floods the colonies below it, a released or burst lake sends a flood and debris down a gadhera faster than any warning, and an unannounced release floods the colonies too, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments. 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.

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 Uttarakhand, Housing Department. *Uttarakhand Building Construction and Development Bye-laws/Regulations, 2011 (Amendment 2015)*, as amended, made under section 57 of the Uttar Pradesh Urban Planning and Development Act, 1973 as applicable in Uttarakhand; read in the Department's compilation of the amendments of 2015 to 2019 (bye-laws 2.3, 2.41, 4.4(III)–(V), 5.6, 6.4, 6.5 and Appendix 1), hosted by MDDA as "Compiled ByeLaws Part I". The 2011 text as first notified and the 2015 amendment notification were not read, and the printing "30.0–30.0" and "10.0–10.0" metres in bye-law 4.4(III) is to be checked against the gazetted text [TBC]. https://mddaonline.in/wp-content/uploads/2026/03/Compiled_byelaws_I.pdf
- Government of Uttarakhand, Housing Department. Amendment notification No. 180884 of 10 January 2024 (clause 7.14(III), filling stations; adoption by development-authority boards, para 4). https://cdnbbsr.s3waas.gov.in/s3ac1ad983e08ad3304a97e147f522747e/uploads/2025/04/20250416679158818.pdf ; draft *Bye Laws/Regulations, 2011 (Amendment 2017)*, hosted by MDDA as a draft and not seen notified.
- Government of Uttarakhand, Housing Department. *Uttarakhand Unified Zoning Regulations*, notification No. 568/E.No. 92710 of 20 November 2025 under section 8(2) of the 1973 Act (chapter 11, E-1, rivers and waterbodies). https://cdnbbsr.s3waas.gov.in/s3ac1ad983e08ad3304a97e147f522747e/uploads/2025/12/2025120419332991 91.pdf
- Government of Uttarakhand, Housing Department. Order No. 1995/V-2-2017-58(आ0)/2014 of 29 November 2017 on development on the banks of the Ganga in the hill areas, https://cdnbbsr.s3waas.gov.in/s3ac1ad983e08ad3304a97e147f522747e/uploads/2025/01/2025012837847117 9.pdf ; and letter e-file 46063 of 1 June 2023 linking it to the Irrigation Department's floodplain notifications, https://cdnbbsr.s3waas.gov.in/s3ac1ad983e08ad3304a97e147f522747e/uploads/2025/04/2025041613147309 95.pdf
- Government of Uttarakhand. *Uttarakhand Flood Plain Zoning Act, 2012* (Uttarakhand Act No. 07 of 2013), ss. 2, 3, 5, 8–13, 17, 24. https://faolex.fao.org/docs/pdf/ind213361.pdf ; the Amendment Act of 2024 (seen only as quoted in the Irrigation Department's compliance report below; number and date not seen) and the Rules approved by the cabinet on 12 October 2026 (text not found).
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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 Hindi, Garhwali and Kumaoni 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 SW 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).

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 Uttarakhand 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 Uttarakhand 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 Uttarakhand, 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.

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 Uttarakhand 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

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 Uttarakhand, 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.

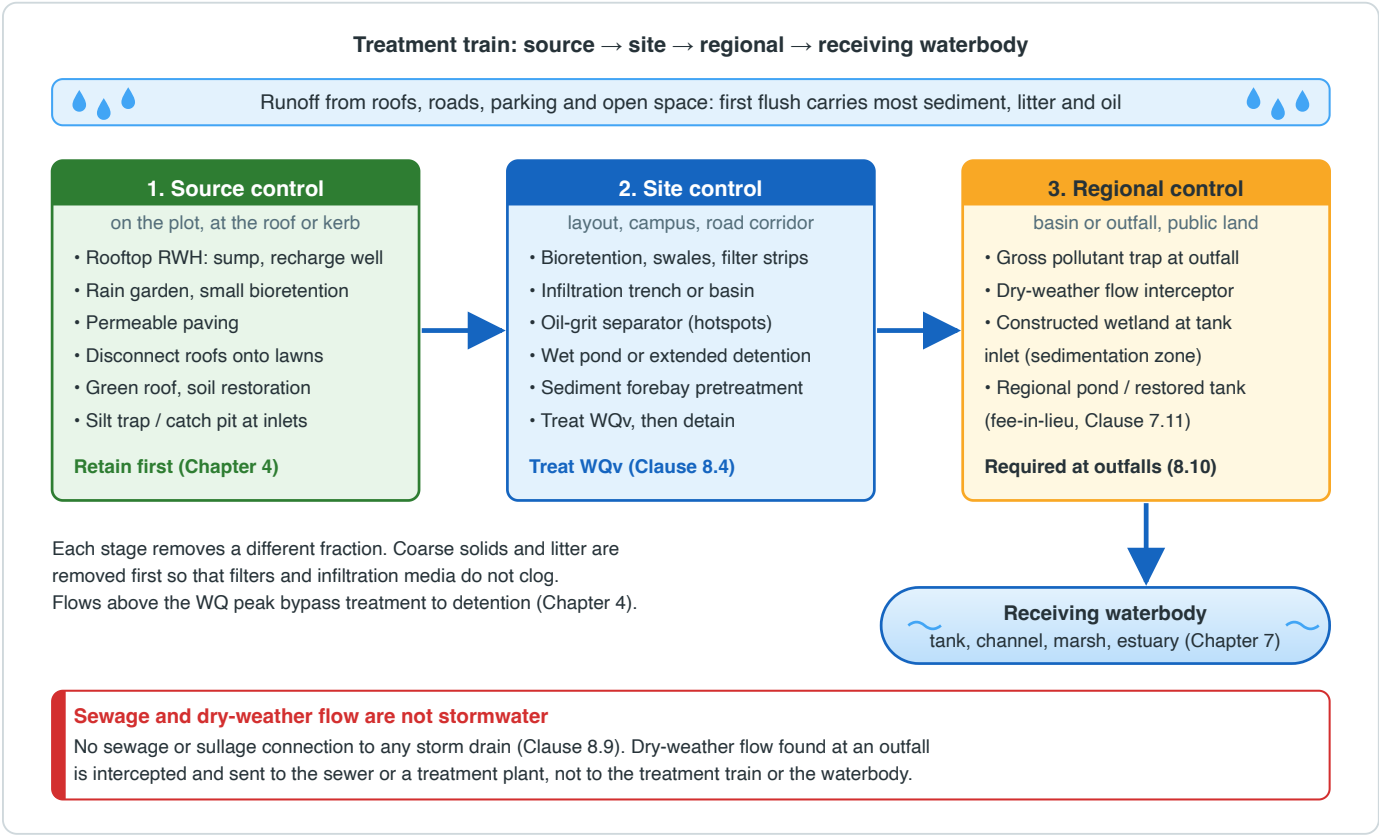


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater 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 Uttarakhand

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Doon Gravels, bhabar fans, river sands	Laterite / hard rock	Terai, Siwalik mudstone or hill colluvium / high water table	Uttarakhand 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	Doon Gravels, bhabar fans, river sands	Laterite / hard rock	Terai, Siwalik mudstone or hill colluvium / high water table	Uttarakhand 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 Uttarakhand 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. Uttarakhand 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.

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.

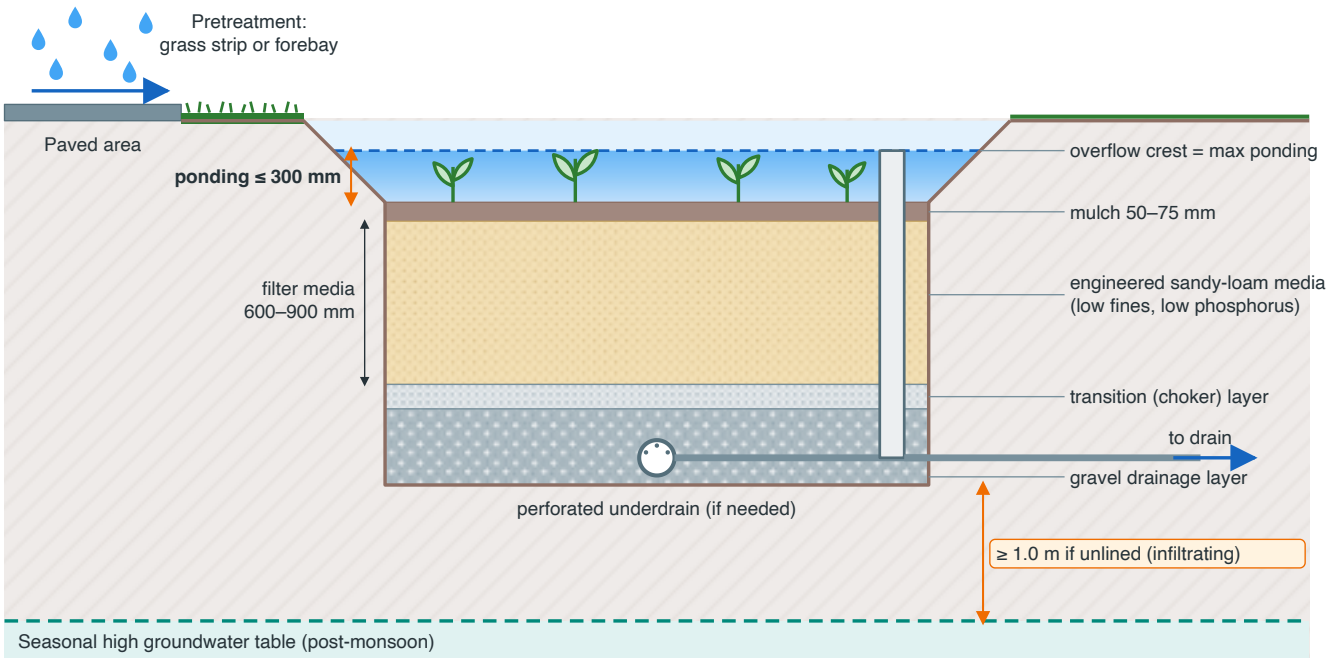
> **Commentary.** The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in Uttarakhand. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Uttarakhand. 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 Uttarakhand's rain falls in the south-west monsoon: the State's normal is 1,326.1 mm a year, of which about 78% falls from June to September and July and August alone bring nearly 53%, with about 10% from March to May, 9% in the winter months of December to February, from western

disturbances, and 3% in October and November (IMD, *Climate of Uttarakhand*, normals of 1961–2010). The gauge normals differ more than the district normals: the outer ridge, at Nainital, Mussoorie, Rajpur and Dehradun, receives about 2,000 to 2,500 mm a year, and the rain-shadow valleys of the inner hills, at Srinagar, Joshimath and Pithoragarh, about 500 to 1,000 mm (IMD, gauge normals). The monsoon now sets in at Dehradun on about 20 June and at Roorkee on about 28 June, and withdraws from Roorkee by about 25 September and from Dehradun by about 27 September (IMD, new normal dates, 2020), but the largest late storms have come in October. From October to the monsoon, taals fall and springs weaken unless they are fed: Naini lake was reported 18 ft below its normal level in 2017 and at a five-year low in 2025 (as reported), and the number of functional springs in the Almora region is reported to have fallen from 360 to 60 over 150 years (NITI Aayog, 2018). In the towns the feed of a drain or pond in the dry months is often sewage, because the raos and nalas 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 hill towns, where Clause 8.8.1 bars infiltration on the slopes 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, and above about 1,500 m every BMP is also checked for frost, snow and ice from December to March. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; taals, khals, recharge flats, springs 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 Uttarakhand 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.

Bioretention cell (rain garden): section, not to scale



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 Uttarakhand, which has no coastal sand areas (Clause 8.8.9). For this Clause the seasonal high groundwater table is the highest post-monsoon level (September to November), and in the terai, where the deeper aquifers are confined and wells flow at the surface, the higher of that level and the level to which a flowing well near the site rises. Uttarakhand needs opposite rules in its three belts, and Clause 8.8.1 applies with the following. **(i) Recharge first on the Doon Gravels and the bhabar.** On the Doon Gravels of the Dehradun valley and the bhabar fans along the foot of the hills (Bhagwanpur and part of Bahadrabad in Haridwar district, Haldwani, Ramnagar, Kotdwar and Tanakpur), where the water table lies tens of metres down (40 to 75 m below ground in the bhabar of Nainital district, CGWB) and the gravels take water readily, recharge, with pretreatment, is the first means of meeting retention wherever this Clause is met. The bhabar is the intake of the terai's artesian aquifers, whose flowing zone is shrinking (CGWB, 2016), and Bahadrabad, Bhagwanpur, Haldwani and Kashipur were the State's semi-critical blocks in the assessments of 2020 and 2022 (CGWB). **(ii) No infiltration on hill slopes.** The hill infiltration rule of Clause 4.11 applies to every facility under this Chapter: no deliberate infiltration practice (soakaway, soak pit, recharge pit, shaft or well, infiltration trench, unlined bioretention, or permeable paving with an exfiltrating base) shall be built or credited on natural ground sloping more than 10°; on a mapped landslide or creep zone, or within the landslide-prone setting of bye-law 4.4(IV)–(V); on colluvium, slide debris or moraine, whatever its slope; or upslope of a cut slope or retaining wall within a distance of 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. Roof water there goes to the storage tank of bye-law 6.5, and its overflow, with all other runoff, is led by lined drains through a sediment trap to a stable natural channel (or, in a lake town, to the lake through a trap), 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. Water put into a hill slope raises the pore pressure in the colluvium and can carry its fines away: seepage from drains and from the wastewater of buildings is named among the causes of the slides along the Balia Nala below Naini lake (2022 study), the Mishra Committee asked in 1976 for the soak pits of Joshimath to be closed, and the infiltration of rain and wastewater was named among the causes of its subsidence in 2023 (both as reported). **(iii) No infiltration in the terai where the water is within 1 m.** In the terai of Udham Singh Nagar and Haridwar, where the water table stands about 1 to 7 m below ground in Udham Singh Nagar and more than 2,000 artesian wells were counted in five of its blocks (CGWB), no infiltration facility, recharge pit, recharge well or recharge shaft shall receive runoff of any kind where the seasonal high water table is within 1 m of the ground, where the ground is waterlogged, or where wells flow at the surface; the exception for roof water in Clause 8.11.3(c) does not apply there, no infiltration is credited, and retention is met by storage for use and by detention under Chapter 4 (bye-law 6.5 already exempts waterlogged areas from rainwater harvesting). Elsewhere in the terai this Clause applies on a test at the site. **(iv) Springs and lake recharge areas.** Within the recharge area of a naula, dhara or other spring used for drinking water, as a hydrogeologist maps it, and on the recharge flat of a taal, such as Sukhatal for Naini lake, only roof water and runoff that has passed a filtering BMP may be infiltrated, where item (ii) allows any infiltration at all; road runoff, sewage and septic effluent never are, no infiltration facility is placed within the 10 m of a spring kept by bye-law 4.4(III), and a recharge flat is kept open and unpaved (Clause 7.5). **(v) Quality.** In the assessment of 2024, nitrate exceeded 45 mg/L in about 17% of the samples (Almora, Dehradun, Haridwar, Nainital and Udham Singh Nagar), arsenic exceeded 10 µg/L in about 4% (Almora, Haridwar and Udham Singh Nagar), uranium exceeded 30 µg/L at one place in Haridwar and fluoride exceeded 1.5 mg/L at one place in Almora, all at "sporadic locations" (CGWB). In Haridwar and Udham Singh Nagar districts a recharge well or shaft is used only after a check of the groundwater quality at the site, water drawn back from a recharged aquifer is tested before any drinking use, and no sewage-laden or industrial runoff is led to any recharge structure anywhere. Where recharge is through a well or shaft into fractured rock or deep gravel, a hydrogeologist's report shall confirm the depth to water, the receiving zone, and that no drinking-water well or spring within 30 m will be

harmed. The 10° trigger, the distance of twice the wall height, the 1 m limit in the terai and these conditions are set by this Manual; no Uttarakhand rule on infiltration or soak pits on slopes was found. 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. Uttarakhand has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The Doon Gravels, the bhabar fans and the sands and boulders of the river beds are not coastal sand areas: Clause 8.8.1 applies there in full, 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 quartzite, phyllite, slate, schist, limestone and granite of the Lesser and Higher Himalaya, as around Mussoorie, Nainital, Almora, Pithoragarh, Tehri and Srinagar, where groundwater is held in the weathered veneer, in fractures and in perched bodies and comes out at springs (CGWB), and the Siwalik sandstone, mudstone and conglomerate of the outer hills; on any slope in these areas the hill limits of Clause 8.8.1 apply first):

- (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 terai of Udham Singh Nagar and Haridwar where the seasonal water table is within about 1 m of the ground, the ground is waterlogged or wells flow at the surface, the silted beds of taals, khals and talabs, the Siwalik mudstone, and the clayey colluvium and slide debris of the hills, 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 Uttarakhand precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Uttarakhand RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.
>
> No statewide map of hydrologic soil groups for Uttarakhand, and no measured infiltration rate for the Doon, the bhabar, the terai or a hill slope, was found, and every infiltration design needs the tests of Clause 8.8.3; the geology, depths and categories below are from the CGWB's assessments, brochures and aquifer-mapping reports for the State. About 85% of the State is mountainous and underlain by hard rock, where groundwater is held in the weathered veneer and in fractures and comes out at springs whose discharge in the Lesser and Central Himalaya ranges from 60 to 600 litres a minute; the other 15% is the bhabar and the terai (CGWB, 2024). The Doon valley is filled with the Doon Gravels, "boulders and pebbles embedded in sandy and silty matrix", "highly porous" with a hydraulic conductivity of 13 to 583 m a day and the water 20 to 125 m below ground (CGWB, Dehradun, 2011).

The bhabar, a belt of coalesced boulder fans 4 to 20 km wide along the foot of the hills, is "the main intake area" of the plains' aquifers, with the water table 40 to 75 m down and up to 173.71 m at Haldwani (CGWB, Nainital, 2010), and it covers most of Bhagwanpur block and part of Bahadrabad in Haridwar district (CGWB, Haridwar). Below the spring line the terai, 8 to 25 km wide and sloping at less than 1%, is mostly clay with sand beds, the water stands about 1 to 7 m below ground, and more than 2,000 artesian wells flow in five blocks of Udham Singh Nagar (CGWB, Udham Singh Nagar); its flowing zone is shrinking, by 5 to 7 km in the east, and the CGWB names the clearing of the bhabar forests that recharge it and the multiplying of shallow tube wells as possible causes (aquifer mapping, 2016). The State draws 53.54% of its extractable groundwater, with 4 of its 20 assessment units semi-critical (CGWB, 2024); Bahadrabad, Bhagwanpur, Haldwani and Kashipur were the semi-critical blocks in the assessments of 2020 and 2022, all of them on or below the bhabar. Water quality is mostly good, but at "sporadic locations" nitrate exceeded 45 mg/L in about 17% of the samples of 2024, arsenic exceeded 10 µg/L in about 4% (Almora, Haridwar and Udham Singh Nagar), uranium exceeded 30 µg/L at one place in Haridwar and fluoride exceeded 1.5 mg/L at one place in Almora (CGWB, 2024). In the hills the springs are the water supply: government water schemes depend on springs for about 70% of their sources in Chamoli district, 84% in Ghaat block and about 87% in Rikhnikhal (GBPNIHE, 2019), and the number of functional springs in the Almora region is reported to have fallen from 360 to 60 over 150 years (NITI Aayog, 2018); a Spring and River Rejuvenation Authority was reported constituted in 2025 and to have treated 929 water sources (as reported), but no constitution order was found. Water put into a hill slope is a hazard as well as a resource: seepage from drains and the wastewater of buildings, raising the pore pressure of the perched water, is named among the causes of the slides along the Balia Nala below Naini lake (2022 study); the Mishra Committee asked in 1976 for the soak pits of Joshimath to be closed; and an IIT Roorkee study of the subsidence of 2023 named infiltration of rain and wastewater as a likely cause (both as reported). This Manual's interim soil groups follow from these: the Doon Gravels and bhabar fans A, the terai C (D where the water table is within about 1 m), the Ganga alluvium B to C, Siwalik regolith C (D on mudstone), and hill colluvium, slide debris and moraine designed as D with no infiltration credit on slopes (Chapter 3). **The State therefore needs opposite rules in its three belts.** On the Doon Gravels and the bhabar, recharge comes first, with pretreatment, because they feed the plains' aquifers. On the hill slopes, no water is put into the ground on purpose, under the hill infiltration rule of Clause 4.11, which Clause 8.8.1 applies. In the terai, where the water is within 1 m or flows at the surface, no infiltration is used, and retention is met by storage for use and detention. 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)), and arsenic, nitrate and uranium are checked where Clause 8.8.1 says so. Clause 8.8.9 has no effect in Uttarakhand, which has no coast.

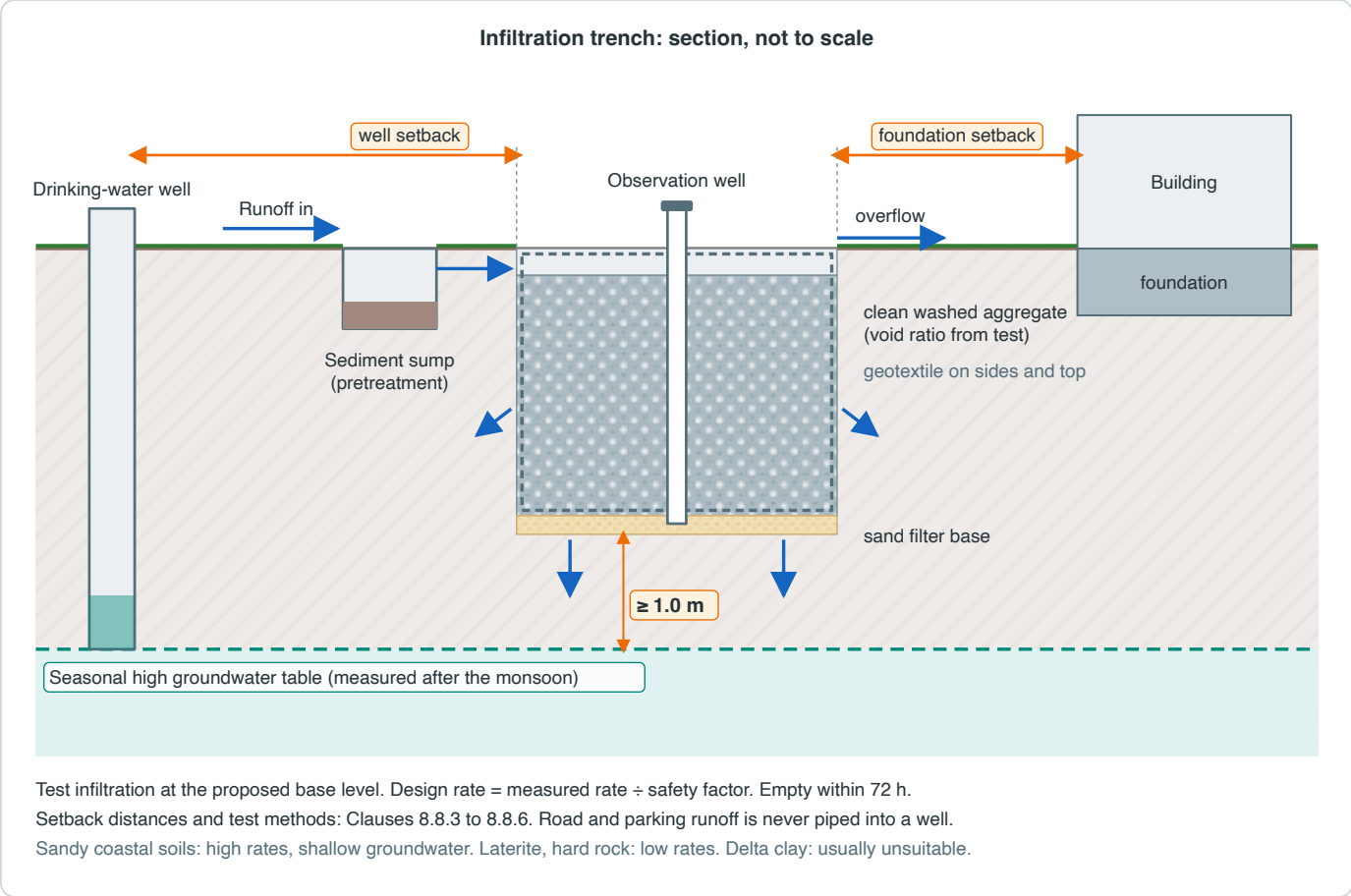


Figure 8.3 — Infiltration trench in section: pretreatment sump, aggregate-filled trench in geotextile, observation well, overflow, the 1.0 m minimum separation to the seasonal high groundwater table, and setbacks to wells and foundations. Original drawing for this Manual, adapted from the Georgia Stormwater Management Manual, 2016 (Vol 2), and CIRIA, The SuDS Manual (C753), 2015.

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 Uttarakhand Environment Protection and Pollution Control Board (UEPPCB) 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 SW 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 Uttarakhand. 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 Uttarakhand the raos and nalas carry the sewage, and the State's answer has been interception and diversion (I&D) at the drain mouth under Namami Gange. On the Rispana in Dehradun, 187 of the 208 drains have I&D works, 19 more now reach the sewers and 2 are clean forest streams; the I&D project for the Rispana and the Bindal, sanctioned in 2021, tapped 200 drains with 22.34 km of sewers, sending the Rispana's drains to two 20 MLD treatment plants at Mothrowala and the Bindal to the 68 MLD plant; and the floods of 16 and 17 September 2025 damaged 83 of those I&D structures (Uttarakhand Peyjal Nigam, affidavit of December 2025 in NGT O.A. 417/2022). Statewide, the CPCB monitored 200 drains carrying about 1,891 MLD, of which 114 were completely tapped, 13 partly tapped and 70 untapped before the monsoon of 2025, and it lists the Rispana, the Bindal Rao, the Rambha at Rishikesh and the Kalyani at Rudrapur among "rivers reported as drains" (as quoted in a submission of 12 March 2026 in NGT O.A. 200/2014). The CAG found in 2017 that 47 of the 111 nallas identified in the Ganga towns of Uttarakhand had been tapped, with 26.292 MLD of sewage still falling into the river (Report No. 39 of 2017; its Report No. 1 of 2018 counts 65 of 112 still to be tapped). The adapted Municipal Acts were not read for any power to require separate drains for sewage and rain-water [TBC]. Every I&D structure on a rao or nala is a DWF interceptor under Clause 8.9.5, and Clause 8.9.5(b) applies to it in full: it is sized from the measured dry-weather flow of its drain, does not reduce the drain's capacity for the minor and major events or raise the flood level behind it, and passes the storm flow above its capacity on down the drain to the river, never to the treatment plant or back into the colonies. On a rao or gadhera, where a flash flood carries boulders and can destroy it, an interceptor and its chamber are also placed above the 25-year flood line of the reach where one is notified, or otherwise protected against the scour and debris of the 1% AEP flood (Chapter 9), with the bypass shown to pass that flood; this condition is set by this Manual.

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 Uttarakhand 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.

8.11 Rainwater harvesting integration

8.11.1 **RWH mandate continues.** The rainwater harvesting required by the Uttarakhand Building Construction and Development Bye-laws 2011 (bye-law 6.5, which makes rainwater harvesting mandatory for every permitted construction with a ground coverage of 125 m² or more, except in areas with a waterlogging problem, with storage of at least 2.0 m³ up to 250 m² of coverage, 3.5 m³ up to 400 m², and 0.5 m³ more for each further 50 m² or part of it, reduced to one-third of that storage on a plot of more than 400 m² where groundwater recharge is provided by a bore well, recharge pit, well or trench, and confirmed on the building plan before approval; that storage is about 8 to 16 mm of rain over the covered area) continues to apply, subject to the limits of Clause 8.8.1 (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 SW monsoon (JJAS) 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. Uttarakhand's building rules make rainwater harvesting mandatory, but none of them sets a detention rule. Bye-law 6.5 of the Bye-laws 2011 requires it, except in areas with a waterlogging problem, for every permitted construction with a ground coverage of 125 m² or more, as a storage of at least 2.0 m³ up to 250 m² of coverage, 3.5 m³ up to 400 m², and 0.5 m³ more for each further 50 m² or part of it; on a plot of more than 400 m² where groundwater recharge is provided by a bore well, recharge pit, well or trench, one-third of that storage suffices; the provision must be shown on the building plan before approval, and the drainage and storage works do not count in the ground coverage (compilation of 2015–2019). The storage is about 8 to 16 mm of rain over the covered area, and the marginal 0.5 m³ per 50 m² is 10 mm. Structures for rainwater harvesting, conservation and storage, including underground tanks, are among the works exempt from permission, and the open area over a basement may carry a recharge well (bye-law 5.6(vi)). A draft revision of the bye-laws, the "Amendment 2017" hosted by MDDA, would have applied harvesting to plots above 100 m² and made recharge mandatory on plots of 500 m² and more, with recharge wells at least 10 m from any structure handling sewage or industrial waste water, but it is not found notified. The Uttarakhand Ground Water (Regulation and Control of Development and Management) Act, 2016, whose section 20 would have let an authority order harvesting for recharge, was repealed in 2017 (Act No. 11 of 2017), so the State has no groundwater law with a harvesting mandate, and the Central Ground Water Authority's guidelines of 2020, as amended in 2023, apply to extraction (CGWB, 2024). Enforcement is by plan approval and drives: MDDA's Vice-Chairman ordered harvesting in residential projects to be improved within a week in June 2024, and the authority said that approved maps often show provisions that were not built (as reported); and the CAG found that Dehradun Smart City's integrated drainage works made no provision for storm-water reuse (CAG, 2025). The rules set no test of the recharge pit, no protection of the aquifer from road runoff, no storage to be empty before a storm, and no limit on recharge pits on slopes. On the Doon Gravels and the bhabar, and in the semi-critical blocks of Bahadrabad, Bhagwanpur, Haldwani and Kashipur, recharge is the main function of harvesting (Clause 8.11.2(b)); on hill slopes, landslide and creep zones, colluvium, slide debris and moraine, and in the terai where the water table is within 1 m, harvesting is for storage and use, and the recharge pit of bye-law 6.5(III) is not used unless Clause 8.8.1 allows it, so the one-third reduction of storage, which depends on recharge, is not taken there under this Manual (Clause 8.8.1). RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a July to September monsoon burst or cloudburst against the outer Himalaya, or a late-season storm such as that of October 2021 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.

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 SW monsoon (June to September) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **31 May**; and
- (c) any area exposed between 15 June 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 SW 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 Uttarakhand's 2-year 24-hour depths are high and construction sites are commonly left exposed

through the SW monsoon. The 2 ha division between traps and basins, the 31 May stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 31 May 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 Uttarakhand sediment, not sewage alone, is the dominant pollutant of the hill drains: the State's slopes are steep, its soils skeletal and erodible, road and building works leave cut slopes and loose spoil, and the rivers carry heavy loads (about 7.88 million tonnes of suspended sediment a year in the Bhagirathi at Devprayag, as reported). In a hill town the silt, gravel and debris settle in the lake at the end of the drains, such as Naini lake, on the recharge flats that feed it, where dumped debris has reduced Sukhatal's recharge (NITI Aayog, 2018), and in the barrage ponds, such as the Gaula barrage, reported silted with debris and boulders upstream (as reported). Solid waste adds to the load: the CAG found most of the State's dump sites near national highways or rivers, with waste flowing into them (Report No. 4 of 2024). In the hills the outlet of a sediment basin or trap under Clause 8.12 discharges to a lined drain or a stable channel and never onto an unprotected slope, and no sediment basin or trap is designed to infiltrate where Clause 8.8.1 bars infiltration; in a lake catchment, a construction site also keeps its sediment out of every drain that reaches the lake.

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 SW monsoon; and
- (b) wet-weather sampling of at least three events each SW 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 Uttarakhand 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.

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).

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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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	Uttarakhand 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, rao, gadhera, nala, taal, reservoir or barrage pond 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 any dam or barrage upstream, such as Tehri and Koteshwar on the Bhagirathi above Rishikesh and Haridwar, the Pashulok (Virbhadra) barrage below Rishikesh and the Bhimgoda barrage at Haridwar on the Ganga, the Dakpathar

barrage on the Yamuna and the Asan barrage at Dhalipur, the Gaula barrage at Kathgodam, the Kosi barrage at Ramnagar and the Banbasa barrage on the Sarda; 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 Haridwar that outfall to the Ganga, for those of Rishikesh that outfall to the Ganga and the Chandrabhaga, for those of Roorkee that outfall to the Solani, for those of eastern Dehradun and Doiwala that outfall to the Song, for those of Haldwani that outfall to the Gaula through the Rakasia and Kalasia nalas, for those of Ramnagar that outfall to the Kosi, for those of Rudrapur and Kichha that outfall to the Kalyani and the Kichha, for those of Banbasa, Tanakpur and Khatima that outfall to the Sarda, and for the drains of Nainital, all of which end in Naini lake; for an outfall to a reservoir, barrage pond or taal, its maximum water level or maximum pond level (for example Tehri 835 m, Dakpathar 456.40 m, Asan 401.50 m and the high pond level of the Gaula barrage, 513.250 m), or its full tank level plus the surcharge in the design flood, as Chapter 5 sets it, or, where neither is published, the full tank level plus 0.5 m (set by this Manual); for an outfall to Naini lake, the maximum level of 12.5 ft on the PWD gauge at Tallital (NIH; 12 ft in the press), converted to a level above mean sea level before use, until the sluices are sealed on 15 October, and the level of the lake on that date after it; for an outfall to a rao or gadhera that has no gauge, among them the Rispana, the Bindal, the Suswa and the Tons (Tamsa) in Dehradun and the gadheras above the valley towns, the level of the 1% AEP flood in the reach, computed with the sediment and debris allowances of Chapter 6 and checked against surveyed flood marks, or the 100-year line of a final notification under the Uttarakhand Flood Plain Zoning Act 2012 where it is higher; the level held in a drain by any sluice, interception and diversion structure, check dam, pond outlet weir or pumping station downstream of the outfall, among them the interception and diversion structures that take the dry-weather flow of the drains of the Rispana and the Bindal to the sewage treatment plants, taken as a fixed control at its gate-closed level, its weir crest or the start level of its pumps; and the joint case of Clause 2.12. At Haridwar the levels are those of the CWC site on the Ganga at Dudhia Band (warning level 293.0 m, danger level 294.0 m, high flood level 296.30 m of 19 September 2010, which one CWC table dates to 17 June 2013, when the river is reported to have peaked at about 295.75 m); at Rishikesh 339.5 m, 340.5 m and 341.72 m (5 September 1995); on the Song at Satyanarayan 337.2 m, 338.2 m and 338.49 m (28 June 2019); on the Solani at Roorkee a warning level of 260.5 m and a danger level of 261.5 m, with a high flood level of 260.58 m (14 October 2021) that lies below the danger level; on the Gaula at Kathgodam a high flood level of 498.93 m (20 October 2021) with no warning or danger level; on the Kosi at the Ramnagar barrage a high flood level of 220.75 m or 220.95 m (19 October 2021; the two published values conflict); and on the Sarda at Banbasa a danger level of 223.3 m and a high flood level of 224.9 m (19 October 2021) (CWC levels as transcribed by SANDRP, as reported; the datum is not stated); readings of a local gauge published in the press, on another zero, are never mixed with them. No document found sets a design river, reservoir, barrage, taal or rao level at any outfall in Uttarakhand; until one 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).

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.

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:

> HWo = ho + H − L·S

> H = [1 + ke + (19.63 n² L) / R^1.33] · V² / 2g (SI units, full barrel)

> ho = the greater of TW and (dc + D)/2

where ho 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), ke 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), dc 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 ke (outlet control, full or partly full)

Barrel and inlet	ke
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.

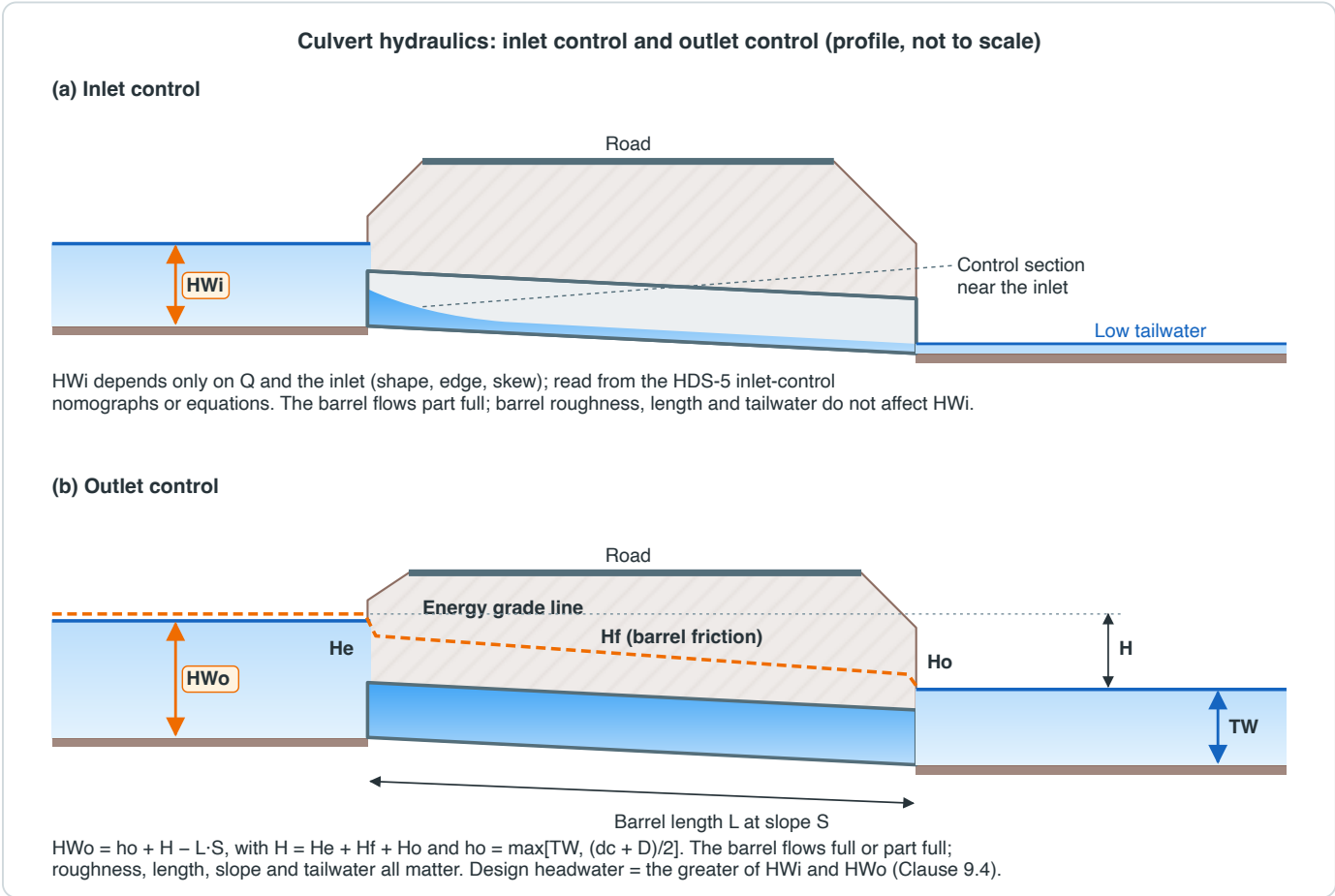

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

> **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 Uttarakhand where a road is rebuilt on top of an old culvert, and they hold standing water and silt upstream.

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 Haridwar and Rishikesh that outfall to the Ganga between and below the Pashulok and Bhimgoda barrages, on the drains of Roorkee that outfall to the Solani, on the drains of Haldwani, Ramnagar, Banbasa and Tanakpur that outfall to the Gaula, the Kosi and the Sarda below their barrages, on the drains of Nainital that end in Naini lake, on the flat terai drains of Rudrapur, Kichha and Khatima, and on the steep khalas, raos and gadheras of the Doon and the hill 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 Uttarakhand (the boulder gravels of the Doon fans and the bhabar, the silts and fine sands of the terai and of the Ganga alluvium at Haridwar and Roorkee, the clays and sandy loams weathered from the Siwalik mudstones and sandstones, and the stony colluvium, slide debris and moraine of the hill slopes, on which the boulders 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 Uttarakhand 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.

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:

> $D50 = 0.2 \cdot D \cdot [Q / (g^{0.5} \cdot D^{2.5})]^{(4/3)} \cdot (D / TW)$

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.

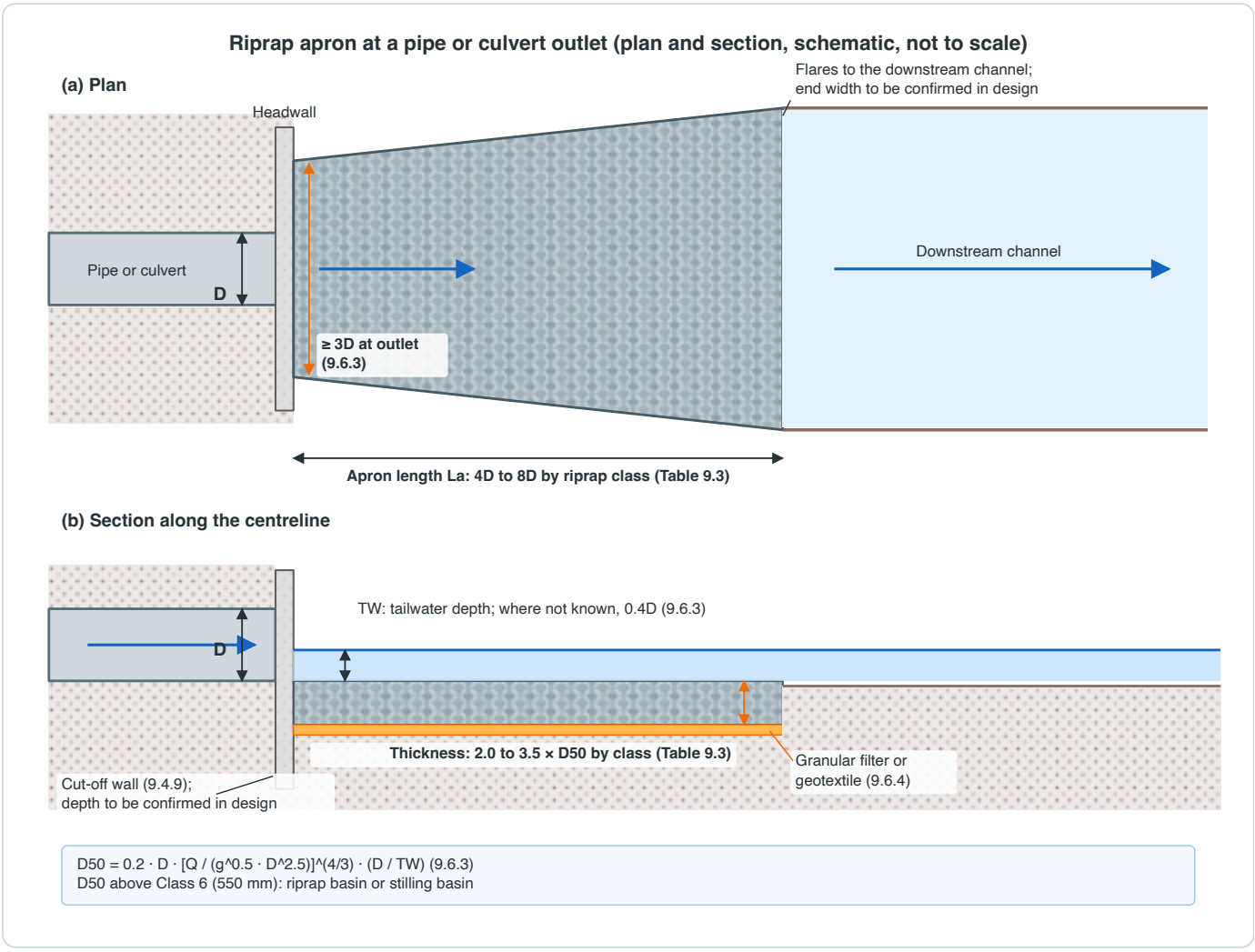

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design 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 (m^2/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.

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:

> $Q = Cd \cdot A \cdot (2\,g\,h)^{0.5}$

where A is the orifice area (m^2) 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. Cd 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 = Cw · L · H^1.5, with:

- (a) sharp-crested rectangular weirs: Cw = 1.84 (SI), with the effective length reduced by 0.1 H for each end contraction;
- (b) V-notch weirs: Q = 1.38 · tan(θ/2) · H^2.5 (SI), where θ is the notch angle; and
- (c) broad-crested weirs and spillway crests: Cw = 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.

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, θ is the angle of the rack from the horizontal, and β 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 m³/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.

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 Θ 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 m^3/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.

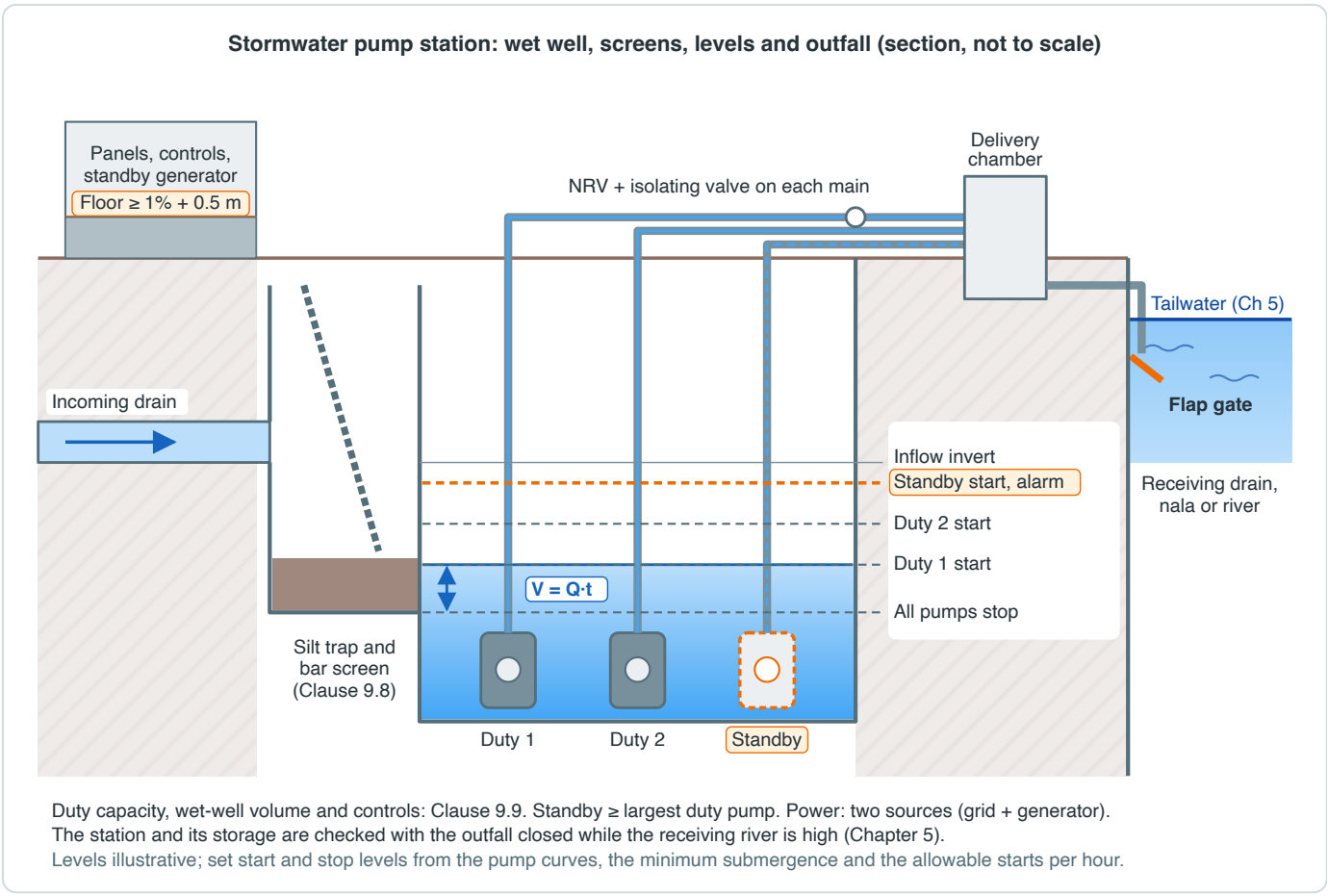

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **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.

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". Uttarakhand 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, barrage-pond, reservoir or taal level of Chapter 5. Gates are still required below the 1% still-water level, because the outfalls of the plains and foothill towns end in rivers that floods and barrages hold high. At Haridwar the drains outfall to the Ganga below the Bhimgoda barrage, where the CWC site at Dudhia Band has a warning level of 293.0 m, a danger level of 294.0 m and a high flood level of 296.30 m (19 September 2010, dated 17 June 2013 in one CWC table), and about 375,000 cusecs (about 10,600 m³/s) was reported at the barrage in June 2021 (CWC levels as transcribed by SANDRP; as reported); the operation of the barrage and the canal head is reported to rest with the Irrigation Department of Uttar Pradesh, which was not confirmed. At Roorkee the drains outfall to the Solani, whose CWC site has a high flood level of 260.58 m (14 October 2021) below its danger level of 261.5 m (as reported); SANDRP warns that at 18 of the CWC sites upgraded in the State the published high flood level lies below the danger or warning level, so no outfall is checked against such a figure without the CWC site sheet. A drain at Haridwar or Roorkee that outfalls below these levels is closed for as long as the river stands above its invert, so it needs a flap gate, a penstock and either storage or a pumping station sized under Clause 9.9 and the outfall-closed check of Chapter 5. Upstream, Tehri (full reservoir level 830 m, maximum water level 835 m, THDC) took an inflow of about 7,000–7,500 m³/s on 17 June 2013 and released about 500 m³/s (as reported), but experts called that attenuation a matter of chance, not design (as reported), and no rule obliges the dam to hold a flood for the towns below; the Pashulok (Virbhadra) barrage below Rishikesh has 15 bays of 18 m designed for 67 m³/s per metre (Irrigation Department). On the Yamuna the Dakpathar barrage has a maximum pond level of 456.40 m and a waterway for the 50-year flood of 11,620 m³/s, and the dam-safety review found that its upstream high flood level "is yet to be determined for the revised flood"; the Asan barrage, whose pond is the Asan Conservation Reserve, has a maximum pond level of 401.50 m and a design flood of 4,500 m³/s (UJVN Ltd, O&M manuals of 2021). The Gaula barrage at Kathgodam, above Haldwani, was designed for 115,000 cusecs (3,250 m³/s), passed 123,000 cusecs in 1993 and has a maximum pond level of 510.750 m and a high pond level of 513.250 m (Irrigation Department), and its pond is reported silted with boulders; the Kosi at the Ramnagar barrage rose to 220.75 m or 220.95 m on 19 October 2021, some 3.8–4.0 m above its previous record, and the Sarda at the Banbasa barrage on the border with Nepal reached 224.9 m against a danger level of 223.3 m on the same day (CWC levels, as reported). These barrages and dams are works of the Irrigation Department, THDC India Ltd and UJVN Ltd, designed to dam-safety standards and not to this chapter, but their pond levels and releases are this chapter's boundary conditions, and no release rule, spillway rating or record of gate operation for any of them was found. Naini lake is the State's one closed-basin outfall. Every drain of Nainital ends in the lake,

which leaves only through five sluices at Tallital, each 2.5 ft wide and 1.25 ft high, installed in 1888 (NIH, 1998–99); the Hill Slide Committee of 1927 limited their opening to 6 inches while the gauge is below 9 ft and to 12 inches while it is below 9.5 ft, to protect the Balia ravine below, which still slides; the maximum level is 12.5 ft on the PWD gauge (NIH; 12 ft in the press); the sluices are sealed on 15 October; and the lake rose to a reported 12.2 ft and overflowed on 19 October 2021 (as reported). Their operation is reported to have passed from PWD to the Irrigation Department in 2018 [TBC]. A drain that enters the lake is therefore checked against the lake at its maximum level, with the gauge converted from feet on its own zero to metres above mean sea level, and with a sediment trap at its mouth (Clause 9.8.1(d)); no flap gate can help a drain whose receiving water has nowhere to go, so its storage is the lake itself, and the Lake Development Authority and the custodian of the sluices are consulted on any change to its inflows. Most of the State drains steeply. The khalas and streets of the hill towns fall at 10–60%, the raos of the Doon and the drains crossing the bhabar fans at 2–5% (this Manual's reading of the terrain), 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. IRC:SP:42-2014 (§8.5.1) says the same of hill roads: their side drains are lined because the slope is high and "rolling stones cause high friction", culverts are needed at closer intervals than on the plains, and stepped chutes or baffles are provided where the bed slope exceeds critical. In Uttarakhand the following are set by this Manual for a structure on a drain whose catchment includes an undeveloped hill slope, rao or gadhera: (a) a drop or stepped channel shall have each pool shaped to drain dry and reachable by machine, 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, 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 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 deposited at the site in past floods and a stated debris-yield method, because no Indian 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 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; (d) 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 taal or an interception structure; and (e) 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. The need is shown by the floods: on 15–16 September 2025 the raos of Dehradun carried away 13 bridges and 10 culverts and damaged 83 interception and diversion structures (as reported; Peyjal Nigam, 2025); the Supreme Court's committee on the Char Dham roads found that "no slope drainage measures had been taken" and asked for roadside drainage and toe protection (*Citizens for Green Doon*, 14 December 2021); and the experts on the subsidence of Joshimath named inadequate drainage and blocked natural water paths among its causes (2023, as reported). No structure of this chapter is designed to pass a debris flow or a glacial-lake outburst: in sub-area UK-F, and on any drain with a glacier, a glacial lake or a mapped debris-flow fan above it, the screening of Clause 2.3.6(i) comes first, and a structure is sited out of the hazard, as at Kedarnath in June 2013, Raini in February 2021 and Dharali in August 2025, where the flows came down channels no drain could have carried. Screens matter as much as gates, because the drains also carry silt, solid waste and sewage: CAG found 65 of 112 nallas in the priority Ganga towns still untapped (Report No. 1 of 2018) and most of the State's dumpsites near rivers or highways (Report No. 4 of 2024), and CPCB counted 70 untapped drains in 2025 (as quoted), so a rack on an Uttarakhand nala is checked in the blocked case of Clause 9.8.4. No inventory of the sluices, flap gates, debris racks, sediment traps, interception structures and pumping stations on the drains of any Uttarakhand town, with their capacities and operating rules, no operating rule for the gates of Tehri, Koteshwar or the State's barrages, and no design river, barrage, taal or rao 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, sluice or penstock that fails, or is jammed open by silt, gravel, boulders, solid waste or woody debris, lets a river, barrage pond or taal in flood back into the drain network, and one jammed shut blocks it. The raos, gadheras and nalas of Uttarakhand carry boulders, gravel and debris as well as silt, solid waste and sewage: the pond of the Gaula barrage is reported silted with boulders and debris; the floods of 16 and 17 September 2025 in Dehradun

damaged 83 of the interception and diversion structures on the drains of the Rispana and the Bindal (Peyjal Nigam, affidavit before the National Green Tribunal, December 2025) and carried away 13 bridges and 10 culverts (as reported); CPCB counted 70 untapped drains in the State in 2025 (as quoted in a filing before the National Green Tribunal, March 2026); and most of the State's dumpsites were found near national highways or rivers, with waste flowing into a nearby river (CAG Report No. 4 of 2024), so a gate, its screen, the debris rack above it and the interception structure beside it are exposed to the same load and must be kept clear together; and because the Ganga at Haridwar and Rishikesh, the Solani at Roorkee and the Sarda at Banbasa can stand near or above their danger levels through a wet spell, and Naini lake is held near its maximum level until its sluices are sealed on 15 October, a gate that leaks or jams can be 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 Uttarakhand towns.

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
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*.

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 Uttarakhand 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 Uttarakhand 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 Uttarakhand 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.

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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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 Uttarakhand the failure is one of missing criteria and of drains that have not kept up with the towns. No document of the Housing Department, the Urban Development Department, T&CP, a Nagar Nigam or a development authority stating a design return period, intensity or runoff coefficient for the storm drains of any town was found; the only stated basis is that of the consultants for ADB's Dehradun drains, 2 years for roadside drains and 5 years for the main channels, with no allowance for climate change (ADB, 2021; Chapter 11). The approval route shapes this chapter. Uttarakhand did not replace the building rules it took from Uttar Pradesh in 2000 with a new code: it still amends the Uttarakhand Building Construction and Development Bye-laws/Regulations 2011 (Amendment 2015), which the Housing Department makes under s.57 of the Uttar Pradesh Urban Planning and Development Act 1973 as applicable to and amended in Uttarakhand, piecemeal, by notifications of 27 September 2022, 13 March 2023, 10 January 2024 and 13 June 2024 among others, of which only that of 10 January 2024 touches water, by keeping filling stations at least 50 m from rivers, nalas, waterbodies, springs and the flood plain and 5 m from a nala; each development authority must adopt every amendment through its board (notification of 10 January 2024). A comprehensive "Amendment 2017" with green-building and climate-resilience provisions was put out for comment by MDDA as a draft in 2018 and has not been seen notified, so it is not cited as law. Building permission is given by the development authority in its area (MDDA for Dehradun, Mussoorie and Rishikesh, HRDA for Haridwar and Roorkee, and the district development authorities formed in 2016–17) or by UHUDA or the local body elsewhere, under the Bye-laws. They already ask for much of what a drainage submittal needs: rainwater harvesting shown on the plan before approval (bye-law 6.5(IV)); a contour plan at 2 m intervals with sections of the site (4.4(IV)(i)); a site plan in the hills showing the landslide-prone areas near the site and, on a sloping site, the diversion of the uphill runoff away from the foundations (4.4(V)); the setbacks of 30 m from rivers and lakes, 10 m from springs and at least 5 m from nalas (4.4(III)); structural and soil certificates for a basement, covering the stability of the ground around it and the water table

(5.6(xi)); a sewer-capacity no-objection, or a sewage treatment plant, for premises of more than 1,000 m² (6.4(III)); an external development charge for sewer and drainage; and an inspection at plinth level, or before the basement slab is cast. In a reach notified under the Uttarakhand Flood Plain Zoning Act 2012 no activity may be undertaken in the prohibited (25-year) or restricted (100-year) area without the permission of the Flood Zoning Authority, which is deemed given if not refused in 90 days (s.12(3)); in the restricted area the Rishikesh notification of 2020 asks for a plinth at least 1.00 m above the high flood level and a no-objection from Peyjal Nigam on sewerage; and on the banks of the Ganga in the hills the Housing Department's order of 29 November 2017, revised on 1 June 2023, applies where the Irrigation Department has not notified the floodplain. The Ground Water Act of 2016, which would have let the State enforce rainwater harvesting for recharge, was repealed in 2017, so rainwater harvesting rests on bye-law 6.5 alone. The municipal Acts, the Uttar Pradesh Municipal Corporation Act 1959 and the Uttar Pradesh Municipalities Act 1916 as adapted in Uttarakhand in 2002 (CAG, 2022), vest the public drains in the local body, but their Uttarakhand texts were not read [TBC]. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a "zero runoff" condition. Every stormwater item in this chapter is therefore written so that the architect or engineer on record can certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the Authority can check it with the building plan, alongside the contour plan, the runoff-diversion proposal and the rainwater harvesting that the Bye-laws already require, at the plinth-level inspection, at completion, and, in a notified reach, with the permission of the Flood Zoning Authority and the Irrigation Department. This chapter is the process.

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.

10.3 Submittal stages

10.3.1 Submittals shall be made in the following stages, linked to the approval steps of the Uttarakhand Building Construction and Development Bye-laws 2011 (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
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.

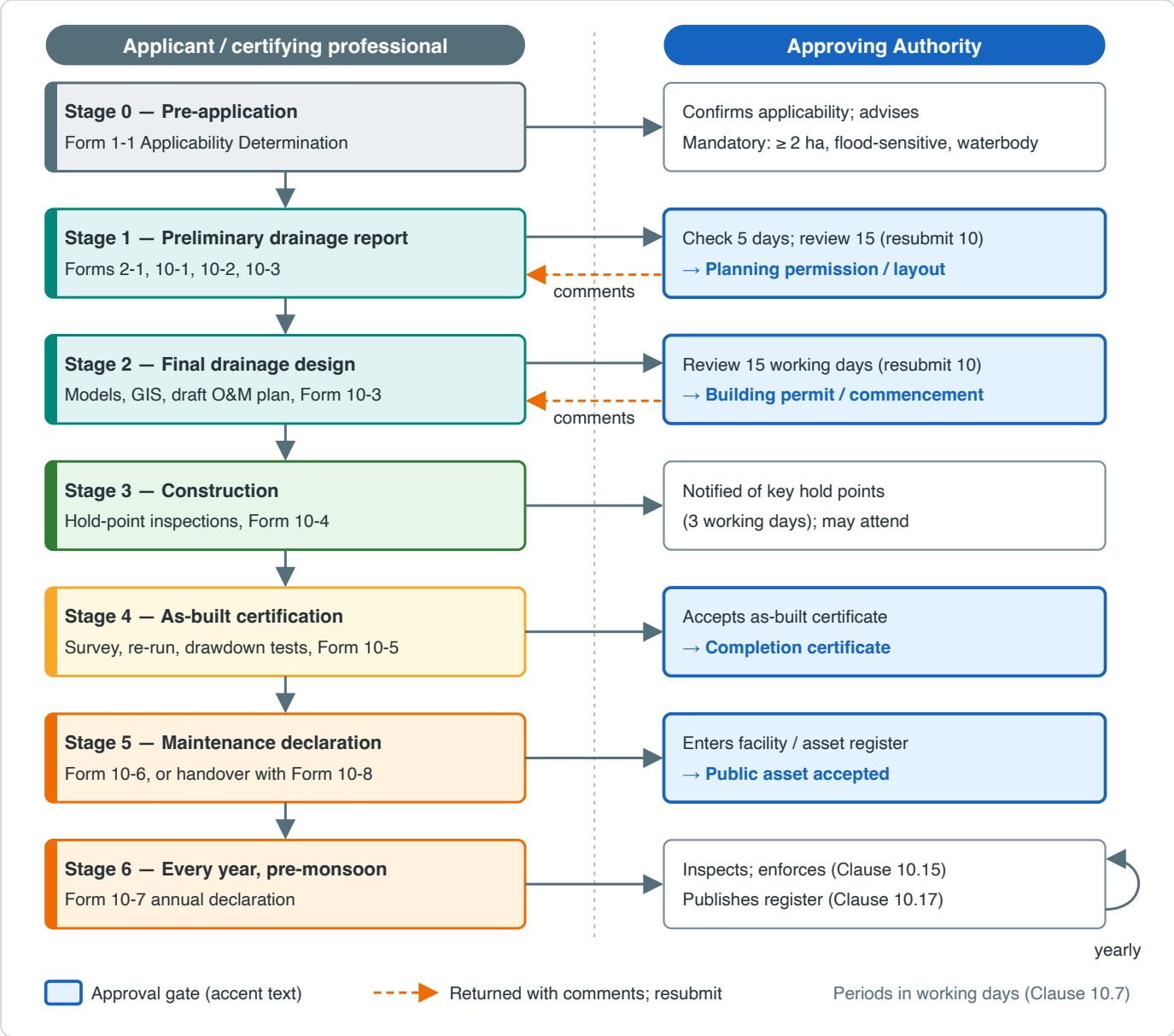

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **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 Bye-laws 2011 steps an Uttarakhand 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.

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 (44N east of 78° E, which includes Dehradun city, Mussoorie, Rishikesh, Haridwar and all of Kumaon, and 43N west of 78° E, which includes Roorkee, Vikasnagar, Herbertpur, Chakrata, Selaqui and Prem Nagar; the meridian of 78° E passes about 2.7 km west of the centre of Dehradun, and a project that crosses it uses one zone for all its layers and states which), 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 gauges on the receiving rivers, of the Irrigation Department's barrage, reservoir and canal levels, of the dam and barrage levels of THDC India Ltd and UJVN Ltd, of the PWD gauge at Tallital for Naini lake (read in feet on its own zero) and of the flood lines of notifications under the Uttarakhand Flood Plain Zoning Act 2012 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

Form	Title	Stage
2-1	Design Rainfall Sheet	1, 2
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. Uttarakhand has no notified design return period or design storm for its urban drains. The only stated basis is in ADB's climate risk assessment for the Uttarakhand Integrated and Resilient Urban Development Project (2021), which quotes the national consultants for the Dehradun drains: "a storm frequency of once in 2 years" for roadside drains in residential areas, "once in 5 years" for the primary and secondary channels, a minimum drain of 250 mm × 250 mm, velocities of 0.6–3.0 m/s and outfall inverts above the high flood level of the receiving water; it adds that the designs "do not include an allowance for climate change" and recommends drains that carry "10-20% more flow" (ADB, 2021). It is a project's basis for one city, not a State standard, and this Manual supersedes it. The integrated drainage works of Dehradun Smart City Ltd were built without the storm-water reuse its proposal promised (CAG, 2025), the drainage master plans that the Irrigation Department is preparing for Haldwani and the Kumaon towns have been reported without a design storm (as reported), and no design basis was found for the drains of Haridwar, Rishikesh, Roorkee, Rudrapur, Kashipur or the hill towns. The rainfall studies do not supply one either: the Dehradun panel of IMD's national IDF study (Das et al., 2022) repeats a generic curve and is not Dehradun data, and the regional equation of Ram Babu, Dhyani and Nirmal Kumar (2006) gives a 2-year 24-hour depth at Dehradun of about 63 mm against about 152 mm from the station record (ADB, 2021), and is not used. The bursts on record, 98 mm in an hour, 143 mm in 3 hours and 189 mm in 6 hours at the Dehradun self-recording gauge (1970) and 100 mm in an hour at Uttarkashi (1979), and the 24-hour records, 487.0 mm at Dehradun on 25 July 1966 (IMD), exceed what the drains were built for. The State's design values are therefore those of the CWC Flood Estimation Reports for subzone 1(e) in the plains and zone 7 (Western Himalayas) in the Doon and the hills, with the interim provisions of Chapter 2, and each submission must state its own design basis. Form 2-1 and Form 10-2 ensure that every design states its inputs.

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). An Uttarakhand calculator serves Tier B authorities in particular, where it may be the whole calculation.

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 T&CP:

- (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 T&CP 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 Bye-laws 2011

registration and adds empanelment for the higher-risk cases. The 1 ha limit is set by this Manual.

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 T&CP 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 permission of the Flood Zoning Authority for any activity in the prohibited or restricted area of a reach notified under the Uttarakhand Flood Plain Zoning Act 2012 (s.12(3)), the approval of the Irrigation Department for a work on, or a discharge to, one of its rivers, embankments, barrages, reservoirs or canals, among them the Gaula barrage and the Baur, Haripura and Tumaria reservoirs, the consent of THDC India Ltd or UJVN Ltd for a work that drains to Tehri, Koteshwar or the Dakpathar or Asan barrage, the conditions of the Housing Department order of 2017 (revised 2023) for the banks of the Ganga in the hills, the permission of the Municipal Commissioner or Executive Officer to connect to a municipal drain or to build over one (Uttar Pradesh Municipal Corporation Act 1959 and Uttar Pradesh Municipalities Act 1916, as adapted in Uttarakhand, whose drain chapters were not read [TBC]), the no-objection of Peyjal Nigam on sewerage that bye-law 6.4(III), a floodplain notification or that order requires, the views of the Lake Development Authority, Nainital, and of the custodian of the Tallital sluices for a work that drains to Naini lake, the views or permission of the Uttarakhand State Wetland Authority or the Forest Department for a work in or next to a notified wetland, the Asan Conservation Reserve or a river bed outside municipal limits, which the High Court has held to be forest land, the consent of PWD, NHAI or NHIDCL for a discharge to a side drain, catch-water drain or culvert of one of their roads, the consent of the body that owns or runs the receiving drain where that body is not the Authority (for example UUSDA or Dehradun Smart City Ltd until its drains are 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.

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.

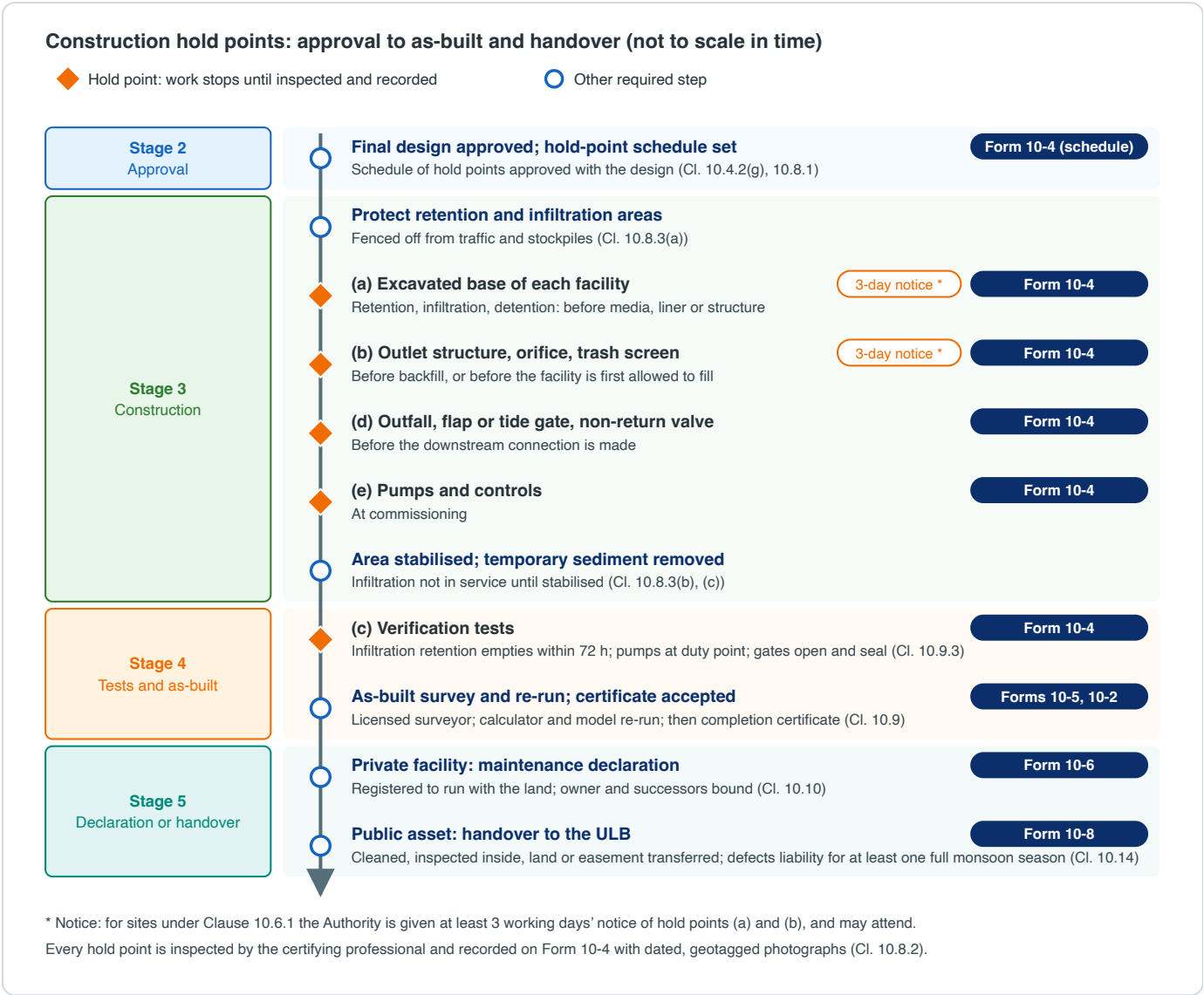

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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.

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.

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 May** 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 Uttarakhand because detention tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 31 May date is set by this Manual to fall before the south-west monsoon (June–September), when most Uttarakhand extreme rainfall occurs.

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. Uttarakhand has no dated State order fixing pre-monsoon desilting: the Chief Minister's direction that drains and canals be cleaned before 15 June (2024), a minister's call to clean them "at least twice before the monsoon" and the setting up of flood posts in every district before 15 June are known from the press, and USDMA's standard operating procedure, which is reported to fix a "monsoon session" of 5 June to 15 September, could not be read. The drains are run by several hands: the Nagar Nigams, Nagar Palika Parishads and Nagar Panchayats for the municipal drains; PWD for road drains, which in Dehradun's Paltan Bazaar were split between it and Dehradun Smart City Ltd, with electricity poles left standing in the drain line (CAG, 2025); UUSDA and

Dehradun Smart City Ltd for the drains they build until they are handed over; Peyjal Nigam for the interception and diversion structures on the raos and Jal Sansthan for their operation; and the Irrigation Department for the rivers, flood works and barrages. The gates that matter most are run by rules made for other purposes: the Tallital sluices of Naini lake by the Hill Slide Committee's rules of 1927, which limit their opening to protect the Balia ravine, with the operation reported moved from PWD to the Irrigation Department in 2018; and Tehri, whose moderation of the flood of June 2013 was called a matter of chance, not design (as reported). No operating rule for any sluice, flap gate, interception structure or pumping station in an Uttarakhand town, linking it to a river stage, a barrage 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.

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 May)	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 Uttarakhand, the pre-monsoon inspection of sluices, flap gates, non-return valves, debris racks, sediment traps, debris basins, culvert inlets and pumped facilities, including the sluices and gates on outfalls to barrage ponds, reservoirs and taals and on outfalls that the Ganga, the Solani, the Song, the Gaula, the Kosi or the Sarda can close, with the desilting and the clearance of boulders and debris from every drain, inlet, rack, trap, basin and culvert and the pump duty and gate seal tests, shall be completed by **31 May**; inlets, trash and debris racks, culverts, outfall gates and pumped facilities, with their standby generators, shall be certified ready by **15 June**, before the normal onset of 20 June at Dehradun, with every gate on an outfall to a river, barrage pond or taal operated through its full travel. Pumps, their standby power and the gates shall then be kept on monsoon standby, with the monthly test run, until **31 October**, after the normal withdrawal of 25 September to 1 October, because the storms of 9 October 1956 and 18–19 October 2021 were among the largest on record in Kumaon, and at an outfall to a river regulated by a dam or barrage upstream until the releases have ended and the river at the governing gauge has fallen below its danger level where one is published, if that is later. In the hill area of bye-law 2.3 of the Bye-laws 2011, every public drain, inlet, debris rack, sediment trap, debris basin and culvert shall be

cleared a second time, of the sediment and debris of the monsoon, by **15 October**. In towns above about 1,500 m, inlets, gratings, catch-water drains and culvert entrances shall be kept clear of snow and ice from **December to March**, and checked after every snowfall and every winter storm.

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).

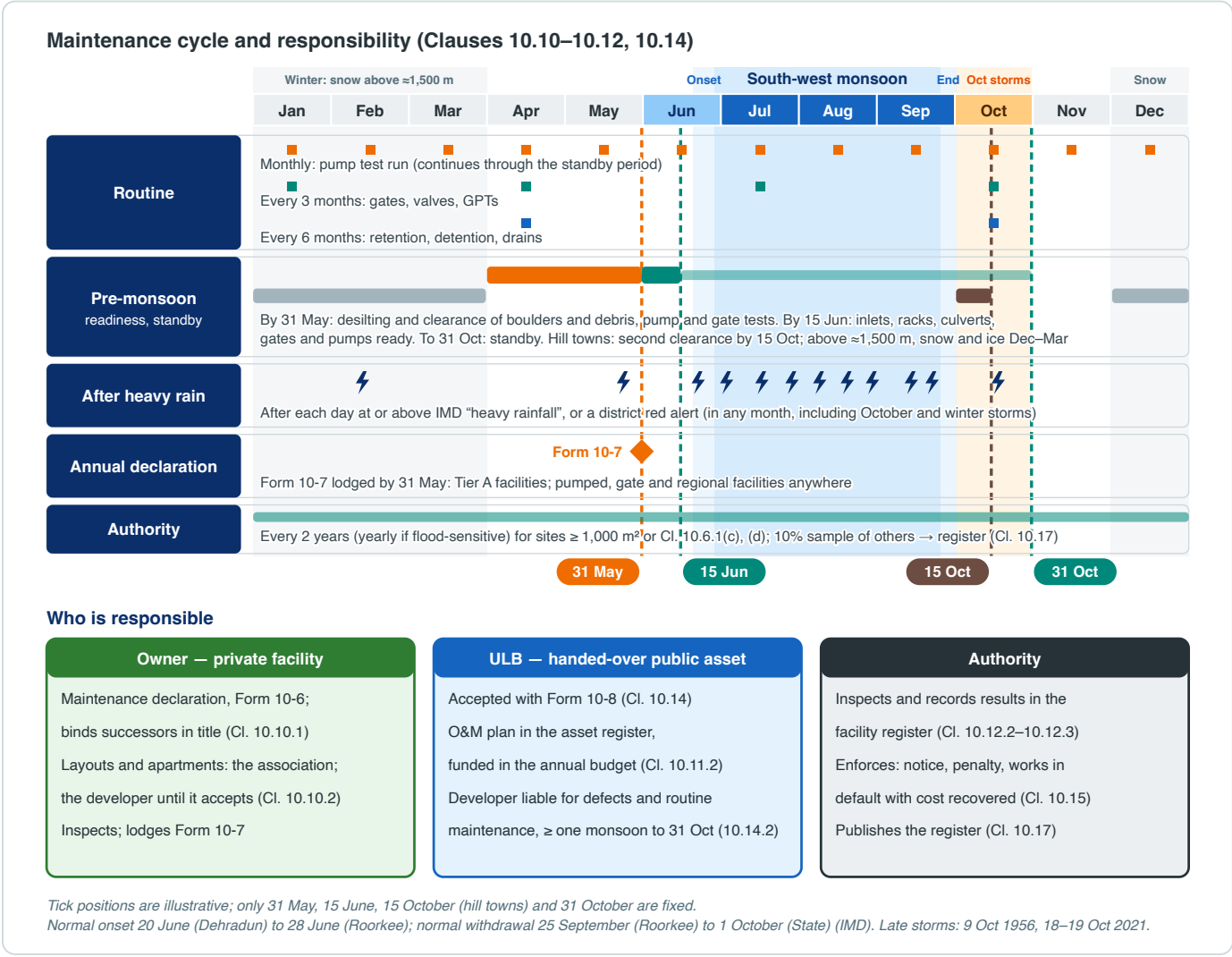

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 May) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the south-west monsoon (June–September); 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 May deadline is set by this Manual for the onset of the south-west monsoon in the second half of June: the new normal onset is 20 June at Dehradun and 28 June at Roorkee, and the monsoon covers the State by about 30 June (IMD, 1961–2019 normals); it covered the whole State on 28 June in 2024 and 24 June in 2025 (IMD). Large falls come in June and before it: 350.5 mm at

Ranikhet on 16 June 1970, 98 mm in an hour at the Dehradun self-recording gauge in June 1970, the storm of 15–17 June 2013 that destroyed Kedarnath, and 208.3 mm at Nainital on 31 May 1956 (IMD; WIHG). No dated State or municipal order fixing a deadline for desilting was found, only a direction to clean drains before 15 June and a monsoon period of 5 June to 15 September in USDMA's procedure, both known from the press; this Manual takes 31 May for desilting and debris clearance, the pre-monsoon inspection and the annual declaration. NDMA (2010) sets 31 March for pre-monsoon desilting nationally; this Manual allows until 31 May so that dry-season work can be finished. Inlets, racks, culverts, gates and pumps must in addition be certified ready by 15 June, before the earliest normal onset. The normal withdrawal is 25 September at Roorkee and 27 September at Dehradun, and the State is clear by about 1 October (IMD; the Meteorological Centre Dehradun gives 30 September), but October brings the largest storms of Kumaon, on 9 October 1956 and on 18–19 October 2021, when 403.9 mm fell at Pantnagar and 340.8 mm at Mukteshwar in 24 hours (IMD, as reported), and 315.0 mm fell at Kashipur on 2 October 1954 and 291.0 mm at Ramnagar on 14 October 1985 (IMD); pumps and gates are therefore kept on standby to 31 October (Figure 10.3). Hill drains fill with sediment and debris during the season, so in the hill area a second clearance is made by 15 October, the date on which the sluices of Naini lake are sealed. Winter storms of western disturbances bring snow above about 1,500 m and falls of 100–200 mm in a day, 192.0 mm at Mukhim in February 1979 and 210.0 mm at Naitwar in February 1986 (IMD), so inlets in the higher towns are kept clear of snow and ice from December to March. The post-event inspections of Table 10.3 cover storms at any time of year.

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 Uttarakhand cities make a fixed width hard to apply to every site, so this Manual sets functional requirements. Annex 10C covers maintenance access dimensions.

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 15 June 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 Uttarakhand drainage show up only in the first SW monsoon.

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.

Step	Action
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 Uttarakhand Building Construction and Development Bye-laws 2011 are made and from the municipal Acts. The graduated steps are set by this Manual. In Uttarakhand the courts and the National Green Tribunal have become the working regulators of the raos, lakes and floodplains. The High Court, on a petition against encroachment on "water bodies and khalas/storm water drains" in the Rajpur area of the Doon, recorded a survey of 37.93 ha of encroached river bed in Dehradun tehsil and 57.4 ha in Vikasnagar, held the river beds outside municipal limits to be forest land, made the Municipal Commissioner personally responsible for removal within them and asked for weekly reports with photographs (*Urmila Thapa v. State*, WPPIL 58/2019, August 2022); it has heard the Gaula at Haldwani (*Ravi Shankar Joshi v. State*, WPPIL 178/2013), stopped construction on the Sukhatal lakebed that recharges Naini lake (2022, as reported) and upheld the relocation of families living in the dry bed of the Rispana as rehabilitation from flash floods (*Rajeshwari Yadav Gupta v. State*, WPMS 739/2026, 1 April 2026). On the Rispana the Tribunal directed the Chief Secretary to remove encroachments from its floodplain (16 December 2024), an order the Supreme Court held in abeyance (10 February 2025), and on 18 August 2025 recorded 89 encroachments on Nagar Nigam land and 413 on MDDA's, most of them older than 11 March 2016, and the final floodplain notification of 5 May 2025 (OA 417/2022); NMCG has since counted 330 structures in the river's 1-in-5-year flood zone and issued notices under the Environment (Protection) Act (2026). The statutes carry limited powers: the Flood Plain Zoning Act fines a breach up to ₹500 (s.13) but lets the Flood Zoning Authority order an unauthorised obstruction removed at the owner's cost (s.24), and the Uttarakhand Special Provisions for Urban Local Bodies and Authorities Act 2018 bars the eviction of settlements that existed before 11 March 2016, a moratorium extended in 2025 (as reported in the High Court's judgment of 2026). Rainwater harvesting has been enforced case by case, as when MDDA ordered the systems of residential projects put right within a week and recharge pits built where approved plans showed systems that were never built (2024, as reported). This shows that a rule without routine enforcement does little, and that where the State has not drawn a line on the ground the courts and the Tribunal have. Professional accountability (step 6) is often more effective than fines on owners, because it acts on the person who signs the design.

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 (the Ganga at Haridwar or Rishikesh, the Song at Satyanarayan, the Solani at Roorkee, the Gaula at Kathgodam, the Kosi at Ramnagar, the Sarda at Banbasa, or the Alaknanda, the Bhagirathi or the Mandakini at the CWC site nearest a valley town) or of the receiving barrage pond, reservoir or taal, with the level of Naini lake on the Tallital gauge and the openings of its sluices, and, where it is gauged, at the outfall, each on a named datum, with any reading of a local gauge kept apart from the CWC levels; for an ungauged rao or gadhera, the flood marks surveyed after the event and the debris and boulders deposited at crossings; the state of every sluice, flap gate, debris rack, sediment trap, debris basin, interception and diversion structure and pumping station on the outfall and on the drain upstream of it, with the volume of debris removed from each, the hours each pump ran and any loss of power; and the gate openings and releases of any dam or barrage that sets the receiving level, such as Tehri and Koteshwar, the Pashulok and Bhimgoda barrages, the Dakpathar and Asan barrages, the Gaula barrage, the Kosi barrage at Ramnagar or the Banbasa barrage;
- (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), USDMA, 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. Uttarakhand's disasters have been studied more than its town floods. The Kedarnath disaster of June 2013 was examined by scientists, who recorded 325 mm in 24 hours at the Chorabari glacier camp before the lake above Kedarnath emptied in minutes on 17 June (Dobhal et al., 2013), while Dehradun recorded 370.2 mm on 17 June (IMD); the rock and ice avalanche at Raini on 7 February 2021, which turned into a debris flow without any rain (Shugar et al., 2021), and the subsidence of Joshimath in 2023, in which experts named poor drainage and blocked water paths among the causes (as reported), were reviewed by national institutes whose reports were not found. The CAG found that 508 flood-protection works over 74 km were damaged in 2013, that only 45 of the 77 sanctioned had been completed, and that there was no third-party check of their quality (Report No. 2 of 2018). The town floods have no such record. On 18–19 October 2021 Pantnagar, Nainital and Mukteshwar broke their 24-hour records, Naini lake overflowed and the approach to the Gaula bridge at Haldwani collapsed (as reported); on 14 August 2023 Dehradun recorded 175.1 mm (IMD); and on 15–16 September 2025 Sahastradhara recorded 264 mm in 24 hours, which IMD said was not a cloudburst, and the raos of Dehradun carried away bridges and culverts and damaged 83 interception structures (as reported). No review of any flood event in an Uttarakhand town, and no record of flood extents, depths or durations kept by any Nagar Nigam, development authority or USDMA, was found, and final tolls for the events of 2021 and 2025 were not published. 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.

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. Some of Uttarakhand's drainage records are public: the compiled Bye-laws 2011 (labelled a draft compilation on MDDA's website) and the amendment notifications on UHUDA's; the Unified Zoning Regulations 2025; the Flood Plain Zoning Act 2012 and the Irrigation Department's status of floodplain zoning, filed with the National Green Tribunal; the O&M manuals of the Dakpathar and Asan barrages (UJVN Ltd) and the Irrigation Department's sheets for the Gaula barrage and the Baur, Haripura and Tumaria reservoirs; ADB's project documents for the Dehradun drains; the CAG's audits; IMD's *Climate of Uttarakhand* and the monsoon reports of the Meteorological Centre Dehradun; NIH's water balance of Naini lake; and the State Wetland Authority's status report on wetlands. Much else could not be found in the public domain: the Bye-laws as gazetted and the 2015 notification; the Uttarakhand texts of the drain chapters of the municipal Acts; the Flood Plain Zoning (Amendment) Act 2024, the Rules approved in 2026 and the Rispana notification of 2025; the drainage clauses of any master plan; the design basis of any storm drain, including the Irrigation Department's master plans for Haldwani and the Kumaon towns; CWC's site sheets and gauge datums; the datum of the Naini lake gauge; USDMA's operating procedures; the operating rules of the State's dams, barrages and sluices; and an inventory of the gates, racks, interception structures and pumping stations 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.

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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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
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Form 10-3	Professional Design Certificate
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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, taal 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. Uttarakhand's towns have drainage projects and plans, but no published storm-drainage master plan with a design storm. In Dehradun, ADB's Uttarakhand Integrated and Resilient Urban Development Project is building at least 117 km of storm drains "factoring potential climate risks", with outfalls to the Bindal and to the Harrawala, Nakraunda, Kaunwala and Natthanpur nalas whose inverts are to stand above the high flood level of the receiving water, but its stated basis is a 2-year storm for roadside drains and a 5-year storm for the main channels, with no allowance for climate change (ADB, 2021–22); that is practice, and this Manual supersedes it. Dehradun Smart City Ltd's integrated drainage work, of about ₹17 crore, built new drains without the storm-water reuse its proposal had promised (CAG, 2025). The Rispana and Bindal are being "rejuvenated" piecemeal: 187 of the 208 drains reaching the Rispana have been intercepted and diverted to sewage treatment plants (Peyjal Nigam, 2025), the Rispana's floodplain was finally notified on 5 May 2025, and an elevated road of about 26 km is proposed along the two rivers, whose piers the cabinet has allowed in their flood zones (as reported). In Kumaon the Irrigation Department, not the local bodies, is preparing drainage master plans: a committee under the Kumaon Commissioner endorsed plans for seven towns, among them Bageshwar, Pithoragarh, Tanakpur and Banbasa, in April 2026, and Haldwani's plan, of about ₹1,003 crore, with a first phase approved in principle, lines the Rakasia and Kalasia nalas and adds pumping stations in low-lying areas, within a Kumaon-wide programme of about ₹3,394 crore for 15 towns (as reported, April and August 2026); no design storm for them has been published. The Haridwar–Roorkee master plan was reported in February 2026 to await the disposal of objections, and the works for the Kumbh of 2027 include drainage without a storm-drainage plan. No published document sets a design return period for the storm-drain network of any Uttarakhand 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 the Housing Department, the Urban Development Department, T&CP, UHUDA, MDDA, HRDA, any Nagar Nigam, the Irrigation Department or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, raos and gadheras that carry boulders and debris onto the towns built on their fans and terraces, river beds and floodplains built over, as along the Rispana, where 330 structures were counted in its 1-in-5-year flood zone (NMCG, 2026), drains that end in rivers held high by barrages or in Naini lake, raos that carry sewage through interception structures that floods break, and single drains split between a Nagar Nigam, a development authority, PWD, Peyjal Nigam and the Irrigation Department, 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 Uttarakhand, the first mountain State in the series: to towns in three belts, the terai and Ganga plain of Haridwar, Roorkee, Rudrapur and Khatima, whose flat drains outfall to rivers held high by floods and barrages; the Doon and the bhabar fans of Dehradun, Rishikesh, Haldwani, Ramnagar and Kotdwar, crossed by raos and gadheras that are dry most of the year and carry boulders in flood; and the hill towns, Nainital, Mussoorie, Almora, Pithoragarh, Srinagar, Uttarkashi and Joshimath among them, built on slopes, fans and river terraces where landslides and debris flows decide more than the design storm; to a lake town, Nainital, whose every drain ends in Naini lake and whose lake drains only through sluices limited by rules that protect the slope below; to river beds built over, as along the Rispana and the Bindal, and raos that carry sewage through interception structures that the floods of September 2025 broke; to drains vested in the Nagar Nigams beside raos whose beds are forest or revenue land and whose floodplains are the Irrigation Department's; to a State that has a floodplain zoning law and has notified some 615 km of the Ganga system in the hills and the Rispana, but no design return period for the drains of any town; to springs that supply the hill towns and slopes that infiltration can destabilise; and to a monsoon whose recorded days, 487.0 mm at Dehradun in July 1966 and 403.9 mm at Pantnagar in October 2021 (IMD; as reported), exceed the 100-year depths of the CWC plates there, and whose worst floods in the high valleys, Kedarnath in 2013, Raini in 2021 and Dharali in 2025, were debris flows and outbursts that no drain can carry, so that in the high mountains a BSMP begins with the hazard, not the storm (Clause 11.3.3).

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.
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.

Term	Meaning in this Manual
Capital Improvement Programme (CIP)	The ranked, costed list of works in a BSMP (Clause 11.8.4).

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 Uttarakhand town. For the urban areas where the evidence identifies them, the basins are at least the following:

- **Dehradun, Rispana and Bindal:** the catchments of Dehradun that drain to the **Rispana** and the **Bindal** through their khalas, from the hill slopes above Rajpur to their meeting, with the interception and diversion structures on their drains and the sewage treatment plants at **Mothrowala** in the 1D network (Clause 8.9.5), the final floodplain notification of the Rispana (5 May 2025) and the 1-in-5-year line that NMCG has asked for shown, and the 1% AEP level of the ungauged raos, with sediment and debris, as the boundary condition;
- **Dehradun east and Doiwala, Song and Suswa:** the catchments that drain to the **Song** and the **Suswa**, with the level at CWC's **Satyanarayan** site on the Song (warning 337.2 m, danger 338.2 m, high flood level 338.49 m) as the boundary condition;
- **Dehradun west and Vikasnagar, Tons and Asan:** the catchments that drain to the **Tons (Tamsa)** and the **Asan**, with the pond of the **Asan barrage** (maximum pond level 401.50 m), which is also the Asan Conservation Reserve, as the boundary condition;
- **Rishikesh:** the catchments that drain to the **Ganga** through the **Chandrabhaga**, the **Rambha** and the town drains, with the level at CWC's Rishikesh site (danger 340.5 m, high flood level 341.72 m), the releases of **Tehri** and **Koteshwar** and the pond of the **Pashulok** barrage as boundary conditions, and the floodplain lines of the Irrigation Department shown;
- **Haridwar:** the catchments that drain to the **Ganga** at and below the **Bhimgoda** barrage and across the **Upper Ganga Canal**, with the level at CWC's Dudhia Band site (danger 294.0 m, high flood level 296.30 m) as the boundary condition and the outfall-closed case a design case;
- **Roorkee:** the catchments that drain to the **Solani**, with the level at CWC's Roorkee site and the crossings of the Upper Ganga Canal in the 1D network, and the outfall-closed case a design case;
- **Haldwani, Gaula:** the catchments of Haldwani and Kathgodam that drain to the **Gaula** through the **Rakasia** and **Kalasia** nalas, with the Irrigation Department's drainage master plan as the starting point, the **Gaula barrage** pond (maximum pond level 510.750 m, high pond level 513.250 m) upstream and the high flood level at **Kathgodam** (498.93 m) as boundary conditions, and the low-lying areas where pumping is proposed modelled with the outfall closed;
- **Nainital, Naini lake:** the catchment of **Naini lake**, 4.7 km² with the lake and the Sukhatal sub-basin (NIH), with the lake as storage, the **Tallital** sluices and their rules as the outlet, the recharge flat of **Sukhatal** kept open, and the **Balia Nala** below the sluices shown as a landslide hazard;
- **Rudrapur, Kichha and Kashipur:** the terai catchments that drain to the **Kalyani**, the **Kichha** and the **Dhela**, with the Baur, Haripura and Tumaria reservoirs and the Dhela barrage as boundary conditions where they reach them;
- **Ramnagar:** the catchments that drain to the **Kosi** below the Ramnagar barrage, with its high flood level (220.75 m or 220.95 m; conflict stated) as the boundary condition;
- **Banbasa, Tanakpur and Khatima:** the catchments that drain to the **Sarda**, with the level at the **Banbasa** barrage (danger 223.3 m, high flood level 224.9 m) as the boundary condition; and

- **valley towns, among them Srinagar, Rudraprayag, Uttarkashi and Joshimath:** the catchments of the town and of every gadhera that crosses it, with the high flood level of the river at the nearest CWC site (Srinagar 537.9 m, Rudraprayag 634.85 m, Uttarkashi 1,124.13 m, Joshimath 1,388.65 m) as the boundary condition, and the debris fans, landslide and creep zones above the town mapped.

Hazard first in the high mountains (set by this Manual). In sub-area UK-F (High Himalaya and snow-fed) of Annex 2A, and in any basin with a glacier, a glacial lake or a mapped debris-flow fan above it, the BSMP begins with a hazard screening for glacial-lake outbursts, debris flows and landslide dams, made with USDMA, ULMMC and CWC's glacial-lake monitoring, and uses site-specific hydrology in place of the zone-7 report (Clause 2.3.6(i)); the hazard zones are shown on the 1% AEP map, no drain, storage or pumping station is sited in them, and no work in the CIP is sized to carry a debris flow or an outburst. Other Tier A bodies, among them Kotdwar, Almora and Pithoragarh, shall define their basins in the first BSMP that covers them. Where the Irrigation Department, CWC, THDC India Ltd, UJVN Ltd, the Lake Development Authority or a court has a high flood level, a pond or lake level, a floodplain line or an operating rule for a dam, barrage, sluice or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

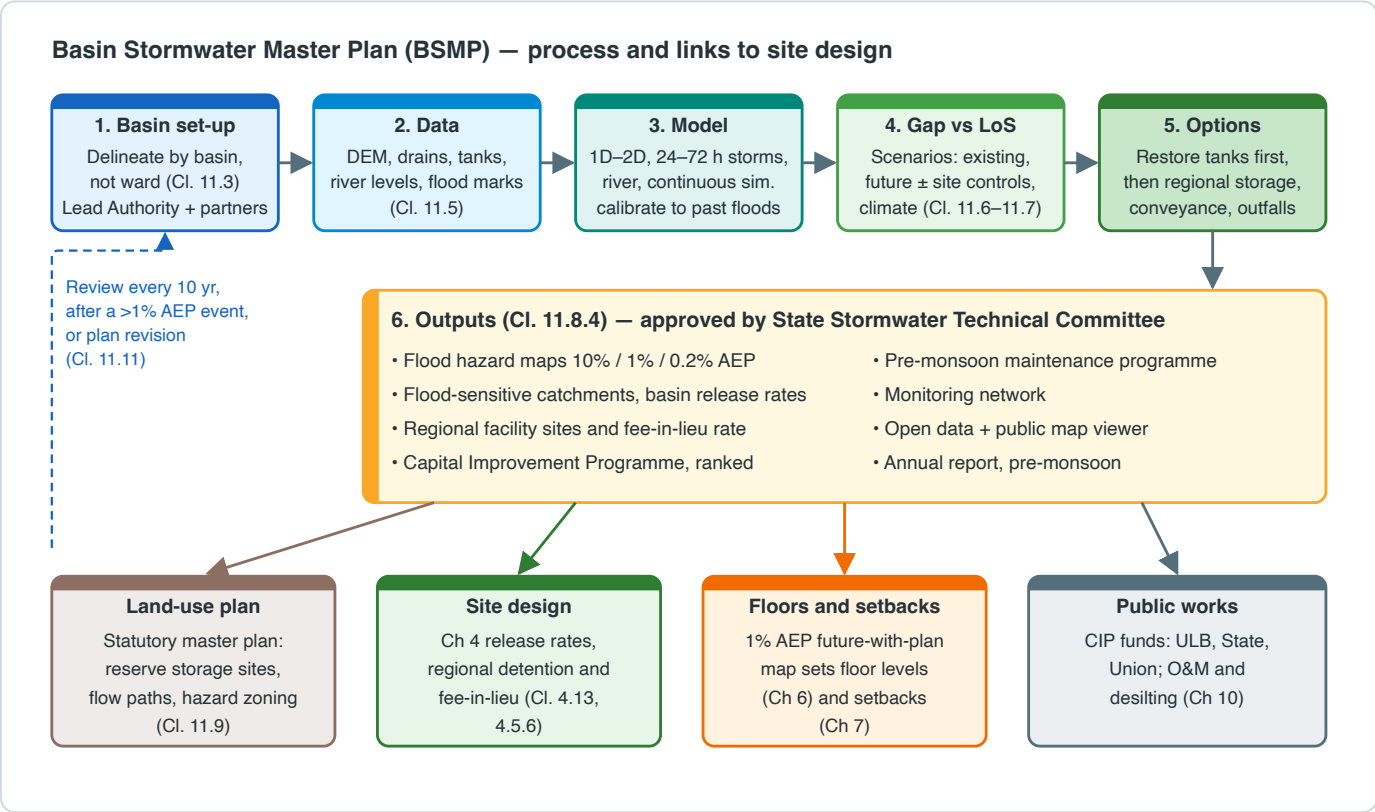


Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

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 Uttarakhand a single rao passes through many hands on its way to a river. In Dehradun the beds of the Rispana and the Bindal outside municipal limits are forest land (High Court, 2022); their floodplains are zoned by the Irrigation Department under the Flood Plain Zoning Act; the interception and diversion of the 208 drains that reach the Rispana, and the sewers behind them, are Peyjal Nigam's (2025); the drains in the town vest in the Nagar Nigam under the adapted Municipal Corporation Act; encroachments on the floodplain are counted separately by the Nagar Nigam, MDDA, the Nagar Palika Parishad of Mussoorie and the District Magistrate (National Green Tribunal, 2025); the drains built under ADB's project and the Smart City Mission are UUSDA's and Dehradun Smart City Ltd's until they are handed over; and the road drains are PWD's. No rule divides the raos and natural nalas from the municipal drains (as this Manual reads the record). The raos carry

sewage across these boundaries: the Rispana, the Bindal Rao, the Rambha at Rishikesh and the Kalyani at Rudrapur are among the "rivers reported as drains" (CPCB, as quoted, 2026), and statewide 70 drains were untapped in 2025. This clause makes the basin the planning unit, so that one model carries each rao from its head on the hill to the river whoever owns each reach, and so that the interception works are tested against the capacity of the raos they tap (Chapter 8, Clause 8.9.5).

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of a town with a Nagar Nigam: the **Nagar Nigam** (in Dehradun, **DMC**; elsewhere the Nagar Nigams of Haridwar, Rishikesh, Roorkee, Kotdwar, Srinagar, Haldwani, Rudrapur, Kashipur, Almora and Pithoragarh, as reported [TBC]), in which the public drains vest under the Uttar Pradesh Municipal Corporation Act 1959 as adapted in Uttarakhand, jointly with the development authority of its area, **MDDA** for Dehradun, Mussoorie and Rishikesh, **HRDA** for Haridwar and Roorkee, or the district development authority, which prepares or carries the master plan into which the BSMP is taken (Clause 11.9); either may prepare the plan as the Urban Development Department and the Housing Department direct. Where the **Irrigation Department** has prepared, or is preparing, a drainage master plan for a town, as for Haldwani and the Kumaon towns, it is a joint Lead Authority with the local body, and its plan is brought up to this chapter as the first BSMP. Where a basin extends beyond the Nagar Nigam, the other local bodies and development authorities in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the raos and natural nalas from the municipal drains, or the drains of the local bodies from the rivers, barrages 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: the **Irrigation Department** for the rivers, raos and gadheras with their beds, banks and floodplains, for flood works, for floodplain zoning under the Flood Plain Zoning Act 2012 and for its barrages, reservoirs and canals, among them the Gaula barrage and the Baur, Haripura and Tumaria reservoirs; **THDC India Ltd** for Tehri and Koteshwar and **UJVN Ltd** for the Dakpathar and Asan barrages, for their pond levels and releases; the **Forest Department** as owner of the river beds outside municipal limits; the **Nagar Nigam**, **Nagar Palika Parishad** or **Nagar Panchayat** for the drains and nalas vested in it; **MDDA**, **HRDA**, a district development authority, **UHUDA** or a colony developer for the drains of their schemes, and **UUSDA** and **Dehradun Smart City Ltd** for the drains they build, until handed over in writing; **PWD** for the side drains, catch-water drains, scuppers and culverts of the State roads and hill roads, and NHAI, NHIDCL and BRO for theirs; **Peyjal Nigam** and **Jal Sansthan** for the sewers and the interception and diversion structures on the drains and raos; the **Lake Development Authority, Nainital**, with the custodian of the Tallital sluices [TBC], for Naini lake and its catchment; the **Uttarakhand State Wetland Authority**, with the Forest Department, for notified wetlands and the Asan Conservation Reserve; and **USDMA** and **ULMMC** for the mapping of landslide, debris-flow and glacial-lake hazards that a BSMP must show.
- In Tier B bodies: the Lead Authority is named by the Urban Development Department. Basins draining to a common river reach, barrage pond or taal may be grouped into one district-level plan.

USDMA, ULMMC and the district administration shall be consulted on every BSMP; the Lake Development Authority on every BSMP in the catchment of a Kumaon lake; the Uttarakhand State Wetland Authority on every BSMP whose basin drains to a notified wetland or the Asan Conservation Reserve; the Uttarakhand Environment Protection and Pollution Control Board and the State Mission for Clean Ganga on every BSMP that proposes works on a drain or rao that carries sewage to the Ganga system; and, for a basin whose outfall lies on a river or canal shared with Uttar Pradesh, such as the Ganga and the Upper Ganga Canal below Haridwar or the Solani below Roorkee, the irrigation department of that State, through the Irrigation Department.

The Irrigation Department 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.

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, taal, 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, raos, barrages, reservoirs and taals	The datum of every level named; outfall invert levels against the warning, danger and high flood levels of the receiving river at the nearest CWC site and its recorded peaks (on the Ganga at Haridwar a warning level of 293.0 m, a danger level of 294.0 m and a high flood level of 296.30 m, dated 19 September 2010 in one source and 17 June 2013 in another; at Rishikesh 339.5 m, 340.5 m and 341.72 m; on the Song at Satyanarayan 337.2 m, 338.2 m and 338.49 m; on the Solani at Roorkee 260.5 m and 261.5 m, with a high flood level of 260.58 m; CWC levels as transcribed by SANDRP, as reported), with any local gauge kept as a separate series; for the ungauged raos and gadheras, surveyed flood marks and the 1% AEP flood level with its sediment and debris, and the 25-year and 100-year lines of any notification under the Uttarakhand Flood Plain Zoning Act 2012, with the 1-in-5-year line that NMCG has asked for on the Rispana; for outfalls to barrage ponds, reservoirs and taals, the maximum pond or water level, full reservoir level and spillway and gate data from the Irrigation Department, THDC India Ltd or UJVN Ltd (for example Tehri, full reservoir level 830 m and maximum water level 835 m; Dakpathar, maximum pond level 456.40 m; Asan, maximum pond level 401.50 m; the Gaula barrage, maximum and high pond levels of 510.750 m and 513.250 m; Baur and Haripura, full reservoir level 242.32 m), naming which is used; for Naini lake, the Tallital gauge (maximum level 12.5 ft, NIH; 12 ft in the press) tied to a level above mean sea level, the sluices and the rules of 1927 for opening them and the sealing date of 15 October; the release records of Tehri, Koteshwar and the barrages; the debris-flow fans, landslide and creep zones and glacial lakes above the basin, from USDMA, ULMMC and CWC's glacial-lake monitoring where mapped; and the sluices, flap gates, debris racks, sediment traps, debris basins, interception and diversion structures and pumping stations on the outfalls, with their capacities and operating rules

Data	Minimum requirement
Rainfall and levels	All available rain gauges (IMD, including its observatories at Dehradun, Roorkee and Mukteshwar (rainfall since 1901), its stations at Tehri, Mussoorie, Joshimath and Nainital, whose records end between 1980 and 2012, and the automatic weather stations and rain gauges reported by the Meteorological Centre Dehradun, among them Sahastradhara, Maldevta, Jolly Grant, Narendranagar, Kalsi and Didihat; the district and tehsil rain gauges of the State, whose records IMD tabulates in the *Climate of Uttarakhand*; the observatory at Pantnagar; the self-recording gauges at Dehradun, Nainital, Tehri and Uttarkashi used for the CWC Flood Estimation Report for zone 7; the rain and river gauges of CWC and of the Irrigation Department, including those at its barrages and reservoirs; the records of THDC India Ltd and UJVN Ltd at their dams and barrages; and any gauges kept by the Nagar Nigams, the development authorities, USDMA and Dehradun Smart City Ltd) and water-level records, including those for the 16–17 June 2013 (370.2 mm at Dehradun on 17 June, IMD), 18–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, with new high flood levels on the Gaula, the Kosi and the Sarda, as reported), 14 August 2023 (175.1 mm at Dehradun, IMD, with the Ganga above its danger level at Rishikesh, as reported) and 15–16 September 2025 (264 mm in 24 hours and 54 mm in an hour at Sahastradhara, with the raos of Dehradun in flood, as reported) 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
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 terai and on the Ganga plain at Haridwar and Roorkee, where slopes are gentle and the water table is near the surface, on the fans and river terraces of the Doon, Haldwani and the valley towns, where a raised road or a low wall can turn the overflow of a rao from one side of a fan to the other, and around Naini lake, where the 30 m line of bye-law 4.4(III) is drawn from the lake's maximum level, 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 16–17 June 2013 (370.2 mm at Dehradun on 17 June, IMD), 18–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, with new high flood levels on the Gaula, the Kosi and the Sarda, as reported), 14 August 2023 (175.1 mm at Dehradun, IMD, with the Ganga above its danger level at Rishikesh, as reported) and 15–16 September 2025 (264 mm in 24 hours and 54 mm in an hour at Sahastradhara, with the raos of Dehradun in flood, as reported) events are the best calibration data Uttarakhand has, and much of the evidence is held in photographs, news reports and residents' records that should be collected before it is lost.

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

Element	Minimum level of service
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 taal 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. Uttarakhand's storage is in its lakes, its floodplains and its recharge flats more than in tanks. Naini lake, 0.46 km² of water holding about 8.58 million m³ in a basin of 4.7 km², is the one urban taal whose water balance has been studied (NIH, 1998–99); about half of its subsurface recharge is estimated to enter through the Sukhatal zone of about 2 ha (NIH, as cited by NITI Aayog, 2018), on whose bed the High Court stopped construction in 2022 (as reported), and the lake fell to 4.7 ft on its gauge, a five-year low, in 2025 (as reported). Bhimtal, of about 47.8 ha, drains a catchment of about 17 km² (as reported). Bye-law 4.4(III) of the Bye-laws 2011 bars construction within 30 m of the bank or maximum level of every lake in the State, and the Unified Zoning Regulations 2025 put ponds, lakes, nalas and streams in a Conservation Use Zone. The Asan Conservation Reserve, 444.4 ha at the meeting of the Asan and the Yamuna canal behind the Asan barrage, is the State's only Ramsar site (2020); the State Wetland Authority, constituted in 2019, lists 192 wetlands from the national atlas but no wetland has been found notified under the Wetlands Rules 2017. In the hills the khals and chals, small ponds in the saddles of ridges, have been revived in places as recharge ponds (as reported). The losses are visible in the floodplains: about 95 ha of river bed found encroached in Dehradun and Vikasnagar tehsils (High Court, 2022) and the structures counted in the Rispana's active floodplain (NMCG, 2026). No survey of the storage of any taal other than Naini lake, or of any floodplain inside a Nagar Nigam, was found.

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.

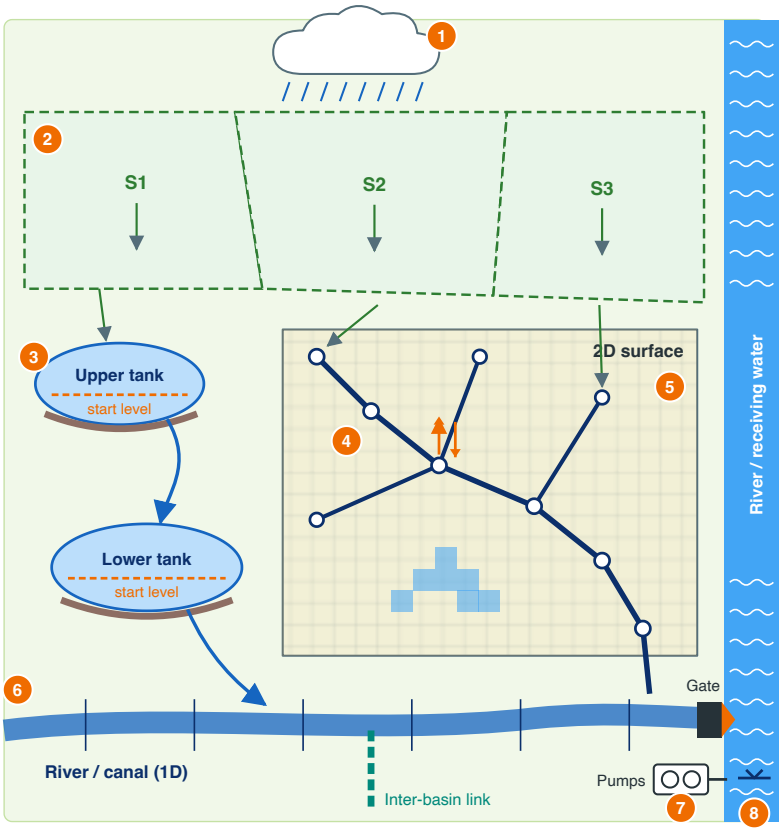
11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms 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 Uttarakhand has been adopted with a design factor; ADB's climate risk assessment for the Dehradun drains (2021) projects a mean rise in heavy daily rainfall of 10% (RCP4.5) to 16% (RCP8.5) by 2036–65 and recommends drains that carry 10–20% more flow, while noting that its own designs include no allowance; no significant trend in heavy-rain days has been found at Dehradun, Pantnagar, Tehri or Mukteshwar over 1983–2023 (Singh and Thapliyal, 2026); and station records, 487.0 mm at Dehradun on 25 July 1966 (IMD) and 403.9 mm at Pantnagar on 19 October 2021 (as reported), exceed the 100-year 24-hour depths of the CWC plates there (this Manual's reading), which is a reason to keep the factors, not to reduce them; in snow-fed basins of sub-area UK-F the climate scenario adds no rainfall factor, and the debris-flow and glacial-lake hazards of Clause 11.3.3 are mapped instead.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the 16–17 June 2013 (370.2 mm at Dehradun on 17 June, IMD), 18–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, with new high flood levels on the Gaula, the Kosi and the Sarda, as reported), 14 August 2023 (175.1 mm at Dehradun, IMD, with the Ganga above its danger level at Rishikesh, as reported) and 15–16 September 2025 (264 mm in 24 hours and 54 mm in an hour at Sahastradhara, with the raos of Dehradun in flood, as reported) events where data exist.

BSMP model: elements required by Clause 11.7 (schematic, not to scale)



1 **Design rainfall**
Ch. 2 storms incl. 24, 48, 72 h; 50%, 10%, 1%, 0.2% AEP; areal reduction (Cl. 2.7.3, 11.7.2)

2 **Sub-catchments**
Runoff by Ch. 3 methods; land use for each scenario (a)–(e) of Cl. 11.7.4

3 **Tanks and ponds**
Surveyed FTL, MWL, stage–storage, sluices, surplus weirs (Cl. 11.5.1); start level from continuous run (Cl. 3.13.5, 11.7.3)

4 **1D drain network**
Minor system: drains, pipes, culverts with surveyed inverts and silt (Cl. 11.5.1)

5 **2D surface**
Major (overland) system on the DEM, 0.15 m RMSE or better; exchange with 1D at inlets and manholes

6 **Rivers and canals (1D)**
Sections ≤ 200 m apart and at every structure; diversions between basins mapped (Cl. 11.3.2)

7 **Outfall**
Sluices, flap gates and pumps; joint and outfall-closed cases of Ch. 5

8 **Downstream boundary**
River (CWC or UKID gauge) or lake level (MWL or FTL + surcharge), per Ch. 5

Calibrate and validate with at least two major past flood events where data exist (Cl. 11.7.5).

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 taals 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:** taals, 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 to the Ganga at Haridwar and Rishikesh, the Solani at Roorkee, the Song, the Gaula, the Kosi and the Sarda, with storage or pumping behind them where a river in flood or a barrage pond can close an outfall, as the Irrigation Department is reported to propose for the low-lying parts of Haldwani; debris racks, sediment traps and debris basins where raos and gadheras from the hills enter the towns, with ramps for the machines that empty them; drop structures, chutes, energy dissipators and protected outfalls where steep drains reach a rao or river; interception and diversion structures that take the dry-weather flow of the drains of the Rispana, the Bindal and the Ganga to the sewage treatment plants without taking their storm capacity, rebuilt above the 25-year flood line where they can be; the Tallital sluices of Naini lake, whose operation is limited by the rules that protect the Balia Nala below; and the operating rules of Tehri, Koteshwar and the barrages that set the receiving levels, agreed with the Irrigation Department, THDC India Ltd and UJVN Ltd;
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 Dehradun, CWC flood forecasts and river stages at its sites, among them the Ganga at Rishikesh and Haridwar and the Song at Satyanarayan, notice of releases from Tehri, Koteshwar and the barrages at Pashulok, Bhimgoda, Dakpathar, Asan, Kathgodam, Ramnagar and Banbasa to the towns downstream, the sirens and the flash-flood and landslide monitoring that USDMA is reported to be installing, and the district emergency operation centres), 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 groundwater recharge on the Doon Gravels and the bhabar, which feed the artesian aquifers of the terai and include the semi-critical blocks of Bahadrabad, Bhagwanpur, Haldwani and Kashipur (CGWB, 2020 and 2022), the stability of hill slopes, where water put into colluvium, slide debris or moraine raises the pore pressure, as along the Balia Nala at Nainital and at Joshimath, the naulas and dharas that supply the hill towns and their recharge areas, the recharge of Naini lake through Sukhatal, the high water table of the terai, and the quality of the groundwater, with nitrate and arsenic at places in Haridwar and Udham Singh Nagar, and of the rivers, raos and taals that the runoff reaches (Chapter 8);
- effect on downstream basins and the receiving river, rao, taal or canal; 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 storage comes first because many of Uttarakhand's town outfalls are closed or limited in the wettest weeks, and because the storage left is in floodplains and lakes that the towns are filling. The Ganga at Haridwar and Rishikesh, the Song, the Solani, the Gaula, the Kosi and the Sarda have all stood near or above their danger levels in recent floods, and in October 2021 the Kosi at Ramnagar and the Sarda at Banbasa rose to new high flood levels (as reported). The raos once spread their floods over wide beds: the High Court recorded 37.93 ha of encroached river bed in Dehradun tehsil and 57.4 ha in Vikasnagar (2022), NMCG counted 330 structures in the Rispana's 1-in-5-year flood zone (2026), and the Flood Plain Zoning (Amendment) Act 2024 lets a final notification be narrowed where "riverbank development" can protect land and buildings (as quoted), which would trade floodplain storage for embankments. Conveyance alone has not served: ADB's Dehradun drains are built for the 2- and 5-year storms (ADB, 2021), and on 15–16 September 2025 the raos of Dehradun destroyed bridges, culverts and interception works (as reported). On a hill slope storage means a lined tank or a terrace, not a pond that soaks into the slope (Clause 8.8.1). The storms are large for drains with no stated design basis: IMD has recorded 487.0 mm in a day at Dehradun (25 July 1966), and 403.9 mm fell at Pantnagar on 19 October 2021 (as reported), above the 100-year 24-hour depths of the CWC plates there (this Manual's reading). Conveyance upgrades on their own move water faster to an outfall that the Ganga, the Solani, the Song, the Gaula, the Kosi or the Sarda in flood, or a barrage pond held at its maximum level, may close, to Naini lake, whose outflow is limited by the rules for its sluices, to a rao or gadhera whose bed and banks shift with the boulders and debris it carries, or to an outfall limited by the capacity of its sluice, interception structure or pumping station. Groundwater in Uttarakhand calls for recharge in one belt and for restraint in the others. The State's stage of extraction was 53.54% in 2024, with 16 of its 20 assessment units safe and 4 semi-critical (CGWB, 2024); in 2020 and 2022 the semi-critical blocks were Bahadrabad and Bhagwanpur in Haridwar district, Haldwani and Kashipur, all on or below the bhabar. The Doon Gravels and the bhabar fans take water readily, with hydraulic conductivities of 13–583 m/day in the Doon and water 40–75 m below ground in the bhabar of Nainital district (CGWB), and they feed the terai, where more than 2,000 artesian wells were counted in five blocks of Udham Singh Nagar and the water stands 1–7 m below ground (CGWB), so recharge there adds to waterlogging. In the hills about 85% of the State is hard rock (CGWB), the springs supply most of the drinking water in many blocks, about 70% in Chamoli and up to 84–87% in some blocks (GBPNIHE, 2019), and the functional springs of the Almora region have fallen from 360 to 60 over 150 years (NITI Aayog, 2018); but water put into a hill slope raises the pore pressure in its colluvium, as along the Balia Nala at Nainital (2022 study) and at Joshimath (2023, as reported). Quality limits recharge too: nitrate above 45 mg/l in about 17% of samples and arsenic above 10 µg/l in about 4%, in Haridwar and Udham Singh Nagar among other districts (CGWB, 2024). Uttarakhand has no groundwater law in force, the Act of 2016

having been repealed in 2017, and bye-law 6.5 credits recharge without regard to slope or water table. This is why recharge, slope stability, springs, waterlogging and groundwater quality 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 master plans and zonal plans approved by the State under the Uttar Pradesh Urban Planning and Development Act 1973, as applicable to and amended in Uttarakhand, among them those of the MDDA area and of Nainital and, when it is issued, the Haridwar–Roorkee master plan, with the Unified Zoning Regulations 2025 that form part of them; the plans of the district development authorities and of UHUDA's regulated areas; and the layouts and buildings permitted under them and under the Bye-laws 2011. 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. Uttarakhand draws more water lines by rule than most States, but not yet a drainage-flood line. Bye-law 4.4(III) of the Bye-laws 2011 keeps building at least 30 m from a river bank, 10 m from a spring, 5 m from a nala and 30 m from the bank or maximum level of every lake (the first two printed as "30.0–30.0" and "10.0–10.0" m, read here as single distances); bye-law 4.4(IV) bars building on natural slopes steeper than 30°, or 26.5° in Nainital, where landslides are likely to be severe and continuous, and within 250 m of a landslide-prone site; and the Unified Zoning Regulations 2025 put rivers, lakes, nalas and streams in a Conservation Use Zone with no new construction within 30 m of river and lake banks. The Flood Plain Zoning Act 2012 is the State's flood line: the Irrigation Department models the 25-year and 100-year floods, marks them on the revenue maps and the ground, and the final notification makes the first a prohibited and the second a restricted area; some 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini and the Rispana (5 May 2025) are finally notified, the Asan's notification was approved by the cabinet in June 2025 (as reported), and the Gaula, the Kosi, the Suswa, the Song, the Baldi and the Solani have been studied but not notified; an amendment of 2024 extends the period for notices to 24 months and allows a notification to be narrowed by "riverbank development" (as quoted), and Rules approved by the cabinet on 12 October 2026 have not been published. On the Ganga in the hills the Housing Department's order of 2017, revised in 2023, prohibits building within 100 m of the middle of the river or the 25-year flood line, whichever is wider, with a regulated zone of 200 m beyond, while the National Green Tribunal set 100 m from the edge of the river for Haridwar to Unnao until the floodplain is demarcated; the two are stated, not merged. NMCG now asks for the 5-year line as well. These are watercourse and river-flood lines, not drainage-flood lines: where a floodplain line is notified it governs; elsewhere the hydraulic corridor and setback zones of Chapter 7, with a Zone 1 of at least 15 m, and the bye-law lines of 30 m and 5 m apply, whichever is wider, as this Manual's proposal. A BSMP gives the master plans the 1% AEP drainage-flood map, including the raos and gadheras that no notification yet covers, 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 Bye-laws 2011 already require rainwater storage under bye-law 6.5, keep drainage and storage structures out of the ground coverage, and require the site plan of a sloping site to divert the uphill runoff away from the foundations (bye-law 4.4(V)(b)), and the Unified Zoning Regulations 2025 put rivers, lakes, nalas and streams in a Conservation Use Zone whose green buffer may be used for plantation, open space and parks, but no rule sets a detention or peak-runoff limit; 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 it is a lined tank or a shallow terrace, never an infiltration basin (Clause 8.8.1). Placing it on the flow path costs the developer nothing extra and gives the basin storage it would otherwise have to buy.

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.

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 SW monsoon (by 31 May). 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.

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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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 Uttarakhand 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).

Annex 1A — List of Tier A authorities, with the boundaries of the Nagar Nigams and of the development areas of the Mussoorie Dehradun Development Authority, the Haridwar Roorkee Development Authority and the district development authorities

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)	Dehradun Municipal Corporation (DMC)	1.6.1(a)
(b)	Every Approving Authority within the development area of MDDA, the Mussoorie Dehradun Development Authority, under the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, including MDDA itself and the Nagar Nigams of Dehradun and Rishikesh, the Nagar Palika Parishad of Mussoorie and the other local bodies of the area	1.6.1(b)
(c)	Every other Nagar Nigam constituted under the Uttar Pradesh Municipal Corporation Act, 1959, as adapted in Uttarakhand: Haridwar, Roorkee, Kotdwar, Srinagar, Haldwani, Rudrapur, Kashipur, Almora and Pithoragarh (eight Nagar Nigams in the CAG's count of 2021; the later ones as reported [TBC])	1.6.1(c)
(c)	HRDA, UHUDA and every district development authority constituted under the 1973 Act, among them the Haldwani–Kathgodam development authority (notified on 21 December 2016, as cited [TBC]), where it grants permission within the planning area of a Nagar Nigam	1.6.1(c)
—	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 Nagar Nigam and every development authority in the State, and of every Approving Authority within the development area of MDDA, 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 notified development areas and master plans of MDDA, HRDA and the district development authorities reorganised in 2016–17, and the former regulated areas held by UHUDA (the Housing Department, T&CP, UHUDA); the current list and boundaries of the Nagar Nigams, Nagar Palika Parishads and Nagar Panchayats (the Urban Development Directorate; the CAG counted 8 Nagar Nigams, 41 Nagar Palika Parishads and 42 Nagar Panchayats in 2021, and the later Nagar Nigams, among them Srinagar, Almora and Pithoragarh, were not verified for this Manual [TBC]); the hill area of bye-law 2.3 of the Bye-laws 2011 and the foothill zones that the boards are to fix under bye-law 2.3(1), which decide where the hill rules of this Manual apply; and the district and tehsil boundaries (Revenue 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 (Nagar Nigam / Nagar Palika Parishad / Nagar Panchayat / development authority / UHUDA / 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 Nagar Nigam and development-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.

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)	Dehradun's raos	The catchments of the Rispana, the Bindal, the Song, the Suswa and the Tons (Tamsa) and of their khalas within the development area of MDDA. The raos rise on the Mussoorie ridge and the Siwaliks, are ungauged and boulder-laden, and rise within an hour of a burst; the Rispana and the Bindal drain about 53–58 km² and 44 km² (as reported). Dehradun's observatory recorded 487.0 mm on 25 July 1966, Raipur (Dehradun) 487.5 mm on 2 August 1959 and the Dehradun recording gauge 98 mm in one hour on 14 June 1970 (IMD; CWC); on 15–16 September 2025 Sahastradhara recorded 264 mm in 24 hours and 13 bridges and 10 culverts were lost (as reported), and 83 sewage interception structures on the Rispana were damaged (Peyjal Nigam). The Rispana was finally notified under the Flood Plain Zoning Act on 5 May 2025, and the State has counted 330 structures in its 1-in-5-year flood zone (NGT, OA 417/2022)
(b)	Haridwar's low land on the Ganga	The low-lying land of Haridwar, Jwalapur and Kankhal that drains to the Ganga and its channels below the Bhimgoda barrage, whose outfalls are held up when the river is above its CWC warning level of 293.0 m (danger level 294.0 m; highest level 296.30 m, dated 19 September 2010 in one CWC record and 17 June 2013 in another, as transcribed by SANDRP); the Ganga stood near 295.7 m in 2013 and 2023 (as reported)

Item	Catchment	Extent as described in Chapter 4
(c)	Haldwani on the Gaula	The land of Haldwani–Kathgodam that drains to the Gaula and to the nalas that cross the town, among them the Rakasia and Kalasia nalas, at the foot of the wettest cell of the plates (50-year 24-hour depth about 400–440 mm). Haldwani recorded 413.0 mm on 11 July 1970 (IMD); the Gaula barrage passed 123,000 cusecs in 1993 against a design of 115,000 (Irrigation Department), the river reached 498.93 m at Kathgodam on 20 October 2021 and the Gaula bridge partly collapsed (as reported); the Irrigation Department's drainage master plan would line 10.25 km of the Rakasia and 1.55 km of the Kalasia and add pumping stations in low-lying areas (as reported)
(d)	Rudrapur–Kichha terai	The land of Rudrapur, Kichha and Pantnagar that drains to the Kalyani and the Kichha across the terai, where the water table is high, wells have flowed under artesian pressure and the outfalls are flat (CGWB). Pantnagar recorded 403.9 mm in the 24 hours to 08:30 on 19 October 2021, 1.77 times its previous highest day, and Rudrapur was flooded by the Kalyani then and again in August 2023; about 25,000 ha of farmland in Udham Singh Nagar was under water in July 2024 (IMD; as reported)
(e)	Nainital lake catchment	The whole catchment of Naini lake, about 3.49 km² with the Sukhatal basin of 0.75 km², which drains to a closed lake whose only outlet is five sluice gates at Tallital (1888), held to a maximum of 12.5 ft on the PWD gauge and sealed on 15 October under rules of 1927 that protect the Balia ravine below (NIH), and the land along the Balia Nala below the sluices. Nainital recorded 401 mm on 19 October 2021 and the lake rose to a record 12.2 ft and overflowed (IMD; as reported); the town's drain network was built after the landslip of 18 September 1880
(f)	Rishikesh on the Ganga	The land of Rishikesh, Muni-ki-Reti and Dhalwala that drains to the Ganga above the Virbhadra (Pashulok) barrage, or to the Chandrabhaga. The Ganga at Rishikesh has a danger level of 340.5 m and a highest level of 341.72 m (5 September 1995) and stood at 341.3 m in August 2023 (CWC, as transcribed by SANDRP; as reported); Narendranagar, above the town, recorded 396.0 mm on 27 July 1999 (IMD); the right-bank floodplain from the Dhalwala drain to Haripur Kalan is under a notice of intent under the Flood Plain Zoning Act (7 October 2020)
(g)	Valley-floor towns below debris fans	The land of a town built on a river terrace or valley floor below the fan of a gadhera or nala, such as Srinagar, Rudraprayag and Uttarkashi. The flood of 17 June 2013 set the highest levels of the Alaknanda at Srinagar (537.9 m) and Rudraprayag (634.85 m), 1.9 m and 7.85 m above their danger levels (CWC, as transcribed by SANDRP), and the debris flows of Maldevta (2022) and Dharali (5 August 2025) buried land below the fans of side streams (as reported)
(h)	Notified floodplain reaches	The land within, or draining directly into, the prohibited (25-year) or restricted (100-year) zone of a reach finally notified under the Uttarakhand Flood Plain Zoning Act 2012: today the 614.6 km of the Bhagirathi, the Ganga, the Bhilangana, the Alaknanda and the Mandakini (Irrigation Department, 2024) and the Rispana (5 May 2025), and each reach notified later
(i)	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 network (the Nagar Nigams of Dehradun, Haridwar, Rishikesh, Haldwani, Rudrapur and Srinagar, the Nagar Palika Parishads of Nainital, Kichha, Rudraprayag and Uttarkashi, MDDA, Survey of India); the town drains, nalas, khalas and raos with their outfalls and the interception structures on them, with levels on a stated datum (the local bodies, Uttarakhand Peyjal Nigam); the prohibited and restricted lines of every reach notified under the Flood Plain Zoning Act, and the studies of the Gaula, the Kosi, the Suswa, the Song, the Baldi, the Asan and the Solani (the Irrigation Department); the CWC levels at Haridwar, Rishikesh, Srinagar, Rudraprayag and Uttarkashi, and the pond levels and operating rules of the Bhimgoda, Pashulok and Gaula barrages and of the sluices of Naini lake (CWC, the Irrigation Department, UJVN Ltd, the Lake Development Authority); the debris-flow fans above the valley-floor towns (ULMMC, USDMA, the Geological Survey of India [TBC]); and the land flooded in 2013, 2021, 2023 and 2025 (the District Magistrates, USDMA, the local bodies). Kotdwara, Ramnagar, Kashipur and Tanakpur–Banbasa on the bhabar, Roorkee on the Solani and Joshimath on its moraine are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The floodplains of unnotified rivers, the bye-law setbacks from rivers, springs, nalas and lakes, and the Conservation Use Zone of the Unified Zoning Regulations are governed by Chapter 7 and by the instruments that bind there 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 (h), 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

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 Uttarakhand 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 Magistrate and the District Disaster Management Authority, USDMA, or the flood control rooms of the Irrigation 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 taal 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 Nagar Nigam / Nagar Palika Parishad / Nagar Panchayat), dated _____

Subject: Adoption of alternatives under the Policy Supplement to the Uttarakhand Stormwater Design Manual.

The Council, having considered the report of the Municipal Commissioner (Nagar Ayukt) / Executive Officer dated _____, and noting that:

- (i) the Uttarakhand 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: _____ Municipal Commissioner (Nagar Ayukt) / Executive Officer: _____ Date: _____

Annex 1D — Model Bye-laws 2011 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 Uttarakhand Building Construction and Development Bye-laws 2011 at which the new rule and the conditions would be inserted, and the enabling sections of the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand 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 Uttarakhand Building Construction and Development Bye-laws 2011

A.1 **Short title and commencement.**

- (1) These rules may be called the Uttarakhand Building Construction and Development (Stormwater Management) (Amendment) Bye-laws/Regulations, _____.
- (2) They shall come into force on the date six months after their publication in the Uttarakhand Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building bye-laws made by the Government under section 57 of the Uttar Pradesh Urban Planning and Development Act, 1973, as applicable to and amended in Uttarakhand, and adopted by the board of each development authority, the following rule shall be inserted:

> **Rule [_____]. Stormwater management.**
>
> (1) *Definitions.* In this rule, "the Manual" means the Uttarakhand 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 Uttarakhand 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

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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 — Uttarakhand 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 Uttarakhand Building Construction and Development Bye-laws 2011 — 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 (Bye-laws 2011, bye-law 6.5: permitted construction with a ground coverage of 125 m² or more, except in waterlogged areas) — 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 — Uttarakhand 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.

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 rain gauges whose readings IMD tabulates in the *Climate of Uttarakhand*, the gauges of the Irrigation Department, of UJVN Ltd and of THDC at their barrages and dams, and the observatory of G.B. Pant University of Agriculture and Technology at Pantnagar [TBC]), and district and basin boundaries (Survey of India, Irrigation Department). 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
UK-Z1 Plains and foothills	The plains below the Siwalik front, in CWC subzone 1(e), the Upper Indo-Ganga Plains (Clause 2.3.6(b)): Haridwar district and the bhabar–terai of Pauri, Nainital, Udham Singh Nagar and Champawat; catchments that cross a zone line take the higher zone value, and towns on the front (Kathgodam, Kotdwara, Ramnagar, the northern wards of Haridwar) compute both reports and take the higher	Roorkee 42140 (daily record 1901–2012); district gauges with 33–35 years of data in IMD's district tables: Haldwani, Kashipur, Khatima, Rudrapur/Kichha, Bazpur, Kaladhungi, Bambasa; the Pantnagar observatory (16 years in the same table [TBC])	District normals about 1,070–1,200 mm (Udham Singh Nagar 1,071.1, Hardwar 1,202.9 mm), gauges up to 1,747.4 mm at Haldwani (IMD). FER 1(e) 50-yr 24-h about 280 mm at Haridwar–Roorkee rising to 400–440 mm at Haldwani–Kathgodam, the wettest cell of the 1(e) plates; 1-h ratio 0.34, with the floors of Clause 2.3.6(g). Records that qualify under Clause 2.3.6(h): Khatima 405.6 mm (15 Sep 1972) and Haldwani 413.0 mm (11 Jul 1970) (IMD). October storms (Kashipur 315.0 mm, 2 Oct 1954; Ramnagar 291.0 mm, 14 Oct 1985; Pantnagar 403.9 mm, 19 Oct 2021). NIH-DHAARA 50-yr 24-h high here (about 400 mm at Haldwani, Kashipur and Rudrapur; 358 mm at Haridwar)
UK-Z1 Plains and foothills: UK-B Haridwar–Roorkee plains	Haridwar (with BHEL and SIDCUL), Jwalapur, Kankhal, Roorkee, Laksar, Manglaur, Bhagwanpur and Bahadrabad; Roorkee and the west of the sub-area lie in UTM zone 43N; boundaries [TBC]	Roorkee 42140; the Hardwar and Roorkee district gauges (34 and 41 years of data)	FER 50-yr 24-h about 280 mm, 100-yr 280–320 mm with a spot of 311 mm. Records: Roorkee (Obsy) 266.7 mm (20 Sep 1888) and 237.7 mm (25 Jul 1966); Hardwar (Hydro) 495.3 mm (18 Sep 1880), the State's highest day, and Roorkee 284.7 mm (17 Sep 1880), excluded under Clause 2.3.6(h) as records made before 1901 until IMD confirms their gauges [TBC]; no qualifying record raises the plates here (IMD). The bhabar fringe at Bhagwanpur, with water up to about 70 m deep, and Ganga alluvium to the south, with the first aquifer 4–8 m below ground; Bahadrabad and Bhagwanpur semi-critical (CGWB, 2020 and 2022). Receiving waters: the Ganga at Haridwar (CWC warning 293.0 m, danger 294.0 m, highest level 296.30 m, 2010 or 2013) and the Bhimgoda barrage; the Upper Ganga Canal; the Solani at Roorkee (warning 260.5 m, danger 261.5 m, highest level 260.58 m, 14 Oct 2021)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
UK-Z1 Plains and foothills: UK-C Bhabar–terai (Haldwani–Kashipur–Rudrapur–Kotdwara)	Haldwani–Kathgodam, Lalkuan, Kaladhungi, Ramnagar, Kashipur, Jaspur, Bazpur, Gadarpur, Rudrapur, Kichha, Pantnagar, Sitarganj, Khatima, Tanakpur–Banbasa and Kotdwara; boundaries [TBC]	Haldwani (35 years of data), Kashipur (34), Khatima (33), Rudrapur/Kichha (33), Bambasa (35); the Pantnagar observatory [TBC]; Mukteswar 42147 above the front	FER 50-yr 24-h about 400–440 mm at Haldwani–Kathgodam (100-yr 440–480 mm, a spot of 490 mm north-west), 320–360 mm at Ramnagar, about 320 mm at Khatima and Tanakpur [TBC], and 280–320 mm at Kotdwara, Kashipur and Rudrapur. Records: Khatima 405.6 mm (15 Sep 1972), qualifying, for Khatima, Banbasa and Tanakpur; Haldwani 413.0 mm (11 Jul 1970), qualifying, below the plate at Haldwani but raising Pantnagar; Bambasa 340.0 mm (10 Jul 1990); Kashipur 315.0 mm (2 Oct 1954); Rudrapur/Kichha 307.1 mm (25 Jul 1907); Pantnagar 403.9 mm (19 Oct 2021), excluded pending confirmation of its record length; Kotdwara 349.0 mm (1892) and Kathgodam 306.6 mm (1897), excluded as records made before 1901 [TBC] (IMD). Rates of 50–100 mm/h for about an hour at seven stations on 18 Oct 2021 (Thapliyal & Singh, 2023). The bhabar, 4–20 km wide, of boulders and gravel with water 40–75 m deep (173.71 m at Bhotia Parao, Haldwani), is the recharge zone; the terai below it, 8–25 km wide, has water 1–7 m deep and more than 2,000 flowing wells, an auto-flow zone that is retreating; Haldwani and Kashipur semi-critical (CGWB). Receiving waters: the Gaula (Kathgodam, 498.93 m on 20 Oct 2021; barrage pond 510.75–513.25 m), the Kosi (Ramnagar barrage, 220.75 or 220.95 m in 2021), the Dhela and Phika barrages, the Baur, Haripura and Tumaria reservoirs (full reservoir level 242.32 m), the Kalyani and the Kichha at Rudrapur, and the Sarda at Banbasa (highest level 224.9 m, 2021; barrage maximum water level 223.3 m) (as reported)
UK-Z2 Doon and outer ridge	The Doon valley and the first ranges of the outer Himalaya, where the monsoon is forced up and the daily totals are highest, in CWC zone 7, Western Himalayas (Clause 2.3.6(b)); catchments that cross a zone line take the higher zone value	Dehra Dun 42111 (daily record 1901–2012), Mussoorie 42112 (1901–1992), Nainital 42146 (1953–1980), Mukteswar 42147 (1901–2012); the recording gauges at Dehradun and Nainital used by the CWC zone-7 report; the automatic weather stations of Sahastradhara ITI, Maldevta and Jolly Grant	Gauge normals 2,000–2,500 mm (Nainital 2,464.5, Rajpur 2,426.1, Dehradun 2,238.3, Narendranagar 2,209.5, Mussoorie 2,021.6 mm) (IMD). FER zone 7 50-yr 24-h about 240–320 mm in the Doon and on its ridge, rising to more than 440 mm in the closed cell over Nainital. The Doon's records far exceed the plates: Raipur (Dehradun) 487.5 mm (1959), Dehradun (Obsy) 487.0 mm (1966), Rajpur 440.4 mm (1954) (IMD). The ADB Gumbel fits give 50-yr 24-h depths of 291 mm at Dehradun (1901–2020) and 417 mm at Nainital (1953–1970 only) (ADB, 2021). NIH-DHAARA close to the plates here (Dehradun 339, Nainital 426 mm) but low at 1 h

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
UK-Z2 Doon and outer ridge: UK-A Doon valley (Dehradun–Rishikesh)	Dehradun, Rajpur, Raipur–Maldevta–Sahastradhara, Doiwala, Rishikesh, Muni-ki-Reti, Dhalwala, Vikasnagar–Herbertpur, Selaqui, Sahaspur and Prem Nagar; Vikasnagar, Herbertpur, Selaqui and Prem Nagar lie in UTM zone 43N and Dehradun city just east of 78° E; boundaries [TBC]	Dehra Dun 42111; Rajpur (25 years of data); Narendranagar (33 years) for Rishikesh; the Dehradun recording gauges; Sahastradhara ITI and Maldevta (automatic weather stations)	FER zone 7 50-yr 24-h about 280–320 mm at Dehradun and Rishikesh (100-yr 320–360 mm). Records: Dehradun (Obsy) 487.0 mm (25 Jul 1966) and Rajpur 440.4 mm (25 Aug 1954), qualifying, for the Doon within 25 km of them; Narendranagar 396.0 mm (27 Jul 1999), qualifying, for Rishikesh; Raipur (Dehradun) 487.5 mm (2 Aug 1959; 16 years of data) excluded pending confirmation [TBC]; Dehradun 370.2 mm (17 Jun 2013) and 175.1 mm (14 Aug 2023); Sahastradhara 264 mm in 24 hours with 54 mm in one hour (16 Sep 2025, as reported); recording-gauge maxima at Dehradun 98 mm in 1 hour and 143 mm in 3 hours (14 Jun 1970) and 189 mm in 6 hours and 331 mm in 24 hours (24–25 Jul 1973) (IMD; CWC). The Doon Gravels, with hydraulic conductivity of 13–583 m/day and water 2–71 m deep before the monsoon, are the recharge zone; the Siwaliks to the south (CGWB). Receiving waters: the raos, ungauged and boulder-laden (the Rispana and the Bindal to the Suswa and the Song; the Tons; the Asan to the Asan barrage, maximum pond 401.50 m); the Song at Satyanarayan (warning 337.2 m, danger 338.2 m, highest level 338.49 m, 2019); the Yamuna at the Dakpathar barrage (pond 456.40 m); the Ganga at Rishikesh (danger 340.5 m, highest level 341.72 m, 1995) and the Pashulok barrage
UK-Z2 Doon and outer ridge: UK-D Outer-ridge hill stations (Nainital–Mussoorie)	Nainital, Bhimtal, Bhowali, Mussoorie, Landour, Lansdowne, Ranikhet, Mukteshwar, Champawat–Lohaghat, Narendranagar and Chakrata; boundaries [TBC]	Nainital 42146 (1953–1980) and its recording gauges; Mussoorie 42112; Mukteswar 42147	FER zone 7 50-yr 24-h more than 440 mm at Nainital (taken as 480 mm under Clause 2.3.6(c)), about 240–280 mm at Mussoorie and Mukteshwar; 1(e) ratios on the zone-7 plate (Clause 2.3.6(f)). Records: Nainital 313.7 mm (15 Sep 1957) and 401 mm (19 Oct 2021), below the plate; Mukteshwar 340 mm (19 Oct 2021), qualifying, for Mukteshwar, Almora and Bhimtal; Mussoorie 439.4 mm (1890), excluded as a record made before 1901 and not shown in IMD's station extremes, which give 317.0 mm (5 Aug 1964) [TBC]; Ranikhet 350.5 mm (16 Jun 1970), years of data not printed [TBC]; Nainital's 50.9 cm (22 Sep 1958) in the zone-7 annex, contradicted by IMD [TBC]; recording-gauge maxima at Nainital 79 mm in 1 hour and 237 mm in 24 hours (3–4 Jul 1972) (IMD; CWC). Colluvium, slide debris and phyllite, slate and limestone, with perched springs; building barred on slopes of more than 30° (26.5° in Nainital); the Balia Nala and Sher-ka-Danda slides. Receiving waters: Naini lake (0.46 km², catchment 3.49 km² with the Sukhatal 0.75 km²; five sluices at Tallital, maximum 12.5 ft on the PWD gauge, sealed on 15 October) to the Balia Nala and the Gaula; Bhimtal; the headwaters of the Kempty, the Aglar, the Rispana and the Song below Mussoorie
UK-Z3 Inner and high mountains	The inner valleys, middle mountains and high Himalaya behind the outer ridge, in CWC zone 7 (Clause 2.3.6(b)), whose snow-fed catchments the zone-7 report excludes (Clause 2.3.6(i)); catchments that cross a zone line take the higher zone value	Tehri New 42114 (daily record 1956–2012), Joshimath 42116 (1958–2008), Mukteswar 42147; the recording gauges at Tehri and Uttarkashi used by the CWC zone-7 report; Askote (Obsy) and the Pithoragarh district gauges	Rain shadow: gauge normals of about 500–1,000 mm in the valleys (Srinagar 494.7, Pithoragarh 907.1, Joshimath 925.5 mm) against 2,200–2,600 mm on exposed slopes (Dharchula 2,222.9, Askote 2,588.1 mm) (IMD). FER zone 7 50-yr 24-h about 200–280 mm where the plates can be read (Tehri, Uttarkashi), with a closed cell of more than 400 mm on the upper Yamuna and Tons; 1-h ratio 0.425. Short bursts dominate: Uttarkashi 100 mm in 1 hour (12 Jul 1979), Tehri 50 mm in 1 hour (21 Jul 1971) (CWC). Winter storms of western disturbances (Mukhim 192.0 mm, Feb 1979; Naitwar 210.0 mm, Feb 1986) and snow. NIH-DHAARA broken at 1 h here (Joshimath 0.09, Kedarnath 0.12 of 24 h)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
UK-Z3 Inner and high mountains: UK-E Inner valleys and middle mountains (Tehri–Srinagar–Almora–Pithoragarh)	Tehri, New Tehri, Chamba, Srinagar, Pauri, Rudraprayag, Agastyamuni, Gauchar, Karnaprayag, Gopeshwar, Uttarkashi, Barkot, Purola, Almora, Bageshwar, Pithoragarh and Berinag; boundaries [TBC]	Tehri New 42114; Mukteswar 42147 for Almora; Askote (Obsy, 26 years of data) and Berinag (23 years) for Pithoragarh district	FER zone 7 50-yr 24-h about 200–240 mm at Tehri and 240–280 mm at Uttarkashi; not legible at Almora, Pithoragarh and Srinagar [TBC]. Records: Askote (Obsy) 450.0 mm (5 Sep 1982), qualifying, for Pithoragarh town and Dharchula; Berinag 475.0 mm (6 Sep 1965), qualifying, for Berinag and Chaukori; Almora 222.5 mm (29 Sep 1924), Pithoragarh 200.7 mm (24 Jun 1921), Srinagar 190.5 mm (1880), Tehri (Obsy) 194.8 mm (12 Dec 1957), Uttarkashi 150.0 mm (20 Aug 1988) and Bhatwari 300.0 mm (15 Jul 1985) (IMD). Hard rock with weathered and colluvial veneers; springs supply 70–87% of the water in some blocks, and Almora's working springs are reported to have fallen from 360 to 60. Receiving waters: the Alaknanda (Srinagar warning 535.0 m, danger 536.0 m, highest level 537.9 m, 17 Jun 2013; Rudraprayag highest level 634.85 m, 2013), the Bhagirathi (Uttarkashi highest level 1,124.13 m, 1978), the Tehri reservoir (full reservoir level 830 m, maximum water level 835 m) and Koteshwar, the Kosi at Almora and the Ramganga; valley-floor towns on river terraces below debris fans
UK-Z3 Inner and high mountains: UK-F High Himalaya and snow-fed (Joshimath–Kedarnath–Dharchula)	Joshimath (Jyotirmath), Badrinath, Kedarnath, Gangotri, Harsil–Dharali, Yamunotri, Dharchula, Munsiari and Ghangaria, and every catchment with permanent snow or a glacier; boundaries [TBC]	Joshimath 42116 and the Joshimath district gauge (34 years of data); the glacier observatory at Chorabari (WIHG)	Zone-7 relations not used for snow-fed catchments; site-specific hydrology and a debris-flow and GLOF screening (Clause 2.3.6(i)). Records: Joshimath 300.0 mm (21 Jun 1973) and 273.0 mm (21 Jul 1970), Dharchula 271.4 mm (14 Jun 1971), Munsiyari 233.2 mm; Chorabari glacier camp 210 mm in 12 hours and 325 mm in 24 hours (15–16 Jun 2013) (IMD; Dobhal et al., 2013). Moraine and glacial debris (the subsidence of Joshimath, 2022–23); water 0.52 m below ground at Joshimath in January 2025 (CGWB). Events not driven by rain at the gauges: the Chorabari lake outburst (17 Jun 2013), the Raini rock-ice avalanche (7 Feb 2021) and the Dharali debris flow (5 Aug 2025). Receiving waters: the Alaknanda at Joshimath (highest level 1,388.65 m, 7 Feb 2021), the Mandakini, the Dhauliganga and the Kali at Dharchula

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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 Uttarakhand are those of Clause 2.3.6: the CWC Flood Estimation Report ratios for the site's sub-area in Table 2B.1 (zone 7 in UK-A, UK-E and the local catchments of UK-F; 1(e) in UK-B, UK-C and, on the zone-7 plate depth, UK-D), raised at 1 and 3 hours in UK-B and UK-C to the floors of Clause 2.3.6(g) for the 10-yr and rarer storms, and applied to the 24-hour depth before the record check of Clause 2.3.6(h) (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
UK-Z2 (UK-A Doon valley) and UK-Z3 (UK-E Inner valleys and middle mountains; the local catchments of UK-F below the snow)	CWC FER zone 7, 10-yr basis, nine recording gauges (interim design ratios, Clause 2.3.6(f); 2-h value interpolated on logarithmic axes)	0.425		0.600	0.725	0.845	1.00
UK-Z1 (UK-B Haridwar–Roorkee plains; UK-C Bhabar–terai) and UK-Z2 (UK-D Outer-ridge hill stations, on the zone-7 plate)	CWC FER 1(e), 50-yr (interim design ratios, Clause 2.3.6(f))	0.34	0.475	0.56	0.68	0.84	1.00
UK-Z1 (UK-B, UK-C), 10-yr and rarer	Ratio floor of Clause 2.3.6(g)(i), set by this Manual (with the depth floors of Clause 2.3.6(g)(ii))	0.35		0.57			
UK-Z2 (UK-A): Dehradun	CWC FER zone 7, Annex 4.4: the recording-gauge maxima as ratios to the 24-h maximum of the same record (separate storms: 1 and 3 h on 14 Jun 1970, 6 to 24 h on 24–25 Jul 1973; comparison only)	0.30		0.43	0.57	0.65	1.00
UK-Z2 (UK-D): Nainital	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 3–4 Jul 1972 (comparison only)	0.33		0.53	0.77		1.00
UK-Z3 (UK-E): Uttarkashi	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 12–13 Jul 1979, a record of less than five years (comparison only)	0.81		0.84	0.86		1.00
UK-Z3 (UK-E): Tehri	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 21–22 Jul 1971 (comparison only)	0.55		0.99			1.00
UK-Z1 (UK-B): Haridwar	NIH-DHAARA, 50-yr, Haridwar cell (comparison only; 2- to 12-hour values not queried)	0.21					1.00
UK-Z1 (UK-B): Roorkee	NIH-DHAARA, 50-yr, Roorkee cell (comparison only; 3- and 6-hour values not queried)	0.28	0.44			0.83	1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
UK-Z1 (UK-C): Haldwani	NIH-DHAARA, 50-yr, Haldwani cell (comparison only; 2- to 12-hour values not queried)	0.24					1.00
UK-Z1 (UK-C): Rudrapur	NIH-DHAARA, 50-yr, Rudrapur cell (comparison only; 3- and 6-hour values not queried)	0.25	0.40			0.82	1.00
UK-Z1 (UK-C): Kashipur	NIH-DHAARA, 50-yr, Kashipur cell (comparison only; 2- to 12-hour values not queried)	0.27					1.00
UK-Z2 (UK-A): Dehradun	NIH-DHAARA, 50-yr, Dehradun cell (comparison only; not used in the hills, Clause 2.3.6(m))	0.23					1.00
UK-Z2 (UK-A): Rishikesh	NIH-DHAARA, 50-yr, Rishikesh cell (comparison only; not used in the hills)	0.20	0.33			0.79	1.00
UK-Z2 (UK-D): Nainital	NIH-DHAARA, 50-yr, Nainital cell (comparison only; not used in the hills)	0.18					1.00
UK-Z3 (UK-E): Srinagar	NIH-DHAARA, 50-yr, Srinagar cell (comparison only; not used in the hills)	0.23	0.36			0.79	1.00
UK-Z3 (UK-F): Joshimath	NIH-DHAARA, 50-yr, Joshimath cell (comparison only; not used in the hills)	0.09					1.00
UK-Z3 (UK-F): Kedarnath	NIH-DHAARA, 50-yr, Kedarnath cell (comparison only; not used in the hills)	0.12					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

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 Irrigation Department, and the district rain gauges of the State whose records IMD tabulates [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, and in Uttarakhand the reanalysis cells err in a pattern of their own. In the plains they run high: at Kashipur and Rudrapur the IMDAA cells of NIH-DHAARA (about 12 km) give a 50-year 24-hour depth of about 400 mm, against a plate value of 280–320 mm and gauge records of 315.0 mm at Kashipur (2 October 1954) and 307.1 mm at Rudrapur/Kichha (25 July 1907), and at Haridwar about 358 mm against about 280 mm. On the outer ridge they are close to the plates at 24 hours (Nainital 426 mm, Dehradun 339 mm), but at Dehradun the cell's 100-year depth, about 379 mm, is well below the observatory's 487.0 mm of 25 July 1966. In the high valleys they break down at short durations: the cells' 50-year 1-hour depths are about 24 mm at Joshimath and 32 mm at Kedarnath, 0.09 and 0.12 of their 24-hour depths, against the 100 mm in one hour recorded at Uttarkashi on 12 July 1979 and the 210 mm in 12 hours at the Chorabari glacier camp on 15–16 June 2013 (NIH-DHAARA, queried 10 Nov 2026; IMD; CWC; Dobhal et al., 2013); and the Tanakpur cell returned no data. Values of this kind are grid-average values and need these factors before any use as point depths; under Clause 2.3.6 they are not used as design depths in Uttarakhand until this annex and Annex 2A are published, and not used at all in the hills.

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				

Annex 2D — Uttarakhand 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 Uttarakhand 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 automatic weather stations and automatic rain gauges in the State, under the Meteorological Centre Dehradun, the glacier observatory of the Wadia Institute of Himalayan Geology at Chorabari, and any recording gauges of the Irrigation Department, USDMA and Dehradun Smart City Ltd [TBC]), separated into independent storms by a stated rule, and the storms recorded by the recording gauges of the CWC zone-7 report at Dehradun (14 June 1970 and 24–25 July 1973), Nainital (3–4 July 1972) and Uttarkashi (12–13 July 1979), the storm of 15–17 June 2013 at Dehradun and over the Mandakini, the Kumaon storm of 17–19 October 2021, the Dehradun storm of 13–14 August 2023 and the Sahastradhara storm of 15–16 September 2025 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

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
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.

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 Irrigation Department, and the district rain gauges of the State whose records IMD tabulates [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
UK-Z1 Plains and foothills					
UK-Z2 Doon and outer ridge					
UK-Z3 Inner and high mountains					

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 — Uttarakhand 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 1(e) or zone 7 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 July–30 September in sub-areas UK-A, UK-D, UK-E and UK-F and on terai land, whatever its duration, and at any time in catchments draining to a reservoir or barrage pond, Naini lake or Bhimtal, or a river at or 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.

Annex 3A — Uttarakhand 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 Uttarakhand 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 south-west monsoon (June–September). It needs NBSS&LUP and Uttarakhand Agriculture Department (soil survey) [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 Irrigation Department, supplemented by piezometers in the terai below the spring line in Udham Singh Nagar, Haridwar and the south of Nainital district, where wells flow under artesian pressure, the floodplains and low terraces of the Ganga at Haridwar and Rishikesh, the Solani at Roorkee and the Gaula, Kosi, Kichha and Kalyani in the Kumaon plains, the margins of Naini lake and Bhimtal, and hill towns with perched water on unstable slopes, such as Nainital and Joshimath. 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 June–September record	Highest June–September level below ground (m)	Within 0.6 m of ground (Clause 3.10.1)?	Data source

Annex 3B — Uttarakhand CN calibration and supplementary land covers (terraced fields, oak and chir pine forest, slide scars and debris fans, bare rock and scree, boulder-bed raos, terai paddy, taal 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 Uttarakhand 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 terraced fields of the hill slopes, whose risers and bunds hold water on each terrace until it overtops and which are being abandoned in many hill villages; the oak forest of the outer ridge, with its deep litter, and the chir pine forest of the middle mountains, whose needle litter sheds water; the fresh scars, slide debris and debris fans of landslides and debris flows, and the cut slopes and spoil of hill roads; bare rock, scree and the skeletal soils of the steep hills; the wide boulder beds of the raos of the Doon and of the rivers of the bhabar, which lose flow to the gravels until the bed is saturated; the paddy and sugarcane of the terai, with their bunded fields; and the beds of taals, khals and reservoirs, such as the Sukhatal basin above Naini lake and the margins of the Tehri, Baur, Haripura and Tumaria reservoirs, that are dry or drawn down at the start of a storm. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from Irrigation Department 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)
Terraced fields of the hill slopes, with the riser height recorded (cultivated or abandoned)						
Oak forest of the outer ridge, with deep litter						
Chir pine forest of the middle mountains, with needle litter						
Fresh landslide scar, slide debris or debris fan; hill-road cut slope and spoil						
Bare rock, scree and skeletal soil of steep slopes						
Boulder bed of a rao or bhabar river (Doon raos, Gaula, Kosi, Dabka and the like), dry at the start of the storm						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Terai paddy or sugarcane, with the bund height recorded						
Taal, khal or reservoir bed dry or drawn down at the start of the storm (Sukhatal basin; Tehri, Baur, Haripura and Tumaria margins)						
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

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 Uttarakhand.** Uttarakhand is landlocked and has no flat coastal plain, 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 terai, the Ganga alluvium and the taal and reservoir margins are flat in places but are not coastal plain; their slow response is represented by storage and backwater (Clauses 3.10.4 and 3.12.4), not by a lower peak rate factor, while the hills, the Doon and the bhabar 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 1(e) and zone 7, 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 1(e) (Upper Indo-Ganga Plains) and zone 7 (Western Himalayas), 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 two CWC Flood Estimation Reports that cover Uttarakhand, split at the Siwalik front: the Western Himalayas zone 7 report (No. WH/22/1994, November 1994), which names "Uttar Pradesh" because the State did not exist in 1994 and covers the Doon and the hills, including Dehradun, Doiwala, Rishikesh, Mussoorie, Vikasnagar, Nainital, Bhimtal, Almora, Ranikhet, Pithoragarh, Champawat, Tehri, Srinagar, Pauri, Rudraprayag, Gopeshwar, Uttarkashi and Joshimath, but whose relationships are not to be used in its snow-fed catchments; and the Upper Indo-Ganga Plains subzone 1(e) report, approved at the 40th meeting of the Planning and Co-ordination Committee on 23–24 July 1984, whose design-office report number is not on the scanned copy read for this Manual [TBC], and which covers Haridwar, Roorkee, Laksar, Bhagwanpur and the bhabar–terai of Kotdwara, Haldwani, Ramnagar, Kashipur, Rudrapur, Kichha, Sitarganj and Khatima (see the References of Chapter 3); with the zone 7 areal reduction factors for areas above 300 km² and for 24 hours, the 1(e) areal reduction and time-distribution tables, the zone 7 plates for Almora, Pithoragarh, Srinagar and Joshimath, which are not legible on the copy read, the loss rate of the zone 7 worked example, printed as 0.20 cm/h against the 0.5 cm/h the report recommends, and the boundary between the two reports along the Siwalik front, including that at Kathgodam, Haridwar's northern wards and Rishikesh, still to be confirmed on the reports' page images and index maps [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	Zone 7 (Western Himalayas) relationship	Subzone 1(e) (Upper Indo-Ganga Plains) relationship
Time from centre of unit rainfall to peak	tp	h	tp = 2.498 (L·Lc/S)^0.156 (printed with S, not √S; see the note)	tp = 1.858 qp^−1.038
Peak discharge per unit area	qp	m³/s per km²	qp = 1.048 tp^−0.178	qp = 2.030 (L/√S)^−0.649
Width of UH at 50% of peak	W50	h	W50 = 1.954 (L·Lc/S)^0.099	W50 = 2.217 qp^−0.990
Width of UH at 75% of peak	W75	h	W75 = 0.972 (L·Lc/S)^0.124	W75 = 1.477 qp^−0.876
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.189 W50^1.769	WR50 = 0.812 qp^−0.907
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.419 W75^1.246	WR75 = 0.606 qp^−0.791

Parameter	Symbol	Unit	Zone 7 (Western Himalayas) relationship	Subzone 1(e) (Upper Indo-Ganga Plains) relationship
Base width of UH	TB	h	TB = 7.845 tp^0.453	TB = 7.744 tp^0.779
Unit duration	tr	h	1	2
Design storm duration	TD	h	TD = 1.1 tp (it gave the highest peak on all the gauged catchments)	TD = 1.1 tp, limited to 24 h
Design loss rate	—	mm/h	5 (printed "0.5 cm/hr"; the observed modal value of 0.6 cm/h was judged "on higher side", and "Designers can modify this value as per local conditions"); the worked example uses 0.20 cm/h "as recommended in para 3.5", which conflicts with para 3.5 [TBC]; not for snow-fed areas	3.0 (printed "3.0 mm per hour" and, in the worked example, 0.3 cm/h)
Design base flow	—	m³/s per km²	0.05 (27 of 45 events in the range 0.00–0.10)	0.05 (the average of 126 flood events in the range 0.01–0.09)
Ratio of t-hour to 24-hour rainfall	—	—	10-yr, from 9 self-recording gauges: 1 h 0.425; 3 h 0.600; 6 h 0.725; 9 h 0.790; 12 h 0.845; 15 h 0.895; 18 h 0.935; 24 h 1.000	50-yr: 1 h 0.340; 2 h 0.475; 3 h 0.560; 4 h 0.607; 5 h 0.647; 6 h 0.680; 9 h 0.770; 12 h 0.840; 15 h 0.890; 18 h 0.930; 24 h 1.000
Time distribution of rainfall	—	cumulative fraction by hour	3-h storm 0.73, 0.92, 1.00; 6-h storm 0.52, 0.69, 0.82, 0.91, 0.97, 1.00; 12-h storm 0.34, 0.49, 0.60, 0.67, 0.74, 0.81, 0.86, 0.90, 0.94, 0.96, 0.98, 1.00; 24-h storm 0.17, 0.27, 0.36, 0.43, 0.48, 0.53, 0.58, 0.63, 0.67, 0.70, 0.73, 0.76, 0.79, 0.82, 0.84, 0.86, 0.88, 0.90, 0.92, 0.94, 0.96, 0.98, 0.99, 1.00	Average curves of Fig. 12; the worked 12-hour storm puts 58% of the total in the first 2 hours; the 24-hour fractions were not transcribed [TBC]
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	1.15
Areal reduction factor	ARF	% of point rainfall	Annex 4.2: 50 km², 94.00 at 1 h, 96.40 at 3 h, 97.70 at 6 h, 98.25 at 12 h; 100 km², 89.00, 92.90, 95.40, 96.50; 200 km², 80.75, 86.20, 89.80, 93.50; 300 km², 74.25, 80.00, 86.20, 90.50; the worked example uses 0.926 for 3 hours at 103.6 km²; the 24-hour column and the rows above 300 km² (to 2,000 km²) not read [TBC]	Table 6 of the report; at 50 km², 1 h 88, 3 h 92, 6 h 95, 12 h 96, 24 h 98, read by optical character recognition only, and the rows for larger areas not read [TBC]
50-yr 24-hour point rainfall at Uttarakhand towns (100-yr in brackets)	—	mm	Plate 9 (Plate 10), read by eye within about one contour: Dehradun about 280–320 (320–360); Mussoorie and Rajpur about 240–280; Rishikesh about 280–320, on the edge of the plate; Nainital above 440, in a closed cell (above 400 on the 25-yr Plate 8); Mukteshwar and Uttarkashi about 240–280; Tehri about 200–240; Almora, Pithoragarh, Srinagar and Joshimath not legible on the copy read [TBC]	Plate 9 (Plate 10), read by eye within about one contour: Haridwar and Roorkee about 280 (a spot value of 311 nearby); Kotdwara about 280–320 (about 320); Haldwani–Kathgodam about 400–440 (440–480), with a "450+" spot just north-west; Ramnagar about 320–360; Kashipur, Rudrapur and Kichha about 280–320 (about 320); Khatima and Tanakpur about 320, with no label nearby [TBC]
Gauged catchments in Uttarakhand	—	—	1 of the 6 used: the Suswa Nadi at railway bridge 139 on the Laksar–Dehradun line (296.84 km²; L 46.50 km, Lc 20.50 km, S 13.95 m/km; 1966–67); the Bannar Khad at bridge 213 (45.00 km², 1962–66) was listed but not used	Not identified in the copy read [TBC]

Parameter	Symbol	Unit	Zone 7 (Western Himalayas) relationship	Subzone 1(e) (Upper Indo-Ganga Plains) relationship
Catchment area for which the relationships apply	A	km²	25–1,000; not in snow-fed catchments	25–2,500, for "reasonably free catchments"; for "foothill catchments (steep slopes)" a "suitable increase", by an amount the report does not state
Report reference	—	—	§§3.3–3.6, Annexes 3.1 and 3.2, §4.4.2, Annexes 4.1 and 4.2, worked example (pp. 24–26), Plates 8–10	§3.9 (p. 42), §§3.11–3.12 (p. 57), text table (p. 61), Fig. 12, Table 6, §§6.1–6.3, Plates 9 and 10

Note: relationships as printed in the two CWC reports that cover Uttarakhand (References of Chapter 3), read from scanned copies and checked against the page images except where marked. L is the length of the main stream in km, Lc the length to the point nearest the catchment centroid in km, S the equivalent slope in m/km and A the catchment area in km². Zone 7 relates tp to L·Lc/S, printed without the square root that most subzone reports use, and the printed equations reproduce the report's own unit hydrograph only in that form; 1(e) relates qp to L/√S and derives tp from qp. Each column shall be used only in its own area. **Zone 7.** The report was written for Jammu and Kashmir, Punjab, Himachal Pradesh and Uttar Pradesh, whose hill districts are now Uttarakhand, over a zone of 322,170 km², of which the Ganga, the Yamuna, the Ramganga and the Sarda make up about 49,600 km². Its unit hydrograph rests on only six catchments of 44–658 km² (five railway bridges and the Sewa hydro-electric project), with 2–5 years of record each in 1962–67 and 45 flood events, all near the southern edge of the zone in Jammu & Kashmir, Punjab, Himachal Pradesh and the Doon: about 1% of the zone. The report itself warns that a design flood computed from these relations is not to be used "without verifying the results on the basis of alternate methods", and that the relations are "not to be utilised for computation of design flood in the snow fed area of the zone". Its only Uttarakhand catchment is the Suswa at bridge 139; for that catchment the printed relationships give L·Lc/S = 68.3, tp ≈ 4.8 h, qp ≈ 0.79 m³/s per km², TB ≈ 16 h and TD ≈ 5 h (NEER's computation; a yardstick, not a design value). The worked example, the Banu Khad at bridge 629 in Himachal Pradesh (103.60 km², L 21.32 km, Lc 11.58 km, S 69.21 m/km), has two errors. It prints tp = 2.5 h, while its own equations give about 3.05 h, with which the printed qp (0.86) and TB (13.0 h) agree; and it applies a loss of 0.20 cm/h, "as recommended in para 3.5", where para 3.5 recommends 0.5 cm/h. With the 50-yr 24-hour point rainfall of 32.00 cm (Plate 9), the 3-hour ratio of 0.600 and an ARF of 0.926, the report gives a 50-yr peak of 1,365.22 m³/s, about 13.2 m³/s per km²; with 0.5 cm/h the same unit hydrograph gives about 1,311 m³/s (NEER's recomputation). This Manual uses 0.5 cm/h and reads tp from the equations [TBC]. The gauged catchments have slopes of 9.9–84 m/km; the urban hill catchments of Nainital, Mussoorie, Almora and the like are far steeper and far smaller than 25 km², and are designed by the methods of Clause 3.4 with the rules for steep ground of the Commentary to Clause 3.7. In the hill sub-areas the SUH applies to the rural raos, gadheras and rivers of 25–1,000 km² that enter the towns, such as the Rispana (about 53–58 km²) and Bindal (about 44 km²) above Dehradun, the Song, the Suswa, the Tons and the Asan in the Doon, the Chandrabhaga at Rishikesh and the Balia Nala below Nainital; the Irrigation Department's floodplain zoning of the Rispana used the CWC subzone SUH with PMP atlas data (affidavit in NGT OA 417/2022). In sub-area UK-F (High Himalaya and snow-fed) the zone 7 SUH does not apply: catchments with snow or glacier cover, such as those above Joshimath, Badrinath, Kedarnath, Gangotri, Harsil and Dharchula, require a site-specific hydrological study, and no design there is complete without a debris-flow and glacial-lake-outburst screening (Chapter 2). **Subzone 1(e).** The report was derived from 23 gauged catchments (137 bridge-years, 1961–1982), none urban; in Uttarakhand it applies to the rural streams of 25–2,500 km² that enter Haridwar, Roorkee and the towns of the bhabar–terai, such as the Solani, the Ratmau and the Banganga in Haridwar district and the Kichha, the Kalyani, the Dhela and the Bhakra in Udham Singh Nagar, and to the Gaula above Haldwani (617.5 km² at the Gaula barrage) and the Kosi above Ramnagar with the "suitable increase" for foothill catchments, which the designer shall state and justify. **Both.** Where a city catchment lies within the range, the SUH is computed only as the benchmark of its natural condition (Clause 3.11.4), and the catchment itself is designed by the methods of Clause 3.4 with the design rainfall of Chapter 2. The Ganga at Rishikesh and Haridwar, the Yamuna (7,340 km² at Dakpathar), the Alaknanda and the Bhagirathi are far larger than the catchments of either report and are outside Clause 3.11.4 (Clause 3.4.5); below Tehri, Koteshwar, Dakpathar, the Virbhadra and Bhimgoda barrages and the Gaula, Kosi and Banbasa barrages the flood is set by releases (Chapter 5). The design loss rates, 5 mm/h in zone 7 and 3.0 mm/h in 1(e), are φ-indices fitted to the monsoon floods of whole rural catchments; they are used only in rural SUH runs, are not soil infiltration capacities and are not used to assign HSG

(Clause 3.7), in urban SCS-CN or SWMM models, or to size infiltration practices (Chapter 4). The ratios are not to be used to derive intensities for durations shorter than the TD of the SUH (Chapter 2): with the zone 7 ratio of 0.425, the highest 1-hour ratio of any report in this series, the 50-yr 1-hour depth is about 119–136 mm at Dehradun and more than 187 mm at Nainital, against a largest recorded 1-hour fall of 98 mm at Dehradun (14 June 1970) and 79 mm at Nainital (July 1972) (Annex 4.4 of the zone 7 report); with the 1(e) ratio it is about 95 mm at Haridwar and 136–150 mm at Haldwani; Clause 2.3.6 deals with the difference. At 24 hours the opposite holds: Dehradun (487.0 mm on 25 July 1966), Raipur in Dehradun (487.5 mm on 2 August 1959), Rajpur (440.4 mm), Hardwar (495.3 mm on 18 September 1880), Pantnagar (403.9 mm on 19 October 2021), Khatima (405.6 mm) and Mukteshwar (340.8 mm on 19 October 2021) have recorded more than the 100-yr plate values (IMD), so the plate values are a floor under Clause 2.3.3, not a ceiling. **Boundary.** By NEER's reading of the plates, the boundary between the two reports runs along the Siwalik front: the dashed line of zone 7 Plate 9 passes just south of Dehradun, near bridge 139, so Dehradun, Doiwala, Rishikesh, Mussoorie and Vikasnagar are in zone 7; Haridwar (its northern wards within about 5–10 km of the line) and Roorkee are in 1(e); the line meets the Kumaon hills at Kathgodam, about 7–10 km north of Haldwani, which is in 1(e), with Nainital in zone 7; and subzone 1(f) does not reach the State [TBC]. The report is chosen by the catchment's outfall and the location of most of its area, not by its district. Where a catchment drains across the Siwalik front, or its outfall lies near the line, as at Kathgodam, the northern wards of Haridwar, Rishikesh, Ramnagar and Kotdwara, this Manual requires the SUH to be computed with the parameters of each report and the higher 1% AEP peak to be adopted, unless calibration under Clause 3.15 supports the other.

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 — Uttarakhand 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 Uttarakhand 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 — Uttarakhand Stormwater Design Manual, Draft v1.0. One form for each point of comparison (POC). Flows in m³/s, volumes in m³.

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 — Uttarakhand 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.

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 terai below the spring line in Udham Singh Nagar, Haridwar and the south of Nainital district, where wells flow under artesian pressure and the water table stands 1–7 m below ground, the floodplains and low river terraces of the Ganga, the Solani, the Song, the Gaula, the Kosi, the Kichha, the Kalyani and the Sarda and of the rivers of the inner valleys, the margins of Naini lake, Bhimtal and the other taals, the margins of the Tehri, Dakpathar, Asan, Baur, Haripura and Tumaria reservoirs and barrage ponds, and hill sites with perched water, such as Joshimath, 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 SW monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (Irrigation Department, NRSC, Survey of India), the prohibited (25-year) and restricted (100-year) flood zones of the reaches notified by the Irrigation Department under the Uttarakhand Flood Plain Zoning Act 2012 and marked on shajra maps, and its studies of the Gaula, the Kosi, the Suswa, the Song, the Baldi, the Solani and the Asan, the pond and reservoir levels of the Gaula barrage and the Baur, Haripura and Tumaria reservoirs, of the Dakpathar and Asan barrages and of the Tehri and Koteshwar reservoirs, the maximum levels of Naini lake and Bhimtal, the rivers, ponds, lakes, nalas and streams placed in the Conservation Use Zone by the Unified Zoning Regulations 2025, the wetlands mapped by the State Wetland Authority and the boundary of the Asan Conservation Reserve Ramsar site, the landslide-prone areas mapped by ULMMC, town boundaries (MDDA, HRDA and the district development authorities, UHUDA, the Nagar Nigams, Nagar Palika Parishads and Nagar Panchayats, and the Urban Development Directorate), flood maps held by USDMA, observation-well records of the CGWB and the Irrigation Department, and the extent of the Doon Gravels and the bhabar fans, the terai, the Ganga alluvium, the Siwalik rock, and the colluvium, slide debris, moraine and exposed rock of the hills, with the slopes of more than 10° to which the hill infiltration rule of Clause 4.11 applies from soil survey maps (NBSS&LUP, the Uttarakhand Agriculture Department (soil survey) [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 June–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, rao, gadhera, nala or taal (Clause 4.12.1(b)). For the flotation check in the terai, the river terraces and floodplains, and the taal margins 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	terai below the spring line (artesian or waterlogged); river floodplain or low terrace (Ganga, Solani, Song, Gaula, Kosi, Kichha, Kalyani, Sarda, Alaknanda, Bhagirathi or other); taal margin (Naini lake, Bhimtal or other); reservoir or barrage-pond margin (Tehri, Dakpathar, Asan, Baur–Haripura, Tumaria or other); perched water on a hill slope (Joshimath, Nainital or other); other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, SW 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 (m³/ha), standard	SSR (m³/ha), flood-sensitive
UK-Z1 Plains and foothills: UK-B Haridwar–Roorkee plains	B / C / D	50% / 70% / 90%	—	—	—	—	—
UK-Z1 Plains and foothills: UK-C Bhabar–terai (Haldwani–Kashipur–Rudrapur–Kotdwara)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
UK-Z2 Doon and outer ridge: UK-A Doon valley (Dehradun–Rishikesh)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
UK-Z2 Doon and outer ridge: UK-D Outer-ridge hill stations (Nainital–Mussoorie)	C / D	50% / 70% / 90%	—	—	—	—	—
UK-Z3 Inner and high mountains: UK-E Inner valleys and middle mountains (Tehri–Srinagar–Almora–Pithoragarh)	B / 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
UK-Z3 Inner and high mountains: UK-F High Himalaya and snow-fed (Joshimath–Kedarnath–Dharchula)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(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

Permissible discharge (L/s)	H = 0.5 m	H = 1.0 m	H = 1.5 m	H = 2.0 m
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.

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 colony draining to the Rispana in Dehradun; 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 khala draining to the Rispana in Dehradun 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

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)
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 ΔS ≈ (I − Ō) × 300 s, where I is the mean inflow over the 5-minute step ending at the time shown and Ō is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: ΔS = 2,853.0 − 2,613.3 = 239.7 m³, and (1.0891 − (0.2655 + 0.3069)/2) × 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
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

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
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

Item	Requirement	Value	Result
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 khala draining to the Rispana in Dehradun (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 — Uttarakhand 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 Uttarakhand 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 — Uttarakhand 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 — Uttarakhand 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	

Line	Quantity	Computation	Value
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 — Uttarakhand Stormwater Design Manual, Draft v1.0.

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 — Uttarakhand 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 — Uttarakhand 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.

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 Uttarakhand. Uttarakhand has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Uttarakhand 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 rao or gadhera, row F10 records the study, the flood marks and the bed survey of Clause 5.8.5(b), and for an outfall to Naini lake, the gauge tie and the sluice rules of Clause 5.8.5(d).

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
Ganga at Rishikesh, Muni-ki-Reti and Dhalwala, past the Rishikesh gauge and the Pashulok (Virbhadra) barrage; the Chandrabhaga	Dehradun, Tehri, Pauri	Riverine outfall reach and major drains; design river level not below the transferred 341.72 m (5 September 1995); 10% AEP not below the danger level 340.5 m (warning 339.5 m); barrage pond level not found [TBC]; datum [TBC]	5.2, 5.8.1, 5.8.3, 5.8.5
Ganga at Haridwar above and below the Bhimgoda barrage, past the Haridwar (Dudhia Band) gauge, to Laksar; the nalas of Haridwar	Haridwar	Riverine outfall reach and major drains; design river level not below the transferred 296.30 m (dated 19 September 2010 by SANDRP and 17 June 2013 in the CWC table: conflict [TBC]; 295.75 m on 17 June 2013); 10% AEP not below the danger level 294.0 m (warning 293.0 m); outfalls into the Bhimgoda pond closed for the whole storm; Bhimgoda operator [TBC]	5.2, 5.8.1, 5.8.3, 5.8.5
Song at Satyanarayan and Doiwala; Asan at Sabhawala	Dehradun	Riverine outfall reaches; design river level not below the transferred 338.49 m (Satyanarayan, 28 June 2019; danger 338.2 m, warning 337.2 m) and 450.85 m (Sabhawala, 30 September 2019; no danger level)	5.8.1, 5.8.5
Rispana, Bindal, Suswa, Song above Satyanarayan and Tons (Tamsa), and their khalas	Dehradun	Raos and major drains; ungauged; 1% AEP study with bulking, flood marks and the Irrigation Department's floodplain study (Rispana notified 5 May 2025; Suswa and Song studied) [TBC]; outfall at least 0.5 m above the highest surveyed bed level; no outfall in the active channel	5.2, 5.8.1, 5.8.5
Solani at Roorkee, Dosni and Raysi	Haridwar	Riverine outfall reach; design river level not below the transferred 260.58 m (Roorkee, 14 October 2021), 244.65 m (Dosni) and 232.24 m (Raysi), and at Roorkee not below the danger level 261.5 m, which is above the recorded level [TBC]	5.8.1, 5.8.5
Upper Ganga Canal from Bhimgoda through Haridwar and Roorkee	Haridwar	Canal; operator's consent (reported to be the Uttar Pradesh Irrigation Department, unverified [TBC]); design water level and flap gate; drains cross by cross-drainage works	5.2, 5.8.5
Gaula at Kathgodam and through Haldwani below the Gaula barrage; the Rakasia and Kalasia nalas	Nainital	Riverine outfall reach, gadheras and major drains; design river level not below the transferred 498.93 m (Kathgodam, 20 October 2021; a level-monitoring site, no danger level); barrage tailwater 513.25 m (high pond level) [TBC]; barrage releases included (123,000 cusec in 1993); lining of the Rakasia and Kalasia nalas not counted until built	5.2, 5.8.1, 5.8.3, 5.8.5

Water body	Region	Listed as	Clause
Kosi at Ramnagar below the Ramnagar barrage	Nainital	Riverine outfall reach; design river level not below the transferred 220.95 m (19 October 2021; 220.75 m in the CWC list: conflict [TBC]); barrage pond level and operator not found [TBC]	5.8.1, 5.8.3, 5.8.5
Sarda at Banbasa, Tanakpur and Khatima below the Banbasa barrage	Champawat, Udham Singh Nagar	Riverine outfall reach; design river level not below the transferred 224.9 m (19 October 2021); 10% AEP not below the danger level 223.3 m; barrage tailwater 224.9 m (recorded level above the MWL of 223.3 m)	5.8.1, 5.8.3, 5.8.5
Kalyani at Rudrapur; the Kichha; the Dhela at Kashipur; the Khoh at Kotdwar	Udham Singh Nagar, Pauri	Riverine outfall reaches and major drains; no CWC level found [TBC]; modelled or surveyed level required	5.2, 5.8.1, 5.8.5
Alaknanda at Joshimath, Rudraprayag and Srinagar; Mandakini at Rudraprayag	Chamoli, Rudraprayag, Pauri	Riverine outfall reaches below debris fans; design river level not below the transferred 1,388.65 m (Joshimath, 7 February 2021), 634.85 m (Rudraprayag) and 537.9 m (Srinagar) (both 17 June 2013); danger 1,383 m, 627 m and 536.0 m; floodplains notified (Chapter 7)	5.8.1, 5.8.5
Bhagirathi at Uttarkashi; below the Tehri and Koteshwar dams	Uttarkashi, Tehri	Riverine outfall reaches; design river level not below the transferred 1,124.13 m (Uttarkashi, 6 August 1978; danger 1,123 m); Tehri and Koteshwar releases included; floodplain notified (Chapter 7)	5.8.1, 5.8.3, 5.8.5
Tehri and Koteshwar reservoirs	Tehri	Reservoir outfalls; Tehri tailwater 835.0 m (MWL; FRL 830 m); Koteshwar level not found (gauge 546.7 m on 15 August 2013) [TBC]; THDC's consent	5.8.3, 5.8.5
Dakpathar barrage on the Yamuna; Asan barrage	Dehradun	Barrage-pond outfalls; tailwaters 456.50 m (Dakpathar, 200-year high flood level) and 402.00 m (Asan, maximum pond level 401.50 m + 0.5 m) [TBC]; UJVN Ltd's consent; the Asan pond in the Asan Conservation Reserve, a Ramsar site	5.8.3, 5.8.5
Baur, Haripura and Tumaria reservoirs; Dhela and Phika barrages; Kalagarh reservoir	Udham Singh Nagar, Pauri	Reservoir and barrage-pond outfalls; tailwaters 242.82 m (Baur and Haripura, FRL 242.32 m + 0.5 m) and 366.2 m (Kalagarh, MWL) [TBC]; no level found for Tumaria, Dhela or Phika [TBC]	5.8.3, 5.8.5
Naini lake and the Balia Nala below the Tallital sluices	Nainital	Lake outfall; tailwater 12.5 ft on the Tallital gauge, or the surveyed level of October 2021 if higher, converted to metres after the gauge zero is levelled [TBC]; sluices under the 1927 rules, sealed on 15 October; outfalls below it closed for the whole storm; custodian [TBC]; no new discharge to the Balia ravine without a geotechnical certificate	5.8.5
Bhimtal, Naukuchiatal and Sattal	Nainital	Taal outfalls; no level found [TBC]; spill level plus head; custodian [TBC]	5.8.5
Canals and guls of the Irrigation Department; drains of Nagar Nigams and other urban local bodies, development authorities, UUSDA, Dehradun Smart City Ltd, PWD and NHAI 1.0 m wide or more	Uttarakhand	Major drains; owner's consent, design water level and flap gate	5.2, 5.8.5
Tehri, Koteshwar and Kalagarh dams; the Pashulok, Bhimgoda, Dakpathar, Asan, Gaula, Ramnagar and Banbasa barrages; the reservoirs and barrages of the terai	Bhagirathi, Ganga, Yamuna, Asan, Gaula, Kosi, Sarda, Ramganga	Releases and gate operation to be included in river levels (operating rules and release records [TBC])	5.8.3, 5.8.5

Water body	Region	Listed as	Clause
River mouths subject to sand-bar closure	None in Uttarakhand	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 Irrigation Department mouth-maintenance programme. It needs Irrigation Department river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (Irrigation Department), the drain inventories of DMC 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, Irrigation Department canal, the Rispana, the Bindal, the Suswa, the Song, the Tons (Tamsa) and the Asan and their khalas in the Doon, the nalas of Rishikesh and Haridwar that run to the Ganga, among them the Chandrabhaga at Rishikesh, the Solani at Roorkee, the Rakasia and Kalasia nalas and the gadheras that run to the Gaula at Haldwani, the Kalyani at Rudrapur, the drains that feed Naini lake and the Balia Nala below it, the Upper Ganga Canal, any canal or gul that receives storm water, any drain built or held by a Nagar Nigam, a Nagar Palika Parishad, a Nagar Panchayat, MDDA, HRDA or another development authority, UUSDA, Dehradun Smart City Ltd or PWD with an internal width of 1.0 m or more, and every gadhera, khala or rao that drains 8 ha or more 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 Uttarakhand) are assumed closed at the start of the SW monsoon unless the Irrigation 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	Irrigation Department 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	Irrigation Department 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

Annex 5C — Worked example: outfall-closed check for a site on a khala draining to the Rispana in Dehradun

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. It discharges through its own outlet chamber and a flap gate to a public storm drain that joins a khala running to the Rispana in Dehradun, whose level rises when the khala runs full and when the Rispana is in flood, as it was in September 2025, 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 Uttarakhand an outfall to a rao or khala whose invert is below its design level is closed for as long as the computed level of the stream stays above it, or for the whole storm where no hydrograph of the stream has been computed, a river-locked outfall has a single lock of at least 72 hours, and an outfall below the design level of a barrage pond or Naini lake is closed for the whole storm, under Clause 5.8.5, so in each of those cases the facility must store or pump 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 khala would also need the debris trap and the bulking factor of Clause 6.3.6 and an invert above the range of bed movement of Clause 5.8.5(b).

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 15 June 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 terai, the river terraces and floodplains, and the taal margins 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 — Uttarakhand 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 taal, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or taal: 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. River-locked outfalls, raos and gadheras, reservoir, barrage-pond and taal outfalls, rivers below dams and barrages, and canals or drains of other bodies: operator of each gate and pumping station identified, gate sills, bank, wall or embankment crest, installed capacity, operating levels and gate-closing level obtained, with every level tied to the datum of the nearest CWC or Irrigation Department gauge; 1% AEP river level at the outfall from the Irrigation Department's floodplain study or a model, with the dam and barrage releases, and not below the highest recorded level at the nearest CWC gauge transferred to the outfall (296.30 m at Haridwar, 341.72 m at Rishikesh, 338.49 m at Satyanarayan, 498.93 m at Kathgodam, 220.95 m at Ramnagar, 224.9 m at Banbasa, and the other levels of Clause 5.8.5(a)), with the profile used, or, where no gauge level exists, a modelled or surveyed flood level and its source; 10% AEP river level, not below the CWC danger level transferred where one exists (294.0 m at Haridwar, 340.5 m at Rishikesh); drain behind the gate routed with its whole catchment 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; single river lock of not less than 72 hours, or the duration of the largest recorded release below a dam or barrage if longer, and its source, and closure for the whole storm below a barrage pond level; gate-failure and breach checks; for a rao, gadhera or khala, the 1% AEP study with the bulking and blockage of Clause 6.3.6, the surveyed flood marks and their sources, the Irrigation Department's floodplain level where one exists, the bed survey and range of bed movement, the invert at least 0.5 m above the highest surveyed bed level and the scour depth of the foundation; for a reservoir or barrage pond, custodian's consent, MWL or FRL plus design-flood surcharge (FRL + 0.5 m where neither is published; Tehri 835.0 m, Dakpathar 456.50 m, Gaula barrage 513.25 m), not below the highest recorded level, outfall below it treated as closed for the whole storm, waterbody starting at FRL or pond level, no gate operation or Tehri attenuation credited without the custodian's written rule; for an outfall below a dam or barrage, the design storm with the largest recorded release, placed before, during and after the storm; for Naini lake, the consent of the lake custodian and the Irrigation Department, the Tallital gauge zero levelled to a Survey of India benchmark and the conversion from feet, the tailwater (12.5 ft on the gauge, or the level of October 2021 if higher), the 1927 sluice rules and the sealed sluices after 15 October, and the debris and sediment traps before the lake; for Bhimtal or another taal, the surveyed spill level plus head; for a canal, the operator's consent (Upper Ganga Canal: operator [TBC]); Irrigation Department consent, Flood Zoning Authority permission and the bye-law, zoning, Ganga, wetland and court lines checked; owner's consent, permitted rate, design water level or computed channel level, and flap gate (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				
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 (m^3/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)	

Field	Entry
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 Irrigation Department 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 15 June and after closure events (Clause 5.11.5)	
L2. Pump test runs before 15 June (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 Uttarakhand 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	
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — Uttarakhand Stormwater Design Manual, Draft v1.0.

Form 5-2 — Simplified Downstream Statement (small sites)

Supports Clause 5.3.4 of Chapter 5.

Draft form — Uttarakhand 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, DMC, USDMA, Irrigation Department (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 — Uttarakhand 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.

Annex 6A — Standard inlet types for Uttarakhand 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 Uttarakhand 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: Public Works Department (PWD), NHAI and Dehradun Municipal Corporation standard details, IIT Roorkee, NIH Roorkee, the Irrigation Research Institute, Roorkee 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
Grate pattern	Openings parallel to the direction of travel not wider than 25 mm	9.11.3(a)

Item	Requirement	Clause
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 Uttarakhand, 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 south-west monsoon, and catchment land-use and soil data (data and likely sources: desilting records of Dehradun Municipal Corporation and other urban local bodies, Irrigation Department records for channels, land cover from NRSC, soils from the Uttarakhand 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.

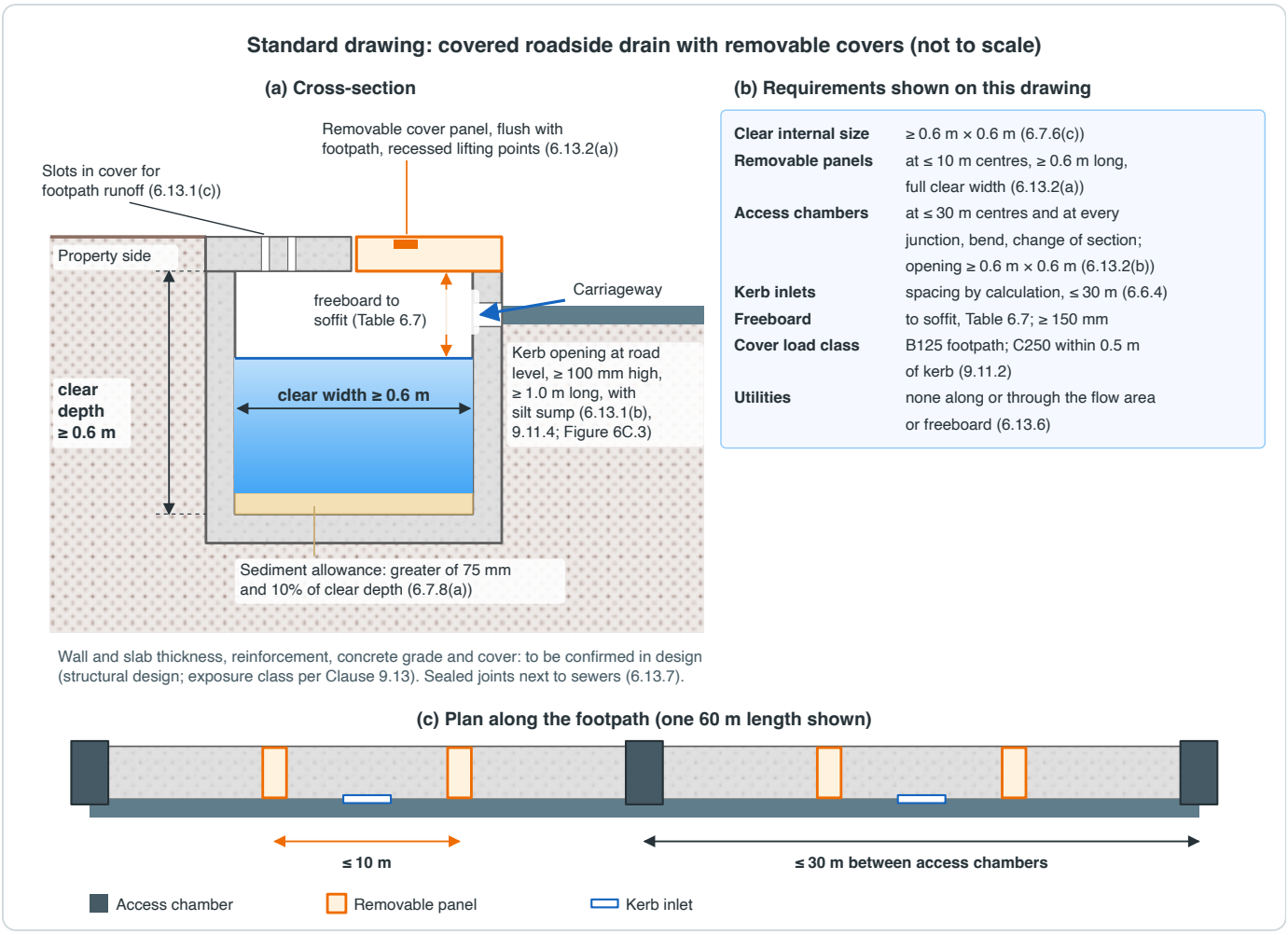

Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 5, and IRC:SP:50-2013.

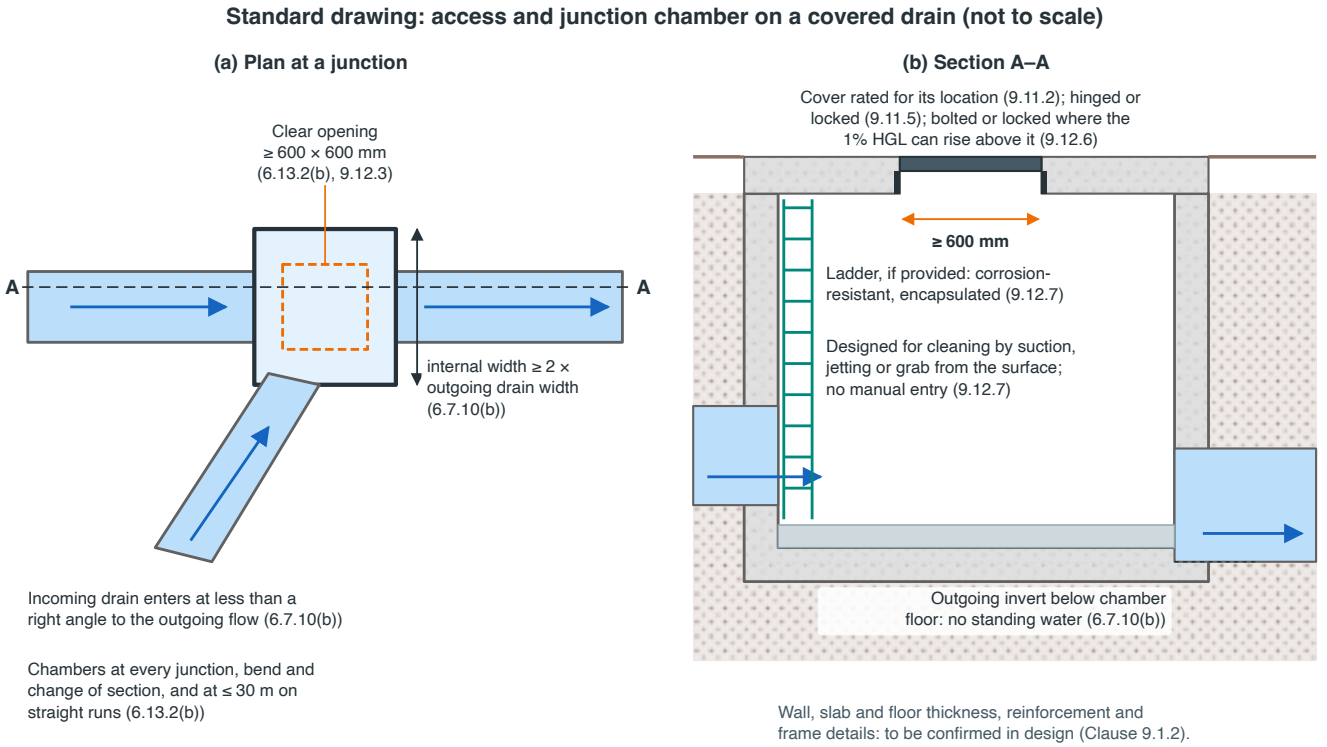

Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), §5.3.4 and Chapter 11.

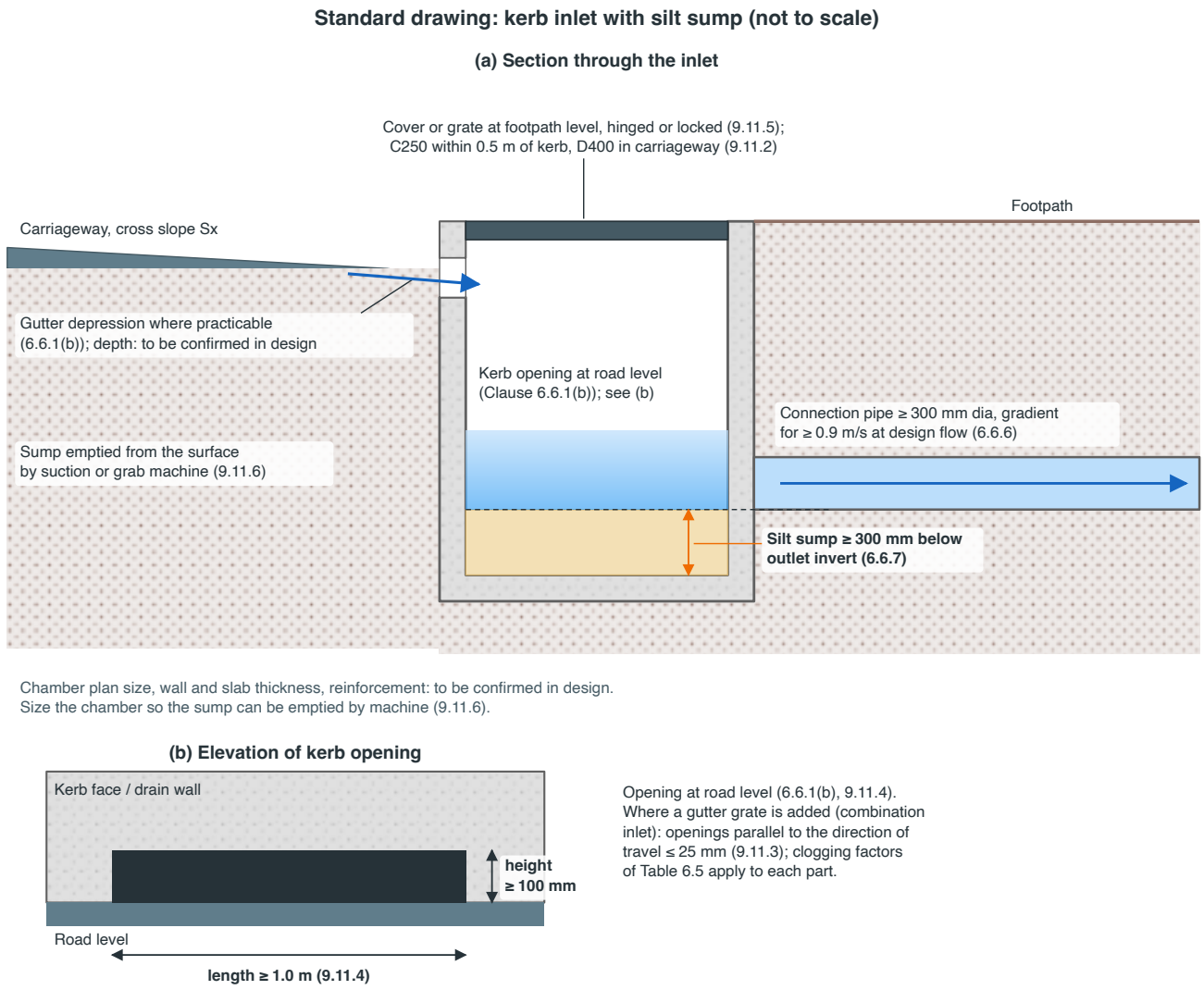

Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th 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 — Uttarakhand 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 — Uttarakhand Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 7

Waterbodies, Taals (Lakes and Ponds) 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 Hindi, Garhwali and Kumaoni 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.

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 Irrigation Department and the Revenue Department. It needs the Revenue records and shajra (village) maps of the Revenue Department, in which rivers, nalas, taals, naulas, dharas and land covered by water are recorded, and on which the Irrigation Department marks the 25-year and 100-year flood lines of a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012, with its boundary pillars; the rivers and waterbodies in the Revenue records, "including ponds, lakes, nalas and streams", that the Unified Zoning Regulations 2025 place in the Conservation Use Zone of a master plan; the drains and watercourses in the records of a Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat; the river-bed land outside municipal limits that the High Court has held to be forest land, in the records of the Forest Department; the setbacks from rivers, springs, nalas and lakes and the 2 m contour plans shown on plans approved under bye-law 4.4 of the Bye-laws 2011; the boundary of the Asan Conservation Reserve (Ramsar site) and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017, and the wetlands of the national atlas that the Uttarakhand State Wetland Authority is ground-truthing; the inventories of springs and water sources of the Jal Sansthan, the Peyjal Nigam and SARRA (as reported); and the lists of encroachments in river beds and floodplains filed before the High Court of Uttarakhand (such as in *Urmila Thapa*) and the National Green Tribunal (such as for the Rispana); the UKID 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 UKID records, with local name	7.3.1(a)
WB_NAME_HI	Text	Hindi script	Yes	Name in Hindi	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, tehsil 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	UKID 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 UKID 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; rao, gad or gadhera (seasonal hill stream); natural drain, khala or nala; gul (irrigation channel); canal; lake or taal; recharge flat; khal or chal (rain-fed hill pond); talab or pond; reservoir or barrage pond; spring (naula or dhara) and its recharge area; simar (seep or marsh); wetland; glacial or moraine-dammed lake; supply channel; surplus course	7.2
CUSTODIAN	Nagar Nigam, Nagar Palika Parishad or Nagar Panchayat (Municipal Acts as adapted); Lake Development Authority, Nainital [TBC]; UKID (division); UJVN Ltd or THDC India Ltd (barrage or dam); Forest Department (river bed outside municipal limits; Asan Conservation Reserve); State Government through the Collector or Tehsildar; Gram Panchayat; Jal Sansthan or Peyjal Nigam (tapped spring or source); development authority or developer (until handed over); Uttarakhand State Wetland Authority (wetland); private owner; 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)
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

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)).

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 UKID control, the operating rule is UKID'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, tehsil, district].
2. Custodian: [UKID 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 SW 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 USDMA red alert	IMD, USDMA	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 SW monsoon (15 June to 31 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the SW 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 SW monsoon (by 31 May) 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.

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 Uttarakhand Environment Protection and Pollution Control Board (UEPPCB) 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 Uttarakhand Environment Protection and Pollution Control Board (UEPPCB) 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 May**. No excavation shall be left open, and no sluice or weir left dismantled, during the SW 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 May)	As-built survey, stage–storage curve, silt disposal record	7.9.8, 7.7.1(b)

Annex 7E — Glossary of Hindi, Garhwali and Kumaoni waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Hindi words, and Garhwali and Kumaoni words where they are in use, for waterbodies, springs, drains and land in Uttarakhand, given in Devanagari and, where Platts gives it, Urdu script. Many of them appear in the names of lakes, streams and places (Nainital, Bhimtal, Kheer Gad, Bindal Rao, Dwarikhal). The name used in the Revenue, Irrigation Department, municipal or Jal Sansthan record for each waterbody should be recorded in the inventory (Annex 7A) alongside the Manual's term. A meaning is given below only where it was confirmed in J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884), in Syamasundara Dasa, *Hindi Shabdasagara* (1965–1975), or in R. L. Turner, *A Comparative Dictionary of the Indo-Aryan Languages* (CDIAL, 1962–1966), all as served by the Digital South Asia Library, with the page or entry number shown there; in the Garhwali and Kumaoni sections of the Hindwi Dictionary of the Rekhta Foundation, which cites the regional dictionaries of Paliwal (Kumaoni, 1985), Bisht (Kumaoni, 1994), Benjwal and Benjwal (Garhwali, 2007) and Nautiyal and Jakhmola (Garhwali, 2016) but gives no page numbers; or in Rawat and Sah (2009), a study of traditional water management in Kumaon. Meanings are the dictionaries' English glosses, or a translation of their Hindi, and modern usage may be narrower or wider. **No printed Garhwali or Kumaoni dictionary was checked page by page for this Manual.** Every term whose meaning or regional use was not confirmed is in Table 7E.4 as not yet verified. The list is to be extended by the State Stormwater Technical Committee, with modern Revenue, Irrigation Department and municipal usage and with the printed regional dictionaries.

The Manual's term for a lake, tank or pond in Uttarakhand is **taal (ताल)**: it is the State's own name for its best-known waterbodies (Nainital, Bhimtal, Sattal, Naukuchiatal) and the word is glossed as "Pond, pool, tank, lake" by Platts and as a pond of standing water in the Garhwali dictionary. **Khal (खाल)** is used, always with a gloss, for a small rain-fed hill pond, because the word also means "skin" and, in place names, a saddle between hills; and **talab (तालाब)** for the ponds of the plains. An engineered detention basin is not called a khal or a taal on its own: it is a detention pond, with the local word in brackets where that helps.

Table 7E.1 — Waterbodies

Term	Meaning	Source of the term	Manual term (Clause 7.2)
ताल / تال (tāl; taal)	"Pond, pool, tank, lake (= tālāb)"; in the Shabdasagara, "वह नीची भूमि या लंबा चौड़ा गड्ढा जिसमें बरसात का पानी जमा रहता है । जलाशय । पोखरा । तालाब ।", low ground or a wide pit in which the rain-water collects; a reservoir; a pond; in Garhwali (ताळ), "स्थिर पानी का पोखर, तालाब", a pond of still water	Platts, p. 306 (second entry); Shabdasagara, p. 2069; Hindwi (Garhwali)	Taal (lake, tank or pond), see the definitions after Clause 7.2
तालाब / تالاب (tālāb; talab)	"Pond, pool, tank, reservoir of water"; in the Shabdasagara, "जलाशय । सरोवर । पोखरा ।", a reservoir; a lake; a pond	Platts, p. 306; Shabdasagara, p. 2071	Talab (pond of the plains); a taal for this chapter

Term	Meaning	Source of the term	Manual term (Clause 7.2)
नौला, नौल (naulā, naul; naula)	In Garhwali, "पानी का कुंड", a reservoir of water; in Kumaoni (नौल), "बावड़ी, जलाशय", a step-well, a reservoir; in Kumaon, a tank closed on three sides and covered, with steps on the fourth, that collects water from a subterranean spring. Platts and the Shabdasagara give नौला only as "mongoose", with no water sense	Hindwi (Garhwali, Kumaoni); Rawat and Sah (2009), p. 250; Platts, p. 1160; Shabdasagara, p. 2712	Spring (naula), see the definitions after Clause 7.2
खाल, खाळ / کھال (khāl; khal)	(1) "A creek, bay, gulf; inlet …; a canal, rivulet, watercourse, river; a moat, trench"; (2) "Skin, hide"; in the Shabdasagara (खाल २), low ground, a hollow; in CDIAL, Western Pahari "hole in the earth, tank" and Garhwali "bottom of a valley"; in Garhwali, "बरसाती पानी का कुंड, ताल", a pond in the high lands formed with rain-water, and also a saddle between two hills; in Kumaon, large depressions on the ridges, in the saddle between two crests, used to harvest rain-water	Platts, p. 868; Shabdasagara, pp. 1156–1157; CDIAL 3849 (Addenda); Hindwi (Garhwali, Kumaoni); Rawat and Sah (2009), p. 251	Khal (small rain-fed hill pond; always glossed), see the definitions after Clause 7.2
सिमार (simār; simar)	In CDIAL, Kumaoni sīm, simār "swampy land"; in Kumaoni, "दलदल, सदा भरी रहने वाली भूमि", a swamp, land always wet; in Kumaon, a marshy tract created by the groundwater, also called gajar	CDIAL 13419; Hindwi (Kumaoni); Rawat and Sah (2009), p. 251	Simar (seep or marsh; a wetland under Clause 7.12)
रौ (rau)	In Kumaoni, "सरोवर, नदी के प्रवाह में बना जलाशय, ह्रद", a pool formed in the course of a river; in Garhwali, a deep and large pool formed by water standing in a river. Platts and the Shabdasagara have no pool headword	Hindwi (Kumaoni, Garhwali)	Pool in a stream; not a design term (for rao as a stream, see Table 7E.4)

Table 7E.2 — Springs, streams and channels

Term	Meaning	Source of the term	Manual term (Clause 7.2)
धारा / دھارا (dhārā; dhara)	"A line of descending fluid, a stream, current …, a channel, a water-course; a torrent"; in the Shabdasagara (sense ४), "पानी का झरना । सोता । चश्मा ।", a spring, a source; in CDIAL, Kumaoni dhāro "spring"; in Kumaon, a spout from which spring water is drawn for drinking. In legal Hindi धारा also means a section of an Act	Platts, p. 538; Shabdasagara, p. 2457; CDIAL 6788; Rawat and Sah (2009), p. 250	Spring (dhara), see the definitions after Clause 7.2
गधेरा (gadherā; gadhera)	In Garhwali, "छोटा बरसाती नाला", a small stream in the hills that flows during the rains; in Kumaoni (गध्यर), "छोटा नाला", a small nala. Not in Platts or the Shabdasagara	Hindwi (Garhwali, Kumaoni)	Gadhera (seasonal hill stream; a natural channel), see the definitions after Clause 7.2
गाड़ (gāḍ; gad)	In Kumaoni, "नदी के लिए प्रयुक्त पर्वतीय शब्द", the hill word for a river; Platts and the Shabdasagara give गाड़ only as a pit	Hindwi (Kumaoni); Shabdasagara, p. 1268	Gad (hill river or torrent; a natural channel), see the definitions after Clause 7.2
गूल / گول (gūl; gul)	"A channel for irrigation, a canal; a dyke, trench"; in CDIAL, Kumaoni kūl "watercourse" and Garhwali kūl, gūl; in Kumaon, channels dug along the contours	Platts, p. 925; CDIAL 3352; Rawat and Sah (2009), p. 250	Gul (hill irrigation channel), see the definitions after Clause 7.2
नाला / نالا (nālā; nala)	"A watercourse; channel (for water), a ravine; a rivulet, brook, canal; a drain, gutter"; in the Shabdasagara, a channel by which rain-water goes to a river	Platts, p. 1117; Shabdasagara, p. 2596	Nala (natural channel or trunk drain; bye-law 4.4(III)(ii))
नाली / نالي (nālī; nali)	"a drain; … a small watercourse, or channel"; "paṭī nālī … A covered drain, a sewer"; in the Shabdasagara, a narrow way for water to flow	Platts, p. 1117; Shabdasagara, p. 2597	Nali (street or house drain)

Table 7E.3 — Land

Term	Meaning	Source of the term	Use in this Manual
सेरा (serā; sera)	In the Shabdasagara (सेरा २), "आबापाशी की हुई जमीन । सींची हुई जमीन ।", irrigated land; in Garhwali, "नदी के तटवर्ती सिंचित समतल खेत", irrigated level fields along a river	Shabdasagara, p. 5275; Hindwi (Garhwali)	Irrigated valley-floor fields; often within the 1% AEP extent, and flood storage under Clause 7.6 where they are

Table 7E.4 — Terms not yet verified

These terms or senses are in use but were not confirmed in a dictionary or an official source 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
चाल (chāl; chal)	A rain-fed hill pond smaller than a khal, used only in "khal-chal" (chal-khal), the traditional technique and its revival in Pauri (as reported)	Platts (p. 418), the Shabdasagara (p. 1515) and the Hindwi Dictionary give no water sense; unsourced
rao in the Doon	The seasonal torrents of the Doon, as in the Bindal Rao, the Sitla Rao and the Rawli Rao	Used in this sense by the CPCB and the Irrigation Department; not dictionary-sourced in that sense (the dictionary sense of रौ is in Table 7E.1)
khala in the Doon	A seasonal storm channel of Dehradun, as in the "khalas/storm water drains" of the Rajpur area in the High Court's record in *Urmila Thapa* (2022)	Used in a court record; not confirmed in a dictionary in that sense (Platts's खाला, p. 868, is a hollow, a ravine)
छोइया (choiyā; chhoiya)	A small spring or seep	Not found in Platts, the Shabdasagara, CDIAL or the Hindwi Dictionary; unsourced
gajar	Another name for a simar	Rawat and Sah (2009) only; not checked in a dictionary
Garhwali and Kumaoni forms of taal, nala and the other terms	Regional words and spellings	Not checked in a printed Garhwali or Kumaoni dictionary

The Manual uses the terms in the last column of Tables 7E.1 and 7E.2, the land term of Table 7E.3, and the Uttarakhand terms defined after Clause 7.2.

Form 7-1 — Waterbody Sheet

Supports Clauses 7.3.2, 7.4 and 7.15(1) of Chapter 7.

Draft form — Uttarakhand 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 Hindi) 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): Revenue records and shajra maps (with any FPZ flood lines), UZR 2025 Conservation Use Zone, municipal drain records, forest records of river beds, bye-law 4.4 setbacks on approved plans, Asan Ramsar and wetland boundaries, spring and source inventories, court and NGT encroachment lists □; UKID / 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 UKID 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 (UKID 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 or approval line: the 25-year prohibited or 100-year restricted zone of a reach notified under the Uttarakhand Flood Plain Zoning Act, 2012; bye-law 4.4(III) of the Bye-laws 2011 (30 m from a river bank; 30 m from the bank or maximum fixed level of a lake; 10 m from a spring; at least 5 m from a nala); the 30 m no-new-construction line of the Unified Zoning Regulations 2025; on the Ganga in the hills, the prohibited zone (100 m from mid-river or the 25-year flood area, whichever is more) and the next 200 m regulatory zone of the Housing Department order of 2017 (revised 2023); below Haridwar, the National Green Tribunal's 100 m from the edge of the river; the boundary of the Asan Conservation Reserve (Ramsar site) or of a notified wetland; a court or Tribunal line (such as the order on the Sukhatal lakebed); a UKID, UJVN or THDC 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 — Uttarakhand 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 SW 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; UKID 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 — Uttarakhand 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.

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.

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)
_____	_____	_____	_____	_____	_____	_____	_____

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 Uttarakhand 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;
- ΣA_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 Uttarakhand 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
_____	_____	_____	_____
_____	_____	_____	_____

Annex 8C — Uttarakhand 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 Uttarakhand, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several SW 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
_____	_____	_____	_____	_____	_____	_____	_____

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

The lists below are **indicative**. They name species that are native or long naturalised in Uttarakhand or the western Himalaya and its foothills and known to tolerate both wet and dry periods, or, where marked, dry ground or the hills only; no Uttarakhand source on planting for stormwater was researched for this Manual. Hindi or Urdu names are given only where J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884, as served by the Digital South Asia Library), gives the name for the species or plant named, with its page; a dash means none was confirmed. Platts often uses older botanical names, which are given in the notes. No Garhwali or Kumaoni name was checked. Final selection shall be confirmed with a horticulturist or the State Forest Department for the site's altitude, soil and water table. Three settings need different plants: the plains, the bhabar and the Doon below about 1,000 m, where the lists below apply as in the plains States; the terai and the floodplains, where the ground stands wet in the monsoon; and the hill towns, where frost and snow from December to March rule out tender species, where bioretention on a slope is lined (Clause 8.8.1), and where planting on banks, cut slopes and the margins of gadheras is chosen first to bind soil.

Table 8D.13 — Indicative plants for bioretention, swales and filter strips

Use	Botanical name	Hindi / Urdu name	Notes
Swales, filter strips, bioretention edges, cut-slope and bank toes	*Chrysopogon zizanioides* (vetiver)	ख़स / خس (ḵẖas)	Deep-rooted clump grass; tolerates flooding and drought; binds soil on side slopes and drain banks; below about 1,000 m. Platts: "A fragrant grass, *Andropogon muricatum* (from the roots of which *taṭṭīs* are made)" (p. 489), an older name of this species
Swales and filter strips (turf)	*Cynodon dactylon* (Bermuda grass)	दूब / دوب (dūb)	Low turf; tolerates drought, traffic and short flooding. Platts: "Bent grass, panic grass, *Panicum dactylon*, or *Cynodon dactylon*" (p. 531)
Swales and banks on floodplain, bhabar and terai sites	*Saccharum spontaneum*	कास / کاس (kās)	Native tall grass of river sands; binds banks; cut back where it would obstruct a channel. Platts: "A species of grass, of which ropes, &c. are made, *Saccharum spontaneum*" (p. 801)
Trees beside swales and channels in the plains, the bhabar and the Doon	*Dalbergia sissoo*	शीशम / شیشم (śīśam)	Riverine tree of the foothills and plains. Platts: "The tree *Dalbergia sisu*, and its wood" (p. 740)
Trees beside channels and wet ground, up to the middle hills	*Ficus racemosa* (syn. *F. glomerata*)	गूलर / گولر (gūlar)	Native fig of stream banks. Platts: "The wild fig, *Ficus glomerata*" (p. 926). Keep roots clear of underdrains, pipes and walls
Trees beside bioretention and swales, up to the middle hills	*Toona ciliata* (toon)	तून / تون (tūn)	Native; grows along streams. Platts: "The tree *Cedrela toona* and its wood" (p. 344), an older name of this species
Trees on dry banks and swale edges (not in the wet zone)	*Bauhinia variegata*	कचनार / کچنار (kaćnār)	Native; for dry banks and the upper edges of swales. Platts: "The mountain ebony, *Bauhinia variegata*" (p. 819)
Banks of gadheras and drains in the hills (live staking)	*Salix* spp. (willow)	बेद / بید (bed)	Willows root from cuttings and bind wet banks; keep out of the waterway where they would obstruct flow. Platts: "A species of willow" (p. 207); the species was not confirmed
Moist slopes and stream banks in the hills	*Alnus nepalensis* (Himalayan alder)	—	Native of moist hill slopes and stream banks; grows fast on disturbed ground. No name in Platts
Slopes above spring recharge areas and drain banks in the hills (not in the wet zone)	*Quercus leucotrichophora* (syn. *Q. incana*) (oak)	बाँज / بانجھ (bāṅj)	Native broadleaf of the outer Himalaya; for upland margins and slopes, not for bioretention cells. Platts: "The tree *Quercus incana*, or *dilatata* (common in the outer Himalaya …)" (p. 126)

Use	Botanical name	Hindi / Urdu name	Notes
Bioretention (flowering, wet zones), below about 1,000 m	*Canna indica*	—	Naturalised; tolerates waterlogging; widely used in constructed wetlands in India; not frost-hardy

Table 8D.14 — Indicative plants for constructed wetlands and wet ponds

Zone	Botanical name	Hindi / Urdu name	Notes
Shallow macrophyte zone	*Typha* spp. (e.g. *T. domingensis*, syn. *T. angustata*)	—	Native; spreads quickly and needs periodic harvesting. No Hindi name was confirmed in Platts
Shallow macrophyte zone	*Phragmites karka*	नल / نل (nal); नरसल / نرسل (narsal)	Native reed; vigorous; keep out of nalas and channels where it would obstruct flow. Platts: "A species of reed, *Amphidonax karka*, or *Arundo karka*" (p. 1152) and "A large species of reed, *Arundo karka*" (p. 1132)
Shallow macrophyte zone	*Canna indica*	—	As Table 8D.13; plains and the Doon only
Open water and deep zones (plains and the Doon only)	*Nelumbo nucifera* (lotus)	कमल / کمل (kamal)	Native; for permanent pools only. Platts: "The lotus, *Nelumbium speciosum*" (p. 849)

Wet ponds and constructed wetlands are not used on hill slopes, where Clause 8.8.1 bars infiltration and there is little flat land (Clause 8.7, Commentary); the plants of this table are for the plains, the Doon and the terai.

Table 8D.15 — Species not to be planted

Botanical name	Hindi / Urdu name	Reason
Eichhornia crassipes (water hyacinth)	—	Invasive; chokes ponds, lakes, nalas and screens
Lantana camara	—	Invasive on forest edges, the Siwaliks and drain banks; not for swales or banks
Ageratina adenophora (syn. *Eupatorium adenophorum*)	—	Invasive on hill slopes, road cuts and stream banks; not for slopes or banks
Prosopis juliflora	—	Invasive on embankments and drain banks in the plains
Ipomoea carnea	—	Invasive in ponds and channels; obstructs flow

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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 SW 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

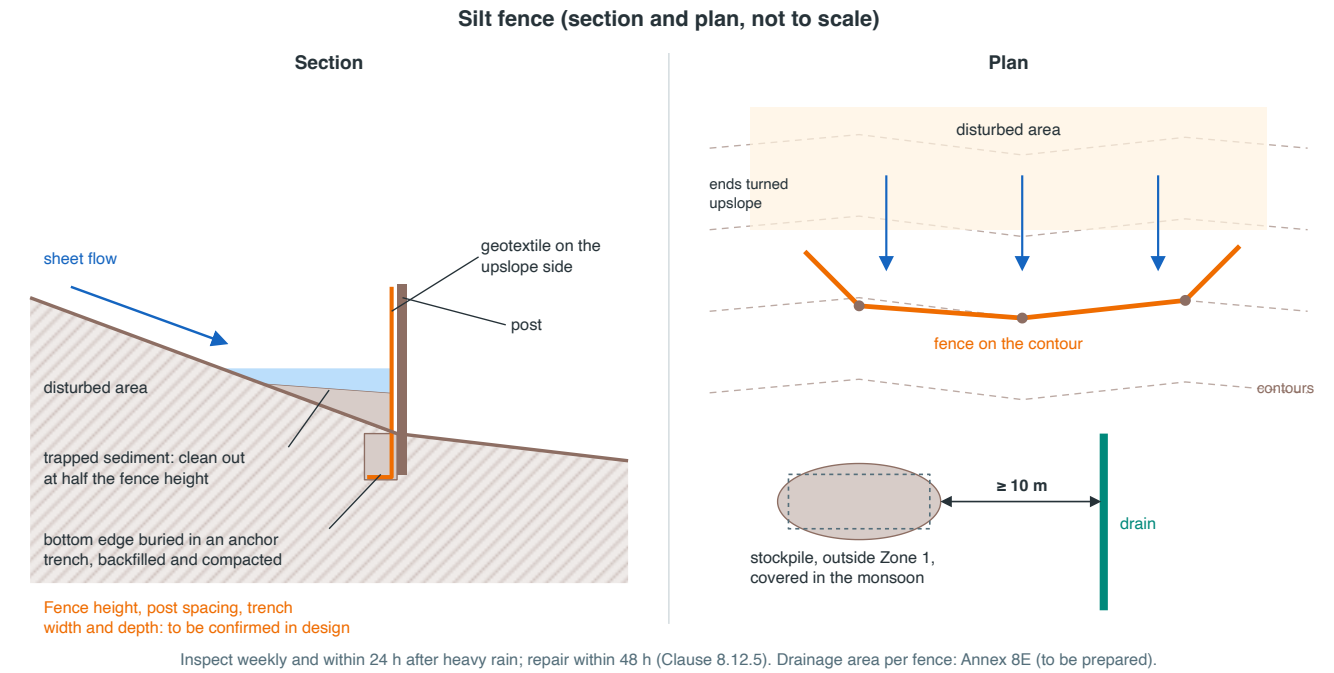


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted 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 Uttarakhand 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):

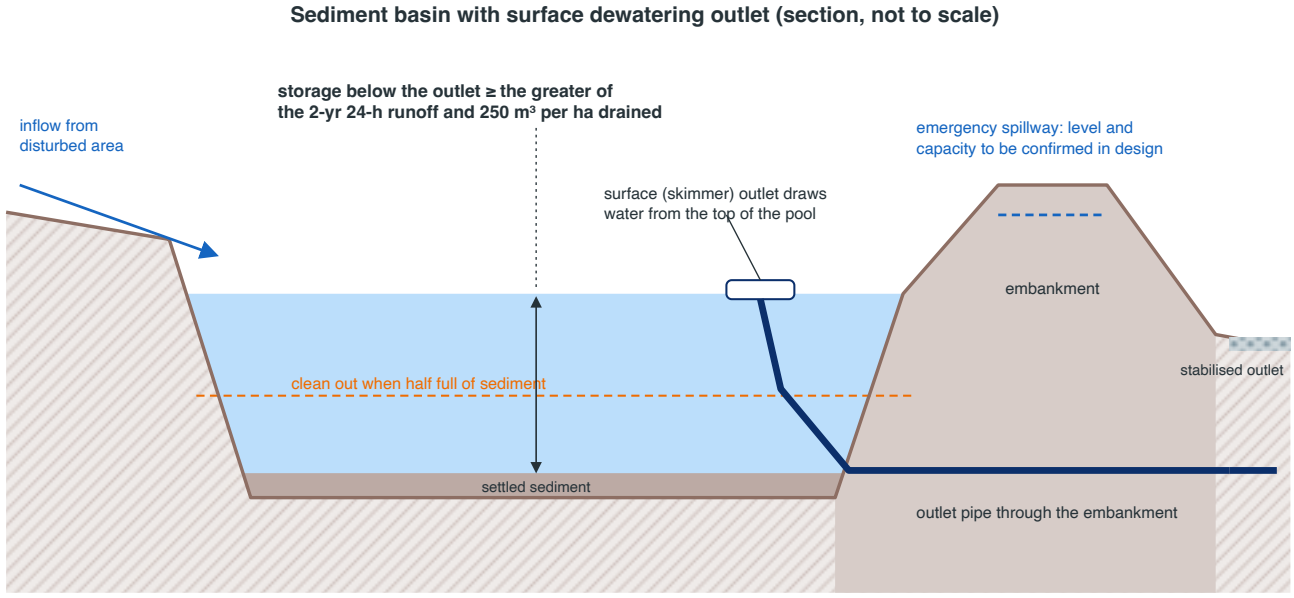
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used 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 SW 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

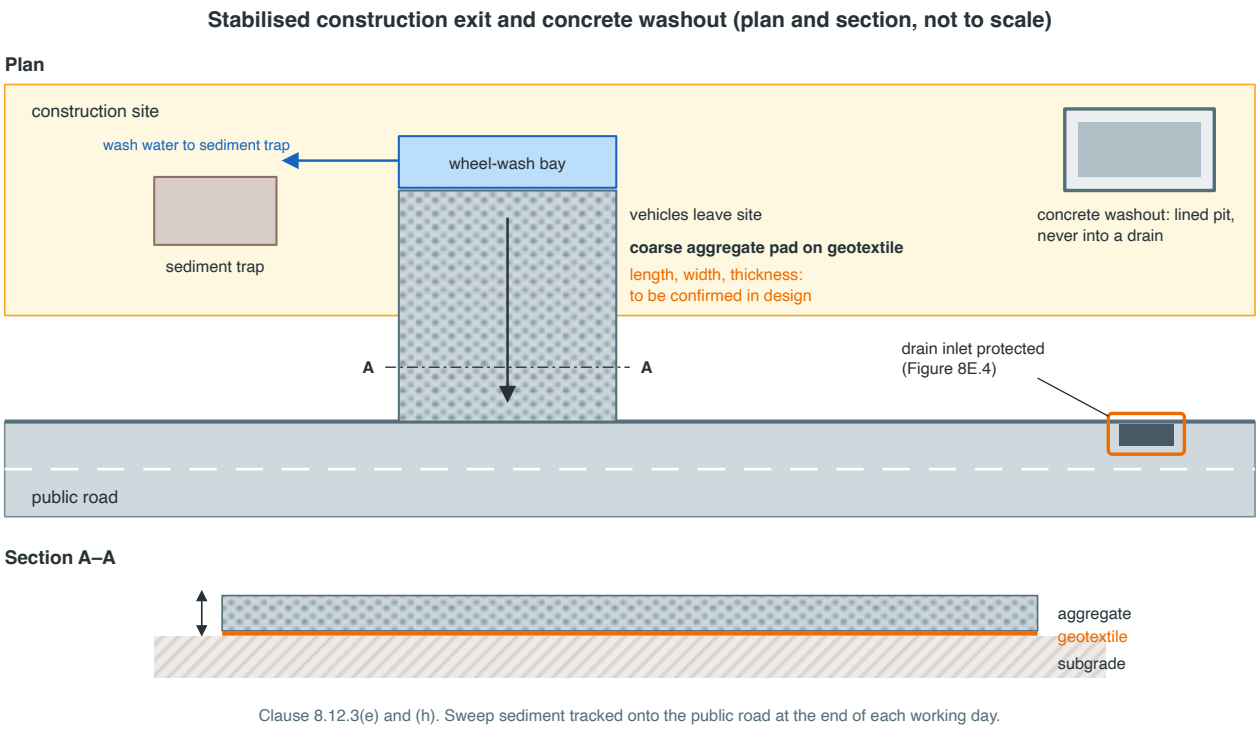


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing 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

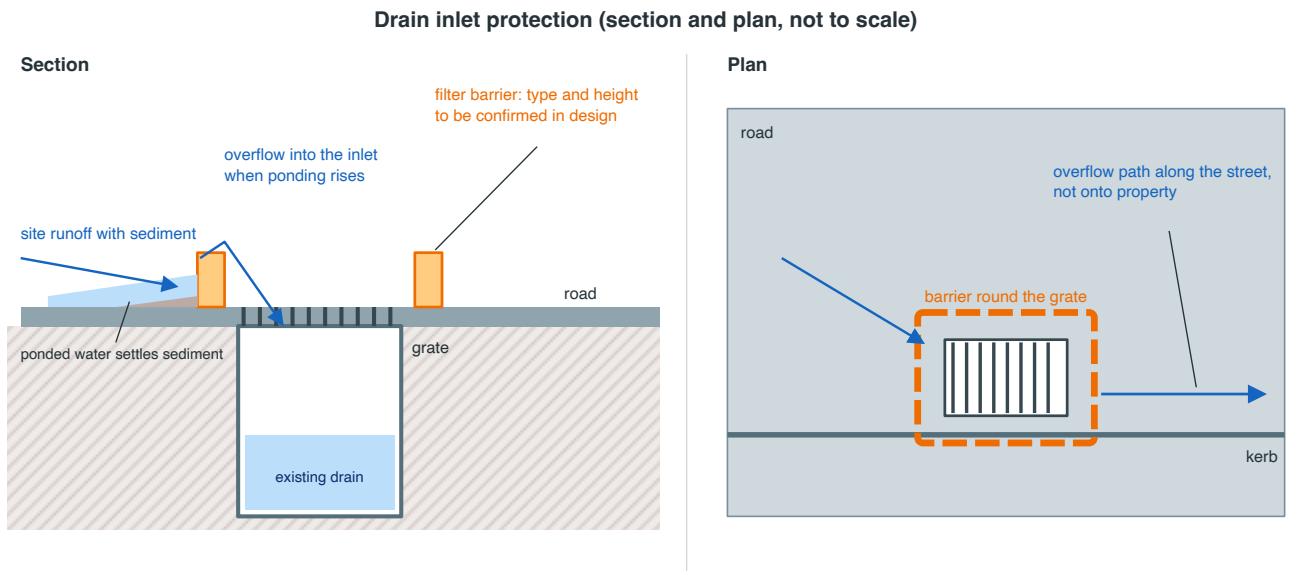


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (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 May
Area cleared between 15 June and 31 October	Sediment controls in place before clearing
Area exposed in the SW 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 — Uttarakhand 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 — Uttarakhand 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.

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.

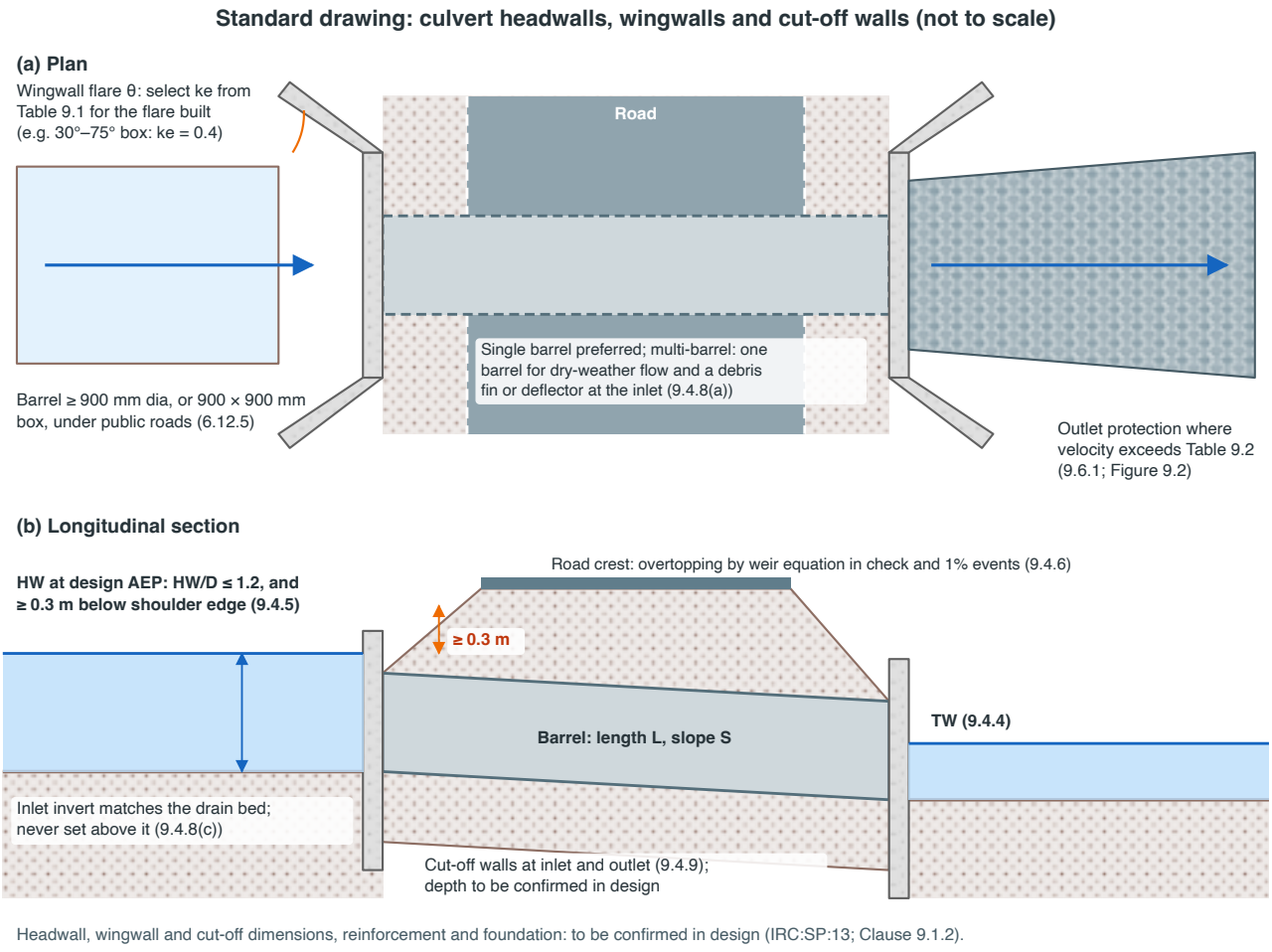


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

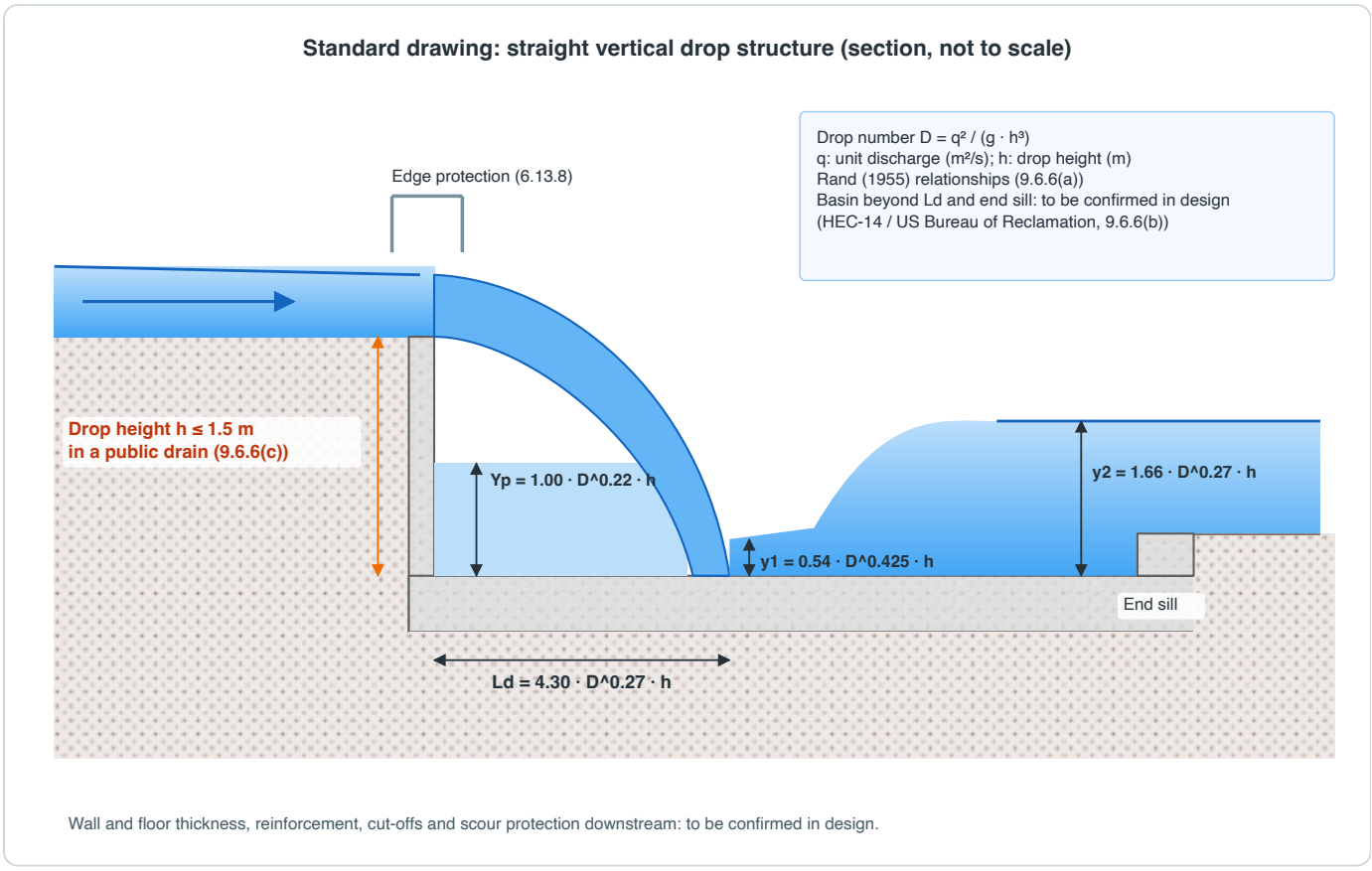


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

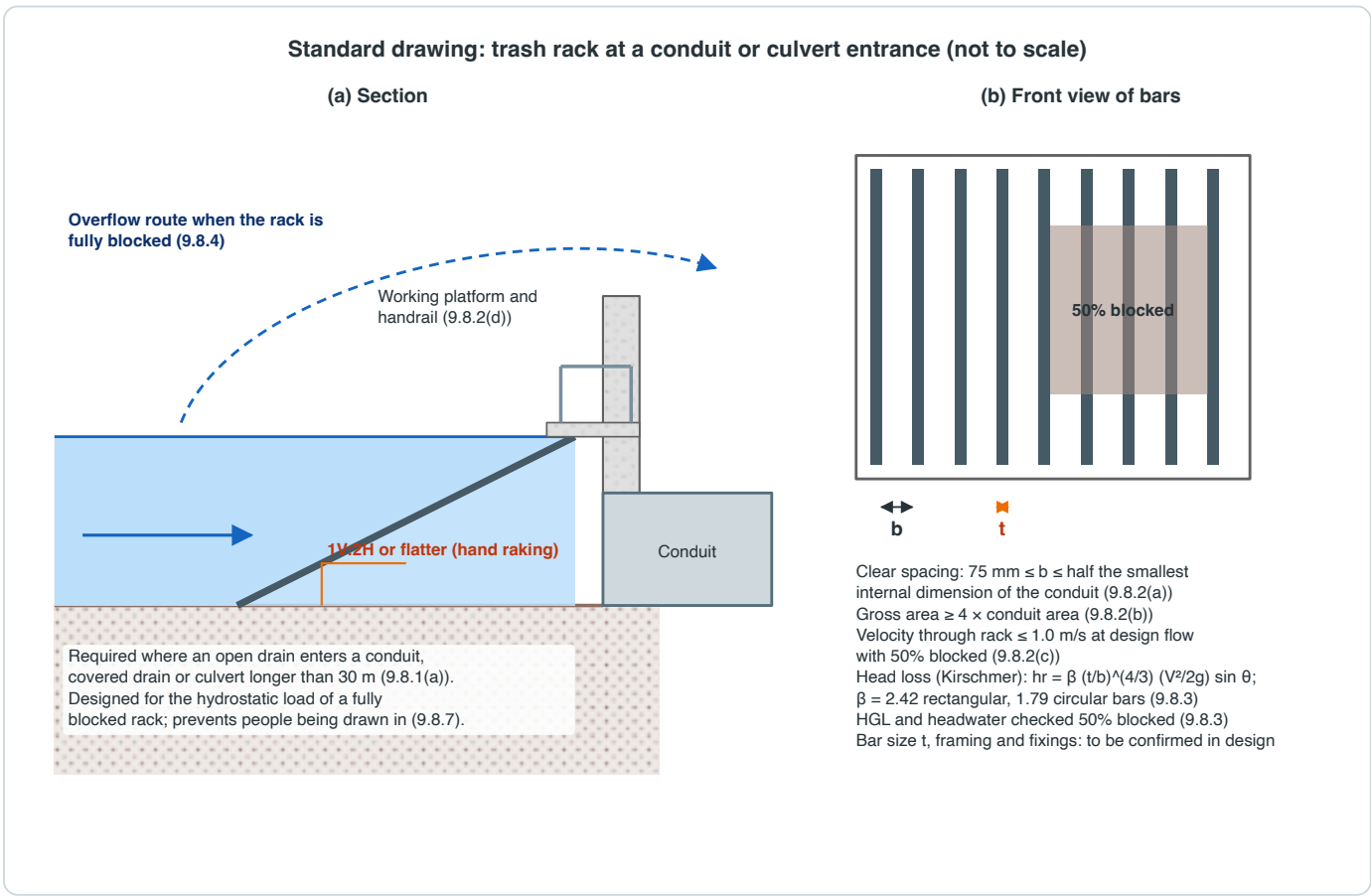


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm Water Drainage Systems (2019), §8.3.1.3.

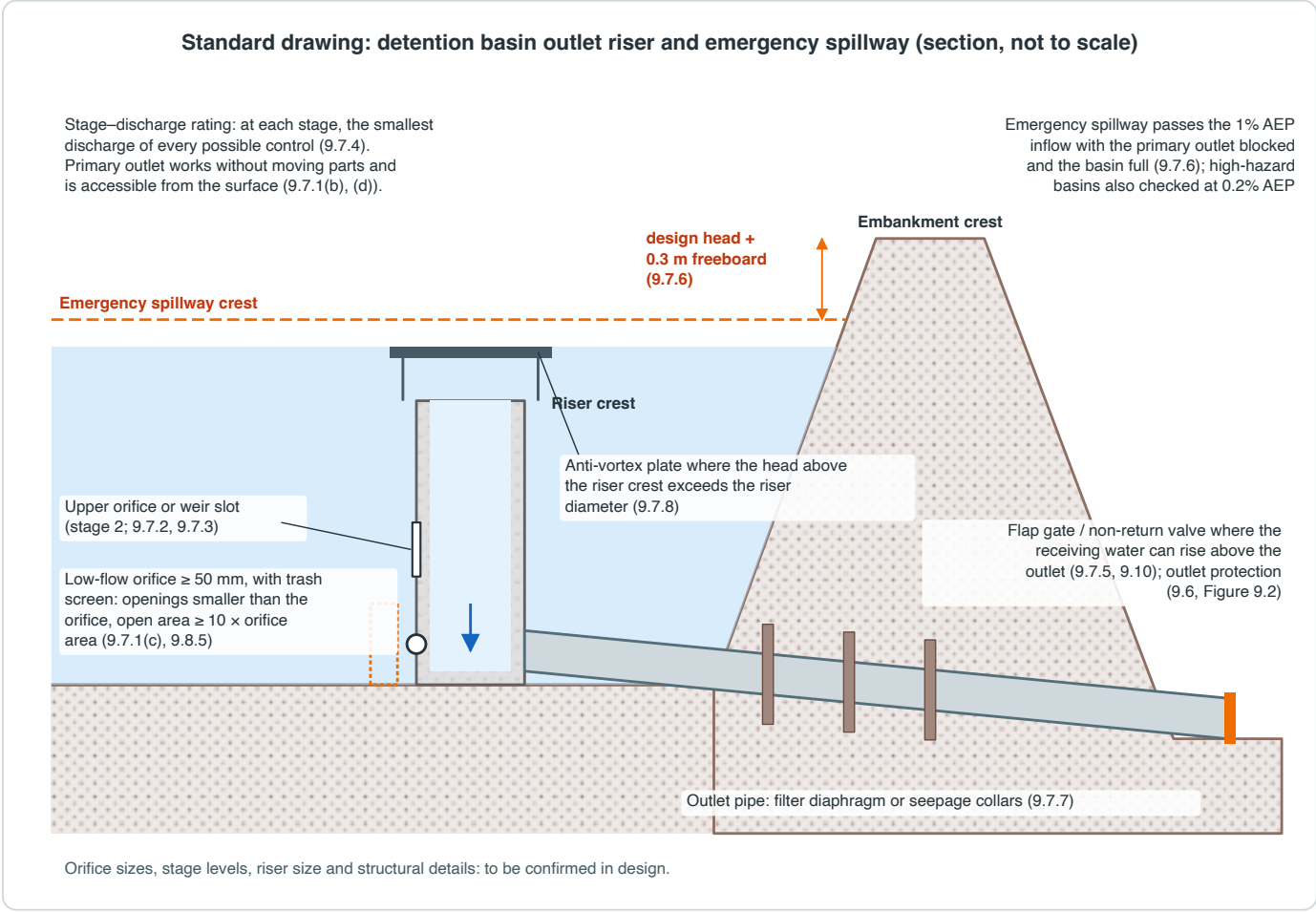


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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

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).

Form 9-1 — Hydraulic Structures Report checklist

Supports Clause 9.14 of Chapter 9.

Draft form — Uttarakhand 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 — Uttarakhand 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.

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 under bye-law 6.5 of the Bye-laws 2011 to every permitted construction with a ground coverage of 125 m² or more, except in waterlogged areas, as storage of at least 2.0 m³ up to 250 m² of coverage, 3.5 m³ up to 400 m² and 0.5 m³ more for each further 50 m² or part, reduced to one-third where groundwater recharge is provided on a plot of more than 400 m², confirmed on the plan before approval; recharge is credited only where Clause 8.8.1 allows it, which is on the Doon Gravels and the bhabar, never on a natural slope steeper than 10°, on a landslide or creep zone, on colluvium, slide debris or moraine, within twice the height of a cut slope or retaining wall upslope of it (unless a geotechnical certificate allows it), or in the terai where the seasonal water table is within 1 m of the ground.	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
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)

Step	Calculation	Clause
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.

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 44N (EPSG:32644) east of 78° E, or 43N (EPSG:32643) west of 78° E (Roorkee, Vikasnagar, Herbertpur, Chakrata, Selaqui and Prem Nagar; a project that crosses 78° E uses one zone for all its layers), 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 gauges on the receiving rivers, of the Irrigation Department's barrage, reservoir and canal levels, of the dam and barrage levels of THDC India Ltd and UJVN Ltd, of the PWD gauge at Tallital for Naini lake (read in feet on its own zero) and of the flood lines of notifications under the Uttarakhand Flood Plain Zoning Act 2012 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 `MDDA–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
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

Field	Type	Unit	Req.	Content	Source
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
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1

Field	Type	Unit	Req.	Content	Source
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
TIDE_REL	Relationship of the vertical datum to the Chapter 5 river datums of the CWC gauges on the receiving rivers, of the Irrigation Department's barrage, reservoir and canal levels, of the dam and barrage levels of THDC India Ltd and UJVN Ltd, of the PWD gauge at Tallital for Naini lake (read in feet on its own zero) and of the flood lines of notifications under the Uttarakhand Flood Plain Zoning Act 2012 (for example, MSL = x.xx m on the site datum)

Field	Content
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
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)

Code	Meaning
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).

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)
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

Element	Requirement	Clause
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 Uttarakhand cities 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.

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 May; 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
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 May; 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 Hindi 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 May; 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)
Full duty test	Before 31 May	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 31 May	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)

Task	Frequency	Standard or trigger	Clause
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 May	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 May	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 31 May	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 May; 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 May	Free of silt and debris	Table 10.3
Check for sewage connections	Each inspection	None; any cross-connection removed	1.5.4, 8.9
Overland flow paths	Each inspection	Not obstructed by walls, fill or stored material	6.9.2, 10.15.1(g)

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 T&CP. 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 Uttarakhand Building Construction and Development Bye-laws 2011 (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.

Form 10-1 — Drainage Report Checklist

Supports Clauses 10.4.1 to 10.4.4 and 10.7.1 of Chapter 10.

Draft form — Uttarakhand 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 gauges on the receiving rivers, of the Irrigation Department's barrage, reservoir and canal levels, of the dam and barrage levels of THDC India Ltd and UJVN Ltd, of the PWD gauge at Tallital for Naini lake (read in feet on its own zero) and of the flood lines of notifications under the Uttarakhand Flood Plain Zoning Act 2012	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 — Uttarakhand 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 — Uttarakhand 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, Bye-laws 2011 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 Uttarakhand 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)	_____	_____	_____

Form 10-4 — Hold-Point Inspection Record

Supports Clauses 10.4.2(g), 10.8 and 10.9.3 of Chapter 10.

Draft form — Uttarakhand 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 — Uttarakhand 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 — Uttarakhand 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, tehsil, 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 May 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	_____

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 — Uttarakhand Stormwater Design Manual, Draft v1.0. Due by **31 May** 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 June to 31 May)	_____
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 May) yes / no	_____
Entered in the facility register (Clause 10.17), date	_____
Follow-up action, if any (Clause 10.15)	_____

Form 10-8 — Asset Handover Certificate

Supports Clause 10.14 of Chapter 10.

Draft form — Uttarakhand 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 15 June 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.

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 Uttarakhand 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, taal 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:** Irrigation Department, wherever the basin includes a river, canal or tank under its control, and [other local bodies, MDDA or T&CP, USDMA] (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 river, rao, taal or canal 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, taal, 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, raos, barrages, reservoirs and taals: outfall invert levels, on a named datum, against the warning, danger and high flood levels of the receiving river at the nearest CWC site (the Ganga at Haridwar or Rishikesh, the Song at Satyanarayan, the Solani at Roorkee, the Gaula at Kathgodam, the Kosi at Ramnagar, the Sarda at Banbasa or another river) and its recorded peaks, with any local gauge kept as a separate series and any conflict between published values stated; for ungauged raos and gadheras, surveyed flood marks and the 1% AEP level with its sediment and debris, and the lines of any notification under the Uttarakhand Flood Plain Zoning Act 2012; for outfalls to barrage ponds, reservoirs and taals, the maximum pond or water level, full reservoir level and spillway and gate data from the Irrigation Department, THDC India Ltd or UJVN Ltd, and for Naini lake its gauge, tied to mean sea level, and its sluice rules; the release records of the dams and barrages that set the receiving levels; the debris-flow fans, landslide zones and glacial lakes above the basin; and sluices, flap gates, debris racks, sediment traps, debris basins, interception and diversion structures 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 Dehradun, Roorkee and Mukteshwar (rainfall since 1901), its stations at Tehri, Mussoorie, Joshimath and Nainital, whose records end between 1980 and 2012, and the automatic weather stations and rain gauges reported by the Meteorological Centre Dehradun, among them Sahastradhara, Maldevta, Jolly Grant, Narendranagar, Kalsi and Didihat; the district and tehsil rain gauges of the State, whose records IMD tabulates in the *Climate of Uttarakhand*; the observatory at Pantnagar; the self-recording gauges at Dehradun, Nainital, Tehri and Uttarkashi used for the CWC Flood Estimation Report for zone 7; the rain and river gauges of CWC and of the Irrigation Department, including those at its barrages and reservoirs; the records of THDC India Ltd and UJVN Ltd at their dams and barrages; and any gauges kept by the Nagar Nigams, the development authorities, USDMA and Dehradun Smart City Ltd), including the 16–17 June 2013 (370.2 mm at Dehradun on 17 June, IMD), 18–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, with new high flood levels on the Gaula, the Kosi and the Sarda, as reported), 14 August 2023 (175.1 mm at Dehradun, IMD, with the Ganga above its danger level at Rishikesh, as reported) and 15–16 September 2025 (264 mm in 24 hours and 54 mm in an hour at Sahastradhara, with the raos of Dehradun in flood, as reported) 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 16–17 June 2013 (370.2 mm at Dehradun on 17 June, IMD), 18–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, with new high flood levels on the Gaula, the Kosi and the Sarda, as reported), 14 August 2023 (175.1 mm at Dehradun, IMD, with the Ganga above its danger level at Rishikesh, as reported) and 15–16 September 2025 (264 mm in 24 hours and 54 mm in an hour at Sahastradhara, with the raos of Dehradun in flood, as reported) 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 groundwater recharge on the Doon Gravels and the bhabar, which feed the artesian aquifers of the terai and include the semi-critical blocks of Bahadrabad, Bhagwanpur, Haldwani and Kashipur (CGWB, 2020 and 2022), the stability of hill slopes, where water put into colluvium, slide debris or moraine raises the pore pressure, as along the Balia Nala at Nainital and at Joshimath, the naulas and dharas that supply the hill towns and their recharge areas, the recharge of Naini lake through Sukhatal, the high water table of the terai, and the quality of the groundwater, with nitrate and arsenic at places in Haridwar and Udham Singh Nagar, and of the rivers, raos and taals that the runoff reaches; effect on downstream basins and the receiving river, rao, taal or canal; 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.

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 fans and valley floors after any large debris flow, the drain network of every drain-owning body (the Nagar Nigams, MDDA, HRDA and the district development authorities, UUSDA and Dehradun Smart City Ltd, and PWD's road drains, with the interception and diversion structures on the drains and raos), the rivers, raos and gadheras with the floodplain lines of the Irrigation Department, the barrages and reservoirs of the Irrigation Department, THDC India Ltd and UJVN Ltd with their pond levels, spillways, gates and operating rules on a stated datum, the release records of Tehri, Koteshwar and the barrages, Naini lake with its gauge tied to mean sea level and the rules for its sluices, the springs and their recharge areas, and the landslide, debris-flow and glacial-lake hazards mapped by USDMA and ULMMC (other likely sources: Survey of India, CWC, CGWB, NIH and the district land records). No basin map of any Uttarakhand town was found. Until the annex is published, the basins of Dehradun, Rishikesh, Haridwar, Roorkee, Haldwani, Nainital, Rudrapur, Kichha and Kashipur, Ramnagar, Banbasa, Tanakpur and Khatima, and the valley towns 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-area UK-F 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
Dehradun (DMC, MDDA)	Catchments draining to the Rispana and the Bindal through their khalas	Interception and diversion structures and the Mothrowala plants in the 1D network; Rispana floodplain notification and 1-in-5-year line shown; 1% AEP rao level with debris as boundary
Dehradun east and Doiwala	Catchments draining to the Song and the Suswa	Song at Satyanarayan (CWC) as boundary
Dehradun west and Vikasnagar	Catchments draining to the Tons (Tamsa) and the Asan	Asan barrage pond (Asan Conservation Reserve) as boundary
Rishikesh (Nagar Nigam, MDDA)	Catchments draining to the Ganga through the Chandrabhaga, the Rambha and the town drains	CWC Rishikesh levels, Tehri and Koteshwar releases and the Pashulok pond as boundary
Haridwar (Nagar Nigam, HRDA)	Catchments draining to the Ganga at and below Bhimgoda and across the Upper Ganga Canal	CWC Haridwar levels as boundary; outfall-closed case a design case
Roorkee (Nagar Nigam, HRDA)	Catchments draining to the Solani	CWC Roorkee levels as boundary; canal crossings in the 1D network; outfall-closed case a design case
Haldwani (Nagar Nigam, Irrigation Department)	Catchments draining to the Gaula through the Rakasia and Kalasia nalas	Irrigation Department's master plan as the start; Gaula barrage pond and Kathgodam level as boundaries; pumped low areas with outfall closed
Nainital (Nagar Palika Parishad, Lake Development Authority)	Catchment of Naini lake, with Sukhatal	Lake as storage; Tallital sluices and their rules as outlet; Balia Nala shown as a hazard
Rudrapur, Kichha and Kashipur	Terai catchments draining to the Kalyani, the Kichha and the Dhela	Reservoirs and barrages as boundaries where reached
Ramnagar	Catchments draining to the Kosi below the barrage	Kosi high flood level as boundary (conflict stated)
Banbasa, Tanakpur and Khatima	Catchments draining to the Sarda	Banbasa levels as boundary

Tier A body or area	Basin	Note from Chapter 11
Valley towns (Srinagar, Rudraprayag, Uttarkashi, Joshimath and others)	Catchments of the town and of each gadhera crossing it	CWC high flood level as boundary; debris fans and slides mapped; in UK-F, hazard screening first
Other Tier A bodies, including Kotdwar, Almora and Pithoragarh	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_HI	Text	Basin name in English and Hindi
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 Irrigation Department 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)

Annex 11C — Depth–damage curves for Uttarakhand 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 Uttarakhand cities, 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 16–17 June 2013 (370.2 mm at Dehradun on 17 June, IMD), 18–19 October 2021 (403.9 mm at Pantnagar and 401 mm at Nainital in the 24 hours to 08:30 on 19 October, with new high flood levels on the Gaula, the Kosi and the Sarda, as reported), 14 August 2023 (175.1 mm at Dehradun, IMD, with the Ganga above its danger level at Rishikesh, as reported) and 15–16 September 2025 (264 mm in 24 hours and 54 mm in an hour at Sahastradhara, with the raos of Dehradun in flood, as reported) floods (Revenue Department and USDMA damage assessments, insurers), and replacement costs (Public Works 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.

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, barrage, reservoir and taal levels, 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 gauges on the receiving rivers, of the Irrigation Department's barrage, reservoir and canal levels, of the dam and barrage levels of THDC India Ltd and UJVN Ltd, of the PWD gauge at Tallital for Naini lake (read in feet on its own zero) and of the flood lines of notifications under the Uttarakhand Flood Plain Zoning Act 2012 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 `rispana_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).

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 — Uttarakhand Stormwater Design Manual, Draft v1.0. Published by the Lead Authority for each basin with an approved BSMP before each south-west monsoon, by **31 May** (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 June to 31 May)	_____
A4	Date of publication (by 31 May) 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 taal 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	_____