ASSAM

Stormwater Design Manual

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

Preserve | Retain | Detain | Convey | Maintain

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Prepared by

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About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Assam, by its Governor, its Council of Ministers or its Legislative Assembly, or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Department of Housing and Urban Affairs (DoHUA), the Directorate of Town and Country Planning (T&CP), the Guwahati Metropolitan Development Authority (GMDA), the Guwahati Municipal Corporation (GMC), the Dibrugarh or Silchar Municipal Corporations, any Municipal Board, Development Authority or Gaon Panchayat, or Guwahati Smart City Ltd. Nor has it been adopted, notified or endorsed by the Bodoland Territorial Council (BTC), the Karbi Anglong Autonomous Council (KAAC) or the North Cachar Hills (Dima Hasao) Autonomous Council (NCHAC), by any District Level Committee or the State Level Committee under the State's water-bodies law, or by any Advisory Committee under the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006. Where it names a body, such as the Water Resources Department (WRD) or its Embankment Officers, the Irrigation Department or the Assam State Ground Water Authority, the Assam State Disaster Management Authority (ASDMA) or a District Disaster Management Authority, the Revenue and Disaster Management Department, FREMAA, the Public Works Department (PWD), the Pollution Control Board, Assam (PCBA), the Assam State Wetlands Authority (ASWA), the Environment and Forest Department, the Guwahati Jal Board, AUWSSB or GMDW&SB, a Deputy Commissioner or a district administration, the Gauhati High Court, the National Green Tribunal (NGT) or the Supreme Court, or a body of the Union or another public body, such as the Brahmaputra Board, the Central Water Commission (CWC), the India Meteorological Department (IMD), the Central Ground Water Board (CGWB), the Central Pollution Control Board (CPCB), the National Institute of Hydrology (NIH), the National Disaster Management Authority (NDMA), the Ministry of Environment, Forest and Climate Change (MoEF&CC), the North Eastern Electric Power Corporation (NEEPCO) or NHPC, or a lender or consultant, such as the Asian Development Bank (ADB), the Japan International Cooperation Agency (JICA) or Haskoning DHV, it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role. Citing a body's document does not make this Manual that body's document.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. Until then, the Assam Building Construction (Regulation) Act, 2010 as amended in 2022, and the Assam Unified Building Construction (Regulation) Byelaws, 2022 as amended in 2024 (the Unified Byelaws 2022); the Master Plan for Guwahati 2025 and the master plans of the other towns, with their Zoning Regulations; the Guwahati Metropolitan Development Authority Act, 1985 and the Assam Town and Country Planning Act, 1959 (the T&CP Act); the Gauhati Municipal Corporation Act, 1969, the Assam Municipal Corporation Act, 2022 (the AMC Act) and the Assam Municipal Act, 1956; the Assam Embankment and Drainage Act, 1953; the State's water-bodies law; the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 (the Hill Land Act); the Assam Ground Water Control and Regulation Act, 2012; orders of courts and tribunals; and approval conditions in force continue to apply.

Assam and the Sixth Schedule. Three areas of the State are Autonomous Districts under the Sixth Schedule to the Constitution: the Bodoland Territorial Region (BTR), under the BTC; Karbi Anglong and West Karbi Anglong, under the KAAC; and Dima Hasao, under the NCHAC. The districts of the BTR are taken to be Kokrajhar, Chirang, Baksa, Udalguri and Tamulpur; this list was not confirmed against a notification [TBC]. Byelaw 1(2) of the Unified Byelaws 2022 extends them "to the master Plan areas or notified Planning areas of whole of Assam except for areas under Autonomous Districts, provided that if any District Council desires that all or any of the provisions of this byelaws shall apply to the Autonomous District concerned, a notification may be issued to that effect", and the Bill of the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024 carries the same opt-in. No building rules of the three Councils and no opt-in notification were found [TBC]. Diphu and Kokrajhar have master

plans prepared by T&CP, as listed, but whether the Unified Byelaws 2022 apply there depends on an opt-in that was not found. Outside the notified Master Plan areas the byelaws do not apply anywhere in the State, so this Manual reaches those areas only through public works and through a body that adopts it. This Manual therefore names its "competent authority for the area" by area and by subject, as Chapter 1 sets out. DoHUA could make it part of the Unified Byelaws 2022 by an amendment under section 4 of the building Act; GMDA and the Development Authorities, with T&CP, could write its drainage reserves, water-body buffers and basin storage into the master plans and Zoning Regulations; GMC and the other local bodies could apply it at building permit and occupancy certificate and to their own drains; WRD could set outfall and sluice conditions under the Embankment and Drainage Act; and a District Council could notify under byelaw 1(2) that the byelaws apply in its district, or adopt the Manual in its own rules. None has done so, and the Manual can reach an Autonomous District only through its District Council. Land outside the Councils' areas is mostly patta land, recorded by district, mouza, revenue village and dag number, with government (khas) land; in the Autonomous Districts land is held under the Councils' own land law, which was not researched for this Manual [TBC]. This Manual reserves drainage corridors and easements in a master plan or secures them by agreement; it does not assume that land can be taken. The paragraphs of the Sixth Schedule were not read for this Manual and are not quoted; the division is described by its effect, from the byelaws and the Bill.

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

- **Guwahati** is the city. The statute that governs its municipal corporation is printed as the **Gauhati Municipal Corporation Act, 1969** (Assam Act I of 1973), and this Manual cites it by that title; a GMC notice of 2025 cites a "Guwahati Municipal Corporation Act, 1971", which appears to be a mis-citation, as reported. The High Court keeps the name **Gauhati High Court**, and the university **Gauhati University**. **Dispur**, the State capital, lies within Guwahati, so where a shared clause names the State's main city or its largest local body, this Manual names Guwahati and GMC. The Guwahati metropolitan area, the 328 km² of the Master Plan for Guwahati 2025, is wider than GMC's area, and GMDA, the PWD, WRD, the Railways, Oil India Ltd (OIL), the National Highways Authority of India (NHAI), the Army and others hold drains in it, as reported;
- IMD names its airport stations after the airfield: **Guwahati (Borjhar) (A)**, also spelt Bhorjar (index 42410); **Dibrugarh (Mohanbari) (A)** (42314); **North Lakhimpur (Lilabari)** (42309); **Silchar (Kumbhigram) (A)** (42620), beside the town station **Silchar** (42619); and **Dhubri (Rupsi) (A)** (42406), beside the town station **Dhubri** (42404). This Manual names the station each figure comes from;
- CWC's flood estimation reports and other older sources use the names of their time: **Nowgong** (Nagaon), **Darang** (Darrang), **Sibsagar** (Sivasagar), **N.C. Hills** (Dima Hasao), **Mikir Hills** (Karbi Anglong) and **Halflong** (Haflong). Old Goalpara district is taken to have included today's Dhubri, Kokrajhar, Bongaigaon and Chirang, and old Lakhimpur district Dibrugarh and Tinsukia; this reading is to be confirmed before a clause relies on it [TBC]. The **"Lakhipur"** of the report for subzone 2(a) is a station in old Goalpara district: it is neither North Lakhimpur nor Lakhipur in Cachar. The districts were reorganised in 2022 and 2023, as reported, and this Manual's list of districts was not confirmed against a notification [TBC]; **Karimganj** district was renamed **Sribhumi**, as reported [TBC], and this Manual keeps "Karimganj" for the town and for the CWC and IMD stations that bear the name. A clause that names a district must be checked against the current list;
- CWC's reports divide the State among three subzones: the north bank in **subzone 2(a), North Brahmaputra** (report No. NB/18/1991); Guwahati, the south bank and the hill districts in **subzone 2(b), South Brahmaputra** (revised report No. SB-2(b)/R-4/44/99, March 2000); and the Barak valley and the south of Dima Hasao in **subzone 2(c), "Barak and others"**, for which CWC never published a report. These subzones are not the five rainfall zones (AS-Z1 to AS-Z5) and eight hydrologic sub-areas (AS-A, AS-A1, AS-B, AS-C, AS-C1, AS-D, AS-D1 and AS-E) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7;
- the beels and channels of Guwahati are spelt in several ways: **Deepor Beel** is Deepar Beel in the Unified Byelaws 2022 and in the State's report to the NGT, and the ADB names its basin "Dipar"; **Sarusola** is also Sorusola; **Borsola** is Barsola in the byelaws; **Silsako** is also Silsaku; and the **Kalmani** is the ADB's "Kalmoni". The heading of the first schedule of the Guwahati Waterbodies (Preservation and Conservation)

Act, 2008 is illegible in the copies read, and this Manual reads it as Sarusola Beel. The **Bahini** rises in Meghalaya and becomes the **Bharalu** at Jonali, and the Bharalu joins the Brahmaputra at Bharalumukh. The **Mora Bharalu**, a channel that the Bharalu abandoned, flows to Deepor Beel; this Manual found no source for any other link between the Bharalu and Deepor Beel;

- the State's building rules spell the word **"Byelaws"**, and this Manual writes "byelaw 74" in the same way when it cites one; the "bye-laws" that a local body makes under its own Act keep their hyphen. **"Unified Byelaws 2022"** is the State's rules as amended in 2024, and **"MBBL 2016"**, in Chapters 1 and 10, is the national Model Building Bye-Laws of 2016, not the State's rules;
- the **Master Plan for Guwahati 2025** is the plan in force: it was published in the Assam Gazette Extraordinary No. 198 of 9 July 2009, for operation from 7 July 2009, and has since been modified. The **draft Master Plan 2045** was released in early 2024 and had not been finally notified by November 2026, as reported; this Manual does not cite it as in force;
- CWC's levels in the State were read only in a transcription by the South Asia Network on Dams, Rivers and People (SANDRP), in metres, and no source read states their datum [TBC]: for example, the danger level of 49.68 m and the highest flood level of 51.46 m (21 July 2004) of the Brahmaputra at Guwahati (DC Court). This Manual names the gauge, the unit and the datum with every level; and
- in this Manual **"the monsoon" and "the monsoon season" mean the wet season of 1 April to 31 October**. That is not IMD's usage: IMD counts April and May as pre-monsoon months, and the south-west monsoon reaches the North East in about the first week of June (about 5 June, as reported; 2–4 June at Guwahati in IMD's revised normals, as quoted in a press summary of IMD's release); the date of its withdrawal from Assam was not obtained [TBC]. The Manual's season begins on 1 April because the April and May storms are among the State's largest (Chapter 2).

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

- the **Assam Unified Building Construction (Regulation) Byelaws, 2022** were made by DoHUA in the Governor's name, by notification No. DoHUA/ECF No. 236697/2 (Assam Gazette Extraordinary No. 688, 15 October 2022), under section 4 of the **Assam Building Construction (Regulation) Act, 2010** (Assam Act XVI of 2010). That Act was the Guwahati Building Construction (Regulation) Act until Assam Act XXVII of 2022 renamed it and extended it "to the whole of the State of Assam"; the notification that brought the amendment into force was not seen [TBC]. The byelaws were amended by the (Amendment) Byelaws, 2024 (No. DoHUA/ECF No. 420084/34, Gazette No. 667, 20 November 2024). A further amendment approved by the Cabinet in 2025 was reported, but no gazette was found, and this Manual does not cite it. Byelaw 131(1) repeals "The Guwahati Building Construction (Regulation) Byelaws, 2010", although no byelaws of 2010 were found and the earlier rules in Guwahati were the Guwahati Building Construction (Regulation) Byelaws, 2014; this Manual treats the byelaws of 2014 as superseded in practice and states the conflict. Some byelaw numbers, such as 26(ix), 44(ix) and 44(iii), were read from the layout of a scanned copy and are to be confirmed against a clean copy [TBC];
- **DoHUA** was formed in 2021 by merging the Guwahati Development Department and the Urban Development Department, as cited; it makes the byelaws and oversees GMDA, GMC and the other local bodies. **T&CP**, a directorate under DoHUA, prepares the master plans of the towns outside the Guwahati metropolitan area for the 24 Development Authorities under the **T&CP Act** (Assam Act II of 1960), and has begun drainage master plans for the major towns, according to the ADB. **GMDA**, under the GMDA Act, 1985 (cited in later Acts as Assam Act XX of 1987; its text was not read for this Manual [TBC]), grants planning permits in the Guwahati metropolitan area; in other editions of this series similar letters stand for other bodies, and in this Manual GMDA means only this one;
- in a notified Master Plan area the 2022 amendment of the building Act divides approval between a **planning permit**, granted by GMDA or a Development Authority, and a **building permit**, granted by GMC, another Municipal Corporation, a Municipal Board or a Gaon Panchayat. The **Gauhati Municipal Corporation Act, 1969** governs GMC's drains (sections 231 to 252); the **AMC Act** (Assam Act VIII of 2022)

governs the Dibrugarh and Silchar Municipal Corporations and requires each to "provide a safe and sufficient outfall … for effectual drainage and proper discharge of storm-water and sewage" (section 171); and the **Assam Municipal Act, 1956** governs the Municipal Boards;

- the **Assam Embankment and Drainage Act, 1953** (Assam Act I of 1954) applies to the whole State. Its "drain" includes "dongs", culverts, ditches, canals and sluices; cutting through an embankment or drain, or opening, shutting or obstructing a sluice, without authority is punishable with up to three years' imprisonment (section 15(ii)); and in a notified area no one may build on, remove or alter an embankment or drain without permission (section 16). WRD's Embankment Officers act under it;
- the **Guwahati Waterbodies (Preservation and Conservation) Act, 2008** (Assam Act XX of 2008) defines "waterbodies" as "the area or areas of land where the rain water accumulates and act as natural or storm water reservoir and shall include wetland", and scheduled four areas of Guwahati by dag number: Sarusola, Borsola and Silsako Beels, and land near Deepor Beel, not the beel itself. Section 22 of the Bill of the **Assam Urban Water Bodies (Preservation and Conservation) Act, 2024**, passed on 29 August 2024, repeals it; the Bill keeps the definition, adds the inflow and outflow channels and all ponds and tanks "irrespective of its size", with exceptions, and extends to all notified Master Plan areas. The enacted text of the 2024 Act (Assam Act XXV of 2024, as cited) and its Rules of 2025 were not read, so this Manual cites the 2008 Act as the Act that the 2024 Bill repeals, and the Bill's section numbers as the Bill's [TBC]. "The State's water-bodies law" in this Manual means the two together, as in force;
- **Deepor Beel** is a Ramsar site (No. 1207, designated on 19 August 2002, as cited), the only one in Assam, as reported, and a wildlife sanctuary, whose denotification the Gauhati High Court stayed on 5 April 2024; its eco-sensitive zone has been published only in draft. The **ASWA** was constituted on 1 November 2018, as cited; no wetland notified under Rule 4 of the Wetlands (Conservation and Management) Rules, 2017 was found;
- the **Hill Land Act** (Assam Act V of 2007) lets the State declare Designated Areas of hill land and "ecological sites", which include "a drainage system, feeding channel"; in a Designated Area a registered owner needs the Advisory Committee's approval for a guard wall or a house (section 14). No Designated Area notification was found [TBC];
- the **Assam Ground Water Control and Regulation Act, 2012** (Assam Act XVI of 2012) is administered through the Irrigation Department, whose Secretary chairs the Assam State Ground Water Authority; its rainwater harvesting directions for premises of 100 m² or more apply only in a notified area (section 19), and no notified area was found. Whether the Authority has been constituted was not confirmed [TBC]. CGWB's North Eastern Region office at Guwahati keeps the observation wells;
- **ASDMA**, under the Revenue and Disaster Management Department, is the State's disaster management authority; the District Disaster Management Authorities are written in full. **FREMAA** carries out the ADB-assisted flood and riverbank erosion programme. **PCBA** prepares the action plans for the State's polluted river stretches; and
- the **Revenue and Disaster Management Department** keeps the land records by district, mouza, revenue village and dag and patta number. Where a shared clause names a revenue subdivision, this Manual uses the **mouza**.

Where a shared clause calls for the local language on a sign, a form field or a basin name, this Manual writes "Assamese". **Assamese is the official language of the State, and English the language of this Manual.** Under the Assam Official Language Act, 1960, as amended, Bengali is in official use in the three Barak valley districts, Cachar, Karimganj and Hailakandi, and Bodo in the Bodoland Territorial Region; the amending Acts and the districts they name were not confirmed for this Manual [TBC]. So, as set by this Manual, **signs and flood-depth markers are in Assamese and English; in the Barak valley districts in Bengali and English, to which Assamese may be added; and in the Bodoland Territorial Region in Bodo, Assamese and English.** In Annex 7A the field WB_NAME_AS holds a water body's name in the local script of its district: Assamese, or Bengali in the Barak valley, both written in the Eastern Nagari script, which spells the two languages differently in a few letters such as ৰ and ৱ. A Bodo name, written in the Devanagari script, goes in the field WB_NAME with a note.

Some local words are used in the text, and are explained again where they first appear:

- a **pukhuri** (Assamese পুখুৰী: a dug tank or pond; plural pukhuris) is this Manual's word for a dug pond or tank. The *Chandrakanta Abhidhan* (2nd ed., 1962, p. 604) gives "a pond; a tank", from a Sanskrit word for a large dug place to hold water, and Bronson's dictionary (1867, p. 351) gives "a tank, a reservoir of water". Assamese marks the plural with *-bor* or *-hot*, not with an ending of this kind, so the English plural "pukhuris" is a convention of this Manual. Where a shared clause writes "tank (pukhuri)", it means a pukhuri, or a beel that has a jan outlet or a sluice; Assam has no cascades of irrigation tanks;
- a **beel** (Assamese বিল: a natural floodplain lake or wetland) is "a lake", a broad body of water without current (*Chandrakanta Abhidhan*, p. 685; Bronson, p. 410), and the statutory word of the water-bodies law and the byelaws. This Manual never calls a natural wetland a pukhuri, and calls engineered storage a **detention pond**, never a pukhuri or a beel;
- a **jan** (Assamese জান: a stream or natural drainage channel, often the outlet of a beel) is "a ravine; a stream", a small river from a channel or beel (*Chandrakanta Abhidhan*, p. 397), and "a drain, a trench, a channel, a creek" (Bronson, p. 225), as in Bondajan, Lakhimijan and Khanajan. A **juri** (Assamese জুৰি: a small hill stream) is glossed so in the *Chandrakanta Abhidhan* (p. 407). A **nala** (নলা) is a built drain (p. 535);
- a **char** (চৰ) is land formed by the river from deposited silt (p. 336), and a **chapori** (চাপৰি) high land of river sand and silt (p. 346), "an island, high table land" in Bronson (p. 196); both flood and move with the river;
- a **mothauri** (মথাউৰি) is "an embankment along the edge of a river" (*Chandrakanta Abhidhan*, p. 737), this Manual's word for a river embankment; a **pani-duwar** (পানী-দুৱাৰ) is "a water-gate; a sluice" (p. 594), though the text keeps the English "sluice"; and **ban** or **banpani** (বান, বানপানী) is a flood (p. 666); and
- the Assamese *doba* is the deepest part of a river or lake, not a pond, and this Manual does not use it. The Embankment and Drainage Act's "dongs" are drains of that Act; this Manual gives the word no other meaning.

Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2 and 3; the Assam Municipal Corporation Act, 2022 is always the "AMC Act";
- GMDA is the Guwahati Metropolitan Development Authority and GMC the Guwahati Municipal Corporation. In other editions of this series and in some sources similar letters stand for other bodies; in this Manual they mean only these;
- "Unified Byelaws 2022" is the Assam Unified Building Construction (Regulation) Byelaws, 2022 as amended, and "MBBL 2016" the national Model Building Bye-Laws 2016. Neither is the building rule of any other State;
- HFL is the highest flood level recorded at a gauge, as CWC uses it, and DL and WL are CWC's danger and warning levels. None is a design level. Byelaw 45(c) sets a plinth above "the highest recorded flood level as fixed by the local authority"; no such level was found for any town, and Chapter 7 says how this Manual finds one;
- T&CP is the Directorate of Town and Country Planning, and the "T&CP Act" the Assam Town and Country Planning Act, 1959.

The sense is clear from the context.

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

Assam's towns flood, and fail, for three reasons. Silchar showed the first in June 2022, when the Barak entered the town through a cut in its embankment at Bethukandi and the town stayed under water for about eleven days, or "about a week" in other accounts, as reported, although the river at Annapurnaghat peaked 0.25 m below its record of 1989, as the district's report gives the peak; Guwahati showed the second on the night of 20 April 2026, when the gauge at the airport recorded 117.4 mm, an April record, and a gauge at Khanapara, on the city's hill fringe, 215.9 mm, as reported; and the Bharalu shows the third every day, because no town in Assam has a centralised sewerage system, and the river "has no natural flow … only the domestic sewage and commercial sewage are being carried", as the Pollution Control Board, Assam found.

1. **Towns that drain into rivers higher than themselves, through sluices that close for weeks.** Assam's riverside towns sit behind about 4,474 km of embankments and drain through sluices in them. When the Brahmaputra or the Barak is high the gates close, and the town drains only by pumping or not at all: "High stages of river Brahmaputra and Barak obstruct free discharge of tributaries causing back flow and congestion near outfalls", WRD told the CAG, and "Inadequate countryside drainages through sluices in embankment system … cause prolonged inundation". At Guwahati "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas", as the ADB's environmental examination of 2017 records; the Brahmaputra reaches its danger level there in most monsoons, as this Manual reads the record, and its highest level, of 21 July 2004, was 1.78 m above it. The Bharalu, the city's main drain, can discharge "72 Cumecs when its Bharalumukh sluice gates are kept open, while the pumps fitted to its sluice gates can discharge only seven Cumecs", as reported in 2008; the capacity installed today was not found. Dibrugarh has drained through a single long channel since the town protection dyke of 1955 "closed all the drainage channels", and "At present, Dibrugarh town is 1.5 m below the bed level of Bramhaputra"; its drain runs 32 km to the Sessa past a beel, and its new outfall sluice was designed "keeping in mind that the beel is full and the drain is also flowing full". Silchar is a bowl behind the Barak embankment. The CAG counted 98 major and 545 minor sluices in 2017, WRD's site gives 94 major, and a reply in the Lok Sabha in December 2024 gives 122; no operating rule or closing time for any of them was found.
2. **Rainfall that two CWC reports read differently across one river, and that no report covers in the Barak valley.** The Brahmaputra divides CWC's subzone 2(a), on the north bank, from subzone 2(b), on the south bank, and the two reports give different ratios of short to 24-hour rain: 0.260 for the hour in 2(a), and 0.48 in 2(b). On the 2(b) plates, read by eye, Guwahati's 50-year day is about 200–240 mm. Neither ratio set holds every fall recorded at the city's own self-recording gauge, 93 mm in one hour on 17 May 1970 and 163 mm in three hours on 18–19 July 1978, which the report itself prints: the 2(b) ratios hold the hour but give only 124–149 mm in three hours, 9–24% short of the 1978 storm, and the 2(a) ratios give 52–62 mm in an hour, short of the 1970 hour by a third or more. Across the river, at North Guwahati, the 2(a) ratio gives an hour about half as deep as on the south bank for the same day, although the hourly falls recorded and modelled on the two banks are alike. Within the city the gauges disagree more than the reports: on 14 June 2022 two gauges of WRD recorded 84.6 mm and 88 mm while the airport recorded about 10 mm, and on 20 April 2026 the gauges ranged from 117.4 mm to 215.9 mm, as reported. The Barak valley, with Silchar, Karimganj and Hailakandi, is in subzone 2(c), for which CWC never published a report, so there is no plate, no ratio and no synthetic unit hydrograph for it at all. Large falls also come before the south-west monsoon: four of the seventeen Assam stations in IMD's tables of extremes recorded their largest day in May, among them Dhubri (Rupsi), with 479.3 mm on 28 May 1989.
3. **Storm drains that are the sewerage.** "No ULB in the state has a centralized sewerage system, including Guwahati … about 90% of households have installed septic tanks or leach pits, no ULB has a systematic mechanism for septage collection", the ADB found in 2025, and the CAG found that "natural drainage systems of the cities carried the sewage". In Guwahati the Bahini, cut off by a sluice at Natun Bazar, "now becomes a sewerage drain", and about 39 outfalls carry some 70,740 m³ of untreated sewage a day into the Bharalu, which CPCB places in Priority I of its polluted river stretches. The Mora Bharalu carries sewage to Deepor Beel. The sewerage project assisted by JICA, whose loan was signed in 2015, had only "begun with the survey" in March 2025, as reported. Dibrugarh's main drain "receives sewage flows" from a major part of the town.

Over all three lie four more. **Beels lost to filling**: the ADB's examination lists the "encroachment of low-lying land", filled swamps and "construction of buildings and roads over the manmade drains" among the causes of waterlogging in Guwahati; Deepor Beel is reported to have shrunk by about 35% since 1991, though other figures conflict; Urpad Beel in Goalpara shrank from 4.84 km² to 3.38 km² between 2003 and 2023, as reported; and the Gauhati High Court took up the "artificial floods" of Palasbari, where builders blocked channels and filled wetland (PIL 53 of 2023). **Hill cutting that silts the drains**: "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels", and in May 2025 the High Court recorded that "hill cutting is still going on". **A water table near the surface**: in Kamrup (Metro) CGWB found the water 1.39–4.08 m below ground in March 2022 and 1.29–2.64 m in November, and water-logged or waterlogging-prone ground after the monsoon in "almost all the districts of Assam". And **building rules with drainage hooks but no design storm**: the Unified Byelaws 2022 keep buildings 15 m, 10 m or 6 m from rivers and named channels and 15 m, 6 m or 10 m from beels and ponds, require a "dry sump (including design calculation) … capable of holding rain water during peak monsoon" on plots liable to flood and in hilly areas, set the plinth 0.3 m above "the highest recorded flood level as fixed by the local authority", and ask for 5 m³ of rainwater harvesting pits for every 100 m² of roof; but no rule says for what storm the sump is designed, what flood level the local authority fixes, or how fast a site may release its runoff.

Behind all of this lie the State's rivers, beels and pukhuris, which set the level at the outfall and hold the water when the gates are shut. The Rashtriya Barh Ayog found 31.50 lakh ha, 40% of the State, prone to flood, as the CAG quotes it; WRD's site gives 31.05 lakh ha, 39.58%, and the two figures are both in use. The National Wetland Atlas (2011) mapped 764,372 ha of wetland, 9.74% of the State. The State's water-bodies law already defines a water body as land "where the rain water accumulates and act as natural or storm water reservoir", so a beel is storm-water storage in law as well as in fact. The char and chapori lands of the Brahmaputra, about 3,60,927 ha in a survey of 2002–03, as reported, flood and move with the river, and Majuli's area is given from several baselines that conflict.

Design for Assam therefore has to cover a wet season that begins with the storms of April and May, before the south-west monsoon reaches the North East in about the first week of June, and that runs past its withdrawal to storms such as those of 30 October 1959 at Haflong (237.1 mm) and 2 October 2012 at Dhubri (186.2 mm); it is this Manual's monsoon season, 1 April to 31 October. Large falls come outside it too, as on 9 November 1955 at Haflong (234.2 mm) and Silchar (174.2 mm) and on 29 March 1922 at Silchar (245.4 mm), so design statistics use the annual maxima of every month. CWC's report for subzone 2(b) finds that "The rainfall is generally spread over a period of eight months, i.e. from March to October", that "May rainfall is more than the September rainfall" and that "The winter season from December to March is practically dry"; most of the subzone receives 1,250–2,500 mm a year, while Jatinga Valley, in the Dima Hasao hills, has a normal of 4,767 mm. There is no snow. Underground, groundwater is plentiful and close to the surface; rainwater is worth storing for use, but on the flood plains it cannot be put into the ground in the season when it falls.

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 tanks for use, and in the ground only where the ground is above the water table and can safely take it;
- release the large storms no faster than the undeveloped land did, or slower where catchments already flood; and
- show that its outfall still works when the receiving jan, beel, pukhuri or river is high, when the sluice at the embankment is shut and the town drains only by its pumps, when a dam upstream is releasing, or when a drain is choked with silt from the hills.

The Manual also sets how public drains, roads and their drains, jans, beels, pukhuris, embankment sluices, pumped outfalls and basin-wide master plans are designed, and how drains below cut hills are protected against silt and debris, 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 Assam's wet season of April to October, with its pre-monsoon storms; to the Brahmaputra, which divides two CWC subzones, and the Barak, whose valley no CWC report covers; to towns that lie behind embankments and below the river's high stage, and drain through sluices and pumps; to Guwahati's hill streams, which rise in Meghalaya; to the dam-release reaches of the north

bank; to the flood-plain silts and clays, the char and chapori sands, the bhabar and terai fans of the northern foothills, the thin red loams over the gneiss of the Guwahati hills and the laterite and red loams of the Karbi and Dima Hasao hills; to a water table that reaches the surface in the monsoon; to the beels and pukhuris; and to storm drains that carry sewage.

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 for the hill roads, and the NDMA urban flood guidelines are also used.
2. **Overall structure.** Kansas City Metro APWA Section 5600 (Version 2025.01), the most recent comprehensive regional standard. It supplies the preserve, retain, detain, convey and maintain sequence and the required retention volume.
3. **Design rainfall.** The CWC *Flood Estimation Reports* for subzone 2(a), North Brahmaputra (NB/18/1991), and subzone 2(b), South Brahmaputra (revised, March 2000), as the interim source, each read by the coordinates of the site: the 2(a) ratios of short to 24-hour rain on the north bank and in the Dima Hasao hills, and the 2(b) ratios in Guwahati, on the south bank, in the Karbi hills and in the Barak valley. Within 5 km of the Brahmaputra's banks, which divide the two subzones, the higher of the two values governs; for Guwahati's streams the design day is averaged over the whole catchment, including the part that lies in Meghalaya; and in the Barak valley, for which no report exists, the design day comes from IMD's two Silchar stations, with floors of 320 mm at 2% AEP and 351 mm at 1% AEP, so that no design depth there falls below the adjoining 2(b) values. Floors at 1, 3 and 6 hours keep every short design storm above the falls recorded in the valley. All these rules are set by this Manual (Chapter 2). NIH-DHAARA is reported beside the design value for comparison only, and IMD's national rainfall intensity curves (Das et al., 2022) are not used, because their Guwahati and Dibrugarh (Mohanbari) panels repeat a curve printed for many other cities.
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 Assam Building Construction (Regulation) Act, 2010 and its amendment of 2022; the Unified Byelaws 2022 and their amendment of 2024, with the Guwahati byelaws of 2014 for comparison; the Master Plan for Guwahati 2025 and its Zoning Regulation, and its schedule of modifications; the T&CP Act; the Gauhati Municipal Corporation Act, 1969 and the AMC Act; the Assam Embankment and Drainage Act, 1953; the Guwahati Waterbodies (Preservation and Conservation) Act, 2008 and the Bill of the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024; the Hill Land Act; the Assam Ground Water Control and Regulation Act, 2012; and the orders of the Gauhati High Court in PIL 14 of 2024, PIL 53 of 2023 and PIL 18 of 2023, and of the NGT in OA 472 of 2018 and OA 673 of 2018. This Manual follows them or, where disclosed, makes them stricter. The enacted text of the Urban Water Bodies Act and its Rules, the GMDA Act, 1985, the modification of the Master Plan of 25 March 2025, the Assam Municipal Act, 1956, the Assam Official Language Act, 1960 and its amendments, any instrument of the three Councils and the Sixth Schedule itself were not read. 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 Assam 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. The State Action Plan on Climate Change is reported to project that "extreme rainfall events will increase by 5–38 per cent", but gives no factor for design that this Manual could find; its text was not read.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. CWC's two reports for the Brahmaputra valley read the same storms differently on the two banks, and the Barak valley has no report at all. IMD's 2022 national set of rainfall intensity curves has panels for Guwahati and Dibrugarh (Mohanbari), but both repeat a curve printed for many other cities. The reanalysis grids of NIH-DHAARA give 24-hour depths 1.3 to 2.6 times the CWC values, most of all in lower Assam, where they give Dhubri 789 mm at 50 years against about 280–320 mm on the CWC plate and an IMD record of 368.3 mm.

Assam has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of DoHUA, T&CP, GMDA, GMC, any other Municipal Corporation or Municipal Board, the PWD or WRD that fixes a return period, a runoff coefficient or a design rainfall for town storm drains, and no IDF relationship with published constants for any station in the State. DoHUA's status sheet records that the town drainage master plans "were prepared before 2015 as per previous FPS system", and no design criteria appear in the documents read. The drain of the Dibrugarh town protection dyke was designed by a "rainfall based approach … rational method", with no return period stated. The first return period found in any official project document is the ADB's target that inundation "from a 1-in-5-year storm or lower return period" be avoided in 434 ha of the Bahini basin of Guwahati, with a "design storm of 65.72 mm hour" whose duration is not stated. GMDA's comprehensive drainage master plan for Guwahati, ordered in August 2024 and followed by the Gauhati High Court in PIL 14 of 2024, was expected by April 2026 and is being revised on the direction of the minister, as reported; it is not final. "Apart from 17 kilometres of drains built between 1973 and 1997, no other extensive and planned drainage network exists in the Guwahati Metropolitan Area", as reported; the ADB found that the storm-water network of the urban local bodies "covers only about 30% of the required areas", and the CAG found coverage of "3 to 37 per cent only". This Manual is offered as a technical companion to the Unified Byelaws 2022, the master plans and their Zoning Regulations, the municipal Acts, the Embankment and Drainage Act, the State's water-bodies law and the Hill Land Act: it supplies the design storm, detention, water-level, tailwater and buffer values that they leave open. It has not been adopted by DoHUA, T&CP, GMDA, GMC, WRD, any District Council or any other body. In particular:

- **The building rules ask for a dry sump with a "design calculation", but name no storm.** Byelaws 74 and 110(h) require, on sites liable to flood and in hilly areas, a "dry sump (including design calculation) in all individual plots, capable of holding rain water during peak monsoon", without saying what peak or what calculation. Byelaw 114 requires rainwater harvesting pits of at least 5 m³ for every 100 m² of roof, and Appendix VI one percolation pit of 1.2 m × 1.2 m × 1.5 m for every 100 m² of plot, with storage and reuse on plots of 134 m² or more; the two rates are not reconciled, and neither is sized to a storm. The Unified Byelaws 2022 contain no storm-water detention, peak-runoff or release-rate rule; the only mention of runoff is a green-building criterion to "Minimize storm water run-off from site by reducing hard paving on site";
- **The rules put rainwater into ground that is already full.** Appendix VI routes "All Rain water outlets/drains and waste water drains" to the road drain "through the percolation pit only". On the flood plains, where the water table lies within about 2 m of the surface after the monsoon and the rising Brahmaputra "reduces the rate of percolation", as the ADB's examination records, and where grey water is mixed in, such a pit is a soakaway in

saturated ground. This Manual states the conflict and asks for storage in its place; it does not override the byelaw. The groundwater Act's rainwater rule for premises of 100 m² or more applies only in notified areas, and none has been notified;

- **The setbacks name Guwahati's channels and stop at 15 m.** Byelaw 26(ix) keeps buildings 15 m from a river "as marked in the plan", 10 m from the Bharalu, the Mora Bharalu and the Bondajan, 6 m from other channels, 15 m from Deepor Beel and Silsako, 6 m from other notified water bodies and 10 m from other large ponds, measured from "the edge"; minor drains and small ponds get only the ordinary setbacks of a building. The table names only Guwahati's waters although the byelaws apply statewide. The Master Plan for Guwahati adds a strip of 15 m from the Brahmaputra's bank on one stretch of riverfront. The Water Bodies Bill points its buffer to the Master Plan and the byelaws, which is this table. No setback from an embankment was found;
- **The water-body law protects storage, but its schedules are still being drawn.** The 2008 Act scheduled four areas of Guwahati by dag number, and the 2024 Bill extends the same protection to every notified Master Plan area through schedules that District Level Committees prepare and the State Level Committee approves; no schedule under the 2024 law was found. Deepor Beel's eco-sensitive zone is still a draft;
- **There is no floodplain law and no line for the floodplain.** Assam has not enacted the Model Flood Plain Zoning Bill. A State Bill was reported in November 2026 by a single source; this Manual does not treat it as law. The byelaws let the Authority refuse a site "likely to be inundated" where "satisfactory arrangements for proper drainage is not possible", and the amendment of 2024 asks master plans to map natural-hazard areas "where construction is not permitted", but no such map or flood line was found; and
- **No document sets the river level for which an outfall is designed.** CWC's danger levels and highest flood levels were found only in transcriptions, on no stated datum. WRD's operating rules for its sluices, the time they stay shut, the pumps now installed at Bharalumukh and the storage of Deepor Beel at each stage were not found. Highest flood levels are records, not design levels.

So each agency and each local body interprets the central manual its own way. GMC, GMDA, the PWD, WRD, NHAI, the Railways and others build and keep drains in Guwahati, and the ADB names "fragmented institutional responsibilities involving multiple institutions" as the reason that storm drainage "remains a challenge". No notification assigns the Bharalu, the Mora Bharalu or the Bahini to one owner. A town's drain may be a municipal drain for part of its length, a PWD roadside drain for another, a scheduled water body where it crosses a beel and a drain under the Embankment and Drainage Act where it passes a WRD sluice. In the Autonomous Districts outside a Council's opt-in, the Unified Byelaws 2022 do not apply at all. 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 five rainfall zones and eight hydrologic sub-areas, with a checked station analysis to govern where one exists; the 2(a) plates and ratios on the north bank; the 2(b) plates and ratios in Guwahati, on the south bank and in the Karbi hills; the higher of the two within 5 km of the Brahmaputra; the whole-catchment rule for Guwahati's streams that rise in Meghalaya; the 2(a) ratios on the Dima Hasao hills; an interim rule from IMD's Silchar stations, with floors, in the Barak valley, where subzone 2(c) has no report; short-storm floors at 1, 3 and 6 hours; and a check of the design day against the largest reliable days recorded nearby (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites, with the dry sump of the byelaws designed as detention (Chapter 4);
- a required tailwater check for every outfall against a design river level, which treats the sluice shut against a high river as the normal monsoon case: the gate closed for the whole of the 72-hour design storm and for as long after it as the river stays above the sill, and for not less than 7 days on the Brahmaputra, the Barak and the Kushiyara where no stage record has been analysed; the receiving beel or pond full at the start; and the stored water pumped down within 48 hours (Chapter 5);
- a design flood line, and corridors and setbacks along jans, rivers and juris and around beels and pukhuris, proposed by this Manual for use where nothing wider binds, with a corridor at least 15 m from the top of bank on every natural channel draining 8 ha or more, and the byelaws' setbacks and any notified line wherever those are wider (Chapter 7);

- no deliberate infiltration on char and chapori land, below the 1% AEP flood level, inside an embankment that ponds when its sluices close, at the margins of beels and pukhuris or where the water table rises within 2 m of the surface; none on hill slopes steeper than 10° without a geotechnical certificate; roof runoff to storage, as the byelaws already require, with its overflow to lined drains; and the interception and screening of dry-weather flow before every outfall to a beel, the Bharalu or a scheduled water body, where drains carry sewage (Chapter 8);
- silt traps at the foot of the hills, allowances for sediment and debris, and sluices, flap gates and pumps designed for the river's high stage (Chapters 6 and 9), with drains, jans, inlets, sluices and pumps cleared, tested and certified ready by 31 March, before the April storms, cleared again by 31 May before the south-west monsoon and by 15 November after it, and standby kept from 1 April to 31 October (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 Municipal Board, a Development Authority in its master plan, DoHUA in the byelaws, or a District Council in its own rules 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); Assam Building Construction (Regulation) Act, 2010 (Assam Act XVI of 2010), as amended by Assam Act XXVII of 2022; Assam Unified Building Construction (Regulation) Byelaws, 2022, No. DoHUA/ECF No. 236697/2 (Assam Gazette Extraordinary No. 688, 15 October 2022), byelaws 1, 26, 44, 45, 74, 110, 114 and 131 and Appendices VI and IX, and the (Amendment) Byelaws, 2024, No. DoHUA/ECF No. 420084/34 (Gazette No. 667, 20 November 2024), byelaw 120; Guwahati Building Construction (Regulation) Byelaws, 2014 (GMDA copy); Master Plan for Guwahati 2025 and Zoning Regulation, Assam Gazette Extraordinary No. 198 (9 July 2009), Report Part II and the Schedule of Modification; Assam Town and Country Planning Act, 1959 (Assam Act II of 1960), as amended; Gauhati Municipal Corporation Act, 1969 (Assam Act I of 1973), ss. 231–252; Assam Municipal Corporation Act, 2022 (Assam Act VIII of 2022), s. 171; Assam Embankment and Drainage Act, 1953 (Assam Act I of 1954), ss. 2, 15 and 16; Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (Assam Act XX of 2008); Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024, ss. 1, 2, 4–7 and 22, and the Assembly's bulletin of 29 August 2024; Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 (Assam Act V of 2007), ss. 2, 4 and 14; Assam Ground Water Control and Regulation Act, 2012 (Assam Act XVI of 2012), ss. 3 and 19; Gauhati High Court, PIL/14/2024 (orders of 23 September 2024 and 26 May 2025), PIL/53/2023 (6 September 2024) and PIL 18/2023, I.A.(C) 924/2024 (5 April 2024); NGT, OA 472/2018 (11 February 2020) and the State's progress report of August 2020 in OA 673/2018; CAG, Report No. 5 of 2018 and Report No. 4 of 2019 (Government of Assam); ADB, Report and Recommendation of the President and Project Administration Manual, Assam Urban Sector Development Project (57262-001, 2025), and Initial Environmental Examinations for the Guwahati and Dibrugarh subprojects of the Assam Urban Infrastructure Investment Program (42265-025, 2017); JICA, ex-ante evaluation of the Guwahati Sewerage Project (2015); PCBA, Action Plan for the Bharalu River (Priority I); DoHUA, status of the town drainage master plans (c. 2016); CWC, Flood Estimation Reports for subzones 2(a) (NB/18/1991) and 2(b) (Revised), No. SB-2(b)/R-4/44/99 (March 2000), Table 4.1, Annexes 4.1 and 4.2 and Plate 9, read by eye; IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); Das et al. (2022), MAUSAM 73(4); NIH-DHAARA (queried 14 November 2026); CGWB, Ground Water Year Book 2022-23, North Eastern Region, and Assam State Profile (2007); SAC/MoEF, National Wetland Atlas (2011); Chandrakanta Abhidhan (2nd ed., 1962); M. Bronson, A Dictionary in Assamese and English (1867); CWC levels as transcribed by SANDRP (2019); reports of the Bharalumukh sluice (2008), of the floods of 2022 and 2026, of the beels of Guwahati and Goalpara, of the Guwahati drainage master plan, of the draft Master Plan 2045 and of the State Action Plan on Climate Change (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.

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

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Abbreviations

Abbreviation	Meaning
ABC Waters	Active, Beautiful, Clean Waters (PUB Singapore's design guidelines)
ADB	Asian Development Bank
AEP	Annual exceedance probability
AIDR	Australian Institute for Disaster Resilience
AMC	Antecedent moisture condition
AMC Act	The Assam Municipal Corporation Act, 2022
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
ARF	Areal reduction factor
ARG	Automatic rain gauge
ASABE	American Society of Agricultural and Biological Engineers
ASDMA	Assam State Disaster Management Authority
ASTM	ASTM International (standards)
ASWA	Assam State Wetlands Authority
AURA	T&CP's mobile application for monitoring urban water bodies (expansion [TBC])
AUWSSB	The State board for urban water supply and sewerage (expansion [TBC])
AWS	Automatic weather station
BOD	Biochemical oxygen demand
BRE	Building Research Establishment (UK)
BSMP	Basin Stormwater Master Plan
BSNL	Bharat Sanchar Nigam Ltd
BTC	Bodoland Territorial Council
BTR	Bodoland Territorial Region
CAG	Comptroller and Auditor General of India
CGP	Construction General Permit (US EPA)
CGWB	Central Ground Water Board
CN	Curve number (SCS/NRCS method)

Abbreviation	Meaning
COD	Chemical oxygen demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPWD	Central Public Works Department
CSE	Centre for Science and Environment
CWC	Central Water Commission
DL / WL	Danger level / warning level (CWC)
DoHUA	Department of Housing and Urban Affairs, Assam
DPR	Detailed project report
DTP	Dibrugarh's town protection dyke of 1955 and its drain, as the ADB names them ("DTP dyke", "DTP drain"; expansion [TBC])
DWF	Dry-weather flow
EN	European Standard (Norme Européenne)
EPD	Environmental Protection Division (Georgia, United States)
ESC	Erosion and sediment control
EV1	Extreme value type I (Gumbel) distribution
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FREMAA	The State agency for the ADB-assisted flood and riverbank erosion risk management programme (expansion [TBC])
FRIMS	ASDMA's flood reporting system (expansion [TBC])
FRP	Fibre-reinforced plastic
GMC	Guwahati Municipal Corporation
GMDA	Guwahati Metropolitan Development Authority
GMDW&SB	The Guwahati board for drinking water and sewerage (expansion [TBC])
GWYB	Ground Water Year Book (CGWB)
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Assam)
HEP	Hydro-electric project
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HSG	Hydrologic soil group
HY-8	FHWA's culvert hydraulic analysis program
IDF	Intensity–duration–frequency
IEE	Initial environmental examination (ADB)
IIT	Indian Institute of Technology
IMD	India Meteorological Department

Abbreviation	Meaning
IMDAA	Indian Monsoon Data Assimilation and Analysis (a regional reanalysis)
IRC	Indian Roads Congress
ISO	International Organization for Standardization
IST	Indian Standard Time
JICA	Japan International Cooperation Agency
KAAC	Karbi Anglong Autonomous Council
KC	Kansas City (Kansas City Metro APWA Section 5600)
KLD	Kilolitres a day
LiDAR	Light detection and ranging (laser survey)
MBBL 2016	Model Building Bye-Laws 2016 (MoHUA; not the State's byelaws)
MePGCL	Meghalaya Power Generation Corporation Ltd
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
NAPCC	National Action Plan on Climate Change
NCHAC	North Cachar Hills (Dima Hasao) Autonomous Council
NDMA	National Disaster Management Authority
NEEPCO	North Eastern Electric Power Corporation
NGT	National Green Tribunal
NH	National Highway
NHAI	National Highways Authority of India
NHPC	NHPC Ltd (operator of the Lower Subansiri project)
NIH	National Institute of Hydrology, Roorkee
NIT	National Institute of Technology
NOC	No-objection certificate
NPDES	National Pollutant Discharge Elimination System (United States)
NRSC	National Remote Sensing Centre
NWIA	National Wetland Inventory and Assessment (ISRO)
OA	Original Application (NGT)
OGC	Open Geospatial Consortium
OIL	Oil India Ltd
PAM	Project administration manual (ADB)
PCBA	Pollution Control Board, Assam
PIB	Press Information Bureau

Abbreviation	Meaning
PIL	Public interest litigation
PSD	Permissible site discharge
PWD	Public Works Department, Assam
RDSO	Research Designs and Standards Organisation (Railways)
RMSE	Root-mean-square error
RRP	Report and recommendation of the President (ADB)
RRV	Required retention volume
RWH	Rainwater harvesting
SANDRP	South Asia Network on Dams, Rivers and People
SAPCC	State Action Plan on Climate Change
SH	State highway
SLA	Sea-level allowance (coastal term; not applicable in Assam)
SRRG	Self-recording rain gauge
SUH	Synthetic unit hydrograph (CWC)
T&CP	Directorate of Town and Country Planning, Assam
T&CP Act	The Assam Town and Country Planning Act, 1959
TBC	To be confirmed: a fact or value not yet found in a source
TCPO	Town and Country Planning Organisation (MoHUA)
TR-55	Technical Release 55 (USDA SCS/NRCS)
UH	Unit hydrograph
ULB	Urban local body (in Assam, a Municipal Corporation or a Municipal Board)
Unified Byelaws 2022	The Assam Unified Building Construction (Regulation) Byelaws, 2022, as amended
USACE	US Army Corps of Engineers
UT	Union Territory
UTM	Universal Transverse Mercator
VR	Value rating (of a BMP treating the WQv)
WQv	Water quality volume
WRD	Water Resources Department, Assam
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 Assam. It applies to private development and to public works, as set out in Clause 1.5.

1.1.2 The Manual has the following objectives:

- (a) to make stormwater management a **condition of development approval**, so that new development and redevelopment do not increase flood peaks or runoff volumes downstream;
- (b) to retain frequent rainfall on site, so that groundwater recharge is sustained and pollutant loads are reduced;
- (c) to size storage for the long-duration storms of the monsoon season, which bring several hundred millimetres in a day (479.3 mm at Dhubri (Rupsi) on 28 May 1989 and 410.0 mm at Lumding on 3 August 1981, IMD) and fall for days on flood plains already saturated, while the Brahmaputra and the Barak stand high and the sluices of the embanked towns are shut, from the pre-monsoon storms of April and May to the October storms about the withdrawal of the south-west monsoon, as well as for short-duration intensities;
- (d) to design outfalls for the rivers and beels into which the towns drain, which in the monsoon stand above the towns behind about 4,474 km of embankments, so that most outfalls pass through sluices that close when the river is high: the Brahmaputra at every riverside town, where at Guwahati it reaches its danger level in most monsoons and the Bharalu's gated outfall at Bharalumukh carries 72 m³/s with its gates open but only about 7 m³/s by pumps when they are shut (2008, as reported); the drain of Dibrugarh, a town "1.5 m below the bed level of Bramhaputra", which runs behind the DTP dyke to the Sessa through Larua Jamira beel (ADB); the Barak round the bowl of Silchar, and the Barak and the Kushiyara at Badarpur and Karimganj; the beels that store a town's water while its sluice is shut, among them Deepor Beel and Silsako; the reaches below the dams on the Ranganadi, the Subansiri and the Kopili and the Umtru below Byrnihat, into which the operators release floods; and the hill streams of the Guwahati fringe and the hill districts, which rise within the hour, including the case where the outfall is closed;
- (e) to protect tanks (pukhuris), 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 byelaws made by the Government under section 4 of the Assam Building Construction (Regulation) Act, 2010 (the Assam Unified Building Construction (Regulation) Byelaws 2022), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> **Commentary.** Assam's floods come from four sources, often together. The first is the river. About 40% of the State is flood-prone: 31.50 lakh ha by the figure of the Rashtriya Barh Ayog as quoted by the CAG, and 31.05 lakh ha (39.58%) on the WRD website, two figures in circulation (CAG, Report No. 5 of 2018; WRD, as quoted; conflict); the WRD gives "reasonable protection" to 16.50 lakh ha (CAG). The towns lie behind embankments (mothauri, the

Assamese word for a river embankment), whose length is given as 4,474.42 km (CAG, to March 2017), 4,473.82 km (WRD, as quoted) and about 4,800 km in a later ministerial reply (as reported; conflict). The great earthquake of 15 August 1950 (magnitude 8.6) killed 1,526 people in Assam and eroded Dibrugarh, which led to the town's protection dyke of 1955 (USGS, as quoted; ADB). The highest recorded levels of the Brahmaputra date the main-stem floods: 27–28 August 1988 at Tezpur and Dhubri, when about 62% of the Brahmaputra valley was reported inundated; 3 September 1998 at Dibrugarh; and 21 July 2004 at Guwahati, 51.46 m (CWC data as transcribed by SANDRP; ICIMOD, 1997). The flood of 2004 is reported to have affected 12.4 million people and killed 251 (as reported; not checked against ASDMA). The second is drainage congestion. In the WRD's words, as quoted by the CAG, "High stages of river Brahmaputra and Barak obstruct free discharge of tributaries causing back flow and congestion near outfalls. Inadequate countryside drainages through sluices in embankment system … cause prolonged inundation" (CAG, Report No. 5 of 2018), and in Guwahati "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB, IEE, 2017). In June 2022, when IMD found the month's rainfall over Assam and Meghalaya, 858.1 mm, the highest since 1901 (IMD, Monthly Climate Summary, June 2022), more than 88 lakh people were affected in the season and 54.57 lakh in 32 districts on 23 June alone; the season's toll is given as about 181 (ASDMA, as reported), 195 and 197 (as reported; conflict). Silchar was flooded from 19 June 2022 after the Barak entered the town through a cut in its embankment at Bethukandi; the police registered an FIR over a breach of 23 May and one person was arrested, the Chief Minister called the flood "man-made" and an official said the breach made little difference given the river level; the town was under water for about 11 days, up to about 4 m deep in places, or for "about a week" in another account (all as reported; conflict). The Barak at Annapurnaghat peaked at 21.59 m on 21 June 2022, 1.76 m above its danger level and 0.25 m below its highest level of 1989 (Cachar district report, as quoted; differences a NEER reading): a flood of a ponded bowl inside the embankment, not a record river stage. Cachar recorded 251.20 mm on 19 June 2022 (district report, as quoted). The third is the urban flash flood of Guwahati, from short bursts on the hill fringe while the Bharalu outfall is gated against a high Brahmaputra. In June 2014 seven people died in flash floods in Guwahati and four by electrocution (CAG, Report No. 4 of 2019). On 14 June 2022 the WRD gauges at Chandmari and Beltola recorded 84.6 mm and 88 mm against about 10 mm at the airport (Borjhar) and 46 mm for the city, four people were killed in a landslide at Nizarapar (Boragaon), and Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar were inundated (as reported). On 31 May 2025 the airport recorded 111 mm in the 24 hours to 08:30, its highest May day, which IMD said was "nothing abnormal", and three people died in a landslide at Bonda (as reported; 120 mm and 99.6 mm in other outlets, conflict). On the night of 19–20 April 2026 the airport recorded 117.4 mm, beating its April record of 116.5 mm (6 April 2004, IMD), with 215.9 mm at SIRD Khanapara the same night, and a woman died after falling into an open roadside drain (as reported). The fourth is the dam release and the embankment breach. In 2017, when 156 people had died in the State's floods by late August, 8 of them in Guwahati (as reported), the Ranganadi project released 1,412.57 m³/s into the Ranganadi in Lakhimpur district (IIT Guwahati report for ASDMA, as quoted); 71 embankment breaches were reported between mid-June and 20 July 2024 (as reported). The seasons since have been severe: 149 deaths to 14 October 2020 with 57.7 lakh affected; a peak about 5 July 2024 with 24,20,722 people affected in 30 districts and 117 deaths to 27 July; 880 flood deaths reported since 2019 (Rajya Sabha reply, as quoted); 111 deaths by 30 August 2025; and floods in Upper Assam in July 2026, with 11,45,109 people affected in 25 districts between 29 April and 3 August and 105 deaths by 17 August (all as reported). The tolls differ in whether landslides, storms and lightning are counted; ASDMA's official tolls were not obtained [TBC]. In the hill districts and on the Guwahati hills, slides and debris add a fifth source that no drain is sized for.

Missing design makes all four worse. No design storm, return period or drain standard was found in any drainage master plan of the State's towns: the town plans of the Department of Housing and Urban Affairs (DoHUA) were "prepared before 2015 as per previous FPS system" and await revision to the CPHEEO guideline of 2015 (DoHUA, status sheet, c. 2016). The CAG found storm-water drainage in the urban local bodies it test-checked covering "3 to 37 per cent only" of their areas, and that the "natural drainage systems of the cities carried the sewage" (CAG, Report No. 4 of 2019); the ADB puts the coverage at "only about 30% of the required areas" (ADB, RRP 57262-001, 2025); and "Apart from 17 kilometres of drains built between 1973 and 1997, no other extensive and planned drainage network exists in the Guwahati Metropolitan Area" (as reported). The Unified Byelaws 2022 set setbacks from rivers and beels, a plinth above the highest recorded flood level and a designed dry sump on flood-liable and hilly plots, but no design storm, release rate or storage method, and outside the notified Master Plan areas and in

the Autonomous Districts they do not apply at all unless a District Council opts in. Objectives (b) to (e) address the storage, outfall and building-level failures, which a drain-sizing manual alone cannot fix; the closed outfall of the second source is the design case of Chapter 5, not an exception; and the breaches, chars and slides are answered by the siting, setback and floor-level rules of Chapters 2, 6 and 7, because no drain is sized to carry a river through a breach.

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 Assam Unified Building Construction (Regulation) Byelaws 2022 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.

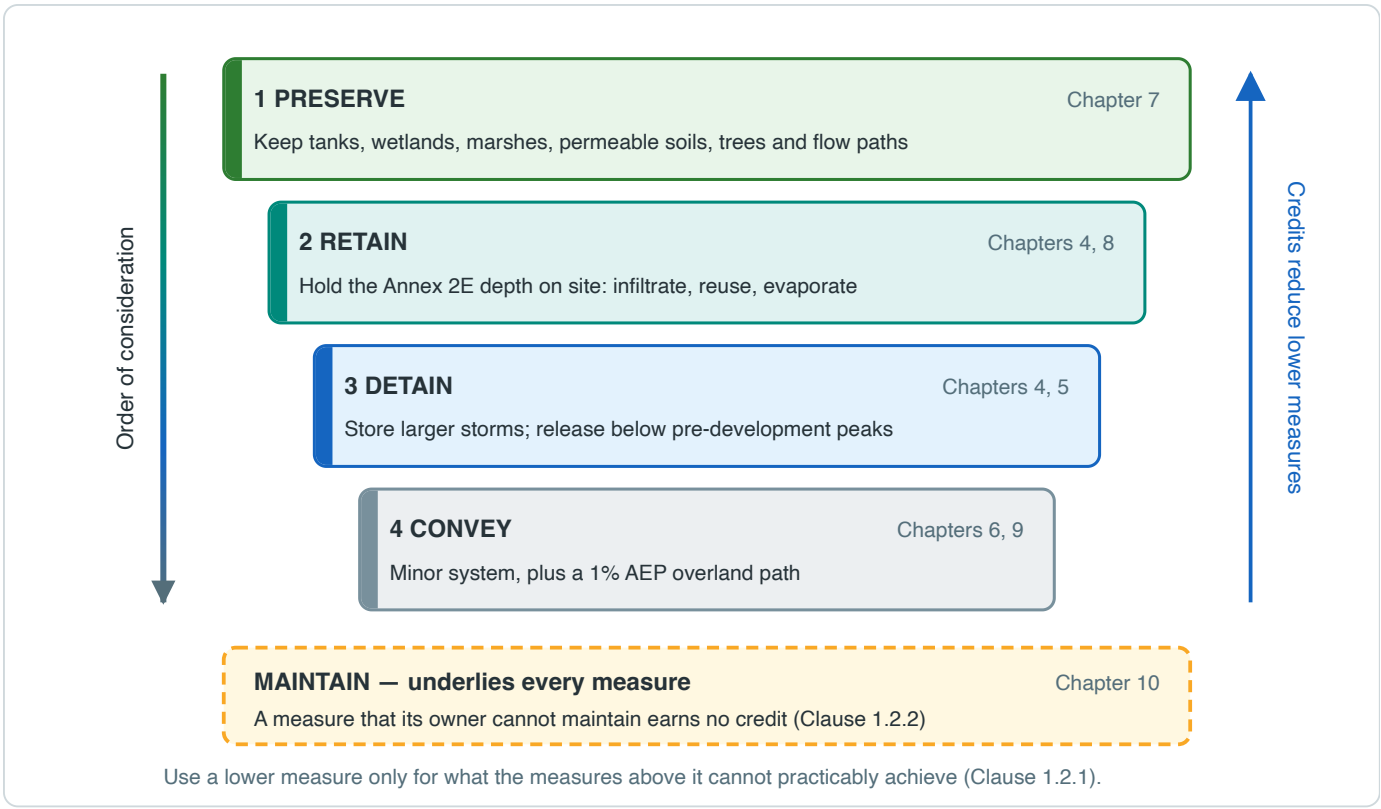

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

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 Assam, the top two layers have a particular meaning. Much of the State's natural storage lies in its beels (beel: Assamese বিল, a natural floodplain lake or wetland), which with other wetlands cover about 764,372 ha, 9.74% of the State (National Wetland Atlas, 2011, as quoted; the counts of wetlands conflict and are not used); in Deepor Beel, the Ramsar site of Guwahati (No. 1207, designated 19 August 2002, as quoted), which holds about 10.1 km² of water in winter and up to about 40.1 km² in floods (as reported); in the jans (jan: Assamese জান, a stream or natural drainage channel, often the outlet of a beel, as in Bondajan, Lakhimijan and Khanajan) and juris (juri: Assamese জুৰি, a small hill stream) that connect them; in the town pukhuris; and in the char and chapori lands of the rivers. "The wetlands and other water bodies in GMA collectively act as the receptors of storm water during the monsoons" (ADB, IEE, 2017). The law treats some of this as drainage. The Guwahati Waterbodies (Preservation and Conservation) Act, 2008 defines "Waterbodies" as "the area or areas of land where the rain water accumulates and act as natural or storm water reservoir and shall include wetland" (s.2(e)) and forbids filling and building on four scheduled areas in Guwahati, among them land **near** Deepor Beel; the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024, passed on 29 August 2024, repeals that Act (s.22(1)) and keeps the same definition for every notified Master Plan area, adding "all natural water channels (that are inflow or out flow channels into or from the waterbody)" and ponds and tanks "irrespective of its size" (s.2(d)); the enacted text, its gazette date and the Rules of 2025 were not read [TBC]. The Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 makes "a drainage system, feeding channel, any water body" an ecological site in a Designated Area (s.2(d)(ii)), but no designated area was found [TBC]. The beels are being lost all the same: Deepor Beel is reported to have shrunk by "about 35% since 1991" (as reported; other figures conflict), Urpad Beel in Goalpara from 4.84 km² to 3.38 km² between 2003 and 2023 (as reported), and the High Court has upheld evictions from Silsako ("Once it is a water body you have to move out", 2023, as reported). On the plains the second layer changes. Groundwater is shallow: in March 2022 most of CGWB's wells in Assam read 2–5 m below

ground and in November 2022 within 5 m (0–2 m in 45.96% of them), and in Kamrup (Metro) the range was 1.39–4.08 m in March and 1.29–2.64 m in November 2022 (CGWB, Ground Water Year Book, North Eastern Region, 2022-23); the ADB notes that the rising Brahmaputra "reduces the rate of percolation" (ADB, IEE, 2017). A soakaway or recharge pit on the flood plain therefore sits in saturated ground when the storm comes. This Manual bars deliberate infiltration on char and chapori land, below the 1% AEP flood level, inside an embankment-protected area that ponds when its sluices close, on beel and pukhuri margins and wherever the seasonal high water table is less than 2.0 m below ground (Clause 4.11, floodplain rule); bars it on natural slopes of more than 10° and on cut, filled or slipped ground in the Guwahati hills and the hill districts without a geotechnical certificate (Clause 4.11, hill rule); and allows recharge only on tested ground outside those, on the bhabar fans of the northern foothills, river terraces above the 1% AEP level and Guwahati's hill-foot colluvium, and never by recharge well in the districts where arsenic or fluoride exceeds the limits (Clause 4.11, recharge rule) (all set by this Manual). Groundwater is not short (CGWB put the stage of development at 22% in 2007 with no over-exploited unit), so rainwater harvesting on most sites is storage for reuse, not recharge. Losing the beels and jans cannot be offset by pipes, and a town that drains through a closed sluice has nothing but its beels, pukhuris and ponds to hold the water until the river falls.

1.3 Legal basis and status

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

- (a) an amendment to the Assam Unified Building Construction (Regulation) Byelaws 2022 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 Assam the building rules are the Assam Unified Building Construction (Regulation) Byelaws, 2022 (Assam Gazette Extraordinary No. 688, 15.10.2022, notification No. DoHUA/ECF No. 236697/2), as amended by the Assam Unified Building Construction (Regulation) (Amendment) Byelaws, 2024 (Gazette No. 667, 20.11.2024, No. DoHUA/ECF No. 420084/34), made by the Governor under section 4 of the Assam Building Construction (Regulation) Act, 2010 (Assam Act XVI of 2010), as amended by Assam Act XXVII of 2022, which renamed the Guwahati Building Construction (Regulation) Act and extended it "to the whole of the State of Assam" (assent 26 September 2022; Gazette Extraordinary No. 655, 29 September 2022). The commencement notification of the 2022 amendment was not seen [TBC]. A further amendment was reported approved by the Cabinet on 14 August 2025, but no gazette of it was found, and this Manual does not cite it. The Unified Byelaws 2022 "extend to the master Plan areas or notified Planning areas of whole of Assam except for areas under Autonomous Districts", with a proviso that "if any District Council desires that all or any of the provisions of this byelaws shall apply to the

Autonomous District concerned, a notification may be issued to that effect" (byelaw 1(2)). Their "Authority" is, by the 2022 amending Act, GMDA, the Guwahati Municipal Corporation, the Municipal Corporations under the Assam Municipal Corporation Act, 2022, the Municipal Boards under the Assam Municipal Act, 1956, the Development Authorities under the Assam Town and Country Planning Act, 1959 "and other local bodies or Panchayats falling under the notified Master Plan areas" (s.6). The planning permit is given by GMDA or a Development Authority under the Master Plan and Zoning Regulations, and the building permit by the GMC, a Municipal Corporation, a Municipal Board or a Gaon Panchayat under the Unified Byelaws 2022. They replaced the Guwahati Building Construction (Regulation) Byelaws, 2014, which already held the same setback, plinth, basement, flood-site, hill, green-area and rainwater-harvesting rules, but the repeal clause names "The Guwahati Building Construction (Regulation) Byelaws, 2010" (byelaw 131(1)), a year printed "2010" on the page; no byelaws of 2010 were found (the 2010 instrument is the Act), and the compounding appendix refers to permissions "prior to byelaws of 2014". This Manual states the conflict: the 2014 byelaws are superseded in practice, but the repeal clause names 2010. The Unified Byelaws 2022 carry drainage hooks: building setbacks from natural drainage channels and water bodies of 15 m, 10 m and 6 m (byelaw 26(ix), repeated as 44(ix) [TBC: sub-item numbers read from the OCR layout; confirm against a clean copy]); refusal of sites near a water body or water course that would be contaminated, divert the channel or be inundated without satisfactory drainage, or that are "a filled up tank or low lying" (byelaw 44(iii) [TBC: confirm against a clean copy]); a plinth "0.3 m higher than the highest recorded flood level as fixed by the local authority for ordinary buildings and 0.6 higher for lifeline buildings" (byelaw 45(c)); no basement "in low-lying areas and areas without adequate drainage facilities" (byelaw 66(3)); on sites liable to flood and in hilly areas, roof-water harvesting, a silt fence and a "dry sump (including design calculation) in all individual plots, capable of holding rain water during peak monsoon" (byelaws 74 and 110(g)–(i)); special protection on slopes greater than 10° and cuts generally of 4 m to 6 m (byelaw 110(d), (e)); a drainage plan "upto the available permanent/pucca drain of municipal/other authority" (byelaw 94) and the improvement of drains to the nearest outlet as directed, with a penalty of 25% of the cost at PWD rates where it is not done (byelaw 101(vi)); and rainwater harvesting for every building (byelaw 114). They set no design storm, return period, release rate or detention volume, and no rule found in them limits peak runoff or asks for storm-water detention. The route of Clause 1.3.1(a) therefore runs through an amendment to the Unified Byelaws 2022 under section 4 of the Act, which DoHUA, the department that makes them, could prepare. It reaches only the notified Master Plan areas. Outside them, the Manual reaches development only through public works (Clause 1.5.1(b)) and through any body that adopts it. In the Autonomous Districts of the Sixth Schedule to the Constitution, the Bodoland Territorial Region (Bodoland Territorial Council, BTC; Kokrajhar, Chirang, Baksa, Udalguri and Tamulpur districts [TBC: confirm the list]), Karbi Anglong and West Karbi Anglong (Karbi Anglong Autonomous Council, KAAC) and Dima Hasao (North Cachar Hills Autonomous Council, NCHAC), the Unified Byelaws 2022 apply only where the District Council has notified that they do; no such notification and no building rules of any of the three Councils were found [TBC]. Diphu and Kokrajhar have Master Plans of the Directorate of Town and Country Planning (publication notices listed, as quoted), but whether the Unified Byelaws 2022 apply there depends on an opt-in that was not found (NEER reading). In an Autonomous District the Manual could take effect only through the District Council: the Council could notify under byelaw 1(2) that the byelaws, as amended to include the Manual, apply in its district, or adopt the Manual in its own rules (Annex 1D). This Manual is a draft; neither the Government, DoHUA, GMDA, the GMC, any District Council nor any other 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 competent authority for the area: in a notified Master Plan area, the Development Authority (GMDA in the Guwahati Metropolitan Area) for the planning permit and the Municipal Corporation, Municipal Board or Gaon Panchayat for the building permit, each under the Unified Byelaws 2022 (Assam Building Construction (Regulation) Act, 2010, s.2 as amended in 2022); the local body for its own drains and works under the Gauhati Municipal Corporation Act, 1969, the Assam Municipal Corporation Act, 2022 or the Assam Municipal Act, 1956; the Water Resources Department (WRD), through its Embankment Officer, for any work that cuts, crosses, alters or discharges through an embankment, sluice or drain under the Assam Embankment and Drainage Act, 1953 (ss.4, 15 and 16); the District Level Committee and the State Level Committee for scheduled water bodies under the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024 (Bill, ss.4–8); the Advisory Committee under section 14 of the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 in a Designated Area; the State Ground Water Authority in a notified groundwater area (none has been found); and, in an Autonomous District, the District Council or the authority it designates, only where the Council has notified that the byelaws or this Manual apply (none has), 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 Assam Unified Building Construction (Regulation) Byelaws 2022 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).
Flood-sensitive catchment	The catchments of Guwahati's Bharalu–Bahini basin to Bharalumukh, with the Noonmati–Bondajan diversion; of the Mora Bharalu–Deepor Beel–Khanajan system, with the Basistha and the Kalmani, and the Silsako basin; of the hill streams of the Guwahati fringe that come down from Meghalaya at Khanapara and Jorabat; of Dibrugarh behind the DTP dyke and its drain to the Sessa; of Silchar behind the Barak embankment; of Karimganj on the Kushiyara, with Hailakandi and Badarpur; of Palasbari–Mirza; of the north-bank towns on dam-release and flash-flood reaches, North Lakhimpur on the Ranganadi, Dhemaji, the Subansiri reach and Tezpur on the Jia Bharali; of Dhubri and Goalpara on the lower Brahmaputra; of Majuli and the char lands; and of Haflong and Diphu, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (pukhuri), 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.

Term	Meaning in this Manual
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 Assam Unified Building Construction (Regulation) Byelaws 2022 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 Assam Gazette.
Competent authority for the area	The body that grants permission for the site, or consents to the work, under the instrument that applies there: in a notified Master Plan area, the Development Authority (GMDA in the Guwahati Metropolitan Area) for the planning permit and the Municipal Corporation, Municipal Board or Gaon Panchayat for the building permit, each under the Unified Byelaws 2022; the local body for its own drains and works under the Gauhati Municipal Corporation Act, 1969, the Assam Municipal Corporation Act, 2022 or the Assam Municipal Act, 1956; the WRD, through its Embankment Officer, for any work that cuts, crosses, alters or discharges through an embankment, sluice or drain under the Assam Embankment and Drainage Act, 1953; the District Level Committee and the State Level Committee for scheduled water bodies under the water-bodies law of 2024; the Advisory Committee under the Hill Land Act in a Designated Area; the State Ground Water Authority in a notified groundwater area (none found); and, in an Autonomous District, the District Council or the authority it designates, only where the Council has notified that the byelaws or this Manual apply (none has). Where this Manual says "the Authority", the competent authority for the area is meant.
Planning permit; building permit	The permission given by GMDA or a Development Authority under the Master Plan and Zoning Regulations (planning permit), and the permission given by the GMC, a Municipal Corporation, a Municipal Board or a Gaon Panchayat under the Unified Byelaws 2022 (building permit), as defined in the Assam Building Construction (Regulation) Act, 2010, as amended in 2022. The occupancy certificate follows the building permit.
Notified Master Plan area	An area for which a Master Plan has been notified under the GMDA Act, 1985 or the Assam Town and Country Planning Act, 1959; the Unified Byelaws 2022 and the water-bodies law of 2024 apply only in such areas. The Guwahati Metropolitan Area of the Master Plan for Guwahati 2025 covers 328 km².
Autonomous District, District Council	The Bodoland Territorial Region (Bodoland Territorial Council, BTC), Karbi Anglong and West Karbi Anglong (Karbi Anglong Autonomous Council, KAAC) and Dima Hasao (North Cachar Hills Autonomous Council, NCHAC), under the Sixth Schedule to the Constitution. The Unified Byelaws 2022 and the water-bodies law apply there only where the District Council has notified that they do; no such notification and no Council building rules were found [TBC]. This Manual reaches an Autonomous District only through its District Council.
Embankment, sluice, drain (1953 Act)	As defined in section 2 of the Assam Embankment and Drainage Act, 1953: an embankment includes sluices and appurtenant land, but not field ridges (*ali*) or roads; a drain includes "dongs", culverts, ditches, canals, sluices and any device for "excluding, regulating or retaining" rain, flood or subsoil water. A river embankment is a mothauri (Assamese মথাউৰি) and a sluice a pani-duwar (পানী-দুৱাৰ); this Manual uses the English words.
Beel; jan; juri	Beel (Assamese বিল): a natural floodplain lake or wetland. Jan (Assamese জান): a stream or natural drainage channel, often the outlet of a beel. Juri (Assamese জুৰি): a small hill stream. A jan or juri draining 8 ha or more is a natural channel under Chapter 7.
Char; chapori	Land formed in or beside a river by the deposit of its sand and silt (char, Assamese চৰ; chapori, চাপৰি, the higher such land), which the river builds and removes.

Term	Meaning in this Manual
Patta land; khas land	Land held privately under a patta and recorded by district, mouza, revenue village and dag number (patta land), and land of the Government (khas land). Most land in the State is patta land. Where this Manual reserves a drainage corridor, an easement or a regional facility site on patta land, it is reserved in a Master Plan or secured by agreement, not taken (set by this Manual); in the Autonomous Districts, land is held under the Councils' land law [TBC: not researched].

> **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 Assam Unified Building Construction (Regulation) Byelaws 2022;
- (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 Assam, 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 byelaw 114 of the Unified Byelaws 2022 to every building in the notified Master Plan areas, with recharging or percolating pits or trenches of at least 5 m³ for every 100 m² of roof, under Appendix VI with percolation pits of 1.2 × 1.2 × 1.5 m for every 100 m² of plot, grass paving on the paved areas of the larger categories and "rain water harvesting storage and reuse" on plots of 134 m² and above, and under byelaw 111 with 20% of every plot for trees and greenery; and, in an area notified under section 19 of the Assam Ground Water Control and Regulation Act, 2012, to premises of 100 m² or more (no notified area has been found), 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.

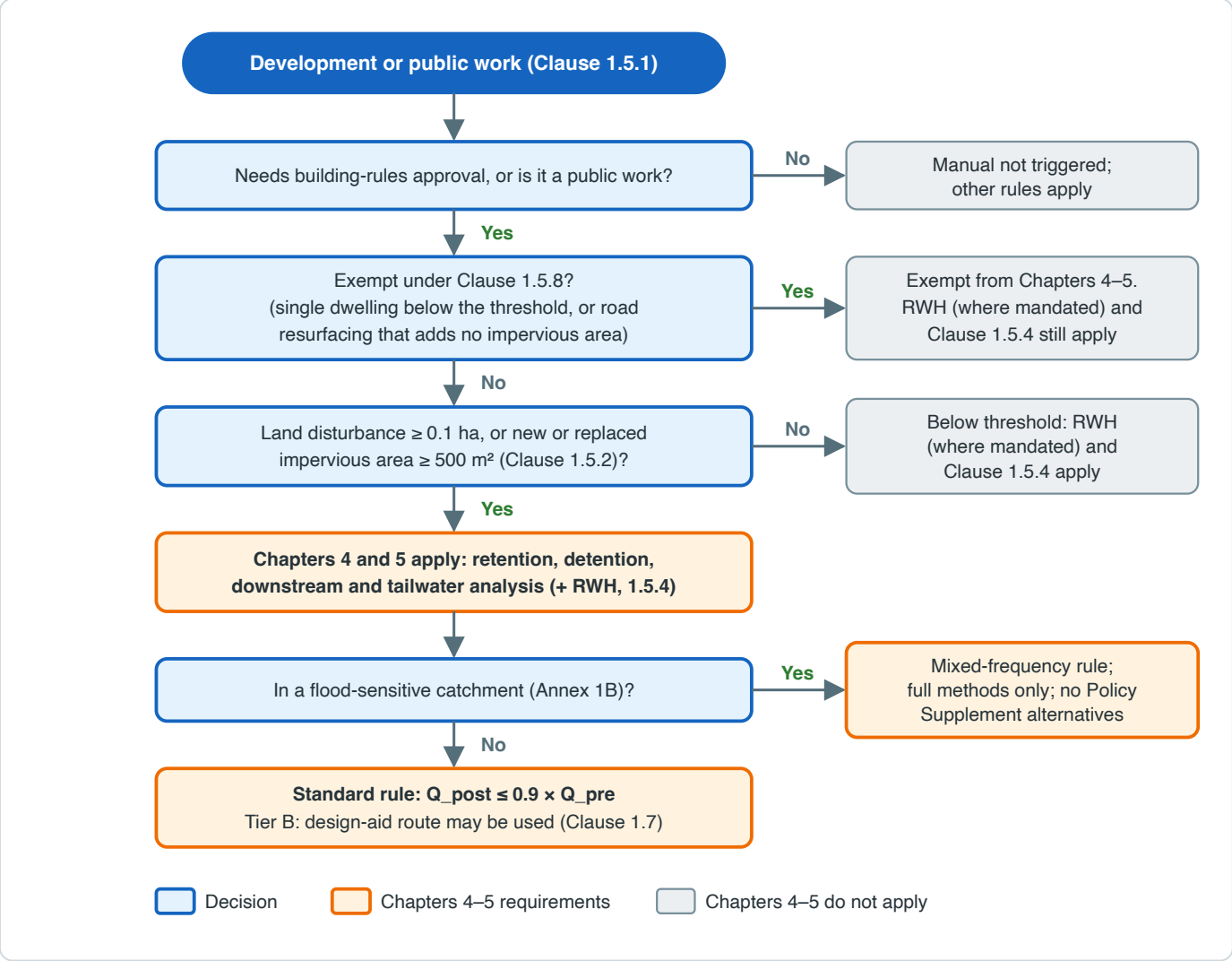

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Assam plots are small and the cumulative effect of many small plots is what fills Guwahati's drains. For small buildings in Assam, the Unified Byelaws 2022 already reach every building in the notified Master Plan areas with rainwater harvesting: recharging or percolating pits or trenches of "at least 5 cubic metres dimension for every 100 sq. metres. of roof area" (byelaw 114), percolation pits of 1.2 × 1.2 × 1.5 m for every 100 m² of plot, and "rain water harvesting storage and reuse" on plots of 134 m² and above (Appendix VI); 20% of every plot for trees and greenery (byelaw 111); and, on sites liable to flood and in hilly areas, a dry sump "capable of holding rain water during peak monsoon", with its design calculation (byelaws 74(ii) and 110(h)). None of these sets a design storm, and the byelaw's dry sump has no stated volume or outlet, so none of it yet limits what leaves the plot in a design storm; Chapter 4 supplies the calculation the byelaw asks for. Appendix VI also requires that "All Rain water outlets/drains and waste water drains shall be connected to the roadside side through the percolation pit only": on a floodplain site, with grey water mixed in and the water table near the surface, that pit is a soakaway in saturated ground. This Manual states the conflict with its floodplain rule (Clause 4.11) and requires storage in place of the pit there; the applicant seeks the Authority's relaxation of the pit, and the Manual does not override the byelaw. Clause 1.5.4(b) applies to every building whatever its size, because the plinth rule of byelaw 45(c) is tied to a "highest recorded flood level as fixed by the local authority" that no local authority was found to have fixed for any town [TBC], and a small house on the flood plain or behind an embankment is where a floor level does most good. An Authority may make the floodplain rule and the hill rule of Clause 4.11 a condition of every building permit in its area, whatever the size of the site (a recommendation of this Manual, not a requirement of Clause 1.5.4). Outside the notified Master Plan areas, and in the Autonomous Districts unless a District Council opts in, small buildings follow no State building rule that this Manual can reach.

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) the Guwahati Municipal Corporation (GMC);
- (b) GMDA and every other Approving Authority within the Guwahati Metropolitan Area, the area of the Master Plan for Guwahati 2025 (328 km²), as that area is notified from time to time, whichever has jurisdiction over a site; and
- (c) the Dibrugarh Municipal Corporation, with the Development Authority of the Dibrugarh Master Plan area, and the Silchar Municipal Corporation, with the Development Authority of the Silchar Master Plan area (the names of the two Development Authorities are to be confirmed [TBC]).

1.6.2 **Tier B authorities.** All other Municipal Corporations, Municipal Boards, Development Authorities and other local bodies and Panchayats in notified Master Plan areas 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 Guwahati Metropolitan Area of the Master Plan for Guwahati 2025, or the Master Plan area of a Municipal Corporation, 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.** Guwahati Municipal Corporation, with storm-water drainage data that the CAG could not obtain because the Corporation "was involved with works of drain desilting only", although it spent ₹32.57 crore on desilting from 2013–14 to 2017–18, in a State whose urban local bodies cover only "3 to 37 per cent" of their areas with storm drains (CAG, Report No. 4 of 2019), about 550 drains to clean before each season (2026, as reported) and only 17 km of planned drains built between 1973 and 1997 in the whole metropolitan area (as reported), and a small Municipal Board 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 Guwahati.

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
Assam Building Construction (Regulation) Act, 2010 (Assam Act XVI of 2010; assent 29 April 2010; notification No. LGL.7/2010/10 of 12 May 2010, Gazette Extraordinary No. 135), as amended by Assam Act XXVII of 2022 (assent 26 September 2022; notification No. LGL.7/2010/70 of 28 September 2022, Gazette Extraordinary No. 655 of 29 September 2022)	Continue. The 2022 Act renamed the Guwahati Building Construction (Regulation) Act and extended it "to the whole of the State of Assam", with "different dates" for different areas; it defines the "Authority", the "Building permit" given by the Corporations, Municipal Boards and Panchayats under the byelaws, the "Planning Permit" given by GMDA and the Development Authorities under the Master Plan and Zoning Regulations, and the "Notified Master Plan areas" (s.6). The 2010 Act defines a "drain-surface water" as "a drain used or constructed to use solely for conveying to any drain any rain water but shall not include any rainwater pipe" (s.2(20)), asks plans to show the drains and an "arrangement for proper drainage" (section number not confirmed [TBC]), and lets the byelaws cover "drainage, water supply/sewerage, rainwater harvesting". The commencement notification of the 2022 amendment was not seen [TBC].
the Assam Unified Building Construction (Regulation) Byelaws 2022 (Assam Gazette Extraordinary No. 688, 15.10.2022, notification No. DoHUA/ECF No. 236697/2), as amended by the (Amendment) Byelaws, 2024 (Gazette No. 667, 20.11.2024, No. DoHUA/ECF No. 420084/34), made under section 4 of the Act (both read); the Guwahati Building Construction (Regulation) Byelaws, 2014 (number and date not seen [TBC]); the Assam Notified Urban Areas (other than Guwahati) Building Rules, 2014 (title and a setback passage only, as quoted)	Continue. They apply to the notified Master Plan areas and planning areas of the State, and in an Autonomous District only where its District Council has notified that they do (byelaw 1(2)); none has been found [TBC]. They set building setbacks "from the edge of natural drainage channels": 15 m from a river "as marked in the plan", 10 m from the Bharalu, the Mora Bharalu and the Bondajan, 6 m from other channels, 15 m from the notified water bodies Deepar Beel and Silsako, 6 m from other notified water bodies (Sarusola, Barsola), 10 m from other large ponds and water bodies marked in the plan, and the ordinary building setbacks from minor drains and small ponds (byelaw 26(ix), repeated as 44(ix) [TBC: sub-item numbers from the OCR layout]); let the Authority refuse a site near a water body or water course, a site likely to be inundated without satisfactory drainage, or "a filled up tank or low lying" site (byelaw 44(iii) [TBC]); set the plinth "0.3 m higher than the highest recorded flood level as fixed by the local authority" for ordinary buildings and 0.6 m for lifeline buildings (byelaw 45(c)); bar basements in low-lying and undrained areas (byelaw 66(3)) and keep surface drainage out of them (byelaw 67(c)); on sites liable to flood and in hilly areas require roof-water harvesting, a silt fence and a "dry sump (including design calculation) in all individual plots, capable of holding rain water during peak monsoon" (byelaws 74 and 110(g)–(i)); require special protection on slopes greater than 10°, cuts generally of 4–6 m and 30% vegetation on hill plots (byelaw 110(d), (e), (k)); require a drainage plan "upto the available permanent/pucca drain" (byelaw 94) and the improvement of drains to the nearest outlet, with a 25% penalty where it is not done (byelaw 101(vi)); exclude multistoreyed buildings from areas "on or abutting natural drainage channels" and wetlands (byelaw 117); and, since 2024, require Master Plans to map natural-hazard areas "where construction is not permitted" (byelaw 120), forbid C&D waste in "Nalas, Rivers and other water bodies" (byelaw 120A) and leave half of the landscaped open space unpaved (byelaw 92). The 2014 byelaws held the same drainage rules; the repeal clause of the 2022 byelaws names "The Guwahati Building Construction (Regulation) Byelaws, 2010" (byelaw 131(1)), a conflict this Manual states (Commentary to Clause 1.3). An amendment of 2025 was reported but no gazette was found, and it is not cited. They set no design storm, release rate or detention volume, and no rule on infiltration in high groundwater. The design criteria of Chapters 2–6, the floodplain, hill and recharge rules of Clause 4.11 and the corridors of Chapter 7, whose Zone 1 is at least 15 m, are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the Unified Byelaws 2022, a Master Plan or a statute are stricter, they govern (Clause 1.3.3).
Rainwater harvesting: Unified Byelaws 2022, byelaws 38(i), 104(i), 111 and 114 and Appendix VI; byelaw 92 (2024); Assam Ground Water Control and Regulation Act, 2012, s.19	Continue unchanged. Byelaw 114 requires every building to "provide one or more rainwater harvesting structures to collect the roof top run-off", with recharging or percolating pits or trenches of "at least 5 cubic metres dimension for every 100 sq. metres. of roof area"; Appendix VI asks for percolation pits of 1.2 × 1.2 × 1.5 m for every 100 m² of plot, through which "All Rain water outlets/drains and waste water drains" are to be connected to the road drain, grass paving on the paved areas of the larger categories, and storage and reuse on plots of 134 m² and above; the pit rate gives 2.16 m³ per 100 m² of plot and byelaw 114 asks for 5 m³ per 100 m² of roof, which the text does not reconcile (NEER reading). Byelaw 111 keeps 20% of every plot for trees and greenery (10% where at least 25% of the FAR is affordable housing). Section 19 of the 2012 Act lets the State Ground Water Authority direct rainwater harvesting on premises of 100 m² or more in a notified area, and local authorities impose it on building plans there; no notified area was found, so the 100 m² threshold is not a byelaw rule and does not apply anywhere at present. This Manual counts stored water against its retention requirement only as reuse (Clause 4.4.3), never as detention. Where the floodplain rule or the hill rule of Clause 4.11 bars the percolation pit of Appendix VI, the two conflict: this Manual requires storage in its place, and the applicant seeks the Authority's relaxation of the pit; the Manual does not override the byelaw.

Instrument	Relationship
Guwahati Metropolitan Development Authority Act, 1985 (Assam Act No. XX of 1987, as cited in the margins of the Acts of 2008 and 2022; text not read [TBC]); the Master Plan for Guwahati 2025 and Zoning Regulation 2025 (Assam Gazette Extraordinary No. 198, 9 July 2009, published under s.21(1) of the GMDA Act as approved under s.19 by Govt order No. GDD.91/1997/395 of 09/06/2009, "for operation with effect from 07/07/2009"; corrigenda No. 199 of 10 July 2009 and No. 62 of 16 March 2010), as modified, including by ECF No. 630736/4 of 25 March 2025 (as quoted; not read); the draft Master Plan for Guwahati 2045	Continue. The plan covers 328 km², the old Guwahati Metropolitan Area of 262 km² and 66 km² added (Schedule I). The GMDA report gives the notification as "GMDA/MP/1/98/Part-I/103 dated 7th July, 2009", while the gazette heading reads "The 9th July, 2009"; this Manual states both dates. Its zoning puts "All notified forest, water bodies, rivers etc." in an Eco-Sensitive Zone; a modification forbids construction within 15 m of the Brahmaputra bank on the riverfront from Sonaram High School to the foothills of Kamakhya and recasts the Eco-Friendly zone as a Hilly Area Zone that takes in "all the hilly areas and also to some adjoining plain areas prone to land slide and soil erosion", including areas declared hazard-prone by the District Disaster Management Authority or GMDA, with slope classes "derived from a study by IIT(G) in the planning and design of drainage in hilly areas" (study not seen [TBC]). No general drainage buffer is set in the plan; the numbered buffers are those of the Unified Byelaws 2022. The draft Master Plan for Guwahati 2045, released early in 2024, has not been finally notified (as reported) and is not cited as in force. Master Plans would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11).
Assam Town and Country Planning Act, 1959 (Assam Act II of 1960; President's assent 6 February 1960; Assam Gazette, 17 February 1960), as amended by Act 17 of 2012 and Act XXVI of 2022 (notification No. LGL.175/2022/3; Gazette No. 662, 30 September 2022); the Master Plans and Zoning Regulations of the other towns; the town drainage master plans of DoHUA and T&CP	Continue. The Act provides for Development Authorities (Chapter IIA) and Master Plans and Zoning Regulations (Chapter III); 24 Development Authorities are reported (as quoted). Final Master Plan notices are listed for 28 towns, among them Dibrugarh, Silchar, Jorhat, Tezpur, Nagaon, Tinsukia, Dhubri, Diphu and Kokrajhar (T&CP listing, as quoted; not opened). The town drainage master plans found were "prepared before 2015 as per previous FPS system" and await revision; a status sheet lists drafts for Tinsukia (11 May 2015), Silapathar and Margherita, Sonari finalised, Dibrugarh delayed by "shortage of fund", Goalpara with "Final hydraulic design work … in progress", and Barpeta Road not completed for want of a land-use plan (DoHUA, c. 2016); a later sheet puts Dibrugarh and Silchar at the "final stage" and Jorhat "prepared" (as quoted). No design criteria appear in any of them.
Gauhati Municipal Corporation Act, 1969 (Assam Act I of 1973), Part V, the chapter on water supply, drainage and sewage disposal (ss.231–252, read from the Legislative Department's scans; amendments of 1976–2021 not checked against these sections [TBC])	Continue. The municipal drains are to be kept "free from public nuisance" and "properly flushed, cleaned and emptied", and the Commissioner may build "reservoirs, sluices, engines and other works" (s.231); may empty them into any place within or outside the city, but not into a new place without the Corporation's sanction (s.232: a power, not a duty, and no storm-water outfall duty like that of the 2022 Act was found); may alter, enlarge or close them (s.234); may direct an occupier to make "an entirely distinct private drain" for rain water and unpolluted subsoil water (s.237(1)); may pull down a building over a drain vested in the Corporation (s.239); and no one may make or alter a drain into a municipal drain without permission (s.242). No building within one hundred feet of a municipal drain may be built or occupied until it is drained into it (s.244), and the connecting drain vests in the Corporation (s.250(2)). GMC's notice of 2025 cites a "Guwahati Municipal Corporation Act, 1971", a mis-citation (as reported); this Manual cites the Act by its printed title.
Assam Municipal Corporation Act, 2022 (Assam Act VIII of 2022; assent 27 April 2022; Gazette Extraordinary, 4 May 2022), Chapter XXII; Assam Municipal Act, 1956 (Municipal Boards; as cited, not read)	Continue. The Act extends to the whole of the State except cantonments. Each Corporation shall "construct and maintain drains and sewers, and provide a safe and sufficient outfall, in or outside the Municipal Corporation area, for effectual drainage and proper discharge of storm-water and sewage … in such manner as may not cause any nuisance, whether by flooding any part of the Municipal Corporation area, or of the areas surrounding the outfall", and from a notified date "no sewage shall be discharged into any watercourse until it has been so treated" (s.171); public drains vest in the Corporation (s.173) and may be handed over to or taken over from another authority (s.174); the Commissioner may require "an entirely separate drain for rain water or unpolluted sub-soil water" (s.176); and may alter, flush and restrict discharges into municipal drains (s.177). Dibrugarh's Corporation was notified on 20 November 2023, and Silchar's dates conflict (a gazette of 28 November 2024 per one report, effective 2 September; a High Court case cites 28.11.2022) (as reported). The Municipal Boards act under the 1956 Act.

Instrument	Relationship
Assam Embankment and Drainage Act, 1953 (Assam Act I of 1954; replaces Assam Act VI of 1941; whole of Assam; read by OCR; later amendments not checked [TBC])	Continue. An "embankment" includes sluices and appurtenant land, but not field ridges (*ali*) or roads, and a "drain" includes "dongs", culverts, ditches, canals, sluices and any device for "excluding, regulating or retaining" rain, flood or subsoil water (s.2). The Embankment Officer may remove or alter an embankment, drain or obstruction that endangers a town or interferes with drainage (s.4); no compensation is due for changes in "percolation or floods" (s.10); the works vest in the State (s.14); damaging or obstructing an embankment or drain is punishable (s.15(i)), and cutting through one, or opening, shutting or obstructing a sluice without authority, with up to three years and ₹1,000 (s.15(ii)) — the cut at Bethukandi in May 2022 is such an offence (NEER reading); and in a notified area no building on, or removal or alteration of, an embankment or drain may be made without the permission of the Deputy Commissioner or the Embankment Officer (s.16). PWD and the Public Health Department must be consulted (s.18). No setback distance from an embankment was found [TBC]. Every outfall of this Manual through an embankment or sluice needs the WRD's permission under this Act (Chapter 5).
Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (Assam Act XX of 2008; Gazette Extraordinary No. 243, 8 August 2008; notification No. LGL.103/2008/14, dated 7 August in one scan and 9 August in another; conflict), and its amendment of 2010 (Assam Act 14 of 2010, as quoted); the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 (passed on 29 August 2024; the Act is cited as Assam Act XXV of 2024, as quoted; the Bill as introduced read; the enacted text, its gazette date and the Rules of 2025 not read [TBC])	The 2008 Act, which the 2024 Bill repeals (s.22(1), with a saving clause; the enacted text is to be confirmed [TBC]), defined "Waterbodies" as land "where the rain water accumulates and act as natural or storm water reservoir and shall include wetland" (s.2(e)), forbade filling, building and dumping in four scheduled areas of Guwahati, listed by mouza, revenue village and dag number — Sarusola (heading read from a garbled scan), Borsola, Silsako and land **near** Deepor Beel, not the beel itself (Schedules I–IV) — with up to three years' imprisonment or ₹50,000 (s.6), and set no buffer distance. The Bill keeps the definition for every notified Master Plan area except the Autonomous Districts, unless a District Council opts in (s.1(2)); adds the inflow and outflow channels and ponds and tanks "irrespective of its size", but excludes private water bodies of less than 2 acres, those in reserved forests, sanctuaries and national parks and the ponds of Government fish farms (s.2(d)); sets up District Level Committees, chaired by the Deputy Commissioner and in the GMDA area by GMDA's Chief Executive Officer, with the Deputy or Assistant Director, T&CP as Member Secretary, to prepare schedules by dag number and "ensure no construction zone within a buffer around the Water Bodies as prescribed in the Notified Master Plan and Assam Unified Building Construction (Regulation) Bye law, 2022" (ss.4–5) — the buffer of byelaw 26(ix) — and a State Level Committee chaired by the DoHUA Minister to approve them, after which the State publishes them in the Gazette (ss.6–7); forbids filling, structures other than "nature based solutions" and obstruction of inflow and outflow (s.15), with up to three years or ₹1 lakh and restoration (s.16). Because the law already treats beels as storm-water reservoirs, Chapter 7's rule that counts their storage and forbids its loss restates the law. Section numbers are those of the Bill until the Act is read.
Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 (Assam Act V of 2007; assent 16 January 2007; Gazette Extraordinary No. 20, 20 January 2007; No. LGL.169/2005/13)	Applies in a Designated Area once one is notified under s.4; no notification of a designated area, and no commencement notification, was found [TBC]. Ecological sites include "a drainage system, feeding channel, any water body having and potentiality of becoming water source" and marshy land, ponds, lakes and swamps (s.2(d)); no earth cutting that damages a hill and no alteration of an ecological site (s.3); in a Designated Area the owner of hill land takes the Advisory Committee's prior approval for a guard wall and for any house (s.14) — in Kamrup (Metro) a committee chaired by the Commissioner of the Lower Assam Division with GMDA's Chief Executive Officer and the GMC's Commissioner among its members (s.5); penalty up to six months or ₹5,000 (s.19). In the four scheduled areas of the 2008 Act, that Act overrode this one (2008 Act, s.11). Hill-site drainage duties come from byelaw 110, not from this Act. The High Court recorded on 26.05.2025 that "hill cutting is still going on" (PIL/14/2024).
Assam Ground Water Control and Regulation Act, 2012 (Assam Act XVI of 2012; assent 14 May 2012; Gazette Extraordinary No. 226, 19 May 2012; No. LGL.64/2002/71); the Rules of 2022 (notified 18.05.2022, as stated in an affidavit, as quoted)	Continue. The State Ground Water Authority, chaired by the Secretary, Irrigation, with Zonal Authorities by the jurisdictions of the Irrigation Superintending Engineers (s.3), may have areas declared "notified areas" (s.5(2)), where wells need permits (s.6) and rainwater harvesting can be directed (s.19); "rain water harvesting" includes storage "at surface or in sub-surface aquifer" (s.2(f)). The High Court directed the Authority's constitution by 31.01.2023 (as reported); its constitution was not confirmed [TBC], and no notified area was found. Applicants abide by its restrictions under byelaw 101(iv). Groundwater is shallow and not over-drawn (CGWB), so recharge is not a design objective of this Manual (Clause 4.11).

Instrument	Relationship
Wetlands (Conservation and Management) Rules, 2017; the Assam State Wetlands Authority (Notification No. FRM.10/2010/Pt/16 of 01.11.2018, as quoted); Deepor Beel (Ramsar site No. 1207, 19 August 2002, as quoted; wildlife sanctuary, 2009)	Continue. No wetland of the State was found notified under rule 4. Deepor Beel is the State's only Ramsar site (as reported). Its sanctuary notification of 2009 was restored on appeal, and on 05.04.2024 the High Court directed the State "not to issue any notification de-notifying" it after the Cabinet had decided to (PIL 18/2023, I.A.(C) 924/2024); its eco-sensitive zone exists only in drafts, of about 148.9 km² (2021) and about 38.84 km² (2025) (as reported), and is not final. Beels, pukhuris and other water bodies are governed by Chapter 7.
Floodplain zoning: no Act	Assam has not enacted the Model Flood Plain Zoning Bill (PIB, as quoted). A proposed Assam Flood Plain Zoning Bill, with prohibited and restricted zones and Flood Zoning Authorities, was reportedly reviewed by the Chief Minister on 5 November 2026 (single source, unverified); it is not law. The "Natural Hazard Prone Areas" of the Unified Byelaws 2022, to be notified "based on Hazard Studies viz. … Flood zonation" (definition 2), and the hazard maps that byelaw 120 asks Master Plans to carry are the nearest hooks; the 1% AEP maps of Chapters 6 and 7 are offered as an input to them, not as such a notification.
Gauhati High Court: PIL/14/2024, *North East Eco Development Society v. State of Assam* (orders of 23.09.2024, 17.03.2025 (as quoted) and 26.05.2025; February 2026, as reported); PIL/53/2023, *Khanindra Kalita & 8 Ors* (06.09.2024); PIL 18/2023, *Pramod Kalita & 2 Ors* (I.A. (C) 924/2024, 05.04.2024); the Silsako writ appeals (2023, as reported); PILs 34 or 36 and 42 of 2026 (as reported; the number of the first conflicts)	Apply where they bind; they are court directions, not design standards. In PIL/14/2024 the Court recorded the engagement of Haskoning DHV for the drainage master plan and DPR of Guwahati and, on 26.05.2025, that "hill cutting is still going on"; in PIL/53/2023 it appointed an Advocate Commissioner on builders blocking channels and filling wetland at Palasbari, causing "artificial floods"; in PIL 18/2023 it stopped the denotification of the Deepor Beel sanctuary; and the 2026 petitions on open drains and urban flood policy are pending (as reported). None sets a setback or a design storm.
National Green Tribunal: OA 472/2018, *Rohit Chowdhury v. Union of India* (order of 11.02.2020, Deepor Beel and the Boragaon dump); OA 673/2018 (polluted river stretches; the State's progress report of August 2020); OA 606/2018 (solid and liquid waste; State report of 09.10.2024, as quoted); OA 219/2025, renumbered 99/2025/EZ (Deepor Beel, suo motu; outcome not found, as reported)	Apply where they bind. The State's report in OA 673/2018 lists the Bharalu, Borsola Beel and Silsako Beel as Priority I polluted stretches, Sorusola Priority II and Deepar Beel Priority III, the last polluted by the "Mora Bharalu channel"; in OA 606/2018 the State reported 338.5 MLD of sewage treatment planned against a need of 435.5 MLD (as quoted). Sewage in storm drains is dealt with in Chapter 8 (Clause 8.9).
Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; the Pollution Control Board, Assam	Continue. PCBA's action plan for the Bharalu finds that it "has no natural flow … only the domestic sewage and commercial sewage are being carried" and that the Bahini "now becomes a sewerage drain" (PCBA, as quoted). Chapter 8 governs sewage in storm drains.
Disaster Management Act, 2005; ASDMA, the Revenue and Disaster Management Department, the Deputy Commissioners and the District Disaster Management Authorities	Continue. No urban flood plan or standard operating procedure of ASDMA was read for this Manual [TBC], and no order of the State fixing a date for pre-monsoon desilting was found; the works calendar of Chapter 10 sets this Manual's dates, beginning with 31 March, for drains, sluice gates, flap gates and pumps. The WRD's calendar for embankment works remains its own.

Instrument	Relationship
IRC:SP:42-2014, IRC:SP:48 (Hill Road Manual) and the practice of the Public Works Department and NHAI on road drainage in the Guwahati hills and the hill districts	Apply to road drainage, 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].
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 Assam is framed as a water supply and recharge measure. It works well for that purpose. It cannot, however, be relied on for flood control in the monsoon, because RWH sumps are usually full or the ground saturated by the time a June to August monsoon storm, such as those of June 2022, 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.

Assam is spending on its town drains, but with little stated design basis. In Guwahati, GMDA engaged Haskoning DHV by an order of 21.08.2024 to prepare a "GIS-based Comprehensive Drainage Master Plan and Detailed Project Report (DPR) for Guwahati City" within nine months, under the supervision of the Gauhati High Court (PIL/14/2024, order of 23.09.2024); the State told the Court in February 2026 that it was "expected to be completed by April 2026", and the minister has since directed that the plan and the DPR for the Bahini–Bharalu basin be revised (as reported), so in November 2026 it is under revision and not final. An earlier storm-water drainage report of 2008 was not built (as reported), and the CAG found no action taken against the consultants for "defective DPRs for Storm Water Drainage Project for Guwahati City" (CAG, Report No. 2 of 2024). The ADB's Assam Urban Sector Development Project (57262-001) funds the first works in the Bahini basin: 4.1 km of flood diversion channels, 4.7 km of drains, 7.8 m³/s of added pumping in three stations and a nature-based retention pond of 59,000 m³ with a 1.6 m³/s pump station, with part of the runoff "diverted to a retention basin in the nearby Silsako Basin and gradually pumped out to the Brahmaputra River" (ADB, RRP, 2025); its target is to avoid inundation "from a 1-in-5-year storm or lower return period" in 434 ha of the basin, with a "design storm of 65.72 mm hour" whose duration and return period are not stated (ADB, PAM, 2025, design and monitoring framework). A ₹1,459 crore Guwahati project for the Bahini and the Bharalu, with an automated pumping station at Bharalumukh, was announced in May 2026 (as reported). The Directorate of Town and Country Planning "has started preparing drainage master plans for all major towns in the state" (ADB, RRP, 2025), but the town plans found were prepared under the "previous FPS system" before CPHEEO's guideline of 2015 (DoHUA, status sheet). None of the documents found states a design return period for town drains other than the ADB's Bahini target, and no development-control condition stops new plots in the same catchments from using up the capacity such works create. Linking Chapters 4–5 to approvals closes that gap.

The State's law holds many of the tools. The Unified Byelaws 2022 set setbacks from rivers, named channels and notified water bodies, a plinth above the highest recorded flood level, a designed dry sump on flood-liable and hilly plots, rules for slopes and cuts, and rainwater harvesting on every building; the Gauhati Municipal Corporation Act, 1969 and the Assam Municipal Corporation Act, 2022 vest public drains in the Corporations and let the Commissioner require "an entirely distinct" or "entirely separate" drain for rain water (GMC Act s.237(1); AMC Act

s.176), and the 2022 Act puts on each Corporation a duty to "provide a safe and sufficient outfall … for effectual drainage and proper discharge of storm-water and sewage" (s.171); the Assam Embankment and Drainage Act, 1953 protects embankments, sluices and drains, including "dongs", and makes cutting through an embankment or opening or obstructing a sluice without authority an offence punishable with up to three years' imprisonment (s.15(ii)); the water-bodies law defines a water body as a storm-water reservoir; the Hill Land Act protects drainage channels in Designated Areas; and the Assam Ground Water Control and Regulation Act, 2012 provides for rainwater harvesting in notified areas. The courts and tribunals have acted too: the High Court on Guwahati's drainage (PIL/14/2024), on the "artificial floods" of Palasbari (PIL/53/2023) and on Deepor Beel (PIL 18/2023), and the National Green Tribunal on the dumping at Boragaon (OA 472/2018) and on the polluted Bharalu (OA 673/2018). What the law lacks is a design standard. None of these instruments says which storm a drain must carry, how large a dry sump must be, how long a sluice may be assumed closed, how the "highest recorded flood level" of byelaw 45(c) is to be fixed, or how much storage a paved plot removes; and no floodplain zoning law exists, the reported Assam Flood Plain Zoning Bill of November 2026 being a proposal from a single unverified source, not law. This Manual's checks are framed as part of the planning permit and the building permit given by the competent authority for the area, not as a separate no-objection certificate. This Manual is offered as a technical companion to these instruments, to the orders of the courts and to the drainage works of the towns: it supplies the design storm, detention, outfall-closed, infiltration and corridor numbers they do not set, as a proposal for the Government, the District Councils and the other authorities to consider. Neither DoHUA, T&CP, GMDA, the GMC, any other Municipal Corporation or Municipal Board, the WRD, any District Council 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
Department of Housing and Urban Affairs (DoHUA) and the Directorate of Town and Country Planning (T&CP)	DoHUA, formed by merging the Guwahati Development Department and the Urban Development Department (Governor's order of 20.07.2021, as quoted), makes the Unified Byelaws 2022 under section 4 of the Assam Building Construction (Regulation) Act, 2010 and administers GMDA, the GMC and the other urban local bodies. T&CP, under DoHUA, prepares the Master Plans of the towns outside GMDA, "has started preparing drainage master plans for all major towns" (ADB, RRP, 2025) and provides the Member Secretaries of the District Level and State Level Committees under the water-bodies law. If the Manual were adopted, DoHUA would prepare the amendment of Clause 1.3.1(a) and the model bye-law of Clause 1.3.1(b), and T&CP would show flood-sensitive catchments, drainage reserves and regional facility sites in the Master Plans (Chapter 11) and give regional support to Tier B authorities (Table 1.1).
Guwahati Metropolitan Development Authority (GMDA) and the Development Authorities	Give the planning permit under the Master Plan and Zoning Regulations (GMDA in the Guwahati Metropolitan Area under the GMDA Act, 1985; the 24 Development Authorities under the Assam Town and Country Planning Act, 1959, as quoted). GMDA is the Competent Authority for the scheduled water bodies of Guwahati, the project implementation unit of the ADB's Bahini works and the client of the drainage master plan of Guwahati, and excavates Silsako. Would require the drainage report of Chapter 10 with each planning permit, write drainage reserves, water-body buffers and basin storage into the Master Plans and Zoning Regulations, and record drainage reserves and easements in the permits they grant. The CAG found GMDA "not functioning as per the spirit" of its Act, with "very few technical staff" (CAG, Report No. 2 of 2024).
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).

Agency	Role under this Manual
Guwahati Municipal Corporation (GMC), the Dibrugarh and Silchar Municipal Corporations, the Municipal Boards and the Gaon Panchayats in notified Master Plan areas	Give the building permit under the Unified Byelaws 2022 and hold the municipal drains: the GMC under the Gauhati Municipal Corporation Act, 1969 (ss.231–252), the other Corporations under the Assam Municipal Corporation Act, 2022 (ss.171–177), the Municipal Boards under the Assam Municipal Act, 1956. The GMC desilts the Bharalu, the Mora Bharalu, the Basistha, the Bahini and the Lakhimijan and their feeder drains (as reported) and checks rainwater harvesting at the occupancy certificate (as reported). Would apply this Manual at the building permit and the occupancy certificate and to their own works, keep the drain register of their area, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15).
Water Resources Department (WRD) and its Embankment Officers	Build and maintain the embankments, sluices and drainage schemes, among them the Bharalumukh sluice and the dewatering pumps on the Bharalu, the Mora Bharalu and the Bondajan (as reported), and give permission for works on embankments and drains under the Assam Embankment and Drainage Act, 1953 (ss.4, 15, 16). Would set outfall and sluice conditions under that Act, supply sluice sills, closing levels, operating rules and river levels for Chapter 5, and apply this Manual to its drainage schemes. Its calendar for embankment works remains its own; the dates of Chapter 10 cover the drains, sluice gates, flap gates and pumps of the drainage system.
FREMAA	Carries out the ADB-funded Assam Integrated Flood and Riverbank Erosion Risk Management programme (as quoted). Would apply this Manual to the drainage elements of its works.
Public Works Department (PWD) and NHAI	Build and maintain roads and their drains, among them about 260–263 drains in Guwahati (as reported). Would apply Chapter 6 and the hill-road rules to them and never discharge a road drain onto an unprotected slope.
District Level Committees and the State Level Committee under the water-bodies law; the Advisory Committees under the Hill Land Act	The District Level Committees, chaired by the Deputy Commissioner or, in the GMDA area, GMDA's Chief Executive Officer, prepare the schedules of water bodies and "ensure no construction zone within a buffer" around them, and the State Level Committee, chaired by the DoHUA Minister, approves them (Bill of 2024, ss.4–8); the Advisory Committees approve guard walls and houses on hill land in a Designated Area (Hill Land Act, s.14). Would be the competent authority for the area for those matters and could use the corridors and storage rules of Chapter 7 in their decisions.
Irrigation Department and the Assam State Ground Water Authority	The Authority, chaired by the Secretary, Irrigation, may have areas notified under the Assam Ground Water Control and Regulation Act, 2012 (none found), and applicants abide by its restrictions (byelaw 101(iv)). Would supply groundwater levels with CGWB and be the competent authority for recharge in a notified area. Whether the Department keeps observation wells is not known [TBC].
ASDMA, the Revenue and Disaster Management Department, the Deputy Commissioners and the District Disaster Management Authorities	Prepare for and respond to floods and landslides, publish the daily flood reports and keep the land records (district, mouza, revenue village, dag and patta). The District Disaster Management Authorities ran 21 committees to monitor desilting in Guwahati in March 2025 (as reported). Would supply the flood and landslide inventories used in the screening of Clause 2.3.6(i) and lead post-event reviews with the Authority (Clause 10.16).
Environment and Forest Department and the Assam State Wetlands Authority; the Pollution Control Board, Assam (PCBA)	Administer the Deepor Beel sanctuary and Ramsar site and the Wetlands Rules, 2017; PCBA prepares the action plans for the polluted stretches of the Bharalu, Borsola, Silsako, Sorusola and Deepor Beel. Would be consulted before a notified wetland is used for storage or as an outfall (Chapter 7) and receive the records of sewage found in storm drains under Chapter 8.
Guwahati Jal Board, the Guwahati Metropolitan Drinking Water and Sewerage Board (GMDW&SB), the Assam Urban Water Supply and Sewerage Board (AUWSSB) and Guwahati Smart City Ltd	The Jal Board executes the JICA-assisted sewerage project of Guwahati (loan agreement of 27.02.2015) and has taken over water supply from the GMC from 1 July 2025 (as reported); the role of Guwahati Smart City Ltd in drainage was not researched [TBC]. Would keep sewage out of storm drains as the sewers are built (Chapter 8) and design their own drainage works to this Manual from the dates of Clause 1.11.

Agency	Role under this Manual
Bodoland Territorial Council (BTC), Karbi Anglong Autonomous Council (KAAC) and North Cachar Hills Autonomous Council (NCHAC)	Govern the Autonomous Districts under the Sixth Schedule to the Constitution. The Unified Byelaws 2022 and the water-bodies law apply there only where the District Council notifies that they do (byelaw 1(2); Bill of 2024, s.1(2)); no notification and no Council building rules were found [TBC]. The Manual has no force in their areas unless a Council adopts it. A Council could notify under byelaw 1(2) or adopt the Manual in its own rules; if it did, it, or the authority it designated, would be the competent authority for the area.
NEEPCO, NHPC and the other dam operators	Operate the Ranganadi and the Kopili projects (NEEPCO) and the Lower Subansiri project (NHPC), whose releases flood the reaches below them (2017: a release of 1,412.57 m³/s from the Ranganadi, as quoted). Would supply reservoir levels, release rules and release records for Chapter 5 and the screening of Clause 2.3.6(i).
Brahmaputra Board	Prepared the basin master plans for the Brahmaputra (Part I) and the Barak (Part II), approved in 1997 (as quoted). Its plans would be read with the basin plans of Chapter 11.
Central Water Commission (CWC), Brahmaputra and Barak Basin Organisation, Shillong, a body of the Union	Publishes the Flood Estimation Reports for subzones 2(a) and 2(b) used in Chapters 2 and 3 and runs the flood-forecasting sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries. Would supply river stage records with their datum for Chapter 5 and confirm whether any study for subzone 2(c) exists.
Central Ground Water Board (CGWB), North Eastern Region, Guwahati, a body of the Union	Holds the observation wells (381 in 2007) and publishes the depths to water. Would supply groundwater levels and quality for Clause 4.11 and Chapter 8.
IMD (Regional Meteorological Centre, Guwahati), and road, rail and other owners	IMD's stations supply the rainfall records of Chapter 2; Guwahati (Borjhar) (42410), Dibrugarh (Mohanbari) (42314) and the two Silchar stations (42619, 42620) are the first data requests of Clause 2.3.6(a). The Railways, OIL, NHAI, CPWD, the Army and BSNL hold their own drains (as reported) and would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. Stormwater in Assam is split, first, by the river. The towns drain through sluices in the embankments of the WRD, so the body that holds a town's drains is not the body that decides when its outfall opens. It is split, second, by the Sixth Schedule: the Unified Byelaws 2022 and the water-bodies law reach the notified Master Plan areas outside the Autonomous Districts, and inside them only where a District Council opts in, which none has been found to do. And it is split, third, among the bodies that drain Guwahati. The ADB names "fragmented institutional responsibilities involving multiple institutions, such as the Guwahati Metropolitan Development Authority (GMDA), Public Works Department, and Water Resources Department" as the reason "sustainable management of stormwater drainage remains a challenge" (ADB, RRP, 2025). The GMC desilts the city's rivers and drains; GMDA plans, protects the scheduled beels and builds new drainage; PWD holds the roadside drains; the WRD runs the sluices and pumps at the Brahmaputra and desilts the Bondajan; and the Railways, OIL, NHAI, CPWD, the Army and BSNL hold their own drains (as reported). The Guwahati Metropolitan Area of the Master Plan, 328 km², is also wider than the GMC's area. The Bharalu shows why the split matters. It is at once the trunk storm drain of the city, its sewer, since "No ULB in the state has a centralized sewerage system, including Guwahati" (ADB, RRP, 2025) and the river "has no natural flow … only the domestic sewage and commercial sewage are being carried" (PCBA), and a channel whose outfall the WRD closes against the Brahmaputra. No notification was found that assigns the Bharalu, the Mora Bharalu or the Bahini to one owner (NEER reading) [TBC]. Until the State issues such a rule, 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 **drain register** giving every reach its owner, its land status (patta, khas or government, or Council land), whether it is a scheduled water body or an inflow or outflow channel of one, whether it is an embankment drain under the Assam Embankment and Drainage Act, 1953, and its outfall (set by this Manual). The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers, and on patta land it is put into effect by reservation in the Master Plan or by agreement, not by acquisition.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Municipal drains in Guwahati; desilting of the Bharalu, the Mora Bharalu, the Basistha, the Bahini and the Lakhimijan and their feeder drains	The GMC (Gauhati Municipal Corporation Act, 1969, ss.231–252: cleansing s.231, outfalls s.232 (a power, not a duty), alteration s.234, private drains s.237(1), connections s.242, the 100-ft rule s.244, vesting of connecting drains s.250); desilting by the 2022 split (as reported)
Municipal drains in Dibrugarh, Silchar and the other Municipal Corporations	The Corporation (Assam Municipal Corporation Act, 2022: outfall duty s.171, vesting s.173, transfer s.174, separate rain-water drains s.176, alteration s.177)
Municipal drains of a Municipal Board	The Board (Assam Municipal Act, 1956)
Roadside drains of State roads; drains of national highways	PWD (about 260–263 drains in Guwahati, as reported); NHAI
Embankments, sluices and drainage schemes; the Bharalumukh sluice and pumps; the dewatering pumps on the Bharalu, the Mora Bharalu and the Bondajan; desilting of the Bondajan	The WRD (Assam Embankment and Drainage Act, 1953)
New drainage works in the Guwahati Metropolitan Area, the ADB Bahini works, the excavation of Silsako and the scheduled water bodies of the GMDA area	GMDA (the project implementation unit of the ADB works)
Drains of the Railways, OIL, NHAI, CPWD, the Army and BSNL	Their owners (as reported)
Drains in the Autonomous Districts outside any area where the byelaws apply	The District Council or the body it designates [TBC]

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. Assam has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to the Brahmaputra, the Barak or a tributary through an embankment sluice, to a beel behind a sluice, to a gated and pumped outfall such as Bharalumukh, or to a reach below a dam, 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 large river.

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 Assam the State Cabinet decided on 27.03.2024 to denotify the Deepor Beel sanctuary, which the High Court stopped (PIL 18/2023, order of 05.04.2024); builders blocked channels and filled wetland at Palasbari, causing "artificial floods" (PIL/53/2023, order of 06.09.2024); the High Court recorded on 26.05.2025 that "hill cutting is still going on" in Guwahati (PIL/14/2024); and the ADB names among the causes of waterlogging in Guwahati the "construction of buildings and roads over the manmade drains" and the "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas" (ADB, IEE, 2017).

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 Guwahati Metropolitan Area of the Master Plan for Guwahati 2025 and of the Dibrugarh and Silchar Municipal Corporations and their Master Plan areas
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model Unified Byelaws 2022 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 Assam. Where the GMC, GMDA, a Municipal Corporation, a Municipal Board, a Development Authority or a District Council has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Assam trace to the rainfall input, not the hydraulics. Assam shows how. No design storm was found for the drains of any town except the ADB's Bahini works, whose target is a 1-in-5-year storm with a "design storm of 65.72 mm hour" of unstated duration (ADB, PAM, 2025); the town drainage master plans were prepared under the "previous FPS system" and state no design criteria (DoHUA, status sheet), and Dibrugarh's main drain was designed by the rational method with no return period stated (ADB, IEE, 2017). The published sources that seem to fill the gap do not. The two CWC reports that cover the Brahmaputra valley disagree across one river: the 2(b) report converts a 24-hour depth to 1 hour with 0.48 on the south bank and the 2(a) report with 0.260 on the north bank, so the same storm gives North Guwahati little more than half Guwahati's hour, and the 2(a) ratio gives Guwahati's 50-year plate depth about 52–62 mm in an hour against 93 mm recorded by its gauge in 1970. The Barak valley lies in subzone 2(c), for which CWC has published no report. The Guwahati and Dibrugarh panels of IMD Das et al. (2022) repeat a generic curve, and NIH-DHAARA gives Dhubri 789 mm in a day at 50 years, against about 280–320 mm on the plate (Clause 2.3.6). The rainfall figures that circulate after a flood often conflict: Guwahati's day of 31 May 2025 is reported as 111 mm, 120 mm and 99.6 mm, the gauges of 14 June 2022 differ eightfold, and IMD's highest day for Goalpara, 712.1 mm, is twice the 2(a) report's 357.4 mm for the same station (IMD; CWC; as reported). 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.
Monsoon season (as used in this Manual)	1 April to 31 October. In this Manual "the monsoon" and "the monsoon season" mean this wet season, which takes in IMD's pre-monsoon thunderstorm months of April and May as well as the south-west monsoon; it is the Manual's season, not IMD's. IMD's south-west monsoon reaches the North East about the first week of June: its normal onset there is given as about 5 June (as reported), and IMD's revised normals are reported to put Guwahati at 2–4 June (as quoted from a press summary of the IMD release); its normal date of withdrawal from Assam was not obtained for this Manual [TBC]. The season begins on 1 April because the storms of April and May are among the State's largest. Four of the 24-hour records of the 17 Assam stations in IMD's *Extremes* are May storms: Dibrugarh (Mohanbari) 231.5 mm (10 May 1996), Dhubri (Rupsi) 479.3 mm (28 May 1989), Rangia 217.0 mm (29 May 1977) and Silchar 290.3 mm (30 May 1893); Haflong's highest May day, 248.2 mm (10 May 1958), is 80% of its record; and Silchar's wettest month on record is May (1,314.2 mm, 1883) (IMD, *Extremes*; ratio a NEER reading). In Guwahati the April record of 116.5 mm (6 April 2004, IMD) was beaten by 117.4 mm at the airport on 20 April 2026, with 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG the same night, and a woman died after falling into an open roadside drain on 19 April (as reported); Chaparmukh's highest pre-monsoon day is 193.2 mm (23 April 1982, IMD). The CWC 2(b) report finds that "The rainfall is generally spread over a period of eight months, i.e. from March to October", with thunderstorms in April and May, and that "May rainfall is more than the September rainfall. Similarly, April rainfall is more than October rainfall" (CWC, 2(b), §2.4.1). A works deadline of 30 April, first suggested for the Brahmaputra valley in the research for this Manual, would leave the April storms uncovered, so the pre-monsoon deadline of 31 March is set before the season begins (Chapter 10), and it covers the drains, sluice gates, flap gates and pumps of the drainage system; the WRD's calendar for embankment works is its own. The wettest months on record run from 803.0 mm at Guwahati (August 2005) and 913.6 mm at Dibrugarh (June 1998) to 1,148.8 mm at North Lakhimpur (July 1984), 1,309.4 mm at Dhubri (July 1895) and 1,428.5 mm at Haflong (June 2012) (IMD, *Extremes*). The antecedent moisture rule of Clause 2.11.4 and the standby period of Chapter 10 refer to this season.
Storms outside the season	Large falls come before and after the season, and the October storms that come about the time of the withdrawal fall inside it. In October Haflong recorded 237.1 mm (30 October 1959), Dhubri (Rupsi) 220.0 mm (4 October 1958), Dhubri 186.2 mm (2 October 2012) and Guwahati 160.9 mm (15 October 1991); in November Haflong 234.2 mm and Silchar 174.2 mm (both 9 November 1955); and in March Silchar 245.4 mm (29 March 1922) (IMD, *Extremes*), so March storms reach the Barak valley before the season begins. Gohpur's 312.7 mm of 16 January 1971 is printed by IMD and in the 2(a) report but is implausible for a January day, and is suspect until IMD confirms it [U] (Clause 2.3.6(h)). The CWC 2(b) report finds that "The winter season from December to March is practically dry" (CWC, 2(b), §2.4.1), and December to February is this Manual's works window. Design statistics use annual maxima from all months, no works deadline or operating rule shall assume that heavy rain is confined to June–September, and the works calendar of Chapter 10 keeps standby to 31 October and a post-season clearance by 15 November for this reason.
Climate factor (CF)	Multiplier applied to present-day design depths to represent the design-life climate.
Approved source	A rainfall source listed in Clause 2.3.

2.3 Approved sources of design rainfall

2.3.1 **Primary source.** Design rainfall depths and intensities shall be taken from the National Institute of Hydrology, Roorkee **NIH-DHAARA** platform (Design Hydrology and Advanced Rainfall Analysis, nihdhaara.in). Use its IDF / frequency tools for the site's coordinates, for each duration and AEP required by Clause 2.4. In Assam 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 2(a) (North Brahmaputra), which covers the north bank of the Brahmaputra, including North Guwahati and Amingaon, or 2(b) (South Brahmaputra), which covers the south bank, the rest of Guwahati, the Karbi hills and the north of Dima Hasao, but not the Barak valley and the south of Dima Hasao, which lie in subzone 2(c) (Barak and others), for which CWC has published no Flood Estimation Report, as applicable.

Where the design value is lower than the CWC subzone 2(a) (North Brahmaputra) or 2(b) (South Brahmaputra) plate (whichever covers the site, and the higher of the two within 5 km of the Brahmaputra under Clause 2.3.6(b); not in sub-area AS-E, the Barak valley, which no CWC plate covers and where Clause 2.3.6(c)(ii) sets the floors instead) value for the same AEP, the CWC value shall be adopted as a floor.

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

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

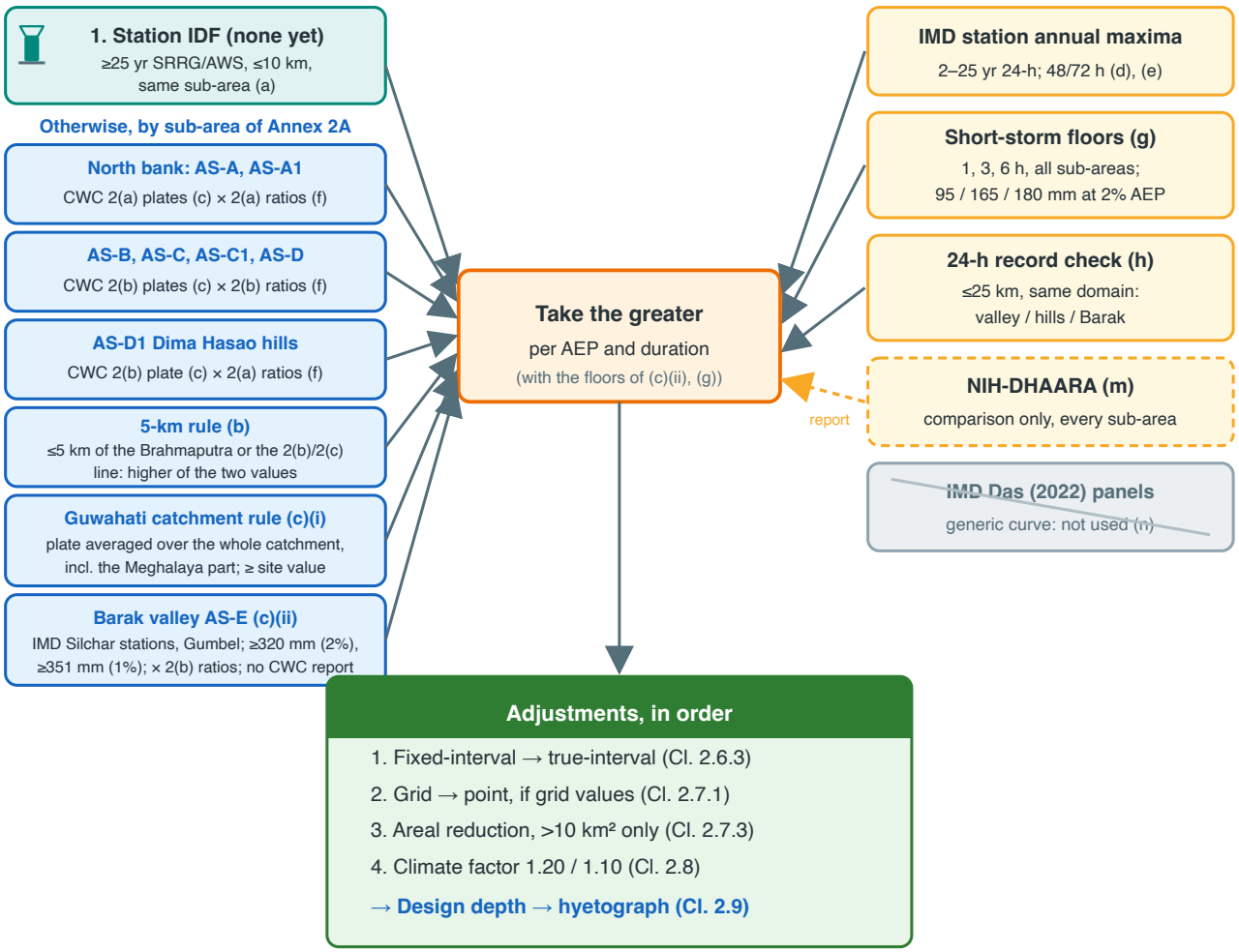

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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 Assam.** 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 Assam, and design rainfall shall be taken as follows:

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station and in the same sub-area of Annex 2A, for the durations and AEPs it covers, in place of (f), and subject to the floors of (c)(ii) 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 outside sub-area AS-E. 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 Assam Clause 2.3.2(a) is read with 25 years in place of 30, as in the other editions of this series that have no long recording-gauge fit (set by this Manual). No IDF has yet been published in Annex 2B, and no station IDF with published constants was found for any station in the State: the IIT Guwahati doctoral thesis on copula-based IDF (2024) and the IIT Guwahati project on IDF curves for North East India gave no station values in the material found; the Guwahati-region IDF of Dey, Sarma and Murali Krishna is derived from TRMM satellite data (1998–2015) for landslide modelling and is not for design; and IMD Das et al. (2022) prints no genuine panel for any Assam station (n) (all seen as summaries [TBC]). The first data requests of this Manual are, in order: (1) the IMD recording-gauge and automatic weather station annual maxima, from 15 minutes to 24 hours, and the return-period tables of **Guwahati (Borjhar) (A) (42410)**, with the owner, logging

interval and archive of the Guwahati city gauges, the City ARG, AAU-HRS, Gauhati University and SIRD Khanapara, and their hourly values of 20 April 2026 [TBC]; (2) the same for **Dibrugarh (Mohanbari) (A) (42314)**, whose plate value under (c) is probably high; (3) the same for **Silchar (42619)** and **Silchar (Kumbhigram) (A) (42620)**, with the one Barak study found, Basumatary, V. and Sil, B.S., *Generation of rainfall intensity-duration-frequency curves for the Barak River Basin*, *Meteorology Hydrology and Water Management* 6(1), 47–57 (2017 or 2018; the year differs between sources), which derives curves for 30 minutes to 24 hours from annual maxima and of which only the abstract was read (the paper was refused) [TBC]; (4) Tezpur (42415), North Lakhimpur (Lilabari) (42309), Dhubri (42404) and Dhubri (Rupsi) (A) (42406), and Haflong (Halflong) (42522); and (5) the recording-gauge series of Nowgong, Chabua and Jorhat behind the 2(b) report.

- (b) **Reports, zones, sub-areas and the 5-km rule.** Two CWC areas with reports cover the Brahmaputra valley. The north bank lies in **subzone 2(a), North Brahmaputra**, whose report (Design Office Report No. NB/18/1991) was placed before the Flood Estimation Planning and Co-ordination Committee at its 49th meeting (24–25 October 1990, Guwahati); it covers the north-bank tributaries from the Tista in the west to the Dibang in the east, with Dhubri town, Kokrajhar, Bongaigaon, Barpeta, Nalbari, Rangia, Mangaldoi, Tezpur, North Lakhimpur, Dhemaji, North Guwahati and Amingaon. The south bank lies in **subzone 2(b), South Brahmaputra**, whose revised report (Design Office Report No. SB-2(b)/R-4/44/99, March 2000, approved by the Committee at its 55th meeting on 13.3.2000, revising SB/8/1984) covers Guwahati and Dispur, Goalpara, Nagaon, Lumding, Diphu, Golaghat, Jorhat, Sivasagar, Dibrugarh and Tinsukia, with Haflong at its southern edge, and describes the subzone as bounded "on the south by Barak Subzone 2 (c)" (CWC, 2(b), p. 18). The Barak valley, with Silchar, Karimganj, Hailakandi and Badarpur, and the south of Dima Hasao lie in **subzone 2(c), "Barak and others" (the Barak, Kaladan and Manipur rivers), for which CWC has published no Flood Estimation Report**: the subzone is listed in Annexure 1.1 of the 2(b) report, but the report's foreword lists 21 reports covering 24 of the 26 subzones, its lists of reports published and revised hold none for 2(c), and the archived index of CWC's downloads holds none (CWC; Wayback Machine). The rainfall zone and sub-area of the site are those of Annex 2A: zone **AS-Z1 North bank**, with sub-areas **AS-A Lower north bank and Bhutan foothills (Dhubri–Kokrajhar–Bongaigaon–Barpeta–Nalbari–Rangia)** and **AS-A1 Central and upper north bank (Mangaldoi–Udalguri–Tezpur–Biswanath Chariali–North Lakhimpur–Dhemaji)**, in subzone 2(a); zone **AS-Z2 Guwahati**, with sub-area **AS-B Guwahati metropolitan area (Guwahati–Dispur–North Guwahati–Amingaon)**, in subzone 2(b), with North Guwahati and Amingaon in 2(a); zone **AS-Z3 South bank**, with sub-areas **AS-C Lower and central south bank (Goalpara–Palasbari–Morigaon–Nagaon–Hojai–Golaghat)** and **AS-C1 Upper Assam (Jorhat–Sivasagar–Charaideo–Dibrugarh–Tinsukia–Margherita)**, in subzone 2(b); zone **AS-Z4 Hill districts**, with sub-areas **AS-D Karbi hills (Diphu–Hamren–Bokajan–Donkamokam)** and **AS-D1 Dima Hasao hills (Haflong–Maibang–Umrangso–Jatinga)**, in subzone 2(b), with the south of Dima Hasao in 2(c); and zone **AS-Z5 Barak valley**, with sub-area **AS-E Barak valley (Silchar–Karimganj–Hailakandi–Badarpur)**, in subzone 2(c). They fix the source of (c), the ratios of (f), the domain of the check of (h) and the screening of (i). A catchment that crosses the line between two zones or two sub-areas of Annex 2A takes, at every duration, the higher value of the two (set by this Manual). Because the Brahmaputra itself is the boundary between 2(a) and 2(b), the riverside towns straddle it: **within 5 km of either bank of the Brahmaputra, including Majuli and every char and river island, and within 5 km of the 2(b)/2(c) line, the higher of the two plates' values at the site is used under (c) and, at each duration, the higher of the two products under (f)** (set by this Manual, as in the plains editions of this series). In AS-B the 2(b) ratios are used on both banks throughout, and on the north bank the 24-hour depth is the higher of the 2(a) plate value at the site and the 2(b) plate value at the nearest point of the south bank. The town lists of Annex 2A are a guide; the plate boundaries govern and are to be confirmed, and the district names follow the reorganisation of 2022–2023 as reported (Karimganj district renamed Sribhumi, as reported) [TBC]. "Lakhipur" in the 2(a) report is a station in old Goalpara district, not North Lakhimpur and not Lakhipur in Cachar.

- (c) **24-hour depth, 2% and 1% AEP (50- and 100-yr).** Outside sub-area AS-E, the 24-hour point value at the site read from the 50- and 100-year isopluvial plates of the report for its subzone (Plates 9 and 10 of the 2(b) report, and Plates 9 and 10 of the 2(a) report, which names its Plates 8, 9 and 10 as its 25-, 50- and 100-year maps (CWC, NB/18/1991, §3.1.2)), 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 (set by this Manual). Plates are read by the coordinates of the site, not by the

town labels, and each reading is recorded on Form 2-1 with the contours on either side. For orientation only, read by eye to about one contour (NEER reading; Plates 8 and 10 of the 2(a) report not yet read for this Manual [TBC]), the 50-year plates give, on the south bank (2(b) Plate 9), about 200–240 mm at Guwahati (the 200 mm line at the city, 240 mm just south, 280–320 mm at the Khanapara–Jorabat foothills and 400 mm on the Meghalaya border), about 200 mm at Nagaon and Jorhat, about 180–200 mm at Lumding and Diphu, about 240–280 mm at Sivasagar and Tinsukia, about 280–320 mm at Dibrugarh, about 320 mm at Goalpara and about 320–400 mm at Haflong, on the 2(b)/2(c) line; and, on the north bank (2(a) Plate 9), about 200 mm at Amingaon and Tezpur, about 240–280 mm at North Lakhimpur and at Rangia–Nalbari, about 280–360 mm at Barpeta, about 280–320 mm at Dhubri, about 360–400 mm at Bongaigaon, about 320 to more than 400 mm at Dhemaji, and more than 440–480 mm at Kokrajhar and the Bhutan foothills. At Guwahati the 100-year 2(b) plate reads about 240 mm, on the line, and the 25-year plate about 180–200 mm. The 2(b) plates print a town "WILTON" at about 95.6° E that has not been identified [TBC]. 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). At Dibrugarh the plate, about 280–320 mm at 50 years, lies above IMD's highest day at Mohanbari, 231.5 mm (10 May 1996), and is probably high (IMD, *Extremes*; NEER reading); Dibrugarh's gauge is the second data request of (a). Two sub-clauses are set by this Manual:

    - (i) **Guwahati catchment rule.** In AS-B, and for any drain or stream in the State whose catchment rises in Meghalaya, among them the Bahini, which rises at Umtyrnga in Meghalaya and becomes the Bharalu at Jonali, the Basistha, the Kalmani and the streams of the Khanapara–Jorabat foothills, the design 24-hour depth is the average of the plate value over the **whole catchment, including the part in Meghalaya**, the plate being the same CWC document on both sides of the State boundary, and not less than the plate value at the site. The gradient is steep: a move of 10 km south from the city to Basistha, Khanapara or Jorabat adds one or two contours, which is why the site's own coordinates and the catchment's are both recorded on Form 2-1. The storm of 19–20 April 2026 showed the same gradient: 117.4 mm at the airport, a new April record for the station, against 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG the same night, a ratio of about 1.8 between gauges in one storm (as reported; ratio a NEER reading). A spatial IDF from the city gauges is the first task of Annex 2A for AS-B.
    - (ii) **Barak valley rule.** In AS-E no CWC plate applies. There the 24-hour depth at every AEP is the Gumbel estimate of (d) from the higher of the IMD annual-maximum daily series of **Silchar (42619, rainfall data 1901–2012)** and **Silchar (Kumbhigram) (A) (42620, rainfall data 1957–1990)**, with the fixed-interval factor of Clause 2.6.3, **and not less than 320 mm at 2% AEP and 351 mm at 1% AEP**. The 320 mm is the lowest value that Plate 9 of the 2(b) report gives on the 2(b)/2(c) line at Haflong, about 320–400 mm (NEER reading of the plate), so that no Barak depth falls below the adjoining 2(b) values; the 351 mm is the record of Silchar (Kumbhigram), 350.6 mm on 2 June 1974 (IMD, *Extremes*), rounded up and applied valley-wide. Karimganj and Hailakandi have no IMD station in *Extremes* and use the same two Silchar stations [TBC]. South of the 2(b)/2(c) line, sites in AS-D1 take the higher of this rule and the plate value on the line. The CWC floor of Clause 2.3.3 does not apply in AS-E, where no plate exists. NIH-DHAARA's 50-year 24-hour depths, 450 mm in the Silchar cell and 513 mm in the Karimganj cell, are reported beside the design depth for comparison only (m). This is an interim rule for a valley that no CWC report covers, set by this Manual because no other source exists for it; the two floors keep every design depth at or above every qualifying 24-hour fall recorded in the valley (h). The Meghalaya edition met the same gap on its southern escarpment and used there the one genuine IMD curve of Das et al. (2022), a curve for an escarpment station outside Assam; the two editions use different methods for different ground, but both state that CWC has published no report for 2(c), and neither falls below the adjoining 2(b) values. That curve is not used in Assam.

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr).** The depth is the Gumbel (EV1) estimate from the annual maximum daily rainfall series, of all months, of the IMD station agreed with the Authority, with 30 or more years of daily record, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3; outside AS-E the 4% AEP depth is not less than the 25-year plate value (Plate 8 of the report for the subzone) read as in (c) (set by this Manual). The stations are Guwahati (Borjhar) for AS-B; Dibrugarh (Mohanbari) for Dibrugarh; Tezpur for Tezpur; North Lakhimpur (Lilabari) for North Lakhimpur; the higher fit of Dhubri and Dhubri (Rupsi) for Dhubri; the two Silchar stations under (c)(ii); Haflong; Lumding; Golaghat; and Chaparmukh for the Nagaon side. Goalpara is

used only after IMD confirms or removes its 712.1 mm of 8 June 1970, and Gohpur only after IMD confirms its 312.7 mm of 16 January 1971 (h). Jorhat, Nagaon, Tinsukia, Bongaigaon, Diphu and Karimganj have no station in IMD's *Extremes*; for them the nearest station with 30 or more years of record, from the candidates of Annex 2A, is agreed with the Authority [TBC]. No Gumbel fit to the annual maxima of any station in the State was found for this Manual [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). Both CWC reports convert 1-day to 24-hour rainfall with a factor of 1.15 (CWC, 2(a) and 2(b)); their plates are 24-hour values, and no further factor is applied to a plate value.

- (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). The Goalpara and Gohpur series are used only after IMD confirms the suspect values of (d). In AS-E the series are those of the two Silchar stations of (c)(ii).

- (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 **AS-A** (Lower north bank and Bhutan foothills) and **AS-A1** (Central and upper north bank), and in **AS-D1** (Dima Hasao hills) on the 2(b) plate depth, the ratios of the 2(a) report: 0.260 at 1 hour, 0.370 at 2 hours, 0.457 at 3 hours, 0.615 at 6 hours, 0.720 at 9 hours, 0.805 at 12 hours, 0.875 at 15 hours and 0.930 at 18 hours, the averaged ratios of a partial-duration analysis of the hourly records of 12 IMD recording gauges, printed for the 50-year depth (CWC, NB/18/1991, §3.1.2, p. 24, and Fig. 10, which gives the 2-hour value); and
    - in sub-areas **AS-B** (Guwahati metropolitan area, on both banks), **AS-C** (Lower and central south bank), **AS-C1** (Upper Assam), **AS-D** (Karbi hills) and **AS-E** (Barak valley), the ratios of the 2(b) report: 0.48 at 1 hour, 0.62 at 3 hours, 0.74 at 6 hours, 0.81 at 9 hours, 0.87 at 12 hours, 0.91 at 15 hours and 0.95 at 18 hours, the ratios of the 10-year t-hour to the 10-year 24-hour rainfall from a partial-duration analysis of the hourly records of the report's six recording gauges, Shillong, Nowgong, Dibrugarh, Guwahati, Chabua and Jorhat, recommended for every return period because "the average ratios beyond T=5 years were comparable in magnitude" (CWC, 2(b), §4.3.2 and Table 4.1, p. 20).

  The two reports disagree across one river: for the same 24-hour depth, the 2(b) ratio gives an hour about 1.8 times the 2(a) ratio (NEER arithmetic), a step that is an artefact of the reports, not of the climate. The Guwahati recording gauge of the 2(b) report shows which set holds where. It recorded **93 mm in 1 hour (17 May 1970)**, and in the storm of 18–19 July 1978 **163 mm in 3 hours, 179 mm in 6 hours, 186 mm in 12 hours and 187 mm in 24 hours** (CWC, 2(b), Annex 4.2, read by OCR). On Guwahati's 50-year plate value of about 200–240 mm, the 2(b) ratios give about 96–115 mm in 1 hour, 124–149 mm in 3 hours, 148–178 mm in 6 hours and 174–209 mm in 12 hours: they hold at 1 and 12 hours, and fall short of the record by 9–24% at 3 hours and by up to 17% at 6 hours. The 2(a) ratios give about 52–62, 91–110, 123–148 and 161–193 mm, short of the record at 1, 3 and 6 hours, and at 1 hour by a third or more (all NEER arithmetic). Elsewhere in the valley the largest hours of the 2(b) recording gauges are 95 mm at Dibrugarh (3 August 1970) and 88 mm at Nowgong (8 October 1985) (CWC, 2(b), Annex 4.2), and NIH-DHAARA's 50-year 1-hour depths are 99–135 mm in its cells on the north bank and 92–126 mm on the south bank (m): the hour-scale storm is of the same size on both banks, while the 2(a) ratio applied to the plate gives Tezpur about 52 mm. The 2(a) set is nevertheless kept on the north bank, because it is that report's own analysis of that bank's gauges and because the floors of (g) make up the short durations; and the 2(b) set is not raised at 3 and 6 hours, because the floors of (g) do that too. On Dibrugarh's plate value of about 280–320 mm the 2(b) ratio gives 134–154 mm in 1 hour against a recorded 95 mm: probably high, which is why Dibrugarh's recording-gauge series is the second data request of (a). In **AS-E**, which has no report, the 2(b) set is used because it was derived from convective gauges of the valley floor and is the more conservative of the two adjoining sets, pending the Barak data of (a); on the 320 mm floor of (c)(ii) it gives about 154 mm in 1 hour at 50 years, about 1.45 times NIH-DHAARA's 106 mm in the Silchar cell, a margin accepted for having no data. In **AS-D1** the 2(a) set is used on the 2(b) plate depth, because the Barail ridge's falls are long and orographic (Jatinga Valley's annual normal is 4,767 mm (CWC, 2(b), Annex 4.1, OCR) and Haflong received 1,428.5 mm in June 2012 (IMD, *Extremes*)), and because the one hill gauge behind the 2(b) set, the Shillong recording gauge, recorded a

single-event 1-hour ratio of 48/347 = 0.14 (CWC, 2(b), Annex 4.2; ratio a NEER reading); on Haflong's plate value of about 320–400 mm the 2(b) ratio would give 154–192 mm in 1 hour, against NIH-DHAARA's 82 mm. The Meghalaya edition put its plateau on the 2(a) set for the same reason and kept the 2(b) set in its foothills facing the Assam valley: the two editions read the same report the same way, the 2(b) ratio fitting the valley-floor gauges at 1 hour (Guwahati 93/187, Dibrugarh 95/207) and falling short at 3–6 hours, the 2(a) ratio fitting the ridge. Between the tabulated durations the ratio is interpolated on logarithmic axes; the 2-hour ratio of 2(b), which the report does not give, is interpolated in the same way. The ratios apply to the 24-hour depth of (c) or (d) before the check of (h).

- (g) **Short-storm floors.** In every sub-area of the State, the 1-, 3- and 6-hour depths for the 10% AEP (10-yr) and rarer shall be not less than the following (set by this Manual):

Duration	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
1 hour	70 mm	85 mm	95 mm	105 mm
3 hours	120 mm	145 mm	165 mm	185 mm
6 hours	130 mm	160 mm	180 mm	200 mm

  The 2% AEP values are the largest falls on the valley's recording-gauge record, rounded up to 5 mm: 95 mm in 1 hour (Dibrugarh, 3 August 1970; Guwahati 93 mm, 17 May 1970), and 163 mm in 3 hours and 179 mm in 6 hours (Guwahati, 18 July 1978) (CWC, 2(b), Annex 4.2). The other AEPs are scaled by the shape, not the values, of NIH-DHAARA's 1-hour growth curve in the Guwahati cell: 75.6/104.3 = 0.725 at 10 years, 0.883 at 25 years by Gumbel interpolation and 116.4/104.3 = 1.116 at 100 years (NIH-DHAARA, queried 14 Nov 2026; ratios a NEER reading), NIH-DHAARA being used for ratios only. The record length behind Annex 4.2 is not printed, and its dates run from 1970 to 1985 [TBC]; treating the record maxima as 50-year values is a floor that keeps every design depth at or above every short fall recorded in the valley, not a frequency estimate. The floors are applied in every sub-area because the hour-scale storm is of the same size on both banks (f) and because no gauge in the hills or the Barak valley shows smaller short storms. The 2-hour depth shall be not less than the value interpolated on logarithmic axes between the 1-hour and 3-hour depths for the same AEP. 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. They are interim: Annex 2B replaces them with station fits under (a), beginning with Guwahati, Dibrugarh and Silchar; if a fit shows 1-, 3- or 6-hour depths above them for a sub-area, the fit governs there, and if together the fits show depths well below them, a reduction may be proposed to the State Stormwater Technical Committee. No other absolute floor is used.

- (h) **24-hour record check, bounded by domain.** The 1% AEP (100-yr) 24-hour depth of (c) or (d) shall be not less than the highest qualifying 24-hour rainfall recorded at any station **within 25 km of the site and in the same domain**, 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). The domains are three: the **Brahmaputra valley** (AS-Z1, AS-Z2 and AS-Z3, one domain, because the river is not a climatic divide, so that a record on one bank counts on the other within 25 km), the **hill districts** (AS-Z4) and the **Barak valley** (AS-Z5); a record never counts across the edge of the Karbi hills, the hills of Meghalaya or the Barail range (set by this Manual). A record qualifies only when it is printed by IMD (in *Extremes of Temperature and Rainfall for Indian Stations*, a climatological summary of the State, a monthly or seasonal climate summary, a later IMD table or an IMD press release that names the gauge and the day); the number of years of data at its gauge is confirmed by an IMD table as at least 20; it was made in 1901 or later, 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; the location of its gauge is known; 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. Values printed only in the CWC reports (Table 7 of 2(a); Annexes 4.1 and 4.2 of 2(b)) are recorded on Form 2-1 as flags but do not qualify until IMD confirms the record

length of their gauges [TBC] (all set by this Manual). Distances below are measured from approximate coordinates of the gauges and towns (NEER reading, to be confirmed from IMD's station coordinates [TBC]). The outcomes at present are:

  - **Qualify and raise depths. Dhubri (Rupsi) (A), 479.3 mm on 28 May 1989** (IMD, *Extremes*, rainfall data 1957–2003), the largest qualifying day in the State: it raises the 1% AEP 24-hour depth to at least 479.3 mm, and the 2% AEP depth to at least 439.3 mm, at Dhubri town, about 15 km from the gauge, and at every site in the valley domain within 25 km of it, against a 50-year plate value of about 280–320 mm, the largest effect of the check in the State; Dhubri's own 368.3 mm (11 June 1909; 1901–2012) also qualifies and is exceeded by it. **Lumding, 410.0 mm on 3 August 1981** (1912–2012), raises the 1% AEP depth to at least 410.0 mm within 25 km of the gauge in the valley domain, against a plate value of about 180–200 mm; Diphu, about 28 km away and in the hill domain, is not raised. **Chaparmukh, 295.5 mm on 17 July 1980** (1954–2012), raises the 1% AEP depth to at least 295.5 mm within 25 km, against a plate value of about 200 mm; Raha (about 3 km), Morigaon (about 19 km) and Nagaon (about 23 km, near the limit, to be confirmed) lie within it. **North Lakhimpur (Lilabari), 261.6 mm on 12 July 1971** (1951–2012), raises the 1% AEP depth at North Lakhimpur wherever the 100-year plate, not yet read, gives less [TBC].
  - **Qualify and lie below the plates.** Guwahati (Borjhar), 194.3 mm on 5 June 1956 (1902–2012); Dibrugarh (Mohanbari), 231.5 mm on 10 May 1996 (1901–2012); Tezpur, 184.9 mm on 30 June 1986 (1901–2012); Golaghat, 147.0 mm on 30 August 1996 (1954–2012); Rangia, 217.0 mm on 29 May 1977 (1957–2012); and, in the hill domain, Haflong, 309.5 mm on 27 June 2012 (1901–2012). Tangla, 224.4 mm on 16 June 1973, and Majbat, 235.0 mm on 9 June 1962 (both 1954–2012), qualify and are compared with the plate read at each site [TBC]. In the Barak domain, **Silchar (Kumbhigram) (A), 350.6 mm on 2 June 1974** (1957–1990), qualifies and is already the 1% AEP floor of (c)(ii).
  - **Excluded until IMD confirms them** [U]: **Goalpara, 712.1 mm on 8 June 1970**, twice the 2(a) report's maximum for Goalpara (357.4 mm, 12 May 1958) and in no annex of either report; **Gohpur, 312.7 mm on 16 January 1971**, an implausible January day, printed by IMD and in the 2(a) report alike; and **Silchar, 290.3 mm on 30 May 1893**, before 1901 and outside the printed data period of the station (1901–2012).
  - **Flags only (CWC reports; record lengths not confirmed by an IMD table)** [TBC]: Damra 508.0 mm (13 August 1968, 2(a), which conflicts with Damra 35.4 cm on 8 July 1946 in 2(b) [U]); Lakhipur 490.3 mm (5 May 1959); Bijni 486.4 mm (9 July 1895); Lanka 471.9 mm (6 October 1916, missing from the 2(b) annex); Baruduar or Barduar 417.0 mm (20 June 1934); Patacharkuchi 406.4 mm (20 June 1989); Kampur 385.0 mm (5 August 1966); Moran 381.0 mm (4 September 1968); Kachugaon and Mankachar 366.0 mm; Goalpara 357.4 mm (12 May 1958); and Lumding 360.0 mm (26 September 1976). They suggest that the plates understate the extremes of lower Assam and of the Nagaon–Lumding area: the Nowgong recording gauge took 427 mm in 24 hours on 3–4 September 1978, twice the 50-year plate value there (CWC, 2(b), Annex 4.2; ratio a NEER reading). Confirming their record lengths is the third data request of this Manual, after the station series of (a).

  No record from a station in Meghalaya reaches a site in Assam, because none lies in an Assam domain. Until Annex 2A is published, the designer lists on Form 2-1 every record and flag within 25 km of the site, with its domain and the tests it passes or fails. The check raises the 24-hour depth and, through (e), the 48- and 72-hour depths. It stops at 24 hours: it does not raise the depths of (f) and (g) for 1 to 18 hours, because the records are daily totals and no hourly record of any of them exists.

- (i) **Hazard-first sites.** Assam has no snow-fed catchment. No design is complete without a screening, recorded in the drainage report, that identifies the hazards below and states whether the site lies on their path, from the flood and landslide maps of ASDMA where they exist [TBC], the Hilly Area Zone of the Master Plan for Guwahati 2025, the hazard maps of byelaw 120 once they are made, and the WRD's records of embankments, sluices and breaches; where it does, the siting, setback and floor-level rules of Chapters 6 and 7 govern, because no drain is sized for them (set by this Manual). The hazards are: sites on active **char and chapori land** and on eroding banks (the land lost to erosion is given as more than 4.27 lakh ha since 1950 and as about 3.86 lakh ha since 1954, both as reported; conflict); sites in an **embankment breach path**, such as that of the cut at Bethukandi that let the Barak into Silchar in June 2022 (as reported); **dam-release reaches**, among them the Ranganadi below the

NEEPCO project (a release of 1,412.57 m³/s in 2017, as quoted in an IIT Guwahati report for ASDMA), the Subansiri below the Lower Subansiri project, the Kopili below the Kopili project and the Manas below Kurichu in Bhutan (release rules of all three [TBC]), and the Umtru below Byrnihat, where the release-reach rule of the Meghalaya edition for New Umtru applies; **bhabar fans and avulsing foothill streams** on the north bank, where debris and channel shift govern; **landslide ground** in the Guwahati hills (four people killed at Nizarapar, Boragaon, on 14 June 2022, and three at Bonda on 31 May 2025, as reported) and in the hill districts; and **cut hill slopes**, on which the High Court recorded in 2025 that "hill cutting is still going on" (PIL/14/2024).

- (j) **Cloudbursts.** IMD calls a fall of 100 mm or more in one hour over a small area a cloudburst (as quoted; no IMD primary document was found for this Manual [TBC]). No measured cloudburst rate was found for Assam: the largest hours recorded in a primary source are 95 mm at Dibrugarh (3 August 1970) and 93 mm at Guwahati (17 May 1970) (CWC, 2(b), Annex 4.2). A blog's "117 mm in one hour" for 20 April 2026 is unverified and is not cited [U]. The floors of (g) at 1% AEP, 105 mm in 1 hour before the climate factor, reach the threshold. What a burst does in a steep catchment of the Guwahati hills that a design storm does not represent is to bring down silt, slope debris and garbage 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 2(b) report analysed 1,040 storms of its six recording gauges in five duration classes, from 2–3 hours to 19–24 hours (CWC, 2(b), §4.3.3); its time-distribution curves were not extracted for this Manual beyond its 13-hour example [TBC].

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

- (m) **NIH-DHAARA.** NIH-DHAARA was queried at 15 points in the State on 14 November 2026 (IMDAA dataset). Its present-day values at the site are reported on Form 2-1 beside the interim values, in every sub-area, for comparison only; they are never a design value, a floor or a check. Its 50-year 24-hour depths exceed the CWC plates everywhere, by 1.3 to 2.8 times (789 mm in the Dhubri cell against about 280–320 mm on the plate, 674 mm at Goalpara, 404 mm at Tezpur against about 200 mm, and 307 mm at Guwahati against about 200–240 mm), and exceed every IMD 24-hour record at Guwahati, Dibrugarh, Tezpur, North Lakhimpur and Silchar; its 1-hour depths are closer (104 mm in the Guwahati cell against the 93 mm recorded hour), and in AS-E its 1-hour depths, 106 mm in the Silchar cell and 117 mm in the Karimganj cell, are the cross-check reported beside (f), not used (NIH-DHAARA, queried 14 Nov 2026; IMD; CWC; NEER comparison). The shape of its growth curve in the Guwahati cell is used only for the scaling of the floors of (g). Its projected depths are not used under Clause 2.8.4.

- (n) **IMD Das et al. (2022).** The paper has two panels for Assam, Guwahati (Fig. 4(vii)) and Mohanbari (Fig. 4(xxi)), and both repeat the generic curve that it prints for several other cities, about 60, 73, 82, 93, 101 and 109 mm/h at 1 hour for 2 to 100 years; they are not station data and are not used as a value, a check or a floor anywhere, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available. The one distinct North-East panel of the paper lies outside Assam and is not used. The paper's ranges for the North-East region are internally inconsistent, 150 cm at 24 hours in its table and 160 cm in its text (IMD Das et al., 2022, Table 1 and p. 895).

- (o) **Earlier design values.** The first design value found in any official Assam document is the target of the ADB's Assam Urban Sector Development Project (57262-001): inundation "from a 1-in-5-year storm or lower return period avoided in 434 ha of frequently flooded areas of Bahini Basin", with "Inundation areas of 693 ha during the design storm of 65.72 mm hour" (ADB, Project Administration Manual, July 2025, design and monitoring framework); the duration behind 65.72 mm/h and its return period are not stated, and the baselines of 616 ha and 693 ha in the same table differ [U]. A 1-in-5-year target is below the 10% AEP minor-drain standard of Table 2.1 for the high-density areas of Guwahati, Dibrugarh and Silchar, and the Manual's AEPs govern for works designed to it; the project set its own target, and this Manual does not judge it. A research abstract simulates about 34

m³/s for a 2-hour, 5-year storm in a proposed Guwahati outfall system (EGU26-18594; research only). Dibrugarh's DTP drain was designed by a "rainfall based approach … The peak discharge computed by rational method", with no return period stated (ADB, IEE, 2017). The town drainage master plans of DoHUA "were prepared before 2015 as per previous FPS system" and await revision to CPHEEO's guideline of 2015 (DoHUA, status sheet), and no design criteria appear in them. A designer who uses any of these reports it on Form 2-1; the return periods of Table 2.1 and the depths of this clause apply.

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

Commentary. NIH-DHAARA is a national, publicly accessible product from a Government of India institution, and it can be queried at any point in the State. That makes it a reproducible default that an approving authority can check. NIH-DHAARA's sub-daily values are derived from hourly records, not disaggregated from daily totals. That makes it the only public source suitable for sizing drains, which depend on short-duration intensity. Its values should still be checked against the long IMD daily record at 24 hours and longer (Annex 2A). In Assam the platform has not yet been shown to meet that purpose. It was queried at 15 points of the State for this Manual. Its 24-hour depths are 1.3 to 2.8 times the CWC plate values everywhere, worst in lower Assam (789 mm at 50 years in the Dhubri cell, against about 280–320 mm on the plate and 479.3 mm, the State's largest qualifying day), and exceed every IMD 24-hour record at Guwahati, Dibrugarh, Tezpur, North Lakhimpur and Silchar; its 1-hour depths are closer, 104 mm at 50 years in the Guwahati cell against the 93 mm that the Guwahati recording gauge recorded in its largest hour. A source that overstates the daily depths by so much cannot be adopted for any of them, so Clause 2.3.6 uses the CWC reports and the IMD station records until Annex 2A has been done, and reports NIH-DHAARA beside the design values, for comparison only; the shape, not the values, of its 1-hour growth curve scales the short-storm floors. The Guwahati and Mohanbari panels of IMD Das et al. (2022) are not used anywhere, because they repeat the generic curve that the paper prints for several of its cities. Assam is the first floodplain-river State of the North East in this series, and three things set its interim source apart. First, two CWC subzones with reports meet on the Brahmaputra and disagree: the 2(a) report of 1991 converts a north-bank 24-hour depth to 1 hour with 0.260, and the 2(b) report of 2000 a south-bank depth with 0.48, so that riverside towns straddle a step that the climate does not have; Clause 2.3.6(b) takes the higher value within 5 km of the river and Clause 2.3.6(g) puts a floor in millimetres under the short durations in every sub-area, because Guwahati's recording gauge has already exceeded the 2(b) products at 3 and 6 hours and the 2(a) products at every duration up to 6 hours. Second, the Barak valley lies in subzone 2(c), for which CWC has published no report; Clause 2.3.6(c)(ii) uses the two IMD Silchar stations with floors that keep the valley's depths at or above the adjoining 2(b) values and its own record. Third, Guwahati's streams rise in Meghalaya, where the plates rise from about 200–240 mm at the city to 400 mm at the border, and the city's gauges differ by nearly two times in one storm; Clause 2.3.6(c)(i) averages the plate over the whole catchment. The receiving waters, not only the rain, set the design of the outfalls (Clause 2.12). The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the 5-km rule, the Guwahati and Barak rules, the sub-area of each town, the two sets of ratios, the short-storm floors, the domain-bounded record check, the hazard-first screening and durations below 1 hour are set by this Manual. Several points are unresolved. The plate values were read by eye, to about one contour, and Plates 8 and 10 of the 2(a) report were not read [TBC]. Annexes 4.1 and 4.2 of the 2(b) report were read by OCR and not checked against page images, and the record length behind the recording-gauge maxima is not printed [TBC]. Goalpara's 712.1 mm and Gohpur's January 312.7 mm wait for IMD's confirmation, and the FER-only falls of lower Assam and Nagaon–Lumding for confirmation of their record lengths (Clause 2.3.6(h)). The Barak study of Basumatary and Sil was not obtained, and no storm-drain DPR for any town of the State with its design rainfall analysis was found for this Manual [TBC].

2.4 Design return periods (summary)

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

Table 2.1 — Design return periods (summary)

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

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

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. Assam's worst floods have come when days of rain raise the Brahmaputra and the Barak while the town outfalls are shut. In June 2022, the wettest June over Assam and Meghalaya since 1901 (IMD), Cachar recorded 251.20 mm on 19 June (district report, as quoted), the Barak at Annapurnaghat rose from 19.62 m to 20.98 m in the 24 hours after it crossed its danger level on 18 June and peaked at 21.59 m on 21 June, and

Silchar stayed under water for about 11 days (as quoted; as reported). The storm of 18–19 July 1978 at Guwahati brought 163 mm in 3 hours and 187 mm in 24 hours, and the Nowgong recording gauge took 427 mm in 24 hours on 3–4 September 1978 (CWC, 2(b), Annex 4.2). The wettest months reach 1,309.4 mm at Dhubri (July 1895) and 1,428.5 mm at Haflong (June 2012) (IMD, *Extremes*). At Guwahati the Brahmaputra reaches its danger level of 49.68 m in most monsoons, and its highest level, 51.46 m (21 July 2004), is 1.78 m above it (CWC data as transcribed by SANDRP; NEER reading), so the outfalls of the city stay closed for days to weeks. The town drains rise within an hour of a burst, but the storage behind a closed sluice, the beel that receives it and the pumps that empty it are set by the whole wet spell and the river's stage, 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 Assam recording gauges. They shall not be lower than the ratios that Clause 2.3.6 sets for the site's sub-area: those of the CWC Flood Estimation Report for subzone 2(a) on the north bank of the Brahmaputra and in the Dima Hasao hills, and those of the CWC report for subzone 2(b) in the Guwahati metropolitan area, on the south bank, in the Karbi hills and in the Barak valley, for which subzone 2(c) has no CWC report; and the 1-, 3- and 6-hour depths shall not be lower than the short-storm floors of Clause 2.3.6(g). IMD Das et al. (2022) prints panels for Guwahati and Dibrugarh (Mohanbari), but both repeat a generic curve and are 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 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 2(a) (North Brahmaputra) or 2(b) (South Brahmaputra): use the ARF curves of the applicable CWC Flood Estimation Report;
- for 10–25 km²: interpolate linearly between ARF = 1.0 at 10 km² and the CWC value at 25 km².

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

> **Commentary.** Gridded and district-average return levels are much lower than point values. For example, IMD gives 858.1 mm for the whole of June 2022 over its Assam and Meghalaya subdivision, the highest since 1901 (IMD, Monthly Climate Summary, June 2022), while Guwahati's gauges differ by more than eight times in a single storm: on 14 June 2022 the WRD gauges at Chandmari and Beltola recorded 84.6 mm and 88 mm against about 10 mm at the airport (as reported). The NIH-DHAARA cell over Dhubri gives 789 mm for the 50-year 24-hour depth, against about 280–320 mm on the CWC 2(a) plate and 479.3 mm, the highest day at Dhubri (Rupsi) (NIH-DHAARA, queried 14 Nov 2026; CWC; IMD, *Extremes*). 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. No design uplift factor has been adopted in Assam. The State Action Plan on Climate Change, version 2.0, is reported to say that "extreme rainfall events will increase by 5–38 per cent", a minister is reported to have given 38% by about 2050 relative to 1971–2000, and more than 25% more flood

events are reported (as reported); the plan text itself was not read for this Manual [TBC]. The NAPCC portal lists a near-term (2011–2040) change in annual rainfall of +0.97% to +3.04% for the State under RCP 4.5 and 8.5 (as quoted). The observed record conflicts: IMD's analysis for 1989–2018 is reported to find decreasing trends in each month from June to September for Assam (as reported), while a study of 26 locations in the State for 1981–2017 found increasing pre-monsoon and monsoon trends (*CWE* 17(2), 435–446, abstract only). Guwahati set new daily records for April (117.4 mm, 20 April 2026) and May (111 mm, 31 May 2025) at the airport (as reported), while its all-time 24-hour record, 194.3 mm on 5 June 1956, still stands (IMD, *Extremes*). The case for an uplift rests on the size of recent short-duration extremes, not on trend statistics. The core's factors of 1.20 for durations up to 6 hours and 1.10 for 6–72 hours are kept as interim values: the higher one lies within the 5–38% reported from the State plan for extreme rainfall, and neither is lowered for long durations, although seasonal totals may be falling, because the core does not go below them. As in the other editions of this series, they are applied after the record check of Clause 2.3.6(h) and to the short-storm floors of Clause 2.3.6(g). NIH-DHAARA's projected depths are not used (Clause 2.3.6(m)). The factors of Table 2.2 are therefore interim values, not Assam 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 (monsoon pattern).** Construct as follows:

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

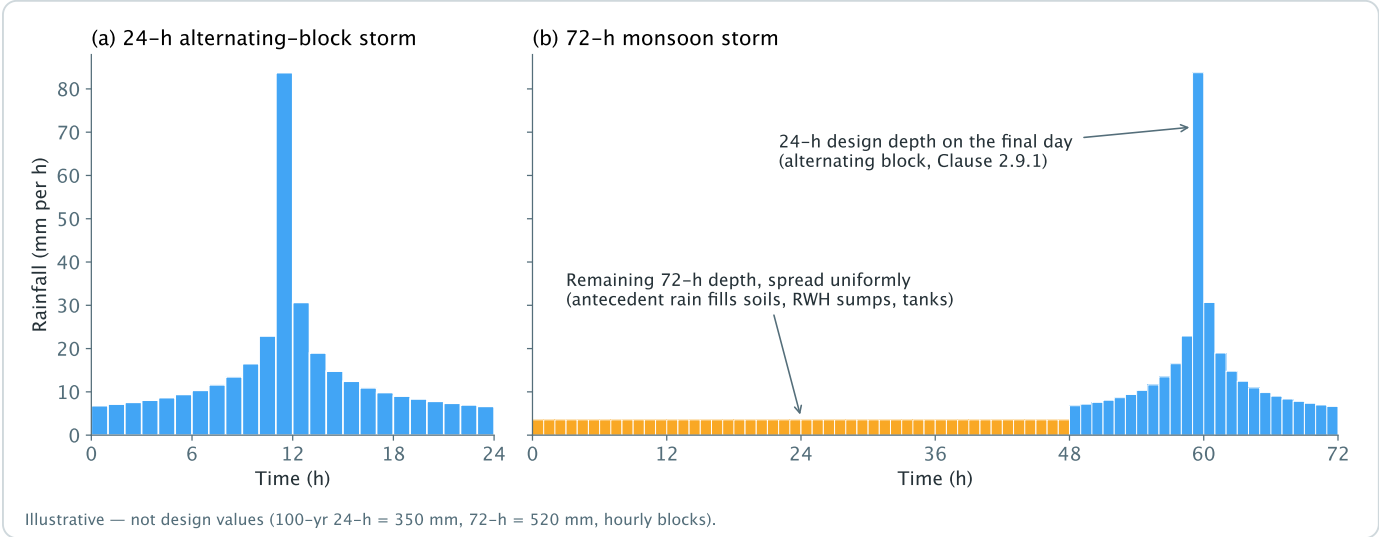

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Assam 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 Assam: by the time the largest falls arrive in June, July or August, after the storms of April and May, the flood plains are saturated, the water table is near the surface, the beels are full, the Brahmaputra and the Barak are high and the sluices of the embanked towns are shut. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Assam 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 Guwahati's Bharalu–Bahini, Mora Bharalu–Deepor Beel and Silsako basins and of its hill-fringe streams, of Dibrugarh behind the DTP dyke, of Silchar, of Karimganj with Hailakandi and Badarpur, of Palasbari–Mirza, of the north-bank towns on dam-release and flash-flood reaches, of Dhubri and Goalpara, of Majuli and the char lands, and of Haflong and Diphu, 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 June to 30 September at a site in sub-area AS-A (Lower north bank and Bhutan foothills), AS-A1 (Central and upper north bank), AS-B (Guwahati metropolitan area), AS-C (Lower and central south bank), AS-C1 (Upper Assam) or AS-D1 (Dima Hasao hills) of Annex 2A, and from 1 May to 31 October at a site in sub-area AS-E (Barak valley). Use AMC III for every design storm from 1 April to 31 October, in every sub-area, on land below the 1% AEP flood level of a river, on char and chapori land, on the margins of a beel or pukhuri and on land behind an embankment. Use AMC III for every design storm at any time of year in a catchment that drains to a reservoir or its backwater, or to a reach below a dam into which the dam releases water, such as the Kopili below the Kopili hydroelectric project, the Umtru below Byrnihat, the Ranganadi and the Subansiri. At any other site or time, including every site in sub-area AS-D (Karbi hills) outside the land and catchments above, use AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm. Use AMC II (average conditions) for every other storm. AMC I is not used for design.

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

Commentary. Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that monsoon extremes arrive after weeks of rain. In Assam the season, the ground and the receiving waters together decide how wet a catchment is. The flood plains of the Brahmaputra and the Barak are recent alluvium of silts and clays (CWC, 2(b), §2.3.2), and their water table is shallow: in November 2022, 45.96% of CGWB's wells in the State read within 2 m of the ground, and in Kamrup (Metro) the range was 1.29–2.64 m (CGWB, Ground Water Year Book, North Eastern Region, 2022-23). The loss rates that the CWC reports adopted for their unit hydrographs are low, 3.5 mm/h in 2(b) and 2.4 mm/h in 2(a) (CWC; NEER conversion), as for saturated ground. Land below the 1% AEP level of a river, char and chapori land, the margins of beels and pukhuris and land behind embankments are wet whenever the river is high, which in Assam is much of the season. In the Barak valley the pre-monsoon storms begin earliest: Silchar's highest day on record fell on 30 May 1893 and its wettest month was May 1883 (IMD, *Extremes*). The reservoirs on the Kopili, the Ranganadi and the Subansiri and the Umtru below Byrnihat release water into reaches that are wet whenever they release. This Manual therefore uses AMC III for every design storm from 1 June to 30 September in sub-areas AS-A, AS-A1, AS-B, AS-C, AS-C1 and AS-D1, the main part of the south-west monsoon; from 1 May to 31 October in AS-E; from 1 April to 31 October, in every sub-area, on land below the 1% AEP flood level, on char and chapori land, on beel and pukhuri margins and on land behind embankments; at any time of year in catchments draining to a reservoir, its backwater or a release reach; and otherwise, including in AS-D, the rain shadow of the Karbi hills, where Plate 9 reads only about 180–200 mm at Lumding and Diphu, 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 hill-fringe colony in south Guwahati draining to the Bahini 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.

Assam has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the river behind an embankment or the beel behind a sluice into which a town drains. For an outfall under river or beel 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 5.8.2. The levels of CWC's flood-forecasting sites are known for this Manual only as transcribed by SANDRP from CWC's tables, with no datum stated (presumably metres above mean sea level [TBC]): on the Brahmaputra, warning, danger and highest levels of 104.70, 105.70 and 106.48 m at Dibrugarh (3 September 1998), 84.04, 85.04 and 87.37 m at Neamatighat (11 July 1991), 64.23, 65.23 and 66.59 m at Tezpur (27 August 1988), **48.68, 49.68 and 51.46 m at Guwahati (DC Court) (21 July 2004)**, 35.27, 36.27 and 37.43 m (31 July 1954) at Goalpara, where another table gives 37.35 m (13 July 2004), and 27.62, 28.62 and 30.36 m at Dhubri (28 August 1988), reported as 30.37 m (17 July 2019) in a bulletin of 2024 (conflicts stated, not resolved); on the Barak, **18.83, 19.83 and 21.84 m at Annapurnaghat, the gauge for Silchar (1 August 1989)**, and 15.85, 16.85 and 18.48 m at Badarpurghat (11 September 2007); and on the Kushiyara 13.94, 14.94 and 16.57 m at Karimganj (10 June 2010) (CWC data as transcribed by SANDRP, 2019). The tributary sites, among them the Jia Bharali, the Subansiri, the Burhidihing, the Dikhow, the Kopili (Kampur, highest level 61.79 m on 20 July 2004, and Dharamtul, 58.09 m on 21 July 2004), the Beki, the Manas, the Puthimari and the Pagladiya, are listed in Chapter 5. At Guwahati the danger level is reached in most monsoons and the highest level is 1.78 m above it, and in June 2022 the Barak at Annapurnaghat stood above its danger level from 18 June and peaked at 21.59 m on 21 June, 0.25 m below its highest level (as quoted; differences a NEER reading), so the outfalls of the embanked towns are designed for gates closed for days to weeks, with the local storm falling before, during or after the river's peak (Chapter 5). The reservoirs on the Ranganadi, the Subansiri and the Kopili, and New Umtru above Byrnihat, release floods into the reaches below them, so outfalls on a release reach are checked against release scenarios, not notices (Clause 2.3.6(i); Chapter 5). No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC], and Chapter 5 sets the interim rule. Every level is stated on a named datum, as Chapter 5 requires.

> Commentary. Assam has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the stage of the river behind the embankment, or of the beel behind the sluice, into which the town drains. The coincidence is the normal case, not the exception. The WRD names "High stages of river Brahmaputra and Barak" that "obstruct free discharge of tributaries causing back flow and congestion near outfalls" as a cause of flooding (as quoted by the CAG, Report No. 5 of 2018); when the Brahmaputra is high the Bharalumukh gates close, and

> Guwahati's Bharalu, which carries 72 m³/s by gravity with the gates open, is left with about 7 m³/s of pumps (2008, as reported). In June 2022 the rain that fell on Silchar fell while the Barak stood above its danger level at Annapurnaghat (as quoted), and Dibrugarh lies "1.5 m below the bed level of Bramhaputra", so that its drain outfall is designed "keeping in mind that the beel is full and the drain is also flowing full" (ADB, IEE, 2017). Dam releases on the Ranganadi and the Subansiri can raise a reach while a local storm is falling on the town beside it (Clause 2.3.6(i)). The river levels give no warning of a local storm that falls while they are high. The levels quoted by different sources differ, and none states its datum: the CWC levels are transcribed by SANDRP, not read in a CWC bulletin, and the highest levels of Goalpara and Dhubri are printed with two values each (CWC data as transcribed by SANDRP; as quoted), which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Assam, which has no coast, the counterpart of surge is the stage of the Brahmaputra, the Barak and their tributaries behind the embankments, raised by the same monsoon rain that falls on the towns: in June 2022, the wettest June over Assam and Meghalaya since 1901 (IMD), the Barak at Annapurnaghat stood above its danger level from 18 June while Cachar recorded 251.20 mm on 19 June (as quoted), and at Guwahati the Brahmaputra reaches its danger level in most monsoons, when the Bharalumukh gates close), 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.

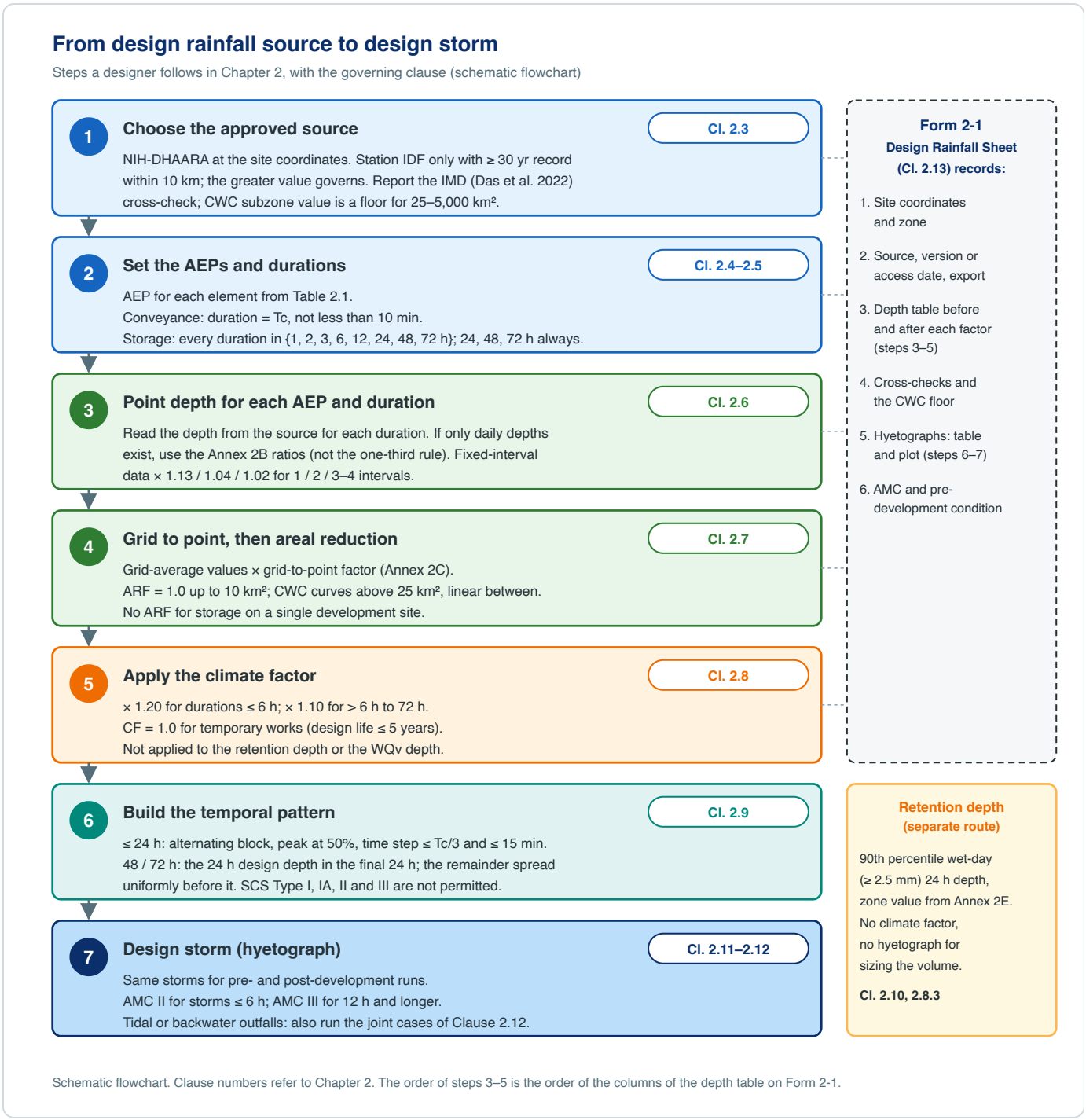

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the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

References (chapter)

- National Institute of Hydrology, Roorkee. NIH-DHAARA: Design Hydrology and Advanced Rainfall Analysis. http://www.nihdhaara.in/
- Das, S.K. et al. (2022). Isopluvial analysis and intensity–duration–frequency curves for different cities in India. *MAUSAM* 73(4), 887–898. https://metnet.imd.gov.in/docs/mausamdocs/173412_F.pdf
- Central Water Commission (2000). Flood Estimation Report for South Brahmaputra Subzone 2(b) (Revised), Design Office Report No. SB-2(b)/R-4/44/99, March 2000, approved by the Flood Estimation Planning and Co-ordination Committee at its 55th meeting on 13.3.2000; revises SB/8/1984 (Plates 8, 9 and 10, the 25-, 50- and 100-year maps, read by eye from page images; p. 18, extent and boundaries; §2.3.2, soils; §2.4.1, the season; §4.3.2 and Table 4.1, p. 20, the short-duration ratios; Annexes 4.1 and 4.2, the heaviest daily falls and recording-gauge maxima, read by OCR; Annex 4.3, areal reduction factors; Annexure 1.1, the subzones; Wayback Machine capture of 12 Apr 2016 of the cwc.gov.in copy). https://cwc.gov.in/regional-flood-estimation-report
- Central Water Commission (1991). Flood Estimation Report for North Brahmaputra Subzone 2(a), Design Office Report No. NB/18/1991, placed before the Flood Estimation Planning and Co-ordination Committee at its 49th meeting, 24–25 October 1990, Guwahati (§3.1.2, p. 24, the short-duration ratios, with Fig. 10, which gives the 2-hour value; Plates 8, 9 and 10, the 25-, 50- and 100-year maps, of which Plate 9 was read by eye and Plates 8 and 10 were not read for this Manual [TBC]; Table 7, the highest daily falls; Wayback Machine capture of 12 Apr 2016). https://cwc.gov.in/regional-flood-estimation-report
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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	Assam 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 (pukhuri) 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 (pukhuris) 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 flood-plain silts and clays of the Brahmaputra and Barak valleys, the char and chapori sands, the bhabar and terai fans of the northern foothills, the thin red loams over the gneiss of the Guwahati hills, and the laterite and red loams of the Karbi and Dima Hasao 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

Purpose	Catchment / condition	Permitted method	Clause
Retention, detention, any storage; pre- vs post-development comparison	Any size	Hydrograph method; **Rational Method not permitted**	3.8–3.12, 3.14
Pipe or drain network with backwater, tidal or tank tailwater	Any size	Hydrograph method with dynamic-wave hydraulic routing	3.12.4; Chapter 5
Catchment-scale flows	25–5,000 km² in CWC subzone 2(a) (North Brahmaputra) or 2(b) (South Brahmaputra)	HEC-HMS or SWMM, benchmarked against the CWC synthetic unit hydrograph (SUH)	3.11.4
Regional facilities	Draining > 25 km²	Design-storm hydrograph method **plus** continuous simulation	3.13
Tank (pukhuri) cascades	Any size	Design-storm hydrograph method **plus** continuous simulation	3.13
Tier B: small sites under Chapter 1	Within the limits of the design aid	Design aids issued under Chapter 4, which are themselves derived by the methods of this chapter	3.4.4
Small sites, any authority	≤ 1 ha, within the limits of Clause 4.14.3	Fixed-coefficient route of Chapter 4 (fixed release coefficients, rainfall-mass storage)	3.4.4; 4.14.3

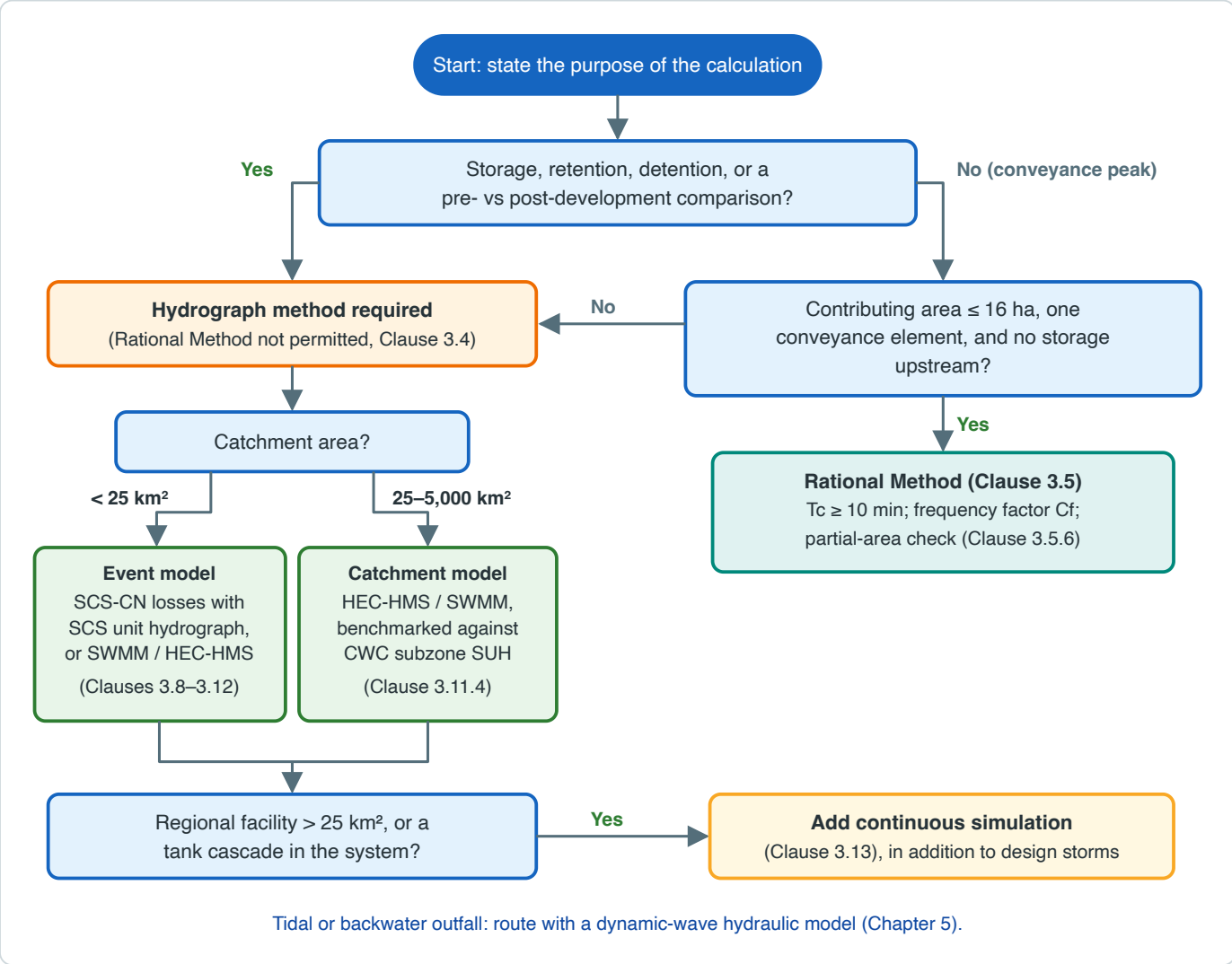

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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

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

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

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

> 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 = Σ(Cj · Aj) / ΣAj, 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 Σ(C · 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 Assam'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.

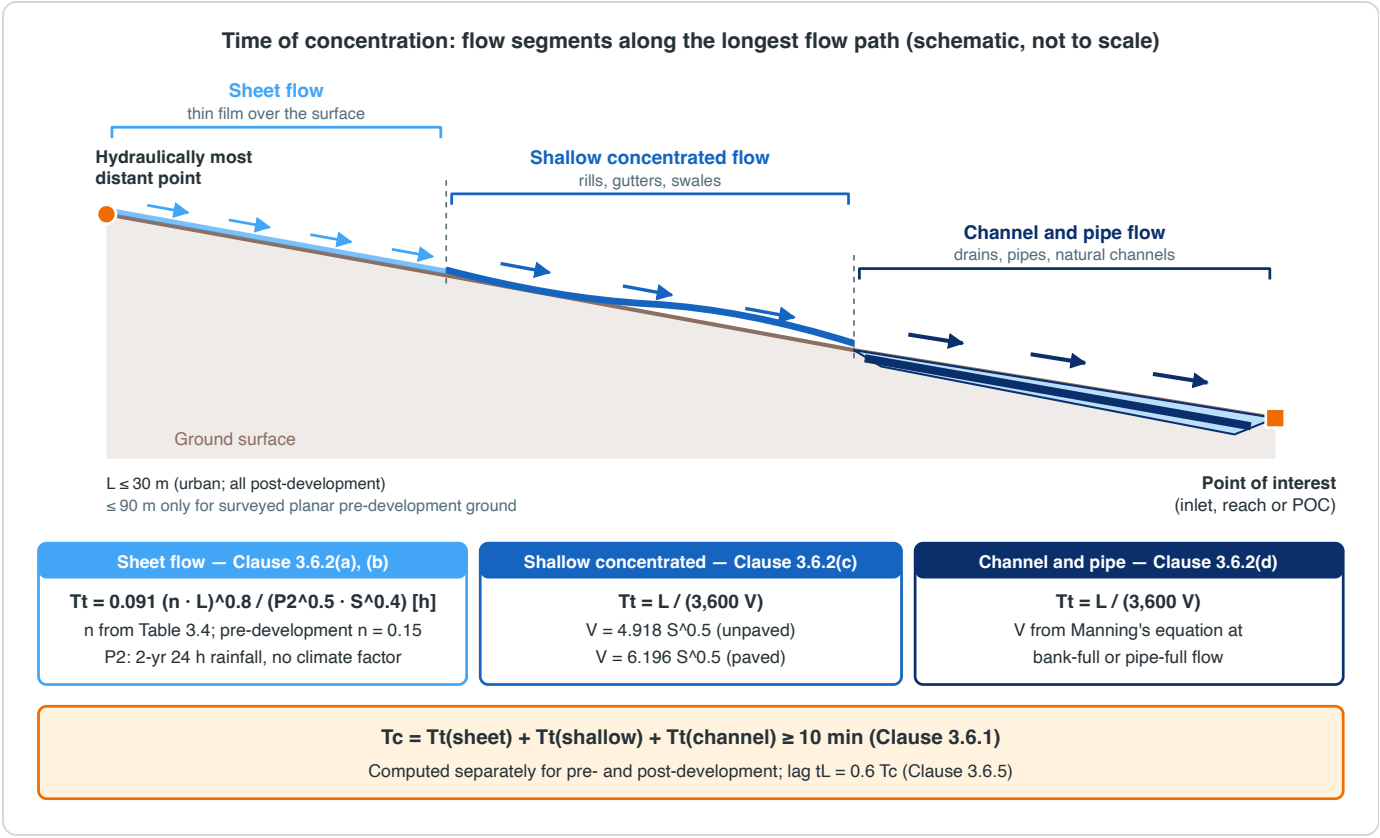

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986), 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 Agriculture Department, Assam (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 Assam: the recent alluvium of the Brahmaputra and Barak flood plains, mostly silty clay loam, HSG C, and HSG D where it is clayey; the clays of the beel basins, the low terraces and the Silchar bowl, HSG D; the char and chapori sands, HSG A or B by texture, but HSG D, with no infiltration credit, for every design storm from 1 April to 31 October, because the river then rises over or beside them and the water table stands at or near the surface; the boulder and gravel fans of the bhabar belt below the Bhutan and Arunachal foothills, HSG A, where debris and the shifting of channels govern the siting before the soil does (Clause 2.3.6(i)); the terai belt below the bhabar, HSG B or C by texture, and HSG D wherever the seasonal high water table is within 0.6 m of the surface; the granite-gneiss of the Guwahati hills with its thin red loams, HSG C, and HSG D on thin soil over rock, on cut slopes and on fill; the laterite and red loams of the Karbi and Dima Hasao hills, HSG C; and urban fill, HSG C, and HSG D where it is clayey or compacted. A field infiltration test is required on every site in a Tier A area and on every other site larger than the limits of the simplified method of Clause 4.14.1, at the depth of the proposed facility; on smaller sites, a soil that has not been tested shall be given the less permeable of the groups listed for it. Whether an infiltration practice may be built at all is governed by the three infiltration rules of Clause 4.11 (the floodplain rule, the hill rule and the recharge rule), not by its HSG. Clause 3.10.1 applies to all of these groups.

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

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

Commentary. NBSS&LUP soil maps are typically at 1:250,000 to 1:50,000 scale and classify soils by series and taxonomy, not by HSG. A lookup table is therefore needed (Annex 3A). Site tests matter most on the char and chapori sands and in the terai belt, where a sand or loam that is HSG A or B by texture behaves as D once the river and the water table rise in the monsoon season (Clause 3.10); at the edges of the beel basins and in the Silchar bowl, where a silty clay loam passes into clay within one site; on the bhabar fans, where a pit can stand in boulder gravel that the next flood buries in debris; and on the Guwahati hill fringe, where a high rate in a pit dug in colluvium or fill can be water entering a slope that cannot take it (Clause 4.11). No soil-series map of Assam from NBSS&LUP, no HSG map or table, no SCS-CN calibration and no measured infiltration rate for any site in the State were obtained during research for this Manual [TBC]. The interim groups follow the soils and geology that the regional sources describe. The CWC subzone 2(b) report records "red loamy soil, red and yellow soil, laterite and alluvial soil of recent origin", and that "The flood plains covering the Dibrugarh, Mariani, Nowgong, Guwahati and Goalpara districts represent alluvial soils of recent origin" (§2.3.2), with about 85% of the subzone under forest (as quoted there from the Irrigation Atlas of 1989); the subzone 2(a) report maps brown hill soil, recent alluvial soil, terai soil and red loamy soil (Plate 6, legend). The CGWB states that "More than 75% of the state is underlain by unconsolidated formations comprising of clay, silt, sand, gravel, pebble and boulders", describes a bhabar belt 11–15 km wide along the northern foothills, with tubewell yields of 27–59 m³/h, a terai zone below it with 80–240 m³/h, and semi-consolidated formations in Cachar with 50–100 m³/h (CGWB, Assam State Profile, 2007). No primary geological source was read for the gneiss hills of Guwahati, the Karbi plateau, the Tertiary rocks of Dima Hasao or the soils of the char and chapori lands and the beel basins [TBC]. The groups for the flood plains are set for the wet season, not for dry ground: over most of the plains the water table stands within a few metres of the surface and rises in the monsoon season (Commentary to Clause 3.10), so a silty clay loam that might test as HSG C in March behaves as D in August, and a char sand that is A by texture is under water or saturated when the design storm comes. Cut slopes and fills are D because "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB, IEE for the Guwahati subprojects of AUIIP Tranche 2, 2017). The only regional measures of losses are the design loss rates of the two CWC reports: 0.35 cm/h (3.5 mm/h) in subzone 2(b), the modal value of 100 flood events, kept from the report of 1984, and 0.24 cm/h (2.4 mm/h) in subzone 2(a) (Annex 3E). They are low, consistent with HSG C and D soils at monsoon saturation, and were fitted to floods of rural catchments gauged at bridges. They shall be used only in rural SUH runs under Clause 3.11.4, each within its own subzone, and 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 design of the char and chapori sands as HSG D through the monsoon season, the design of cut slopes and fill as HSG D and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Assam. The method rules matter as much as the soil, because the State's towns are of two kinds that no CWC relationship describes: flat towns on the flood plain that drain through sluices and pumps into a river that is often higher than they are, and the hill fringe of Guwahati, where streams from the hills reach the valley floor within minutes. The following rules are set by this Manual. (a) Tc shall be found by the velocity-based segment method of Clause 3.6.2, segment by segment, and shall not be taken below the 10-minute minimum of Clause 3.6.1, which matches the shortest design duration of Chapter 2; the Kirpich formula, derived from small farm catchments of moderate slope, shall not be used even as a cross-check where the average slope of the flow path exceeds 10%. (b) The sheet-flow segment over bare rock, a cut slope or a paved hill road 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 valley floor or a plain, such as the Bahini, the Basistha, the Kalmani and the streams of Khanapara and Jorabat in Guwahati, which rise in the hills of Meghalaya, or the streams of the Karbi and Dima Hasao hills, shall be split at the break of slope and the hill sub-area modelled on its own, with the design rainfall taken over the whole catchment, including the part in Meghalaya

(Clause 2.3.6(c)(i)), so that a flatter lower reach does not average away the fast response of the hill. (d) The hill streams of Guwahati, of about 10–120 km², are modelled by a hydrograph method with the segment Tc of (a); the CWC subzone 2(b) unit hydrograph, whose peak depends on area alone and which the report recommends only above 50 km², is a check, not the design model: it is computed as the benchmark of Clause 3.11.4 where the catchment exceeds 25 km², and between 25 and 50 km² it is reported with a note that it lies below the report's range, Clause 3.11.4(d) applying to it as written. (e) The urban catchments of Guwahati, Dibrugarh, Silchar and every other town behind an embankment are designed by the Rational Method under Clause 3.4 for single conveyance elements, and otherwise by SWMM or HEC-HMS with level-pool routing of the storage behind the outfall (the beels, retention ponds, sumps and channels upstream of the sluice) together with the pump ratings and the sluice rule (Clause 3.12.1), the river level at the sluice as the tailwater (Chapter 5) and dynamic-wave routing where the outfall is submerged (Clause 3.12.4); neither CWC unit hydrograph rests on an urban, embanked or pumped catchment, so where such a catchment exceeds 25 km² the SUH is computed only for its natural condition, as the benchmark that Clause 3.11.4 requires, and never as the design model. (f) No CWC unit hydrograph applies in subzone 2(c), the Barak valley (sub-area AS-E) and the south of Dima Hasao: every cross-drainage structure and outfall of more than 1 km² there needs a site-specific hydrology study with the design rainfall of Clause 2.3.6(c)(ii) and the AMC of Clause 3.8.4 (Annex 3E). (g) Catchments that drain to a reservoir or to a reach below a dam, such as the Kopili, the Umtru below Byrnihat, the Ranganadi and the Subansiri, are modelled with storage routing and the operator's release scenarios, not by a peak-flow method alone (Clause 3.12; Chapter 5). (h) No method of this chapter predicts debris flow; on the bhabar fans and in the hill streams the design flow is bulked for sediment and debris, and silt traps at the break between hill and plain, inlets and culverts are designed for 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:

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

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

Cover type	HSG A	HSG B	HSG C	HSG D
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 June to 30 September at a site in sub-area AS-A (Lower north bank and Bhutan foothills), AS-A1 (Central and upper north bank), AS-B (Guwahati metropolitan area), AS-C (Lower and central south bank), AS-C1 (Upper Assam) or AS-D1 (Dima Hasao hills) of Annex 2A, and from 1 May to 31 October at a site in sub-area AS-E (Barak valley); AMC III for every design storm from 1 April to 31 October, in every sub-area, on land below the 1% AEP flood level of a river, on char and chapori land, on the margins of a beel or pukhuri and on land behind an embankment; AMC III for every design storm at any time of year in a catchment that drains to a reservoir or its backwater, or to a reach below a dam into which the dam releases water, such as the Kopili below the Kopili hydroelectric project, the Umtru below Byrnihat, the Ranganadi and the Subansiri; at any other site or time, including every site in sub-area AS-D (Karbi hills) outside the land and catchments above, AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm; and AMC II for every other storm. AMC I is not used. CN for AMC I and III shall be obtained from AMC II by:

> CN(I) = 4.2 CN(II) / (10 − 0.058 CN(II)) CN(III) = 23 CN(II) / (10 + 0.13 CN(II))

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

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

3.8.5 **Initial abstraction.**

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

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

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

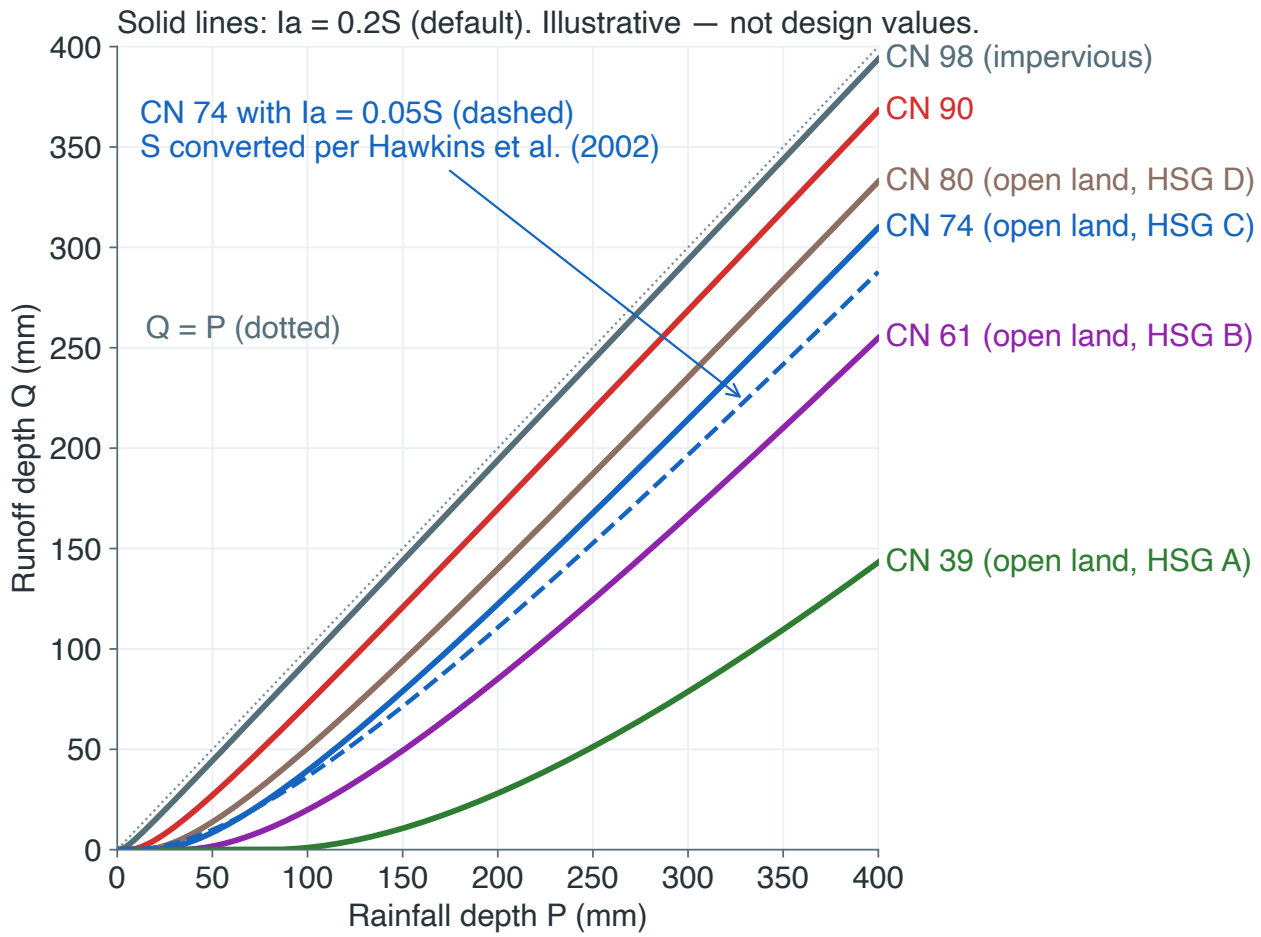

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion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

Commentary. Table 3.5 reproduces standard NRCS TR-55 (1986) values. They were derived from US catchments and have not been calibrated in Assam. 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: $CN_c = CN_p + (P_{imp} / 100)(98 - CN_p)$;
- where total impervious area is below 30% and part of it is disconnected: $CN_c = CN_p + (P_{imp} / 100)(98 - CN_p)(1 - 0.5\,R)$,

where CN_p is the pervious CN, P_{imp} 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 (CN_p 61), 25 mm of rain gives about 9.9 mm of runoff when the two parts are modelled separately, but only about 1.8 mm with the composite CN 79.5. At 200 mm the two methods agree (139.5 mm vs 138.4 mm). *Illustrative — not design values.* The error is largest for the frequent storms that set retention and water-quality volumes. The disconnection criteria of 3.9.3 are set by this Manual, drawing on common practice in US runoff-reduction manuals. Criterion (d) follows the rule of Clause 3.3.3(c) that RWH sumps are full at the start of monsoon storms.

3.10 Groundwater, high water table and tank backwater

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

3.10.2 **Water-table data.** The seasonal high water table shall be taken as the highest level recorded in the monsoon season (April–October), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or 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, pukhuri, 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 over most of Assam the water table stands within a few metres of the surface before the monsoon and close to it after, and whatever infiltration capacity the soil has in the dry season is gone when the design storm arrives. In the CGWB's year book for 2022-23 the water level in Assam in March 2022 was "mostly in the range of 2-5 mbgl (57.43%, 170 Nos.)", with 20.27% of wells at 0–2 m, 17.57% at 5–10 m and 4.05% at 10–20 m, from 0.17 m below ground in Cachar to 22.98 m in East Karbi Anglong; in November 2022 it was "within 5 mbgl (89.13%, 287 Nos.)", with 45.96% of wells at 0–2 m and 43.17% at 2–5 m, and only Dhubri and East and West Karbi Anglong had wells at 10–20 m. In Kamrup (Metro), which holds Guwahati, six wells read 1.39–4.08 m below ground in March 2022, seven read 0.2–2.76 m in August and eight read 1.29–2.64 m in November. Water-logged areas (water within 2 m) and areas prone to it (2–3 m) were found before the monsoon of 2022 in parts of Kamrup (Metro) among other districts, and after it in "almost all the districts of Assam"; the CGWB puts this down to "high rainfall, shallow water level and a poor ground water draft in the vast flood plains" (CGWB, *Ground Water Year Book 2022-23, North Eastern Region*). Older summaries agree: 2–5 m before the monsoon in Kamrup district (CGWB district booklet, 2013, as quoted), and 1.00–7.85 m before and 0.50–4.64 m after the monsoon in the aquifer-mapping area of Goalpara, Kamrup and Barpeta (as quoted from the CGWB) [TBC]. In Guwahati the ADB's environmental assessment adds a rising water table "with the rising of the Brahmaputra", which "reduces the rate of percolation" (ADB, IEE for the Guwahati subprojects of AUIIP Tranche 2, 2017). On the char and chapori lands, in the beel basins and in the Silchar bowl no well record was obtained, but the land is under water or saturated in a flood [TBC]. No water-table depths for individual town sites, and no map of the seasonal high water table, were obtained [TBC]; Annex 3A is to supply them. Clause 3.10.4 reflects the State's receiving waters, which are rivers held between embankments, beels behind sluices and, below them, the Brahmaputra and the Barak. At the CWC site at Guwahati (DC Court) the warning, danger and highest levels are 48.68 m, 49.68 m and 51.46 m (21 July 2004); at Dibrugarh 104.70 m, 105.70 m and 106.48 m (3 September 1998); and on the Barak at Annapurnaghat, the gauge for Silchar, 18.83 m, 19.83 m and 21.84 m (1 August 1989) (CWC tables, as transcribed by SANDRP in 2019; the datum is not stated and is to be confirmed for each site [TBC]). At Guwahati the danger level is reached in most monsoons and the highest level is 1.78 m above it (NEER's reading of the same tables); "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB IEE, 2017), and "Dibrugarh town is 1.5 m below the bed level of Bramhaputra" (ADB, IEE for the Dibrugarh DTP drain outfall, 2017). A site there drains to a water surface that stands above it for weeks, and Clause 3.10.4(b) applies to all the land below that level. The town's own storage is its beels: Deepor Beel, which receives the Basistha and Kalmani side of

> Guwahati and drains to the Brahmaputra by the Khanajan, has a perennial water spread of about 10.1 km² that grows to about 40.1 km² in floods (as reported), and Dibrugarh's DTP drain passes Larua Jamira beel on its way to the Sessa (ADB IEE, 2017). No stage–storage relation for any beel was found [TBC].

3.11 Unit hydrographs and runoff transformation

3.11.1 **Permitted transforms.**

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

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

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

where q_p is the peak flow (m³/s); A is the area (km²); Q is the runoff depth (mm), equal to 1 mm for the unit hydrograph; t_p is the time to peak (h); and 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 km² in CWC subzone 2(a) (North Brahmaputra), which covers the north bank of the Brahmaputra, including North Guwahati and Amingaon, or 2(b) (South Brahmaputra), which covers the south bank, the rest of Guwahati, the Karbi hills and the north of Dima Hasao, but not the Barak valley and the south of Dima Hasao, which lie in subzone 2(c) (Barak and others), for which CWC has published no Flood Estimation Report:

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

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

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

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

> **Commentary.** The SCS unit hydrograph, the 0.6 lag ratio and the 0.133 Tc interval are from NEH Part 630, Ch. 16 (USDA NRCS, 2007). The interval follows from the unit hydrograph geometry: with tp = Δt/2 + 0.6 Tc and Tc + Δt = 1.7 tp, Δt = 0.133 Tc. The SI constant 0.208 is the direct conversion of 484 (cfs, mi², in, h). APWA uses the SCS dimensionless unit hydrograph as its basis (2011, §5602.5). The CWC Flood Estimation Reports give regression equations for SUH parameters, a design storm duration, a constant loss rate and ARF and time-distribution curves for each subzone (CWC 1991 and 2000; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the reports of 1991 and 2000 (the 14 catchments of the 2(b) report were gauged at railway bridges from 1961 to 1983 and at national-highway bridges from 1981, and the 21 catchments of the 2(a) report are also bridge sites on rural rivers; none is urban, embanked or pumped), so they represent pre-development conditions, not urbanised ones. That is why the SUH is used as a benchmark rather than as the post-development model. Clause 3.11.4(d) mirrors the floor principle of Clause 2.3.3. HEC-HMS has been calibrated against CWC subzone SUH responses in Indian studies, which shows the two can be linked.
>
> The lower-factor option of 3.11.5 is based on the NRCS Delmarva unit hydrograph, which uses a peak rate factor of 284 (PRF' ≈ 0.122) for flat, poorly channelled coastal-plain catchments on the Delmarva Peninsula (Welle et al., 1980, as adopted by NRCS; New Jersey Department of Agriculture, Delmarva bulletin, which uses 285). A lower factor gives a lower, later peak. Used only in the pre-development run, it would lower Q_pre and make the release cap stricter; used in a piped post-development run, it would understate Q_post. Clause 3.11.5(b) prevents both biases.

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 beels, pukhuris and retention ponds at their outlet level in 3.12.5 because in Assam the heavy storm comes when the river is high, the outfall sluice is shut and the beel behind it is filling, not drawn down. The Water Resources Department describes the condition itself: "High stages of river Brahmaputra and Barak obstruct free discharge of tributaries causing back flow and congestion near outfalls. Inadequate countryside drainages through sluices in embankment system … cause prolonged inundation" (as quoted by the CAG, Report No. 5 of 2018). The one design found for a town outfall makes the same assumption: the new sluice of the DTP drain at Dibrugarh, with a flood level of 97.50 m at the sluice, was designed "keeping in mind that the beel is full and the drain is also flowing full" (ADB, IEE for the Dibrugarh DTP drain outfall, 2017). Deepor Beel grows from a perennial water spread of about 10.1 km² to about 40.1 km² in floods (as reported), so its storage is taken up by the monsoon before a late storm arrives. No beel or pukhuri in the State was found to have a documented operating rule, a level record or a stage–storage relation [TBC]. The starting levels are therefore as follows (set by this Manual):

- **A beel, pukhuri or retention pond that drains through a gated or pumped outfall** shall be started full to the level of its outlet whenever the outfall is closed, and the outfall is taken as closed for the durations of Clause 5.8.5 (Chapter 5; Clause 5.8.5(e)). In Assam this is the normal monsoon case: at Guwahati the Brahmaputra reaches its danger level of 49.68 m in most monsoons, and its highest level is 1.78 m above that (CWC tables, as transcribed by SANDRP; NEER's reading). The ADB retention pond for the Bahini basin (59,000 m³, with a 1.6 m³/s pump station; ADB, RRP 57262-001, 2025) and the retention basin in the Silsako basin to which part of the Bahini's runoff is to be diverted and "gradually pumped out to the Brahmaputra" are started in the same way, full to the level at which the pumps start, unless their operating rule commits them to be pumped down before the storm.
- **A beel or pukhuri with a free outlet** is started at its surveyed outlet or spill level.
- **Reservoirs.** Four hydroelectric projects set the level at outfalls downstream of them: the Kopili project of NEEPCO at Khandong, for which no levels were obtained [TBC]; the Ranganadi project of NEEPCO in Arunachal Pradesh, whose release reached 1,412.57 m³/s in 2017 (as quoted from an IIT Guwahati report for ASDMA); the Lower Subansiri project of NHPC, whose release rules were not found [TBC]; and the New Umtru project of MePGCL on the Umtru above Byrnihat, whose maximum water level is 132.78 m (MePGCL, guideline for the New Umtru project, 2025). These are not started here; their release scenarios are the tailwater of Chapter 5 (Clause 5.8.5(d)).

A beel or pukhuri is modelled below these levels only where a continuous simulation under Clause 3.13 or a notified operating rule supports it. The window of 1 April to 31 October in Clause 3.13.5(a) is set by this Manual and is the Manual's monsoon season. It starts on 1 April, not with the south-west monsoon, whose normal onset over the North East is about 5 June (as reported; IMD's revised normals put Guwahati at 2–4 June, as quoted in a press summary of the IMD release), because the storms of April and May are among the State's largest: four of the seventeen Assam station records of 24-hour rainfall are May storms, Dibrugarh (Mohanbari) 231.5 mm on 10 May 1996, Dhubri (Rupsi) 479.3 mm on 28 May 1989, Rangia 217.0 mm on 29 May 1977 and Silchar 290.3 mm on 30 May 1893 (IMD *Extremes*); Guwahati's April record of 116.5 mm (6 April 2004, IMD) was beaten by 117.4 mm at the airport on 20 April 2026 (as reported); and the CWC subzone 2(b) report finds that "May rainfall is more than the September rainfall. Similarly, April rainfall is more than October rainfall" (§2.4.1). The beels are smallest after the dry winter ("The winter season from December to March is practically dry", the same report), so the April and May days can only lower the 10% level a little, and wherever an outfall is gated the outfall-closed start above governs. The window ends on 31 October because large falls still come in October, such as 237.1 mm at Haflong on 30 October 1959, 220.0 mm at Dhubri (Rupsi) on 4 October 1958 and 160.9 mm at Guwahati on 15 October 1991 (IMD *Extremes*), while the withdrawal date of the monsoon from Assam was not obtained [TBC]. Pumps, gates and screens are on standby from 1 April to 31 October (Chapter 10).

3.13 Continuous simulation

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

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

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

3.13.2 **Rainfall input.**

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

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

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

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

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

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

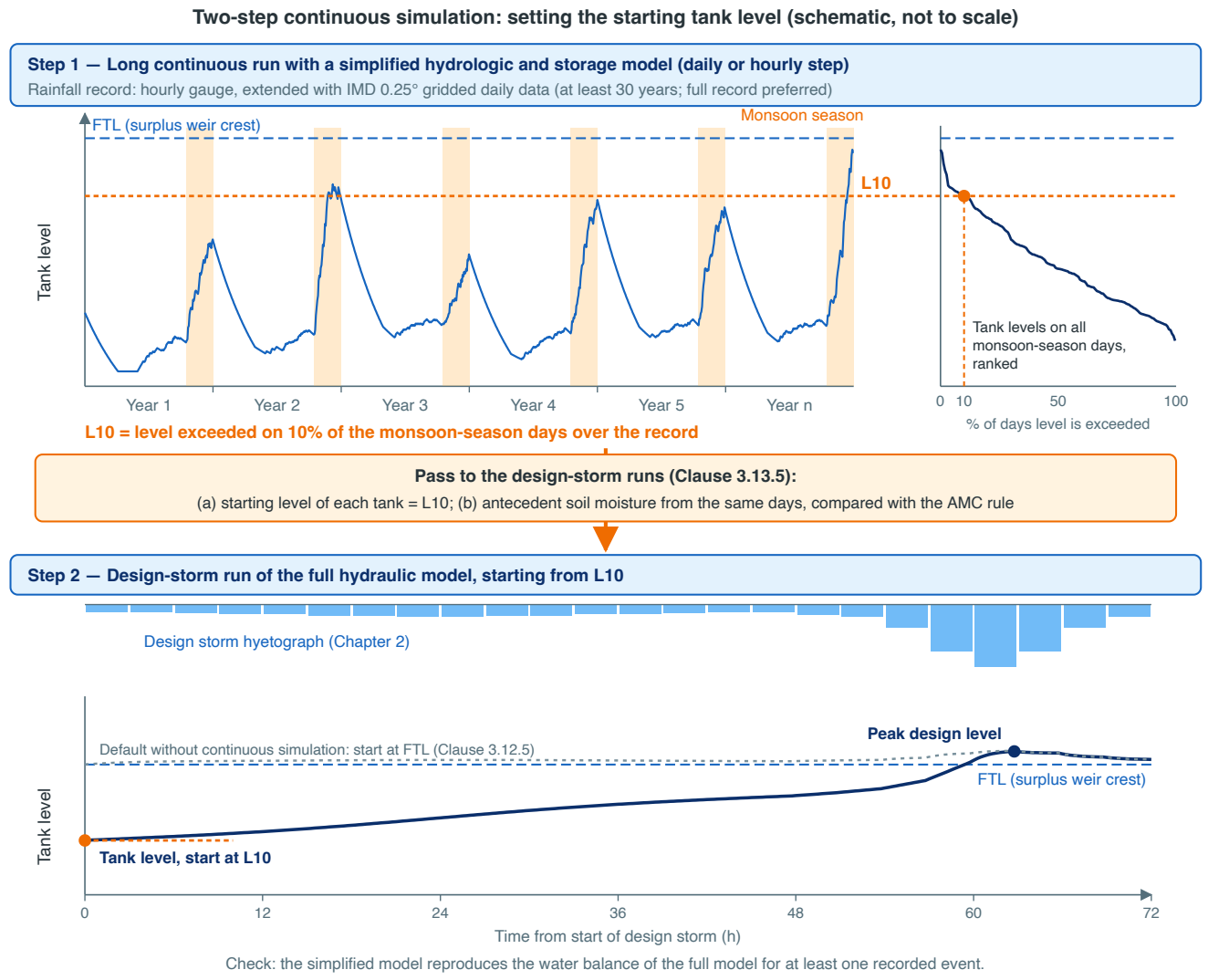

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 April to 31 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place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

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

were in June 2022, when rainfall over the Assam & Meghalaya subdivision, 858.1 mm, was the highest for June since 1901 (IMD, June 2022 summary) and the Barak at Annapurnaghat stood above its danger level from 18 June (as quoted from the Cachar district flood report).

3.14 Pre- vs post-development comparison procedure

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

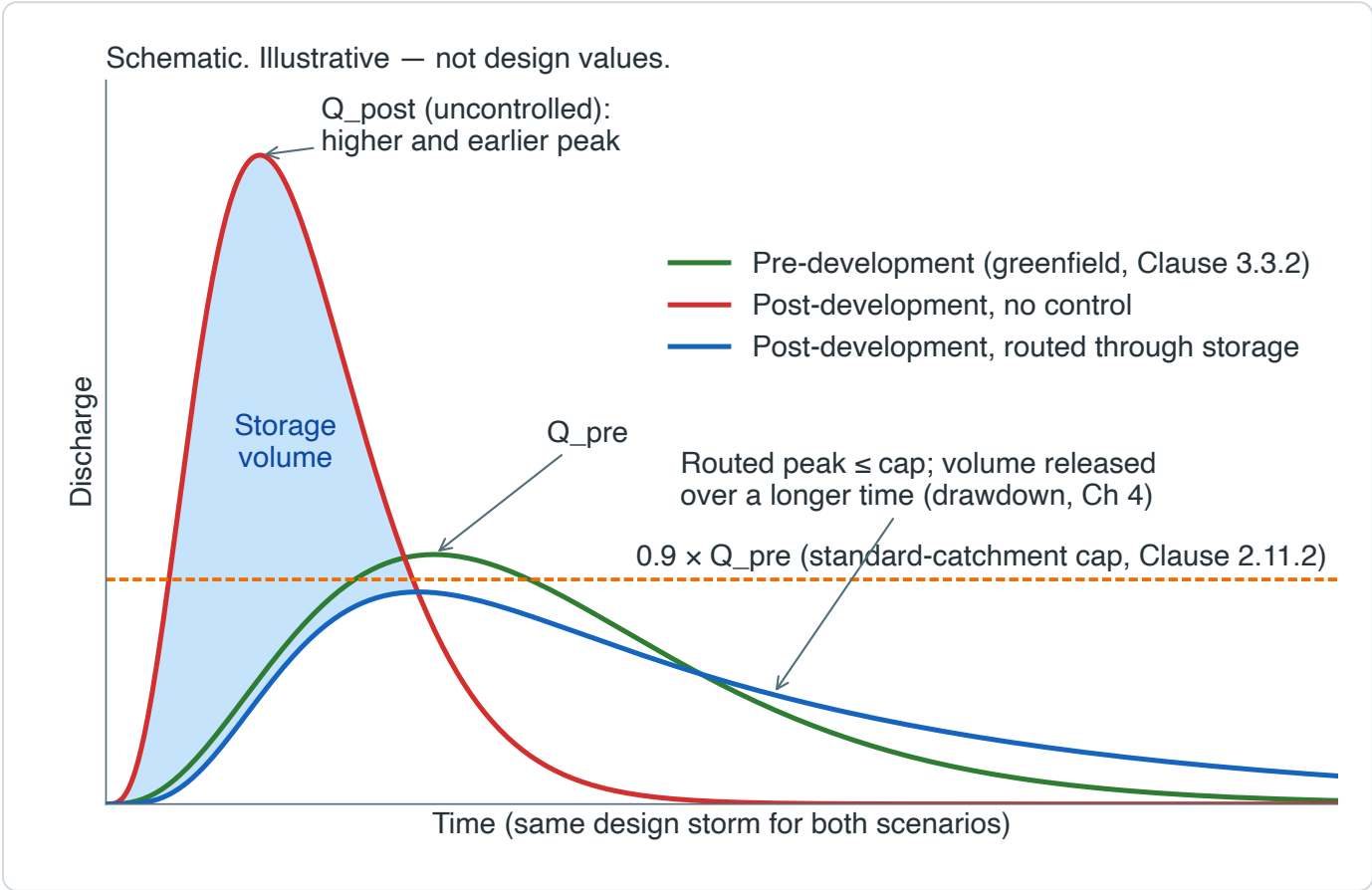

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

> Commentary. The step sequence follows the standard event-based workflow: delineate; set pre-development CN and Tc; set post-development CN and shorter Tc; run identical storms through a unit hydrograph or kinematic model; compare peaks and volumes; and size storage by modified Puls routing. It adds the Assam 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 (WRD gauging sites, GMC or ASDMA level sensors, tank gauges, or surveyed flood marks).

3.15.3 **Events.** At least three independent events shall be used for calibration and at least one further event for validation. At least one event shall be a long-duration monsoon or cyclone event (for example the Silchar flood of June 2022, the Guwahati storms of 14 June 2022 and 31 May 2025, or the overnight storm of 20 April 2026 in Guwahati, 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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[TBC]. http://web.archive.org/web/20160412153137id_/http://www.cwc.gov.in:80/main/downloads/North%20Brahmaputra%20subzone%202%20(a).Pdf

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Annexes and forms

Annex / Form	Content
3A	Assam soil series to HSG lookup; seasonal high water table map
3B	Assam CN calibration and supplementary land covers (hill forest, bunded rice fields, char and chapori land, beel beds and margins, bhabar boulder fans, cut hill slopes and fills, hola hollows)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for subzones 2(a) and 2(b), 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 harvesting structures for every building under byelaw 114 of the Unified Byelaws 2022, with recharging or percolating pits or trenches of at least 5 m³ for every 100 m² of roof; percolation pits, storage and reuse on plots of 134 m² and above, and grass paving, under Appendix VI; roof-water harvesting "mandatory in hilly areas" under byelaw 110(g); and, in a groundwater area notified under the Assam Ground Water Control and Regulation Act 2012, of which none was found, the directions of section 19 for premises of 100 m² or more; all 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 Assam rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or a storage volume sized to a storm. No Assam document found sets a design storm, a return period, a runoff coefficient or a time of concentration for any town drain. The building rules are the Assam Unified Building Construction (Regulation) Byelaws, 2022 (Assam Gazette Extraordinary No. 688, 15.10.2022, notification No. DoHUA/ECF No. 236697/2), as amended by the (Amendment) Byelaws, 2024 (Gazette No. 667, 20.11.2024, No. DoHUA/ECF No. 420084/34), made by DoHUA under section 4 of the Assam Building Construction (Regulation) Act, 2010 (Assam Act XVI of 2010, as amended by Assam Act XXVII of 2022, which renamed it and extended it "to the whole of the State of Assam"). They "extend to the master Plan areas or notified Planning areas of whole of Assam except for areas under Autonomous Districts", unless a District Council asks for them to apply there (byelaw 1(2)); no such notification and no building rules of the Bodoland Territorial Council, the Karbi Anglong Autonomous Council or the North Cachar Hills Autonomous Council were found [TBC], and outside the notified Master Plan areas the byelaws do not apply anywhere. Byelaw 131(1) repeals "The Guwahati Building Construction (Regulation) Byelaws, 2010", a year that matches no byelaws found (the 2010 instrument is the Act); the Guwahati Building Construction (Regulation) Byelaws, 2014, which

already held the same drainage rules, are superseded in practice, but the repeal clause names 2010. A 2025 amendment was reported but no gazette was found, and it is not cited here. The Act defines a "drain-surface water" as "a drain used or constructed to use solely for conveying to any drain any rain water but shall not include any rainwater pipe" (s.2(20)), and requires the plans to show drains, sewers, the drainage of the roof and the "arrangement for proper drainage" (section number not confirmed [TBC]). The byelaws carry several drainage hooks, but every one of them protects the building, the plot or the watercourse; none sizes anything to a storm: Byelaw 26(ix), repeated as byelaw 44(ix) [TBC: numbering read from the OCR layout; confirm against a clean copy], sets the setbacks: "The minimum distance of any building from the edge of natural drainage channels shall be as given below": River (as marked in the plan) 15 m; Bharalu, Mora Bharalu and Bondajan 10 m; other channels 6 m; notified water bodies (Deepar Beel, Silsako) 15 m; other notified water bodies (Sarusola, Barsola and others) 6 m; other large ponds and water bodies marked in the plan 10 m; minor drains and small ponds not marked in the plan as for the building setbacks. The table names only Guwahati's channels and beels although the byelaws are statewide (NEER's reading); Chapter 7 compares it with the Manual's corridor. The Authority may refuse or modify a proposal if the site "is near a water body or water course" and the development is likely to contaminate it or change the course of the channel, if the site "is likely to be inundated and satisfactory arrangements for proper drainage is not possible", or if it is "a filled up tank or low lying" (byelaw 44(iii) [TBC: numbering read from the OCR layout; confirm against a clean copy]). Byelaw 117 excludes multistoreyed buildings from areas "on or abutting natural drainage channels" and "wetlands" and from "Government land in the hills and in the water bodies like beels". The plinth shall be "0.3 m higher than the highest recorded flood level as fixed by the local authority for ordinary buildings and 0.6 higher for lifeline buildings" (byelaw 45(c)); 0.5–0.75 m above the plot, with the ground not raised more than 0.5 m above the nearest street (45(a)). No local authority's "highest recorded flood level" was found for any town [TBC]; this Manual supplies the method (gauge, model or surveyed flood marks, with the return period stated), and its 1% AEP level plus 0.5 m governs where it is higher (Chapters 5 and 7). No building shall be erected "on a site liable to flood or on a slope forming an angle of more than 45 degree with the horizontal or on soil unsuitable for percolation" unless the owner proves it safe, and the permit is then subject to roof-water harvesting, "provision of dry sump (including design calculation) in all individual plots, capable of holding rain water during peak monsoon" and a silt fence along the plot boundary (byelaw 74). In hilly areas the same dry sump is required (byelaw 110(h)), with roof-water harvesting "mandatory" (110(g)), a silt fence "mandatory" (110(i)), drainage "without causing soil erosion" (110(c)), "special protection measures" on slopes of more than 10° (110(d)), cuts "generally … 4 m. to 6m" and not over 6 m "ordinarily" (110(e)), slope calculations vetted by a third party (110(f)) and 30% of the plot under vegetation (110(k)). The drawings show the provisions for conservation and harvesting of rain water and a "Detailed drainage plan for both internal and external required to be constructed upto the available permanent/pucca drain of municipal/other authority" (byelaw 94); "Improvement of drains up to the nearest outlet point is to be made as directed by the Authority. Additional 25% of the cost of improvement at PWD rate be imposed as penalty if such improvement is not done" (byelaw 101(vi)); the Authority may require the developer to build the roads and drains up to those abutting the plot (112(a)); and group housing gets "special regulations for drains" (113). At least 20% of every plot is kept for trees and greenery, or 10% where 25% of the floor area ratio is affordable housing (byelaw 111); ten trees with "unpaved soil surface of minimum 2(two) feet" (104(iii)); since 2024, 60% of the open space landscaped, half of it "unpaved and green" and the rest of the open space allowed to be "covered with permeable tiles/ pavers … to allow rain water to percolate to underground" (byelaw 92); and the green-building criterion "Minimize storm water run-off from site by reducing hard paving on site" (Appendix IX). RWH is required for every building (byelaw 114 and Appendix VI; Commentary to Clause 4.11). "Natural Hazard Prone Areas" are to be notified on the basis of hazard studies, among them "Flood zonation" (definition 2), and since 2024 each Master Plan is to map the natural-hazard areas "where construction is not permitted" (byelaw 120); byelaw 121 commits the byelaws to "flood risk management in a changing rainfall scenario including renovation and futuristic drainage systems and designs", a policy statement with no standard; and byelaw 120A (2024) penalises dumping construction and demolition waste in "Nalas, Rivers and other water bodies". An OCR search of the 2022 text found no storm-water detention, peak-runoff or release-rate rule. The dry sump is therefore the one storage duty in the State's building rules, and the byelaw itself asks for its "design calculation" without saying how to make it. **This Manual supplies that calculation (set by this Manual): the dry sump of byelaws 74(ii) and 110(h) is a detention facility under this chapter.** It is empty before each storm and is never an RWH tank or a store of RWH water; it drains through an orifice outlet

that meets Clauses 4.7 and 4.8, by pump where the outfall is closed; it is sized for the site's detention volume under Clause 4.6 and, where the site's outfall is closed (Clause 5.8.5), for the outfall-closed volume of Chapter 5, so that "capable of holding rain water during peak monsoon" means the volume of the design storms of Chapter 2; and on land to which the floodplain rule of Clause 4.11 applies it is lined and watertight, earns no infiltration credit and is checked for flotation (Clause 4.12.3). Its drawings and calculation go with the byelaw 94 drainage plan (Chapter 10). Read this way, the byelaw's "soil unsuitable for percolation" is the normal case on the flood plains, not the exception. The municipal Acts give the local bodies drains to keep, not a standard to meet. The Gauhati Municipal Corporation Act, 1969 (Assam Act I of 1973) requires municipal drains to be kept "free from public nuisance" and flushed, cleaned and emptied (s.231), lets the Commissioner cause them "to empty into any place, whether within or without the city" (s.232, a power, not a duty), alter or close them (s.234), require "an entirely distinct private drain" for rain water (s.237(1)), and bars any drain into a municipal drain without permission (s.242); no building within one hundred feet of a municipal drain may be occupied until it is drained to it (s.244), and the connecting drain vests in the Corporation (s.250(2)). The Assam Municipal Corporation Act, 2022 (Assam Act VIII of 2022), which governs Dibrugarh and Silchar, goes further: the Corporation "shall … provide a safe and sufficient outfall … for effectual drainage and proper discharge of storm-water and sewage … in such manner as may not cause any nuisance, whether by flooding any part of the Municipal Corporation area, or of the areas surrounding the outfall" (s.171), public drains vest in it (s.173), and the Commissioner may require "an entirely separate drain for rain water" (s.176). Where a town's drain leaves through an embankment, the Assam Embankment and Drainage Act, 1953 (Assam Act I of 1954) applies: in a notified area no one may build on, remove or alter an embankment or drain without the permission of the Deputy Commissioner or the Embankment Officer (s.16), and cutting through an embankment or drain, or "opening, shutting or obstructing a sluice" without authority, carries up to three years' imprisonment (s.15(ii)). None of these sets a design storm, a release rate or a detention volume. The only design figures found in an official document are those of projects. The ADB's Assam Urban Sector Development Project aims to avoid inundation "from a 1-in-5-year storm or lower return period … in 434 ha of frequently flooded areas of Bahini Basin", against a baseline of 616 ha, and its initial flood modelling mapped "Inundation areas of 693 ha during the design storm of 65.72 mm hour" (ADB, Project Administration Manual 57262-001, July 2025, design and monitoring framework); the duration behind 65.72 mm/h and its return period are not stated, and the two baselines differ [TBC]. A 1-in-5-year target is below the 10% AEP minor-drain standard of Table 2.1 for the high-density areas of this Manual; the project's target is its own and is not a standard. Dibrugarh's DTP drain was designed by a "rainfall based approach … The peak discharge computed by rational method", with no return period given (ADB IEE, 2017), and the town drainage master plans of DoHUA "were prepared before 2015 as per previous FPS system" and await revision to the CPHEEO guideline of 2015 (DoHUA status sheet, c. 2016). The drains themselves are few: storm-water drainage covered "3 to 37 per cent only" of the test-checked urban local bodies, and GMC's storm-drain data "was not available as it was involved with works of drain desilting only", although ₹32.57 crore was spent on desilting from 2013–14 to 2017–18 (CAG, Report No. 4 of 2019); "Assam's stormwater drainage network in ULBs covers only about 30% of the required areas" (ADB, RRP 57262-001, 2025); and the CAG found "defective DPRs for Storm Water Drainage Project for Guwahati City" and no action against the consultants (Report No. 2 of 2024). A GIS-based Comprehensive Drainage Master Plan and DPR for Guwahati, for which GMDA engaged Haskoning DHV by an order of 21.08.2024 recorded by the Gauhati High Court (PIL/14/2024, order of 23.09.2024), was under revision in November 2026 and is not final (as reported). Basements are limited for drainage, but with no level. A basement "shall not be permitted in low-lying areas and areas without adequate drainage facilities to ensure drainage from the basement" (byelaw 66(3)), and "Adequate arrangements shall be made so that surface drainage do not enter the basement" (67(c)); no rule found sets a level for a basement ramp or opening. 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). On land to which the floodplain rule of Clause 4.11 applies, in the flood-sensitive catchments of Clause 4.5.3.2 and in any catchment notified under Clause 4.5.4, it recommends that no basement be permitted where the 1% AEP flood level, or the level of water ponded behind an embankment when its sluices close, stands above the surrounding ground; and wherever a basement or lower floor is cut into a hill slope it shall carry the geotechnical certificate of the hill rule of Clause 4.11, with the water behind its walls

drained to a lined drain and not to the ground. For a hill site, this chapter also supplies what byelaw 110(c) leaves open: runoff from the catchment above the site shall be intercepted and carried round the building in the design storms of Chapter 6, and every flow from the site shall discharge to a lined drain or a stable natural channel through an energy dissipator, never onto an unprotected slope or into fill. These are the Manual's proposals, not rules of the Unified Byelaws 2022. This chapter is written so that it can supply, as a technical companion to the Unified Byelaws 2022, the Master Plans and Zoning Regulations and the municipal Acts, the design storm, release rates and storage volumes that they leave open; a competent authority could adopt it for that purpose, for example DoHUA by an amendment to the Unified Byelaws 2022 under section 4 of the Act, but none has. In practice the storm drains of every Assam town are its sewers: "No ULB in the state has a centralized sewerage system, including Guwahati … about 90% of households have installed septic tanks or leach pits" (ADB, RRP 57262-001, 2025); the Bharalu "has no natural flow … only the domestic sewage and commercial sewage are being carried", and the Bahini, "cut off by a sluice at Natun Bazar", "now becomes a sewerage drain" (PCBA, Bharalu action plan); and Dibrugarh's DTP drain "receives sewage flows" (ADB IEE, 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 and, behind a closed sluice, has nowhere to go. 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.
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.

Term	Meaning in this Manual
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 (in a notified Master Plan area, the Development Authority (GMDA in the Guwahati Metropolitan Area) for the planning permit and the Municipal Corporation (GMC in Guwahati), Municipal Board or Gaon Panchayat for the building permit, each under the Unified Byelaws 2022; the local body for its own drains and works under the Gauhati Municipal Corporation Act, 1969, the Assam Municipal Corporation Act, 2022 or the Assam Municipal Act, 1956; and, in an Autonomous District, the District Council or the authority it designates, only where the Council has notified that the byelaws or this Manual apply (none has), as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Guwahati Municipal Corporation (GMC), GMDA and every other approving authority within the Guwahati Metropolitan Area, the area of the Master Plan for Guwahati 2025 (328 km²), whichever has jurisdiction over a site; the Dibrugarh Municipal Corporation, with the Development Authority of the Dibrugarh Master Plan area; and the Silchar Municipal Corporation, with the Development Authority of the Silchar Master Plan area (the names of the two Development Authorities are to be confirmed [TBC]). Tier B: Municipal Corporations, Municipal Boards, Development Authorities and other local bodies and Panchayats in notified Master Plan areas.

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, pukhuris, 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 Assam, 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) **Guwahati's Bharalu–Bahini basin**: the catchment of the Bahini and the Bharalu down to the outfall at Bharalumukh, including the part of the Bahini's catchment in Meghalaya, the Noonmati basin that is pumped to the Bondajan, and the localities that flooded in June 2022 (among them Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar);

- (b) **the Mora Bharalu–Deepor Beel–Khanajan system and the Silsako basin**: the land that drains through the Mora Bharalu, the Basistha and the Kalmani to Deepor Beel and through the Khanajan to the Brahmaputra (a jan, Assamese জান: a stream or natural drainage channel, often the outlet of a beel), and the land that drains to Silsako Beel;
- (c) **the hill streams of the Guwahati fringe**: the catchments of the streams that rise in the hills of Meghalaya and enter Guwahati at Khanapara and Jorabat, with the hill-foot land below them;
- (d) **Dibrugarh behind the DTP dyke**: the land of Dibrugarh that drains to the DTP drain and through it to the Sessa, including Larua Jamira beel;
- (e) **Silchar behind the Barak embankment**: the land of the Silchar Master Plan area enclosed by the embankments of the Barak;
- (f) **Karimganj on the Kushiyara, with Hailakandi and Badarpur**: the land of these towns that drains to the Kushiyara, the Barak and their tributaries behind embankments;
- (g) **Palasbari–Mirza**: the land of the Palasbari–Mirza–Bijoynagar Master Plan area that drains to its channels and wetlands;
- (h) **the north-bank towns on dam-release and flash-flood reaches**: the land of North Lakhimpur that drains to the Ranganadi, of Dhemaji, of the towns on the Subansiri below the Lower Subansiri project, and of Tezpur that drains to the Jia Bharali;
- (i) **Dhubri and Goalpara on the lower Brahmaputra**: the land of the two towns that drains to the Brahmaputra and its embankment sluices;
- (j) **Majuli and the char lands**: Majuli and every char, chapori and river island on which a town or a development under this chapter lies;
- (k) **Haflong and Diphu**: the land of the two hill towns, with the landslide ground round them; and
- (l) 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 closed by a sluice, gate or flap gate in a river embankment when the Brahmaputra, the Barak, the Kushiyara or a tributary is high, or that depends on pumping, such as the Bharalumukh sluice and pumps in Guwahati and the outfall sluice of the DTP drain at Dibrugarh, or that discharges to a beel or retention pond held full behind such a gate, or to a reach below a dam that releases water, such as the Ranganadi, for part of the monsoon season (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and pukhuri 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 Guwahati entries follow the city's drains to the river. The Bahini rises at Umtyrnga in Meghalaya and runs 9.29 km to Jonali, where it becomes the Bharalu, which runs 6.2 km to the Brahmaputra at Bharalumukh; the catchment is about 120 km², roughly half hills, with about 10.94 km² draining the city (PCBA, Bharalu action plan; about 11 km² in a press article: the figures conflict). The Bahini is "cut off by a sluice at Natun Bazar" (PCBA), the Bharalumukh gates close when the Brahmaputra is high, and the pumps there could discharge "only seven Cumecs" against the river's 72 m³/s by gravity (2008, as reported); the Noonmati basin is pumped by four pumps of 1,000 L/s to the Bondajan (as reported). The CAG counted 14 waterlogging points flooding six or seven times a year and, in June 2014, seven flash-flood deaths and four electrocutions (Report No. 4 of 2019); in June 2022 Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar went under (as reported); and the ADB project for the basin targets the 434 ha of the Bahini basin that flood frequently, against a baseline of 616 ha, with 693 ha inundated in its design storm of 65.72 mm/h in initial modelling (ADB, PAM 57262-001, 2025; the baselines differ). The Deepor Beel entry follows the western city: the Basistha and the Kalmani feed the beel, which drains by the Khanajan to the Brahmaputra and grows from about 10.1 km² to about 40.1 km² in floods (as reported); it is Ramsar site 1207 (19 August 2002, as quoted), its sanctuary notification of 2009 was restored on appeal in 2023 and the State was directed not to denotify it (Gauhati High Court, PIL 18/2023, order of 05.04.2024), and its eco-sensitive zone is still a draft (as reported); the Mora Bharalu, with a capacity of about 45 m³/s (2008, as reported), carries polluted water into it (NGT, OA 673/2018, State progress report of August 2020). Silsako Beel, in Schedule III of the Guwahati Waterbodies (Preservation and Conservation) Act, 2008, which the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 repeals (the enacted text is to be confirmed [TBC]), is to receive part of the Bahini's runoff in a retention basin "gradually pumped out to the Brahmaputra" (ADB, RRP 57262-001, 2025), and byelaw 26(ix) sets 15 m from Deepar Beel and Silsako. The hill-fringe entry follows the rain: the 50-year 24-hour depth of the CWC subzone 2(b) plate rises from about 200–240 mm at the city to 280–320 mm at the Khanapara and Jorabat foothills and 400 mm on the border of Meghalaya (NEER's reading of Plate 9), and on 20 April 2026 the gauge at SIRD Khanapara took 215.9 mm overnight against 117.4 mm at the airport (as reported); "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB IEE, 2017). The Dibrugarh entry follows the DTP drain: the 8.62-km DTP dyke of 1955 "closed all the drainage channels", the town is "1.5 m below the bed level of Bramhaputra", and the drain runs 32.053 km past Larua Jamira beel to the Sessa with capacities of 105.50, 142.97 and 61.11 m³/s by reach and an outfall sluice with "a flood level of 97.50 m" (ADB IEE, 2017); the Brahmaputra at Dibrugarh has a danger level of 105.70 m and a highest level of 106.48 m (3 September 1998) (CWC, as transcribed by SANDRP; datum not stated). The Silchar entry follows the Barak: the town is a bowl behind the embankment, whose cut at Bethukandi let the river in in June 2022 (as reported; Clause 4.16); the Barak at Annapurnaghat has a danger level of 19.83 m and a highest level of 21.84 m (1 August 1989) (CWC, as transcribed by SANDRP); the Barak valley has 731 km of embankments (as quoted from a Lok Sabha answer), 450 km of them "extremely vulnerable" (as reported); no CWC report covers the valley (Clause 2.3.6(c)(ii)); and the town's outfall channels were not researched [TBC]. The Karimganj entry follows the Kushiyara at Karimganj, danger level 14.94 m and highest level 16.57 m (10 June 2010), and the Barak at Badarpurghat, 16.85 m and 18.48 m (11 September 2007) (CWC, as transcribed by SANDRP); Karimganj district is reported to have been renamed Sribhumi [TBC]. The Palasbari entry follows the Gauhati High Court's finding that builders blocked channels and filled wetland, causing "artificial floods" (PIL/53/2023, order of 06.09.2024). The north-bank entry follows the dams: the Ranganadi project released 1,412.57 m³/s in 2017 (as quoted from an IIT Guwahati report for ASDMA); a discharge of "around 16000 cumec" on the Subansiri was reported on an undated occasion when both projects opened their gates (as reported), and the Lower Subansiri release rules were not found [TBC]; the Jia Bharali at its NT Road crossing has a danger level of 77.00 m and a highest level of 78.50 m (26 July 2007), and the Brahmaputra at Tezpur 65.23 m and 66.59 m (27 August 1988) (CWC, as transcribed by SANDRP); and the 50-year plate rises to 320 mm and more at Dhemaji

(NEER's reading of Plate 9 of the subzone 2(a) report). The lower Brahmaputra entry follows the largest 24-hour record in the State that passes the record check, 479.3 mm at Dhubri (Rupsi) on 28 May 1989 (IMD *Extremes*), which raises the 1% AEP depth at Dhubri above the plate (Clause 2.3.6(h)), and the river at Dhubri, danger level 28.62 m and highest level 30.36 m (28 August 1988), or 30.37 m (17 July 2019) in a later bulletin, and at Goalpara, 36.27 m and 37.43 m (31 July 1954) or 37.35 m (13 July 2004) (CWC, as transcribed by SANDRP and as quoted: the values conflict). The Majuli and char entry follows land that moves: Majuli's area is given as 733.79 km² in 1940 and 524.29 km² in 2016 (as quoted from a Lok Sabha reply) and as 1,246 km² in 1951 and 487 km² in 2024 (a research abstract), baselines that conflict; 2,251 char villages lie on 3,60,927 ha (survey of 2002–03, as quoted); erosion is put at more than 4.27 lakh ha since 1950 or about 3.86 lakh ha since 1954 (both as reported); and these sites are hazard-first under Clause 2.3.6(i). The hill-town entry follows the rain and the slopes: Haflong, on the line between subzones 2(b) and 2(c), recorded 309.5 mm on 27 June 2012 and 1,428.5 mm in that month (IMD *Extremes*), Lumding, in the same Karbi rain shadow as Diphu (Annex 2A), recorded 410.0 mm on 3 August 1981 (IMD *Extremes*), and Dima Hasao has landslide ground (Clause 2.3.6(i)). Jorhat, Sivasagar, Nagaon, Tinsukia, North Guwahati and the other towns behind embankments 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 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 pukhuri or tank flood storage identified in the basin stormwater master plan (Chapter 11); and
- (c) recorded in the public ledger of Clause 4.13.4, which shall show the volume owed and the volume delivered in each basin.

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

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

> Commentary. Greenfield is the target for all redevelopment, because a dense city only reduces its runoff as it rebuilds. On small, fully built plots in areas such as the built-up localities of Guwahati that flooded in June 2022, among them Anil Nagar, Nabin Nagar and Rajgarh Link Road (as reported), or the old centres of Dibrugarh and Silchar [TBC], there is often no space for the full greenfield storage. A rule that cannot be met invites variances and non-compliance, which help no one downstream. This clause follows the approach of the UK Non-statutory Technical Standards for Sustainable Drainage (Defra, 2015, S2–S3). For previously developed sites, those standards require peak runoff "as close as reasonably practicable to the greenfield runoff rate" and never above the pre-redevelopment rate. The fixed 50% minimum reduction has no direct precedent; this Manual sets it to give reviewers a clear number in place of a "reasonably practicable" judgement. The fee-in-lieu turns the shortfall into regional storage in the same basin, so the basin still receives greenfield-equivalent control in total. Retention and water quality get no relief, because they are small volumes that almost every site can hold.

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 June to 30 September in sub-areas AS-A, AS-A1, AS-B, AS-C, AS-C1 and AS-D1, from 1 May to 31 October in AS-E, and from 1 April to 31 October on floodplain land below the 1% AEP level, char and chapori land, beel and pukhuri margins and land behind embankments, at all times in catchments draining to a reservoir, its backwater or a release reach below a dam, and at other sites and times, including AS-D, 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 hill-fringe colony in south Guwahati draining to the Bahini. They are not NIH-DHAARA values and must not be used for design.

Inputs:

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

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

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

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

How to read it:

- **100-yr cap.** The cap is the largest pre-development 10-yr peak, 356 L/s (72 h). Every 100-yr detained peak is at or below it; the largest is 343 L/s.
- **2-yr cap.** The site is flood-sensitive, so the 2-yr cap is the largest pre-development 2-yr peak, 180 L/s (72 h; Clause 4.5.3.1). The largest 2-yr detained peak is 34 L/s. At 1, 2 and 3 hours the detained 2-yr peak is above the pre-development peak of the same duration (15 against 4 L/s, 20 against 14 L/s, and 22 against 19 L/s). That comparison is not required here. It would be for a site under Clause 4.5.2, and Clause 4.5.5.2 would then apply.
- **Governing storage.** Storage is governed by the **48- and 72-hour** storms: 2,913 m³, which is 0.146 m³ per m² of site, at a maximum depth of 1.17 m. A design that checked only the critical-duration peak storm (1–3 h here) would have provided about 2,000 m³, roughly two-thirds of what is needed.
- **Drawdown.** With the low-flow orifice 50% blocked (Clause 4.8.3), 90% of the 10-yr storage drains in at most 45.3 h (the 24-hour storm), within the 48 hours of Clause 4.7. A 120 mm orifice would drain it in about 42 h when clean but 54 to 75 h when half blocked, so it fails. Annex 4C shows that trial and the routing step by step.
- **Retention credit.** With an illustrative retention depth of 40 mm, RRV = 552 m³, computed for each sub-area (Clause 3.9.4). Modelled as filling from the start of the storm with no infiltration during it, the retention reduces the 24-hour storage by 138 m³ and the 48- and 72-hour storage by 7 m³ or less. The credit under Clause 4.4.6 is therefore effectively zero for this site.

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

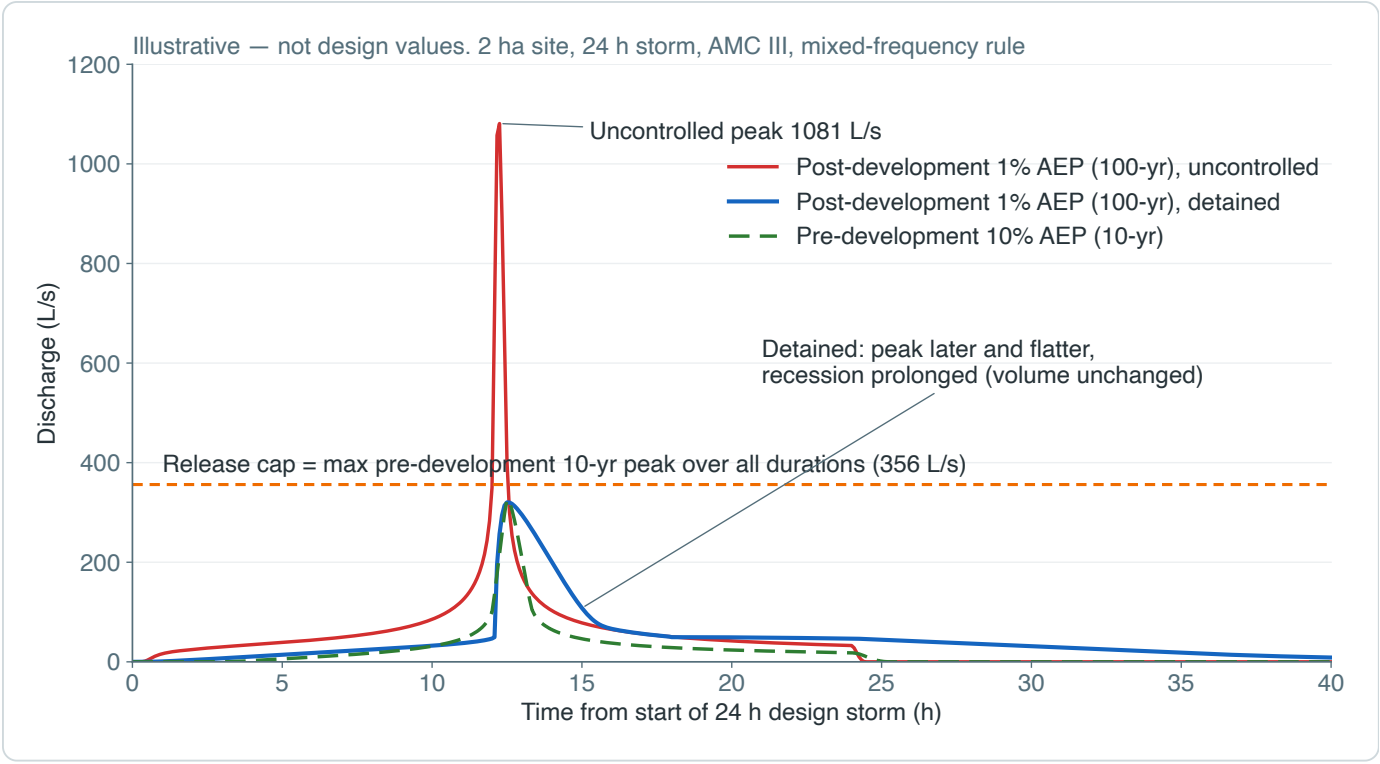


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA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

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

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 Assam storage must hold multi-day volumes. It is still short enough that a basin filled by one monsoon depression will have most of its volume back before the next, which in

June 2022, when Guwahati's gauges recorded 84.6–88 mm on 14 June and the city 46 mm in the 24 hours from 08:30 on 15 June (as reported), and Cachar 251.20 mm on 19 June (as quoted from the district report) 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.

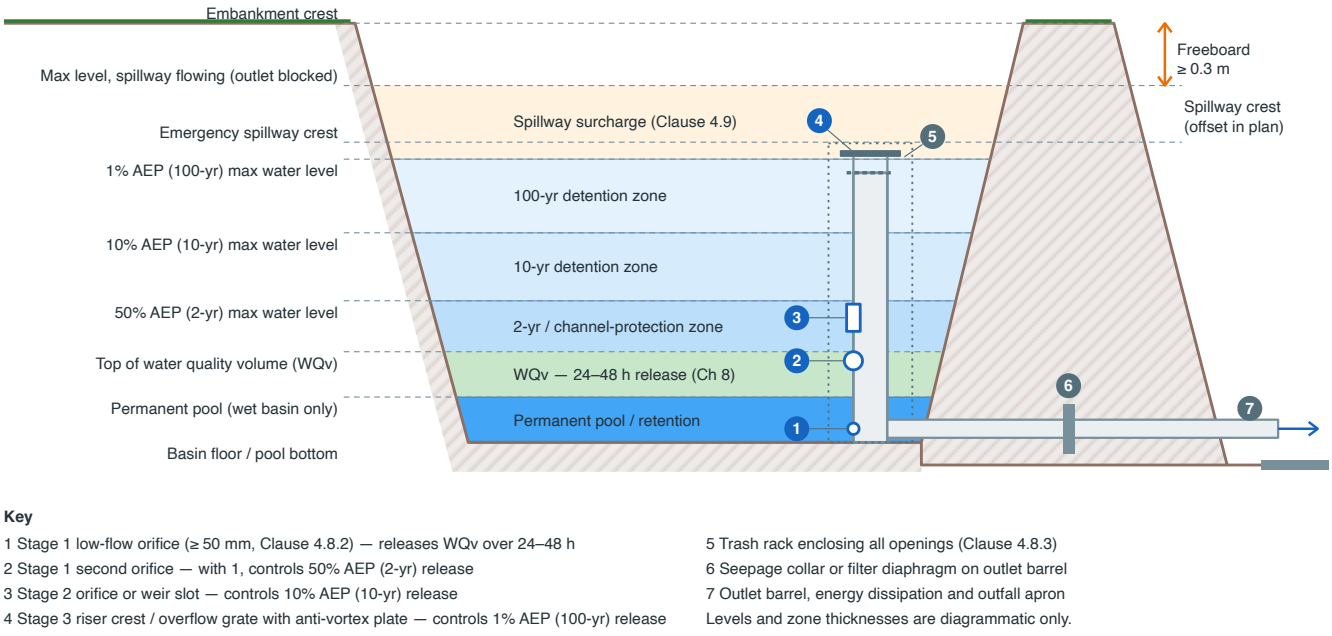


Figure 4.2 — Detention storage stack (permanent pool, WQv, 2-yr, 10-yr and 100-yr zones, spillway surcharge and freeboard) and multi-stage riser outlet. Schematic, not to scale. Original drawing for this Manual, adapted from the multi-stage outlet and storage-zone concepts in MARC/KC APWA Section 5600 (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 green-area rules of the Unified Byelaws 2022, under which at least 20% of every plot is kept for trees and greenery (byelaw 111), group housing and multistoreyed developments use 20% of their area for "organized recreational area / gardening" (byelaw 26(vii)), hill plots keep 30% under vegetation (byelaw 110(k)), and, since 2024, 60% of the open space is landscaped, half of it "unpaved and green" (byelaw 92). Where the ground is outside the floodplain and hill rules of Clause 4.11, a detention area graded into the unpaved part of the open space below the level of the road keeps it pervious and usable, which is what 4.10.6 requires. On land to which the floodplain rule applies, much of the plains, the same surface storage is the preferred form (Clause 4.12.4), but it earns no infiltration credit, its floor is set above the design groundwater level of Clause 4.12.1 or it is lined, and the permeable pavers of byelaw 92 there are laid on a non-exfiltrating base with an underdrain; on hill-rule ground, slopes of more than 10°, colluvium, fill, slide debris and land within twice the height of a cut or wall downslope of it are not

used for ponding, and detention is provided in lined tanks, on rooftops and podiums under 4.10.3 and 4.10.4, or on a level open space only where the hill rule's geotechnical certificate covers it. Four kinds of land are not open space for this purpose. A pukhuri 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 outlet level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows; a beel and its margins are never turned into a detention pond, and engineered storage is called a detention pond, never a pukhuri. The strips of byelaw 26(ix) (15 m from rivers, Deepar Beel and Silsako, 10 m from the Bharalu, Mora Bharalu and Bondajan and from large ponds, 6 m from other channels and other notified water bodies) and the Manual's corridor of Chapter 7 are flood land already: water reaches them first, so they are not counted as detention for the development beside them. Land in the Eco-Sensitive Zone of the Master Plan for Guwahati 2025, which includes "All notified forest, water bodies, rivers etc.", is not graded or paved for detention. And the char and chapori lands carry no permanent detention works at all (Clause 2.3.6(i)).

- Signs and depth markers under Clause 4.15.5, and the flood-warning signs of 4.10.5(b), are in Assamese and English; in the Barak valley districts (Cachar, Karimganj and Hailakandi) they are in Bengali and English, and Assamese may be added; and in the Bodoland Territorial Region they are in Bodo, Assamese and English (set by this Manual). The rule follows the official use of Bengali in the Barak valley districts and of Bodo in the Bodoland Territorial Region under the Assam Official Language Act, 1960, as amended (the amending Acts and the districts they name are to be confirmed [TBC]).

4.11 Rainwater harvesting versus detention accounting

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

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

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

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

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

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

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of byelaws 104(i), 110(g) and 114 and Appendix VI of the Unified Byelaws 2022, any direction of the State Ground Water Authority under section 19 of the Assam Ground Water Control and Regulation Act 2012 in a notified area, any condition of a building permit or occupancy certificate, or any rainwater harvesting rule of a District Council [TBC].

Commentary. Rainwater harvesting in Assam is required for every building, and the byelaws give it two sizes that do not agree, but they size it as infiltration, not as storage. Byelaw 114 of the Unified Byelaws 2022 reads: "Every building shall provide one or more rainwater harvesting structures to collect the roof top run-off. The total dimension of recharging/percolating pits/trenches should be at least 5 cubic metres dimension for every 100 sq.

metres. of roof area", with the structures of Appendix VI also in apartment houses, institutional buildings and "buildings in hilly areas". Appendix VI, to be "shown in plans while applying for planning permission", requires for all buildings other than commercial and apartment buildings "percolation pits of size 1.2m x 1.2m x 1.5m … at the rate of 1 nos. such pit for every 100 sq.m. of Plot area", filled with pebbles, brick jelly or river sand, and adds that "All Rain water outlets/drains and waste water drains shall be connected to the roadside side through the percolation pit only"; since 2022, "All buildings with plot area 134sq m and above shall have the provision of rain water harvesting storage and reuse"; commercial, apartment, institutional, industrial and other buildings get the same pits and grass paving, "a type of perforated paving … where 10-15% of the area is covered by grass … in addition to the mandatory green space"; and a terrace sump with a first-flush valve and filter, open-ground percolation and piped well recharge are printed under a second heading, whose status (optional in the 2014 text) is unclear in the 2022 layout [TBC]. The pit rate gives 2.16 m³ of pit per 100 m² of plot, against byelaw 114's 5 m³ per 100 m² of roof, and the text does not reconcile the two (NEER's reading); neither is sized to a storm. Roof-water harvesting is "mandatory in hilly areas" (byelaw 110(g)). The 2024 amendment adds landscaping "unpaved and green" and permeable pavers "to allow rain water to percolate to underground" in open space (byelaw 92). The Assam Ground Water Control and Regulation Act, 2012 (Assam Act XVI of 2012) defines rainwater harvesting as "collection and storage of rainwater at surface or in sub-surface aquifer" (s.2(f)) and lets the State Ground Water Authority direct RWH structures in premises of 100 m² or more, and local authorities impose RWH conditions on building plans of 100 m² or more, but only in notified areas (s.19; the layout of its sub-sections is uncertain in the copy read), and no area has been found notified [TBC]; the "100 m² plot" often attributed to the building rules is this section, not a byelaw. In practice GMC began RWH inspections on 20 June 2025, with penalties up to revoking the occupancy certificate, while "most of the apartments and commercial buildings in Guwahati conveniently flout" the rule and the builders' association says the Appendix VI structures "have proved to be faulty" (as reported). The structures the byelaws describe are pits that put water into the ground, and on most of the State's town land the ground is full of water when it rains (Commentary to Clause 3.10): in Kamrup (Metro) the water table stood 0.2–2.76 m below ground in August 2022 and 1.29–2.64 m in November, and after the monsoon water-logged or prone ground was found in "almost all the districts of Assam" (CGWB, GWYB NER 2022-23); the rising Brahmaputra "reduces the rate of percolation" (ADB IEE, 2017). This Manual therefore sets three infiltration rules and one sizing rule for credit (all set by this Manual), and credits the byelaw structures as follows:

- An RWH tank or sump is RWH storage. It is not detention (Clause 4.11.1), and it is assumed full at the start of every storm (Clause 4.11.2), because in the monsoon season it is full after the first heavy rain. A tank may also provide detention only if it is built as a combined tank under Clause 4.11.3, with a detention zone above its RWH overflow level that drains through its own orifice; only that zone counts. The dry sump of byelaws 74 and 110(h) is never an RWH tank: it is a detention facility, empty before each storm (Commentary to Clause 4.1).
- **RWH credit rule.** Where the floodplain rule or the hill rule below bars infiltration, the volume of byelaw 114, 5 m³ for every 100 m² of roof (about 50 mm over the roof), is provided as storage in a tank in place of the pits. It counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or washing, demonstrated under Clause 4.4.3, and is then modelled under Clause 4.4.6 like any other retention practice; it is assumed full at the start of every storm and never counted as detention. The rule takes the byelaw's own volume and changes only where it goes; a larger tank is always allowed. The store also serves the dry season: "The winter season from December to March is practically dry" (CWC subzone 2(b) report, §2.4.1).
- Recharge pits, trenches, shafts and wells count as retention only where they meet Clause 4.11.4 and the recharge rule below: they are credited only to the extent that they drain within 72 hours at half the rate measured in a site test (Clauses 4.4.3 and 4.4.5), with their base at least 1.0 m above the seasonal high water table, and the credit is found by routing under Clause 4.4.6, not by deducting their volume.
- **Floodplain rule.** No deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited: on char or chapori land; on land below the 1% AEP flood level of a river or stream; inside an embankment-protected area that ponds when its sluices close; on the margins of a beel or pukhuri (its Zone 1 and Zone 2 under Chapter 7); or wherever the seasonal high water table, the highest level from April to November, is less than

2.0 m below ground. The last condition alone may be set aside where a piezometer record of at least one full April–November season shows that the water table stays at least 2.0 m below ground and at least 1.0 m below the base of the practice (Clauses 4.11.4 and 4.12); the others may not, because a flood or a closed sluice puts water over the practice whatever the water table does. On such land roof runoff goes to storage under the RWH credit rule above, and detention is provided in lined, watertight storage (Clause 4.12.2). The rule is new in this series. It reaches much of the State's town land: the flood-prone area is 31.50 lakh ha, 40% of the State, by the Rashtriya Barh Ayog figure quoted by the CAG (Report No. 5 of 2018), or 31.05 lakh ha, 39.58%, on the WRD website (as quoted) — two figures in circulation; in November 2022, 45.96% of the CGWB's wells in Assam stood within 2 m of the surface (GWYB NER 2022-23); and the char and chapori lands alone hold 2,251 villages on 3,60,927 ha (survey of 2002–03, as quoted).

- **Where Appendix VI requires a percolation pit on floodplain land.** Appendix VI routes "All Rain water outlets/drains and waste water drains" to the road drain "through the percolation pit only". On land under the floodplain rule, with grey water mixed in and the water table near the surface, that pit is a soakaway in saturated ground, not storage. This Manual does not override the byelaw. It states the conflict plainly: on such a site the Manual requires storage in place of the pit, under the RWH credit rule, with the overflow and the waste water taken to the drain without passing through a pit, and the applicant seeks the Authority's relaxation of the pit requirement, citing this rule. Until the Authority relaxes it, the byelaw requirement stands, and a pit that the byelaw forces on such a site earns no credit under this Manual.
- **Hill rule.** On the Guwahati hills in sub-area AS-B, in sub-areas AS-D (Karbi hills) and AS-D1 (Dima Hasao hills), and on any natural slope of more than 10° elsewhere, no deliberate infiltration practice shall be built or credited: on natural ground sloping more than 10°; on colluvium, fill or slide debris, whatever its slope; in a mapped landslide zone, including the Hilly Area Zone of the Master Plan for Guwahati 2025 and any land declared landslide-prone; or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope. On such sites roof runoff goes to storage under the RWH credit rule, with overflow to a lined drain that discharges through a silt trap and an energy dissipator to a stable natural channel, never onto an unprotected slope. The 10° threshold is the byelaws' own: "In hilly areas with slope greater than 10° special protection measures shall have to be provided" (byelaw 110(d)); the other hooks are the cut limits of 110(e) ("generally … 4 m. to 6m", and over 6 m "not … ordinarily permitted"), the third-party slope checks of 110(f), drainage "without causing soil erosion" (110(c)), the RWH, dry sump and silt fence of 110(g)–(i), the 30% vegetation of 110(k), the 45° limit of byelaw 74, and the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 (Assam Act V of 2007), which bars earth cutting that damages a hill in a Designated Area (s.3), requires the Advisory Committee's prior approval for guard walls and houses there (s.14) and punishes breach with up to six months or ₹5,000 (s.19); no Designated Area notification was found [TBC]. Where the third-party check of 110(f) is required, it shall also state whether the site's drainage, storage and any infiltration add water to the slope. The hazard is real: "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB IEE, 2017); the Gauhati High Court recorded on 26.05.2025 that "hill cutting is still going on" (PIL/14/2024); four people were killed in a landslide at Nizarapar/Boragaon on 14 June 2022 and three at Bonda on 31 May 2025 (as reported).
- **Recharge rule.** Recharge is allowed only on tested ground outside the floodplain and hill rules: the bhabar fans of the northern foothills, a belt 11–15 km wide of boulders and gravel (CGWB, Assam State Profile, 2007), where debris and the shifting of channels govern the siting (Clause 2.3.6(i)); river terraces above the 1% AEP level; and the hill-foot colluvium of Guwahati on slopes of 10° or less, where the hill rule's certificate is given. There it needs a silt trap, a filter and a first-flush diverter ahead of the structure, a field infiltration test, a seasonal high water table at least 2.0 m below ground, and the separation of Clause 4.11.4. No recharge or injection well shall be built in a district where groundwater carries arsenic or fluoride above the drinking-water limits: arsenic was found in isolated pockets in Barpeta, Goalpara, Golaghat, Karbi Anglong, Kokrajhar, Lakhimpur, Sibsagar, Nalbari and Karimganj (as quoted from a Lok Sabha answer of February 2025), and fluoride above 1.5 mg/L in parts of Goalpara, Kamrup, Karbi Anglong, Nagaon, Golaghat and Karimganj (as quoted from the CGWB). Recharge is not a design objective in Assam: the stage of

groundwater extraction was 22% in 2007, with no over-exploited, critical or semi-critical unit (CGWB, 2007), and 12.61% in the 2024 assessment (as quoted; columns unlabelled). Everywhere else rainwater harvesting is storage and reuse for the dry season, and on floodplain sites storage for the storm.

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

On the flood plains, water put into the ground has nowhere to go in the monsoon, and on the hills it goes into the slope. In the monsoon season an RWH tank is full after the first heavy rain, and on the flood plain a pit sits in the water table. 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 RWH credit rule, the floodplain rule, the hill rule, the recharge rule, the treatment of the Appendix VI conflict and the polluted-runoff rule are set by this Manual. The 2.0 m water-table screen of the floodplain rule is set by this Manual from the CGWB depths above, because where the water table rises above it a pit of the 1.5 m depth of Appendix VI stands less than 0.5 m above the water, half the 1.0 m separation of Clause 4.11.4. The 10° slope of the hill rule is the byelaws' own, and the distance of twice the height of a cut or wall is set by this Manual as a precaution, as in the mountain editions of this series, pending guidance from a geotechnical study for the State [TBC].

4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the flood plains of the Brahmaputra and Barak valleys, where most CGWB wells stand within 5 m of the surface before and after the monsoon and nearly half within 2 m after it, the Silchar bowl, the char and chapori lands, the beel and pukhuri margins, the land behind embankments, the terai belt of the northern foothills, and the valley floors and hill-foot land of Guwahati, or any area where the groundwater table lies within 3 m of the surface at any time of year shall establish a design groundwater level (DGWL) for the facility. The DGWL is the seasonal high level during or after the monsoon, from:

- (a) site piezometer readings over at least one full April–November season; or
- (b) where (a) is not available, the higher of the CGWB or Irrigation Department record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, jan, beel or pukhuri, or of the water ponded behind any embankment that encloses the site.

For the flotation check of 4.12.3 at sites in the flood plains of the Brahmaputra and Barak valleys, the char and chapori lands, the beel and pukhuri margins and the land behind embankments, 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. Assam is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3 and the saline exposure of 4.12.5, do not apply in the State, and no saline groundwater was reported in the sources read for this Manual [TBC]. The CGWB reports high iron in groundwater on the "Northern Bank of Brahmaputra" (CGWB, Assam State Profile, 2007) and high iron and fluoride in Goalpara (CGWB district booklet, as quoted); where a site test shows aggressive groundwater, concrete and metal parts are designed for the exposure class that the test indicates under 4.12.5 (set by this Manual). The wet cases are most of the plains. The water table stood 2–5 m below ground at 57.43% of the CGWB's wells in March 2022 and within 2 m at 45.96% of them in November 2022; in Kamrup (Metro) it was 1.39–4.08 m below ground in March, 0.2–2.76 m in August and 1.29–2.64 m in November (CGWB, GWYB NER 2022-23), and it rises "with the rising of the Brahmaputra" (ADB IEE, 2017). On the char and chapori lands, the beel and pukhuri margins and the land behind embankments the ground is flooded or saturated when the river is high. There an unlined tank fills with groundwater before the storm, and an empty lined tank or dry sump can float, especially when a river in flood, a beel at its outlet level or water ponded behind an embankment 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, jan, beel or pukhuri, or of the water ponded behind an embankment that encloses the site, where that is higher than the well record; and on the flood plains of the Brahmaputra and Barak valleys, the char and chapori lands, the beel and pukhuri margins and the land behind embankments it is taken as existing ground level for the flotation check unless piezometers show otherwise. Storage there is preferably above ground, on roofs, podiums and landscape (4.12.4), and a dry sump below ground is lined, anchored and checked for flotation with the sump empty (Commentary to Clause 4.1). On a hill site a deep tank is not preferred even where groundwater is deep, because a leaking tank on a slope is an infiltration practice by another name: storage on a slope shall be lined and watertight, and its leakage and overflow taken to a lined drain (Clause 4.11, hill rule). The April–November monitoring season of 4.12.1(a) is set by this Manual to cover the Manual's monsoon season of 1 April to 31 October and the post-monsoon high of November, when more of the CGWB's wells stood within 2 m of the surface (45.96%) than in March (20.27%); a reading taken in March understates the design level. Most of the State's observation wells are those of the CGWB, North Eastern Region, Guwahati (381 in 2007); whether the Irrigation Department, which administers the Assam Ground Water Control and Regulation Act, 2012, keeps observation wells was not found [TBC], and no water-table depths for individual town sites were obtained [TBC]. The factor of 1.2, the 0.5 m allowance, the "ground level" default for the plains, chars, waterbody margins and embanked land, and the exposure rule for aggressive groundwater have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Assam 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 pukhuri or tank storage identified in the plan.

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

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

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

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

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

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

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

> Commentary. The Malaysian DID (2008) checklist favoured community ponds over on-site detention for sites above 0.1 ha. Studies of on-site detention show that its benefit depends on location and fades with distance downstream (Colorado State University thesis; McEnroe for Kansas City), and that a pond low in the catchment can synchronise with the main-stem peak (*Water* 2016). Regional storage therefore has to be sited by basin modelling, not simply aggregated.
>
> Assam has no tank Act, but it has a statute that already treats a water body as storm-water storage. The Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (Assam Act XX of 2008) defines "Waterbodies" as "the area or areas of land where the rain water accumulates and act as natural or storm water reservoir and shall include wetland" (s.2(e)) and bars filling, building and dumping in its four scheduled areas (s.4), Sarusola (as read from a garbled schedule heading), Borsola, Silsako and land near Deepor Beel (Schedule IV is land near the beel, not the beel itself); the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024, passed on 29 August 2024, repeals the 2008 Act (s.22(1)) and extends the same definition to all notified Master Plan areas outside the Autonomous Districts, adding "all natural water channels (that are inflow or out flow channels into or from the waterbody)" and all ponds and tanks "irrespective of its size", but not private water bodies of less than 2 acres, those in reserved forests, sanctuaries and national parks, or Government fish farms (s.2(d)); it requires that

a water body's "area is not diminished and character is not changed" without the State Level Committee's approval (s.3), forbids obstructing "the natural and normal course of inflow and outflow" (s.15) and punishes breach with up to three years or ₹1 lakh, with restoration (s.16) (Bill as introduced; the enacted Act, Assam Act XXV of 2024, and its Rules were not read [TBC]). Since 2024 no use is permitted in the scheduled plots without the Authority's permission (land-use note to the Unified Byelaws 2022). The State's regional storage is of four kinds: the beels (Assamese বিল), natural floodplain lakes and wetlands, which cover, with the State's other wetlands, 764,372 ha, 9.74% of Assam (National Wetland Atlas, 2011, as quoted), and of which the Fisheries statistics counted 2,072 registered beels of 71,843.5 ha in 2021-22 and then 447 registered and 1,625 unregistered beels, a change in counting (as quoted); the pukhuris, dug tanks and ponds; the retention ponds now being built, such as the ADB's nature-based pond of 59,000 m³ with a pump station of 1.6 m³/s for the Bahini basin (ADB, RRP 57262-001, 2025); and the river flood plain behind and between the embankments of WRD. Deepor Beel, Ramsar site 1207, is the one wetland of international importance (as quoted); the Assam State Wetlands Authority was constituted in 2018 (notification No. FRM.10/2010/Pt/16 of 01.11.2018, as quoted), but no wetland was found notified under rule 4 of the Wetlands (Conservation and Management) Rules 2017 [TBC]. Four points follow:

- A beel or pukhuri on the record may not be a working one. No inventory of the beels and pukhuris within the towns, with their beds, outlets and stage–storage relations, was found [TBC], and beels are being lost: Urpad Beel's water area fell from 4.84 km² in 2003 to 3.38 km² in 2023, and Deepor Beel is reported to have shrunk by about 35% since 1991 (both as reported; other figures conflict). A beel or pukhuri is credited only after a survey shows its bed, its outlet and its stage–storage relation, and only for the storage above its outlet level; a natural beel is never turned into a detention pond, and engineered storage is called a detention pond, never a pukhuri or a beel.
- The law already counts the storage. Because the 2008 Act and the 2024 Bill define a water body as a "natural or storm water reservoir", a design that counts a scheduled beel's storage, and a rule that forbids reducing it, restate the law rather than extend it. But the storage is the basin's, not a site's: it is held for the whole catchment, it is scheduled and supervised through the District Level Committee and the State Level Committee, and it can be credited to a development only through the basin stormwater master plan of Chapter 11, never by discharging a site's runoff into a beel.
- A beel behind a sluice is full when it is needed. The receiving beel or pond of a gated or pumped outfall starts full to its outlet level whenever the outfall is closed (Commentary to Clause 3.12; Clause 5.8.5(e)), as the Dibrugarh design assumes "that the beel is full and the drain is also flowing full" (ADB IEE, 2017); its storage below that level is not credited, and its storage above it is credited only when the routing includes the closure.
- An embankment, sluice or drainage scheme of WRD is not regional storage. Storm water spilled to a river through an embankment uses capacity that the river needs for its whole basin, and the sluice shuts when the river is high; in a notified area no one may build on, remove or alter an embankment or drain without the permission of the Deputy Commissioner or the Embankment Officer (Assam Embankment and Drainage Act, 1953, s.16), so a regional facility that relies on one needs WRD's written agreement for a stated flow and level. No notification assigns the Bharalu, the Mora Bharalu or the Bahini to one owner (NEER's reading), and the ADB names "fragmented institutional responsibilities involving multiple institutions, such as the Guwahati Metropolitan Development Authority (GMDA), Public Works Department, and Water Resources Department" as the problem (ADB, RRP 57262-001, 2025); until an order is made, this Manual follows the working assignment of Chapter 1, and each town keeps a drain register giving every reach its owner, its land status, whether it is a scheduled water body or an embankment drain under the 1953 Act, and its outfall.

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

4.14 Simplified methods for small sites

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

4.14.2 **Method.**

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
AS-Z1 North bank: AS-A Lower north bank and Bhutan foothills (Dhubri–Kokrajhar–Bongaigaon–Barpeta–Nalbari–Rangia)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AS-Z1 North bank: AS-A1 Central and upper north bank (Mangaldoi–Udalguri–Tezpur–Biswanath Chariali–North Lakhimpur–Dhemaji)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AS-Z2 Guwahati: AS-B Guwahati metropolitan area (Guwahati–Dispur–North Guwahati–Amingaon)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AS-Z3 South bank: AS-C Lower and central south bank (Goalpara–Palasbari–Morigaon–Nagaon–Hojai–Golaghat)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AS-Z3 South bank: AS-C1 Upper Assam (Jorhat–Sivasagar–Charaideo–Dibrugarh–Tinsukia–Margherita)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AS-Z4 Hill districts: AS-D Karbi hills (Diphu–Hamren–Bokajan–Donkamokam)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AS-Z4 Hill districts: AS-D1 Dima Hasao hills (Haflong–Maibang–Umrangso–Jatinga)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]

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
AS-Z5 Barak valley: AS-E Barak valley (Silchar–Karimganj–Hailakandi–Badarpur)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(ii))	—	—	—	—

Worked example (illustrative — not design values).

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

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

Then:

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

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

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

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

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

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

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

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

Table 4.3A — Fixed release coefficients (provisional)

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

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

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

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

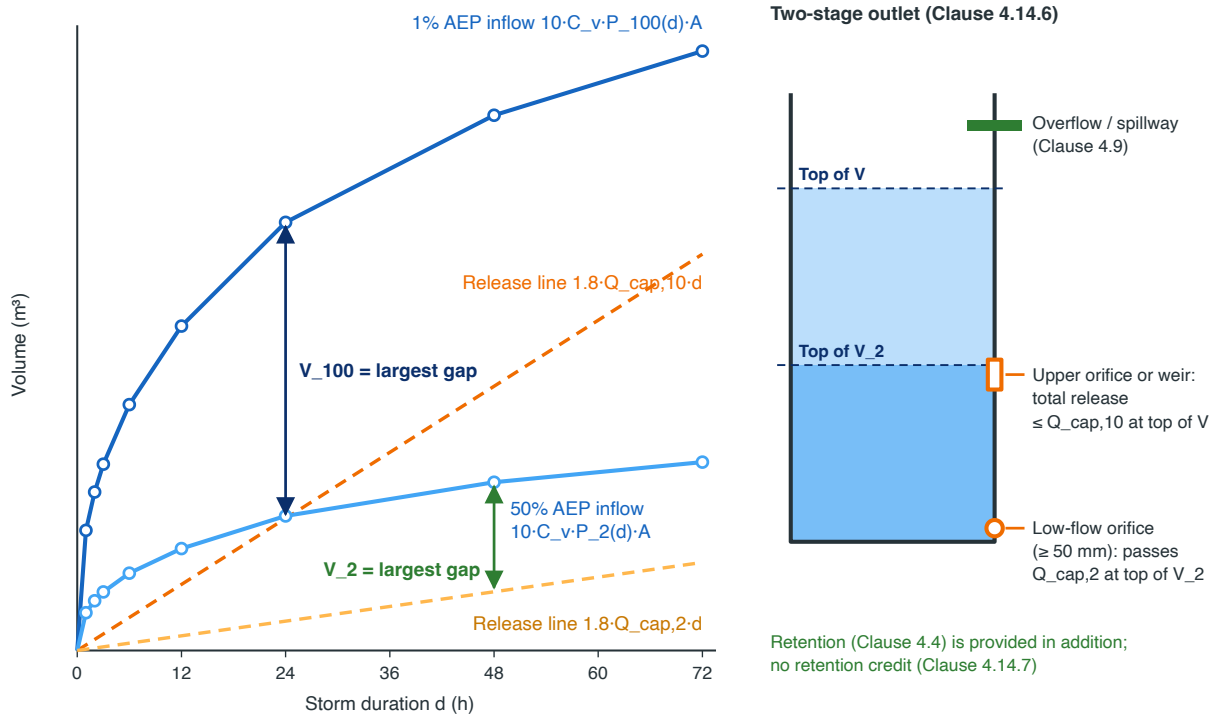
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

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

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

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

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



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

$Q_{cap,10} = 2.78 \times C_{10} \times i_{10} \times A$; $Q_{cap,2} = 2.78 \times C_2 \times i_2 \times A$; (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 $[\ 10 \times C_v \times P_T(d) \times A - 1.8 \times Q_{cap} \times d\ ]$ (m^3) ; 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 Brahmaputra valley floor, 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 Assamese 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 Assam the closed outfall is not the exception but the normal monsoon case. The Water Resources Department describes it: "High stages of river Brahmaputra and Barak obstruct free discharge of tributaries causing back flow and congestion near outfalls. Inadequate countryside drainages through sluices in embankment system … cause prolonged inundation" (as quoted by the CAG, Report No. 5 of 2018). In Guwahati "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB IEE, 2017); when the river is high the Bharalumukh sluice is shut, and "the natural discharge capacity of the Bharalu is 72 Cumecs when its Bharalumukh sluice gates are kept open, while the pumps fitted to its sluice gates can discharge only seven Cumecs" (2008, as reported; the present capacity was not found [TBC]). At Dibrugarh the dyke built in 1955 to protect the town "closed all the drainage channels", "Dibrugarh town is 1.5 m below the bed level of Bramhaputra", and the town drains 32 km to the Sessa through a sluice designed "keeping in mind that the beel is full and the drain is also flowing full" (ADB IEE, 2017). At Silchar, a bowl behind the Barak embankment, the flood of June 2022 entered through a cut in the embankment at Bethukandi, and the town was under water for about 11 days, up to about 4 m deep in places, or for "about a week" in another account (as reported; the accounts conflict); the Barak at Annapurnaghat peaked at 21.59 m on 21 June 2022, 1.76 m above its danger level but 0.25 m below its highest level of 1989 (as quoted from the Cachar district report; NEER's arithmetic), so the disaster was a breach-and-ponding flood inside the embankment, not a record river. What fills behind the closed gate is storm water mixed with sewage, because no town in the State is sewered (Commentary to Clause 4.1). No record of how long any sluice stays shut was obtained, and WRD's sluice operating rules were not found [TBC]; Chapter 5 sets the river level and the closure to be assumed (Clause 5.8.5). A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.

The response in this Manual is layered:

- release below pre-development (Clause 4.5);
- retain the frequent storms (Clause 4.4);

- route long monsoon storms (Clause 4.6.3);
- prefer regional storage in the pukhuri 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 Assam.** Assam is landlocked: it has no coast, no tide and no Coastal Regulation Zone, and the monsoon reaches it as rainfall and as the floods of the Brahmaputra, the Barak and their tributaries, which are dealt with in Chapter 2 and in Clause 5.8, 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 Assam: 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 silt and sand and attack by water that carries sewage), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Assam the receiving water is one of six kinds: a river reached through a sluice or flap gate in a WRD embankment or a town dyke, or through a pumping station, which is normally closed in the monsoon because the Brahmaputra or the Barak stands higher than the town behind it; the gated and pumped channels of Guwahati, the Bharalu–Bahini to the Bharalumukh sluice and the Mora Bharalu, Silsako and Noonmati–Bondajan systems; the drain of a dyke-protected or bowl town, such as Dibrugarh's DTP drain to the Sessa or the drains of Silchar behind the Barak embankment; a tributary with a CWC gauge, or a reach of river below a dam, such as the Ranganadi; a beel (a natural floodplain lake or wetland), a pukhuri or a jan (Assamese জান: a stream or natural drainage channel, often the outlet of a beel, as in Bondajan and Khanajan) that stores the town's water while its outlet is closed; or a juri (Assamese জুৰি: a small hill stream) or other hill stream coming down from Meghalaya or the hill districts, laden with silt and debris; 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 behind an embankment sluice, a gated or pumped channel, a dyke, a release reach, a full beel, pukhuri or pond, a hill stream or a receiving drain, with the locks and closures of Clause 5.8.5(a) to (f) in place of the tidal lock windows.

> **Commentary.** Assam's towns drain into rivers that are often higher than themselves. "High stages of river Brahmaputra and Barak obstruct free discharge of tributaries causing back flow and congestion near outfalls. Inadequate countryside drainages through sluices in embankment system … cause prolonged inundation" (WRD, as quoted by the CAG in Report No. 5 of 2018); at Guwahati "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB IEE, 2017); and "Dibrugarh town is 1.5 m below the bed level of Bramhaputra" (ADB IEE, 2017). So the closed outfall is the design case, not the exception. At Bharalumukh the Bharalu discharges 72 m³/s by gravity when the sluice gates are open, against seven by its pumps when they are shut (2008, as reported); the Brahmaputra at the DC Court gauge reaches its danger level of 49.68 m in most monsoons on this Manual's reading, and its highest flood level of 51.46 m (21 July 2004) is 1.78 m higher (CWC levels as reported; NEER arithmetic); and Silchar, a bowl behind the Barak embankment, was under water for about 11 days in June 2022 after the river came in through a cut embankment at Bethukandi (as reported). The outfalls also belong to one body while the drains above them belong to others: the embankments and sluices are WRD's, the municipal drains GMC's or another local body's, the road drains PWD's or NHAI's, the new drainage works and scheduled water bodies of Guwahati GMDA's, and no notification assigns the Bharalu, the Mora Bharalu or the Bahini to one owner (Chapter 6, Clause 6.9). The ADB names "fragmented institutional responsibilities involving multiple institutions" as the problem (ADB RRP, 2025). No document found during research sets a design level for any outfall in the State, and WRD's sluice operating rules and closure durations were not found [TBC]. A detention basin that meets every release rate in Chapter 4 still fails if the sluice it drains to is shut for a week, if the beel below it is already full, or if the hill stream it drains to has buried its outlet in silt. This chapter makes these failure modes part of the design. Assam 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, WRD canal, the Bharalu and the Bahini, the Mora Bharalu, the Basistha, the Kalmani, the Khanajan, the Bondajan and the Lakhimijan in Guwahati, the DTP drain of Dibrugarh to the Sessa, every channel of a WRD drainage scheme and every drain that discharges through a sluice in an embankment, any drain built or held by GMC, GMDA, a Municipal Corporation, a Municipal Board, a Development Authority, PWD or NHAI with an internal width of 1.0 m or more, and every jan, juri or other natural channel that drains 8 ha or more, or a tidal creek.
Chart datum (CD)	The datum of the published tide tables and nautical charts, to which tidal heights are referred.
Mean sea level (MSL)	Average sea level over a long period at a tide gauge.
MHWS	Mean high water springs: the average of high waters at spring tides.
HAT	Highest astronomical tide: the highest level predicted under average meteorological conditions over a full tidal cycle (18.6 years).
Storm surge	The rise in sea level above the astronomical tide caused by wind and low pressure, mainly during cyclones.

Term	Meaning in this Manual
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, pukhuri** 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 pukhuri under 5.3.1(b), it shall report:

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

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

5.3.3 Analysis points shall be set at least at:

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

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

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

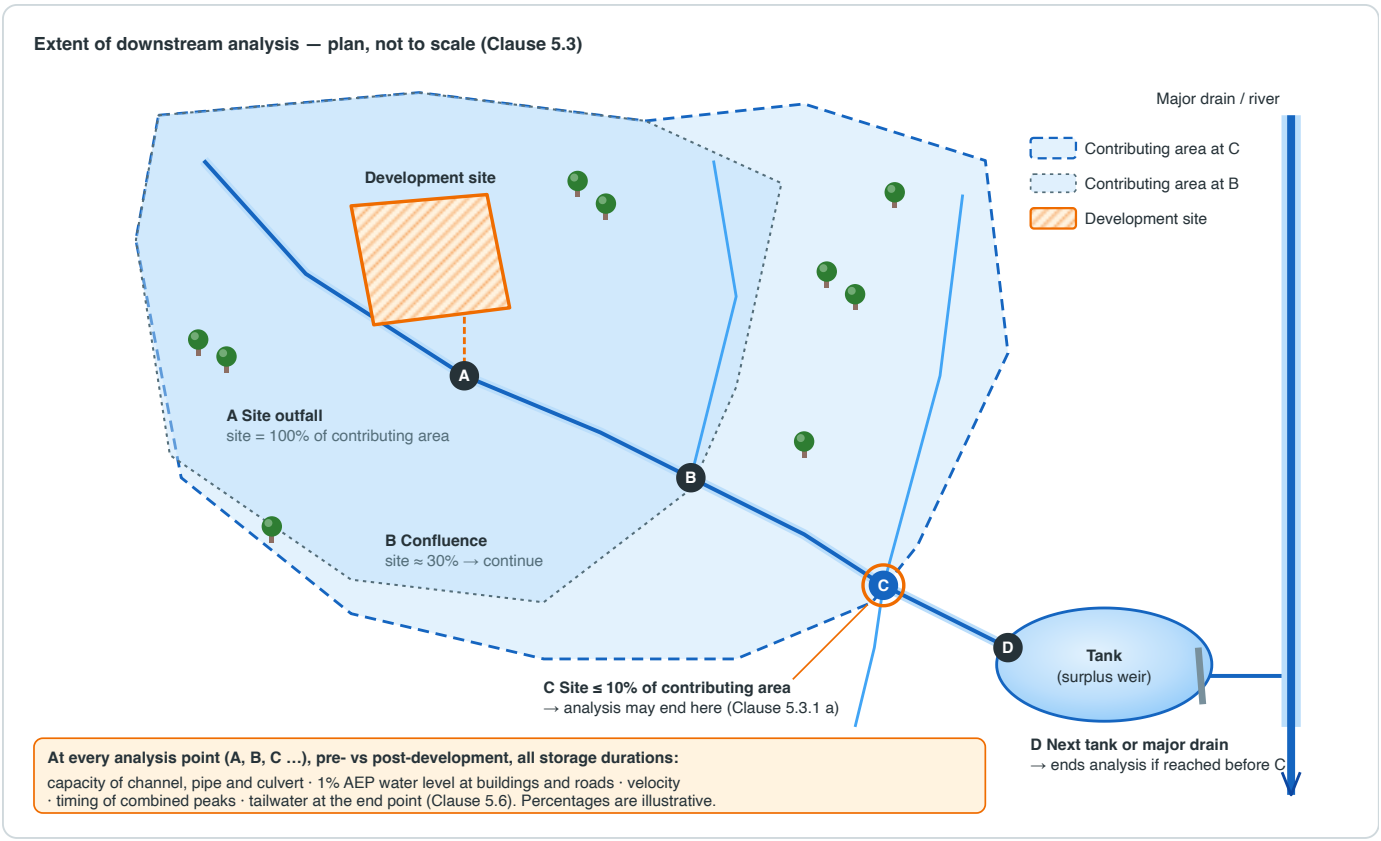

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next pukhuri or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Assam. In Guwahati, where the Bahini rises in Meghalaya and runs 9.29 km to Jonali, where it becomes the Bharalu, and the Bharalu runs 6.2 km on to the Brahmaputra at Bharalumukh (PCBA action plan for the Bharalu, as quoted), and where the Mora Bharalu, the Basistha and the Kalmani run to Deepor Beel and on by the Khanajan to the Brahmaputra, and in Dibrugarh, whose drain runs 32.053 km past Larua Jamira beel to the Sessa (ADB IEE, 2017), 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-locked and embanked towns of Assam, whose outfalls lie behind sluices and embankments and below the high stages of the Brahmaputra and the Barak: at Guwahati the highest flood level at the DC Court gauge, 51.46 m (21 July 2004), stands 1.78 m above the danger level of 49.68 m (CWC levels as reported), which on this Manual's reading the river reaches in most monsoons; Dibrugarh town lies "1.5 m below the bed level of Bramhaputra" behind its dyke (ADB IEE, 2017); and in June 2022 Silchar, a bowl behind the Barak embankment, was under water for about 11 days, up to about 4 m deep in places (as reported; "about a week" in another report). 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 Assam, 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, GMDA or the Authority adopts a higher projection for the planning area; and
- (c) assessed for the design life of the element. For elements with a design life of more than 50 years, the designer shall report the effect of a sea-level rise of twice the SLA as a sensitivity run.

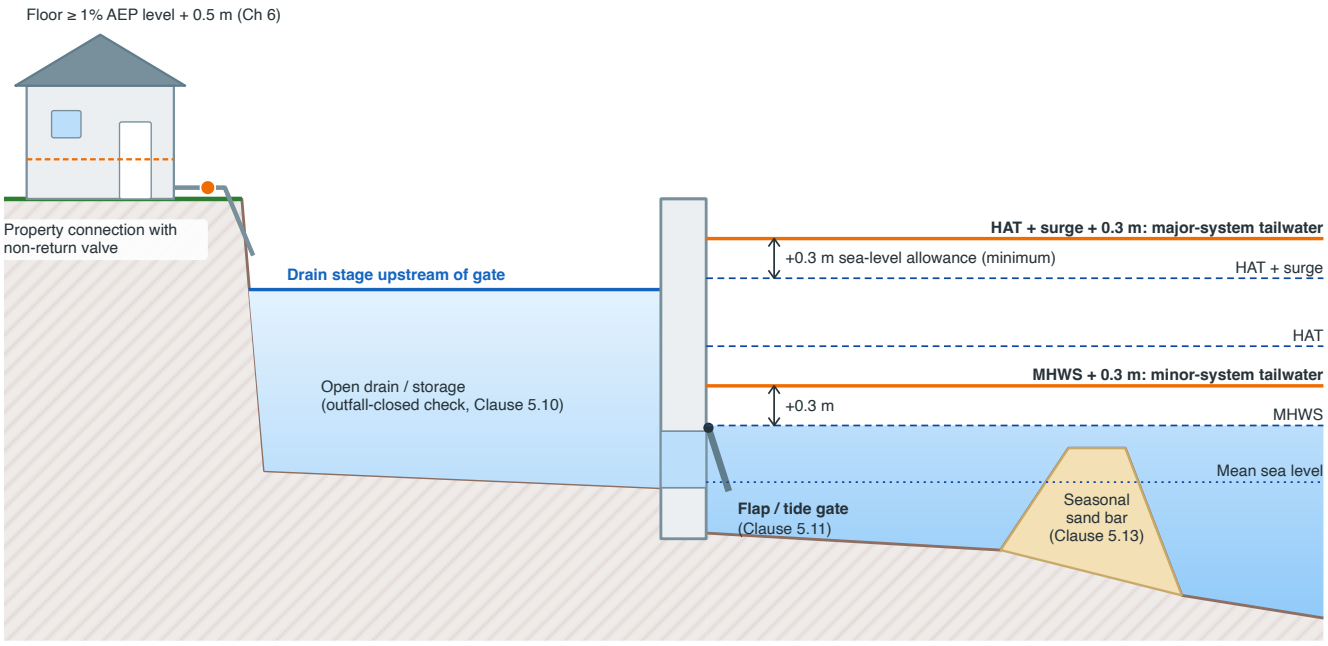

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater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

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

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

CPHEEO also says the joint probability of storm, tide and surge "should" be considered, with the state maritime board consulted. This Manual takes the upper end of each CPHEEO range, adds surge for the major system, and makes the joint case explicit (Clause 2.12). CPHEEO does not require surge to be added; this Manual adds it because the surge records of the coastal States showed why it is needed there; Assam has no coast, and the surge term does not arise in the State, whose rivers are held high by the floods of the Brahmaputra and the Barak, not by the sea (Clause 5.8.5).

> Indian tide tables have been published by the Survey of India since the nineteenth century (Survey of India, Tidal Predictions). Current Indian tidal predictions also appear in the NHO's tide tables. One port document describes the current edition as covering 95 Indian ports, based on NHO observations and on data from civil ports, NIO and INCOIS (Adani Ports, Dahej tide table 2025, citing NHO INP-12). INCOIS runs coastal tide gauges and issues storm-surge and swell-surge warnings. None of these is used for design in Assam, 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 **Brahmaputra** at every town on either bank, among them **Dibrugarh**, **Neamatighat** (Jorhat), **Tezpur**, **Guwahati** with North Guwahati and Amingaon, **Goalpara** and **Dhubri**, through the sluices and pumping stations in WRD's embankments and the town dykes (Clause 5.8.5(a));
- in **Guwahati**, the **Bharalu** and the **Bahini** to the Bharalumukh sluice, the **Mora Bharalu**, **Deepor Beel** and the **Khanajan**, the **Silsako** basin, the **Bondajan** with the Noonmati pump house, and the **Basistha**, the **Kalmani** and the **Lakhimijan** (Clause 5.8.5(b));
- the **DTP drain** of **Dibrugarh** past Larua Jamira beel to the **Sessa** sluice, the **Barak** at **Silchar** (Annapurnaghat) and **Badarpur** (Badarpurghat), the **Kushiyara** at **Karimganj**, and the rivers of **Hailakandi** (Clause 5.8.5(c));
- the tributaries with CWC sites, the **Jia Bharali**, the **Subansiri**, the **Burhidihing**, the **Dikhow**, the **Kopili**, the **Beki**, the **Manas**, the **Puthimari** and the **Pagladiya**, and the **Digaru**, the **Kulsi** and the **Krishnai** (Dudhnai) from Meghalaya (Clause 5.8.5(d));
- the release reaches of the **Ranganadi**, the **Subansiri**, the **Kopili**, the **Manas** and the **Umtru** below **Byrnihat** (Clauses 5.8.3 and 5.8.5(d));
- every beel, pukhuri, jan and retention pond that receives a town's drains, among them **Deepor Beel**, **Silsako**, **Borsola**, **Sorusola** and **Larua Jamira** beel (Clause 5.8.5(e));
- the juris and hill streams of the Guwahati fringe from Meghalaya, of the Karbi and Dima Hasao hills and of the north-bank foothills, and the **Jinjiram** where it comes down from the Garo hills (Clause 5.8.5(f));
- any drain or channel of GMC, GMDA, a Municipal Corporation or Board, a Development Authority, PWD or NHAI, and any drainage channel of a WRD drainage scheme, that receives storm water (Clause 5.8.5(g)); and
- elsewhere: any river or WRD channel listed in Annex 5B.

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

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

5.8.3 **Reservoir and tank releases.** Where a reservoir or tank upstream can release to the river (for example the Ranganadi project of NEEPCO in Arunachal Pradesh, above North Lakhimpur; the Lower Subansiri project of NHPC on the Subansiri; the Kopili project of NEEPCO at Khandong on the Kopili; the Kurichu dam in Bhutan, in the Manas basin; and the New Umtru dam in Meghalaya on the Umtru above Byrnihat), 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 through embankment sluices, Guwahati, dyke-protected and bowl towns, tributaries and dam-release reaches, beels and pukhuris, hill streams, and consents and lines.**

- (a) **River-locked outfalls through embankment sluices.** For an outfall to a river directly, through a sluice (pani-duwar) or flap gate in an embankment (mothauri), a town protection dyke or a wall, or through a drainage pumping station, or into a drain, jan or beel that itself discharges in one of those ways, the designer shall identify the body that operates each sluice, gate and pumping station, and obtain the sill of each gate, the crest of the embankment, dyke or wall, the installed pumping capacity and the operating levels, including the river level at which each sluice is closed. Every level shall state its datum and its connection to the gauge datum of the nearest CWC or WRD gauge, with its operator named. Most embankments and sluices in the State are WRD's: the CAG counted 4,474.42 km of embankments and 98 major and 545 minor sluices in March 2017 (CAG Report No. 5 of 2018), the WRD website gives 4,473.82 km and 94 major and 545 minor sluices (as quoted), a Lok Sabha answer of December 2024 gives 122 major and 545 minor sluices (as quoted), and a later ministerial reply cites about 4,800 km of embankments (as reported). These counts conflict and are not used for design; the designer shall take the record of the sluice concerned. WRD's sluice operating rules and closure durations were not found during research [TBC].
  - **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**, from a flood-frequency study or a hydraulic model under Clause 5.8.2(b). Assam has no floodplain zoning law, and no 1% AEP level has been published for any reach of any river in the State (Chapter 7) [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. The highest levels found during research (Table 5B.1), all as reported in SANDRP's 2019 transcription of CWC tables, with the datum not stated [TBC], are: the Brahmaputra at **Dibrugarh 106.48 m** (3 September 1998), **Neamatighat 87.37 m** (11 July 1991), **Tezpur 66.59 m** (27 August 1988), **Guwahati (DC Court) 51.46 m** (21 July 2004), **Goalpara 37.43 m** (31 July 1954) and **Dhubri 30.36 m** (28 August 1988); the Barak at **Annapurnaghat (Silchar) 21.84 m** (1 August 1989) and at **Badarpurghat 18.48 m** (11 September 2007); and the Kushiyara at **Karimganj 16.57 m** (10 June 2010). Where two values are reported for the same gauge, the higher applies until CWC confirms the level [TBC]: at Goalpara the HFL is also given as 37.35 m (13 July 2004), so **37.43 m** applies; at Dhubri a 2024 CWC bulletin is reported to give 30.37 m (17 July 2019) (as quoted), so **30.37 m** applies. Where a later flood has exceeded the listed level, the later level governs. The recorded level shall be transferred along the river with the water-surface slope of the flood that set it, from the CWC and WRD 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 (set by this Manual). An outfall upstream of every gauge on its reach shall not be designed without a modelled or surveyed profile [TBC].
  - **10% AEP level.** For the cases with the river at its 10% AEP level (Clause 5.8.4(a)), the level shall be taken from the same model or from a frequency analysis of the gauge record, and shall be not less than the **danger level** at the nearest gauge, transferred in the same way: 105.70 m at Dibrugarh, 85.04 m at Neamatighat, 65.23 m at Tezpur, 49.68 m at Guwahati (DC Court), 36.27 m at Goalpara, 28.62 m at Dhubri, 19.83 m at Annapurnaghat, 16.85 m at Badarpurghat and 14.94 m at Karimganj (CWC levels as reported) (set by this Manual). The datum of every CWC 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 sluice, gate, dyke or embankment, and the maximum level in the drain, jan or beel behind it, computed by routing it 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, including any part of the catchment in Meghalaya or another State, its storage as surveyed in its present condition, net of silt, 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 sluice only while the river is lower than the level behind it. A beel, pukhuri, jan or retention pond behind the sluice starts the storm **full to its outlet level** (item (e)). 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 and with the land behind the embankment ponded (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: the gate is closed for the **whole of the 72-hour storm** of Clause 5.10.2 and for as long after it as the coincident river level of Clause 5.8.4 stays above the gate sill, or above the level at which the sluice 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; where no stage record has been analysed, the lock is **not less than 7 days (168 hours)** on the Brahmaputra, the Barak and the Kushiyara and **not less than 72 hours** on a tributary (set by this Manual). The lock covers the whole of the 48- and 72-hour storms, so that storage and pumping handle the full storm volume (Clause 5.9.4). With the gate still closed, the volume stored in the storm shall be pumped down to the level at which the storm started within **48 hours** of the end of the storm, the drawdown time of Clause 4.7, so that the storage is ready for the next storm while the river stays high (set by this Manual). 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 or WRD gauge under Clause 5.10.6 shows it and the Authority approves it.
    - **Gate failure and breach.** Floor levels and pumped outfalls behind a sluice, dyke or embankment shall also be checked for the failure of the gate and for a breach of the embankment, with the land and drains behind it filled to the river level beyond it, as the Barak filled Silchar through the cut embankment at Bethukandi in June 2022 (item (c)).
- (b) **Guwahati.** For an outfall in the Guwahati metropolitan area (the Master Plan 2025 area of 328 km², on both banks), whose six drainage basins are the Bharalu, Dipar, Silsako, Foreshore, North Guwahati and Kalmoni basins (ADB IEE, 2017), and where "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB IEE, 2017):
    - **River level.** The Brahmaputra level at every outfall is that of item (a) at the **Guwahati (DC Court)** gauge, danger level **49.68 m** and highest flood level **51.46 m** (21 July 2004) (CWC levels as reported), transferred to the outfall, on the north bank at North Guwahati and Amingaon as well as on the south bank. On this Manual's reading the river reaches its danger level there in most monsoons, and its highest flood level is 1.78 m higher (NEER reading), so every outfall below the danger level is a river-locked case under item (a).
    - **The Bharalu–Bahini to the Bharalumukh sluice.** The Bahini rises in the Khasi hills of Meghalaya at Umtyrnga and runs 9.29 km to Jonali, where it becomes the Bharalu, which runs 6.2 km to the Brahmaputra at **Bharalumukh**; its catchment is about 120 km², about half of it hills, with about 10.94 km² draining the city (PCBA action plan for the Bharalu, as quoted; about 11 km² in a press article; the Bahini–Bharalu is given as 30.02 km long in another source, as quoted). The Bahini is "cut off by a sluice at Natun Bazar" (PCBA action plan). At Bharalumukh, "the natural discharge capacity of the Bharalu is 72 Cumecs when its Bharalumukh sluice gates are kept open, while the pumps fitted to its sluice gates can discharge only seven Cumecs" (2008, as reported); the present installed capacity was not found [TBC]. Every outfall in the Bharalu basin is river-locked under item (a) at Bharalumukh: the Bharalu and Bahini are routed as a closed storage with the inflow of their whole catchment, the Meghalaya part included, at the rainfall of the Guwahati catchment rule of Clause 2.3.6(c)(i), and with an outflow of no more than the permanent pumps at Bharalumukh that WRD confirms in writing are working, less the largest pump. The joint capacity of 52 m³/s for the Bharalu and Mora Bharalu "during the flood season" that resectioning was reported to give (as reported), and the automated Bharalumukh pumping station of the ₹1,459 crore project announced in May

2026 (Bharalu component ₹958.10 crore, as reported), shall not be counted until they are built and commissioned. The WRD dewatering pumps reported at the Bharalu, the Mora Bharalu and the Bondajan (as reported) are counted only where WRD confirms in writing that they are permanent and working.

- **The Noonmati–Bondajan system.** The Noonmati pump house is reported to have four pumps of 1,000 L/s that divert water through the Bondajan to the Brahmaputra, and an older station two pumps of 1,700 L/s (as reported). An outfall to the Bondajan, or to a drain that ends in it, shall route the Bondajan as a closed storage under item (a) with every pumped inflow to it included in its level (Clause 5.12.3).
- **The Mora Bharalu–Deepor Beel–Khanajan system.** The Mora Bharalu (reported capacity 45 m³/s, as reported) runs to Deepor Beel, which the Basistha and the Kalmani also feed and which drains to the Brahmaputra by the **Khanajan**. Deepor Beel holds about 10.1 km² of water all year and up to about 40.1 km² in floods (as reported); no stage–storage relation was found [TBC]. An outfall to the Mora Bharalu, the Basistha, the Kalmani, the Khanajan or Deepor Beel shall take as tailwater the beel's level under item (e), starting full, and in the coincident case the higher of that level and the Brahmaputra level of this item transferred to the Khanajan's outfall. No link between the Bharalu and Deepor Beel other than the Mora Bharalu shall be assumed. Deepor Beel is a Ramsar site (No. 1207, 2002, as quoted) and a wildlife sanctuary whose denotification the High Court stayed (order of 5 April 2024): no storage in it shall be credited to a project, and no drain shall be brought to it without the interception and screens of Clause 6.3.6(e) and Clause 8.9.
- **Silsako and the ADB Bahini works.** The ADB Assam Urban Sector Development Project provides, in the Bahini basin, 4.1 km of flood diversion channels, 4.7 km of drains, an increase in pumping capacity of 7.8 m³/s in three stormwater pumping stations and "a nature-based flood retention pond of 59,000 m3 and a pumping station with capacity of 1.6 m3 per second", with part of the runoff "diverted to a retention basin in the nearby Silsako Basin and gradually pumped out to the Brahmaputra River" (ADB RRP and PAM, 2025). None of these works shall be counted until it is commissioned and GMDA, the project's implementing unit, confirms its capacity in writing; once commissioned, the retention pond and the Silsako retention basin start every design storm full to their outlet levels under item (e), and their pumps are credited under item (a). The project's target of avoiding inundation "from a 1-in-5-year storm or lower return period" and its "design storm of 65.72 mm hour" (ADB PAM, 2025) are not design values under this Manual (Clause 2.3.6(o)).
- **Hill streams and the master plan.** The Basistha, the Kalmani, the Bahini above Jonali and the streams of the Khanapara–Jorabat fringe, where they come down from the hills, are hill streams under item (f). The comprehensive drainage master plan and DPR for Guwahati that GMDA engaged Haskoning DHV to prepare (Gauhati High Court, PIL/14/2024, order of 23 September 2024) were under revision and not final when research was done (as reported); where they publish a design level for an outfall, the higher of that level and the level of this item governs, until the Authority accepts the plan's levels [TBC]. The storm-water drainage report prepared by Tahal in 2008 was not built (as reported) and gives no level used here.

- (c) **Dyke-protected and bowl towns.** For an outfall in a town that drains through a dyke or embankment to a river higher than itself:
  - **Dibrugarh.** "To protect the town, the 8.62-km DTP dyke was constructed in 1955. The construction of the DTP dyke closed all the drainage channels", and "At present, Dibrugarh town is 1.5 m below the bed level of Bramhaputra"; the town drains by the DTP drain, which runs 32.053 km past **Larua Jamira beel** to the **Sessa**, with capacities of 105.50, 142.97 and 61.11 m³/s by reach and "sewage flows" from a major part of the town; its outfall sluice is to be rebuilt as "two numbers of radial automatic sluice", with backwater "at the sluice with a flood level of 97.50 m", and was designed "keeping in mind that the beel is full and the drain is also flowing full" (ADB IEE for the Dibrugarh DTP drain outfall, 2017). An outfall to the DTP drain, or to a drain that ends in it, shall be river-locked under item (a) at the Sessa sluice, with a tailwater at the sluice not less than **97.50 m** (the IEE's flood level; its datum and its tie to the CWC gauge at Dibrugarh are to be confirmed [TBC]), Larua Jamira beel full to its outlet and the drain flowing full at the start of the storm, as the IEE assumes (set by this Manual). No outfall through the DTP dyke to the Brahmaputra shall be designed to discharge by gravity at any river level above its invert, and the Brahmaputra level there is that of item (a) at the Dibrugarh gauge. The radial automatic sluices shall not be counted until they are commissioned.

    - **Silchar.** Silchar is a bowl behind the Barak embankment, and its gauge is the Barak at **Annapurnaghat**, danger level **19.83 m** and highest flood level **21.84 m** (1 August 1989) (CWC levels as reported). In June 2022 the river crossed its danger level there on 18 June, rising from 19.62 m to 20.98 m in 24 hours, and peaked at **21.59 m** on 21 June between 14:00 and 18:00 (Cachar district flood management report, 2022, as quoted): 1.76 m above the danger level and 0.25 m below the 1989 record (NEER arithmetic). The town flooded through a cut in the embankment at **Bethukandi** (an FIR was registered for a breach of 23 May and one person was arrested; the Chief Minister called the flood "man-made"; an official said the breach made little difference at that river level; all as reported) and was under water for about 11 days, up to about 4 m deep in places (as reported; "about a week" in another report). It was a breach-and-ponding flood inside the embankment, not a record river stage. Every outfall in Silchar is river-locked under item (a) at Annapurnaghat, and floor levels, pumped outfalls and storage there shall be checked for a breach with the enclosed area filled to the Barak level beyond the embankment (set by this Manual). The town's outfall channels (among them the Ghagra, Singla and Longai channels) and any pumps on them were not researched [TBC]. The Barak valley has about 731 km of embankments (as quoted), of which 450 km are reported to be "extremely vulnerable" (as reported).
    - **Karimganj, Badarpur, Hailakandi and the other embanked towns.** At Karimganj the river level is that of the Kushiyara at the **Karimganj** gauge, and at Badarpur that of the Barak at **Badarpurghat** (item (a)). No CWC level for Hailakandi was found; ASDMA listed the Dhaleswari at Gharmura and the Katakhal at Matizuri among the rivers above danger level on 4 July 2024 (ASDMA daily flood report), and their levels are to be obtained [TBC]. Every other town that drains through a WRD embankment, among them Dhubri, Goalpara, Tezpur, North Lakhimpur and the towns of the Jorhat side of Neamatighat, is river-locked under item (a) at its nearest gauge.
    - **Char and chapori land.** No outfall structure, sluice or pumping station shall be built on active char or chapori land or on an eroding bank, which are hazard-first sites under Clause 2.3.6(i); a drain there discharges to the nearest stable outfall, and floor levels govern.
- (d) **Tributaries with CWC sites, and dam-release reaches.** For an outfall to a tributary of the Brahmaputra or the Barak, or to a drain that ends in one:
    - **Tributary levels.** Item (a) applies, with the lock of item (a) for a tributary. The levels found during research (Table 5B.1), as warning, danger and highest flood levels, are (SANDRP's 2019 transcription of CWC tables, as reported, datum not stated [TBC], except where another source is named): the Jia Bharali at NT Road Crossing 76.00, 77.00 and 78.50 m (26 July 2007); the Subansiri at Badatighat 81.53, 82.53 and 86.21 m (28 July 1972); the Burhidihing at Naharkatia 119.40, 120.40 and 122.69 m (17 June 1973) and at Chenimari (Khowang) 101.11, 102.11 and 104.16 m (2 September 2015); the Dikhow at Sivasagar 91.40, 92.40 and 94.23 m (1 August 2018); the Kopili at Kampur 59.50, 60.50 and 61.79 m (20 July 2004) and at **Dharamtul 55.00, 56.00 and 58.09 m** (21 July 2004) (CWC daily flood bulletins of 3 and 4 July 2024, as quoted); the Beki at Road Bridge 44.10, 45.10 and 46.20 m (4 August 2000); the Manas at NH Crossing 47.81, 48.42 and 50.08 m (15 September 1984) and at Mathanguri 98.10 and 99.10 m, with a highest flood level given as 100.28 m in one list and 102.28 m in another (30 October 1973), so that **102.28 m** applies until CWC confirms it [TBC]; the Puthimari at NH Road Crossing 50.81, 51.81 and 55.08 m (31 August 2008); and the Pagladiya at NT Road Crossing 51.75, 52.75 and 55.45 m (8 July 2004). The level-monitoring sites have a highest level only: the Burhidihing at Margherita 137.51 m (26 August 1988), the Dikhow at Bihubar 104.77 m (24 June 1998), the Kopili at Kheronighat 74.07 m (19 July 2004) and the Manas at Panbari 55.96 m (7 July 1991); there the 10% AEP case uses the design river level until a frequency analysis is accepted (set by this Manual). The Digaru at Sonapur, the Kulsi and the Krishnai (Dudhnai), which come down from Meghalaya, have level-monitoring sites with no published level (as reported) [TBC]: on them, and on any reach with no gauge level, the river level is the higher of a modelled level under Clause 5.8.2(b) and the highest flood level surveyed at the outfall from flood marks and from the records of WRD, the local body or the Deputy Commissioner, with its source stated, and no outfall shall be designed without one of them (set by this Manual). An outfall structure on the Kopili shall be designed for the pH measured in the river at the outfall, because acid drainage from mining in its Meghalaya catchment has been reported (a 2014 petition, as reported).

    - **Consent and levels of the operator.** Storm water shall not be discharged to a reservoir or its release reach without the written consent of its operator. The operator's levels shall be used as it gives them in writing; a level given in feet shall be converted at **1 ft = 0.3048 m** exactly, with the conversion and the datum stated on Form 5-1.
    - **Release reaches.** For an outfall to a river below a dam, among them the **Ranganadi** below the Ranganadi project of NEEPCO in Arunachal Pradesh, the **Subansiri** below the Lower Subansiri project of NHPC, the **Kopili** below the Kopili project of NEEPCO at Khandong, the **Manas** below the Kurichu dam in Bhutan, and the **Umtru** below Byrnihat, on the reach below the New Umtru dam in Meghalaya, in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) and the 72-hour storm shall be run with the river at the level that results from the largest recorded release of the dams above, routed to the outfall, with the flow of the catchment below them as it occurred, and with the release placed before, during and after the site storm, and the lock of item (a) applies for not less than 72 hours (set by this Manual). The releases are, until the operator states a larger recorded release and its duration: on the Ranganadi, **1,412.57 m³/s**, the release of 2017 recorded in an IIT Guwahati report for ASDMA (February 2018, as quoted), when an inflow of about 1,511 m³/s followed rain from 30 June and NEEPCO used 200 m³/s for power (as reported); a release of 605.25 m³/s through one gate is reported for an undated event (as reported); on the Umtru, **3,820 m³/s**, the spillway capacity of the New Umtru dam, whose maximum water level is 132.78 m and whose release reach runs 9.80 km to the Byrnihat bridge (MePGCL guideline, as used in the Meghalaya edition of this Manual); and on the Subansiri, the Kopili and the Manas, the operator's spillway design capacity in writing, because no release record, commissioning date for the Lower Subansiri or operating rule was found for any of them [TBC]. An undated report of an expected "discharge around 16000 cumec … from upstream in Subansiri river" (as reported) is not a release record and is not used. No attenuation by the storage of any reservoir shall be credited to the river below, and no dam gate shall be assumed to open earlier or wider than the operator's records show. Catchments that drain to a release reach take the AMC that Chapter 3 sets for them.
    - **Warnings are not notices.** No design shall rely on a notice or a warning of a release, on a reservoir being drawn down before a storm, or on a gate being opened early, late or partly: the release scenarios of this item govern (set by this Manual).
- (e) **Beels and pukhuris as receiving storage.** For an outfall to a beel, a pukhuri, a jan or a retention or detention pond, directly or through a drain that ends in it, among them Deepor Beel, Silsako, Borsola and Sorusola in Guwahati and Larua Jamira beel on the DTP drain at Dibrugarh:
    - **Starting level.** The waterbody starts every design storm **full to its outlet level**: the crest of its outlet weir, the sill of its sluice or the invert of the jan that drains it, or, where it has no defined outlet, its highest monsoon water line surveyed and tied to a Survey of India benchmark, and in every case not less than the highest level recorded at it, as the Dibrugarh DPR assumed "that the beel is full and the drain is also flowing full" (ADB IEE, 2017) (set by this Manual).
    - **Design level.** The tailwater for the major-system and storage cases is the level reached when the inflow of the waterbody's whole catchment is routed through its stage–storage relation from that starting level, with its outlet closed for as long as the river or jan beyond it stands above the outlet (item (a)), and with the project's discharge included (Clause 5.12.3). The stage–storage relation shall be surveyed: none was found for Deepor Beel or any other beel or pukhuri in the State [TBC]. The minor-system tailwater is the starting level.
    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall is closed for the whole storm (Clause 5.9.4), and where the waterbody itself drains through a river-locked outlet, the lock of item (a) applies to both.
    - **Storage is the system's.** Under the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024, a waterbody is land "where the rain water accumulates and act as natural or storm water reservoir", with its inflow and outflow channels (s.2(d) of the Bill; the enacted Act's text was not read [TBC]). The storage of a beel or pukhuri is part of the drainage system: it shall not be credited to one project, and no project shall reduce it (Chapter 7). A pukhuri with no outlet is a closed basin, and an outfall to it is closed for the whole storm. Engineered storage is a detention pond, never a pukhuri or a beel. No drain that carries sewage shall discharge to a beel or pukhuri without the interception and screens of Clause 6.3.6(e) and Clause 8.9.

- (f) **Hill streams from Meghalaya and the hill districts.** For an outfall to a juri or another hill stream, such as the Bahini above Jonali, the Basistha, the Kalmani and the streams of the Khanapara–Jorabat fringe of Guwahati, which rise in the Khasi hills of Meghalaya, the Digaru, the Kulsi, the Krishnai (Dudhnai) and the Jinjiram where they come down from Meghalaya, the streams of Haflong, Diphu and the other towns of the Karbi and Dima Hasao hills, and the foothill streams of the north bank across the bhabar fans, or to a drain that ends in one:
    - **Design level.** These streams have no gauge or published flood level [TBC]. 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, including the part in Meghalaya, with the rainfall of its sub-area in Annex 2A and, for the streams of the Guwahati fringe, the Guwahati catchment rule of Clause 2.3.6(c)(i), the bulking factor of Clause 6.3.6(g) on the peak flow, and the crossings downstream blocked as Clause 6.3.6(h) requires, routed through a hydraulic model of the channel as surveyed, net of encroachment, silt and solid waste; (ii) the level at the outfall of any flood study of the stream made by or for WRD, GMDA or the local body [TBC]; and (iii) the highest flood level surveyed at the outfall from flood marks of the storms of 14 June 2022, 31 May 2025 or 20 April 2026 or of a later flood, and from the records of the local body, WRD or the Deputy Commissioner, with its source stated. No outfall to such a stream shall be designed without items (i) and (iii) (set by this Manual). The Meghalaya edition of this Manual governs the reaches in Meghalaya.
    - **Bed level and siting.** The designer shall survey the bed at the outfall and for at least 100 m upstream and downstream and state the range within which it has moved. The outfall invert, and the seat of any flap gate on it, shall stand at least **0.5 m above the highest bed level** found within 50 m downstream, the foundation shall be taken below the scour depth of Chapter 9 (Clause 9.6) for the 1% AEP flow with the bulking factor, and the outfall shall be built into the bank and not project into the active channel (set by this Manual). Where a hill stream drops its load on reaching the plain, the silt trap of Clause 6.3.6(m) shall be placed above the outfall. On the bhabar fans, where the streams carry boulders and shift their channels, an outfall in the path of a channel shift is a hazard-first site (Clause 2.3.6(i)).
    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall-closed check of Clause 5.10 applies with a single lock that lasts for the design storm plus the stream's recession, computed under item (i) for as long as the stream stays above the invert, and **not less than 24 hours**; where no hydrograph of the stream has been computed, the lock lasts for the whole storm (set by this Manual). Where the hill stream itself ends at a river-locked sluice, as the Bahini does at Bharalumukh, the lock of item (a) governs.
- (g) **Consents and lines.** No outfall structure, gate, pumping station or drain shall cut, cross, alter or discharge through an embankment, sluice or drain under the Assam Embankment and Drainage Act, 1953 without the permission of WRD (its Embankment Officer) or the Deputy Commissioner: in a notified area, building on, removing or altering an embankment or drain without that permission is punishable with up to three years and a fine of ₹1,000 (s.16); cutting through an embankment or drain, or opening, shutting or obstructing a sluice, without authority is punishable in the same way (s.15(ii)); the Embankment Officer may remove or alter a work that endangers a town or interferes with drainage (s.4); and PWD and the Public Health Department are to be consulted (s.18). No written procedure or form for this permission was found during research [TBC]. Storm water shall not be discharged to a drain of another body without the written consent of that body: in Guwahati, no person may without permission make or alter a drain leading into a drain vested in GMC (Gauhati Municipal Corporation Act, 1969, s.242), and the Commissioner's power to make municipal drains empty into any place (s.232) is a power, not a duty to provide an outfall; in the area of another Municipal Corporation, the Corporation's duty to "provide a safe and sufficient outfall … for effectual drainage and proper discharge of storm-water and sewage" without flooding the area or "the areas surrounding the outfall" (Assam Municipal Corporation Act, 2022, s.171) and its power to restrict discharges into its drains (s.177) apply; to a road drain or culvert, the consent of PWD or NHAI; to a work of GMDA, that of GMDA; to a drain of the Railways, OIL, the Army or another body, that body's; and in an Autonomous District, that of the District Council or the body it designates (set by this Manual). Where consent is given, the discharge shall not exceed the rate the consent allows; the tailwater is the higher of the channel's design water level as its owner states it in writing and its level in the coincident case of Clause 5.8.4, computed from all the storm water it receives and with its downstream boundary at the level of items (a) to (f); the channel shall be taken in its present condition, net of silt, encroachment, solid waste and weed, and a

widening, resectioning or diversion that has been proposed but not completed shall not be counted; and the outfall shall have a flap gate (Clause 5.11) where the design water level or the computed level is above the outfall invert. The designer shall also check the outfall against the lines that bind at the time of design (Chapter 7): the building setbacks from "the edge of natural drainage channels" and water bodies of the Unified Byelaws 2022 (byelaw 26(ix), repeated as 44(ix) [TBC: numbering read from the OCR layout; confirm against a clean copy]); the no-construction buffer round scheduled water bodies that the District Level Committees are to ensure (s.5 of the 2024 Bill), the bar on obstructing the inflow and outflow of a waterbody without permission (s.15 of the Bill), and, in Guwahati, the four schedules of the Guwahati Waterbodies (Preservation and Conservation) Act, 2008, which the 2024 Bill repeals (s.22; the enacted text is to be confirmed) [TBC]; the bar on altering an ecological site, which includes "a drainage system, feeding channel", in a Designated Area under the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 (s.3), no designated-area notification of which was found [TBC]; the 15 m no-construction strip from the Brahmaputra bank on the riverfront stretch of the Master Plan for Guwahati 2025 between Sonaram High School and the Kamakhya foothills; and the plinth of byelaw 45(c), "0.3 m higher than the highest recorded flood level as fixed by the local authority" (0.6 m for lifeline buildings), for which no local authority's level was found for any town [TBC], so that the 1% AEP level of this clause and the floor levels of Clause 6.11 govern. Assam has no floodplain zoning law; a proposed Assam Flood Plain Zoning Bill was reported in November 2026 (single report, as reported) and is not applied by this clause.

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

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. Assam's rivers and towns break that assumption, because the same monsoon spell fills the rivers and falls on the towns behind them. In June 2022 rainfall over Assam and Meghalaya, 858.1 mm, "was highest since 1901" (IMD, June 2022 monthly summary); Guwahati flooded on 14–15 June, the Barak at Annapurnaghat crossed its danger level on 18 June, Cachar recorded 251.20 mm on 19 June (Cachar district report, as quoted), and the river peaked at 21.59 m on 21 June while Silchar lay flooded behind its embankment (as quoted). On 4 July 2024 the Brahmaputra was above its danger level at Neamatighat, Tezpur, Guwahati, Goalpara and Dhubri, with the Kopili, the Barak, the Kushiyara and other rivers (ASDMA daily flood report). Several of the State's 24-hour rainfall records are May storms, before the south-west monsoon (IMD *Extremes*), so the coincident case is not confined to June–September. 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 upstream of Assam's north-bank and hill-fringe towns, none of which is operated by a body of the State. The **Ranganadi** project of NEEPCO, in Arunachal Pradesh, is reported to divert 160 m³/s to the Pare basin (as reported); in 2017, after rain from 30 June, its inflow was about 1,511 m³/s, of which NEEPCO said 200 m³/s was used for power and the rest could not be absorbed (as reported), and an IIT Guwahati report for ASDMA (February 2018) records a release of 1,412.57 m³/s (as quoted); the guide dam or ring dyke was reported breached (as reported), a release of 605.25 m³/s through one gate is reported for an undated event (as reported), and releases were also reported after Cyclone Remal in May 2024 (as reported). For the **Lower Subansiri** project of NHPC, the commissioning date and release rules were not found [TBC], and the only figure found is an undated report of an expected "discharge around 16000 cumec … from upstream in Subansiri river" when both projects opened their gates (as reported), which is not a release record. No level or release record was obtained for the **Kopili** project of NEEPCO at Khandong or for the **Kurichu** dam in Bhutan, in the Manas basin [TBC]. On the **Umtru**, the New Umtru dam in Meghalaya, with a maximum water level of 132.78 m and a spillway

of 3,820 m³/s, releases through 9.80 km of ravine to the Byrnihat bridge, below which the river runs into Assam; its operator's guideline says that, because the reservoir is very small and its gates are opened often, "issuing the notification for release of water is not practicable", and that warnings may be given by siren, telephone or SMS (MePGCL guideline, as used in the Meghalaya edition of this Manual). No operating rule that bounds a release, and no release record other than the Ranganadi's, was obtained for any of these dams [TBC]. Until they are available, Clause 5.8.5(d) uses the largest recorded release or the spillway design capacity, with the flow of the catchment below the dam as it occurred in the same event. The river levels used in this Manual come from SANDRP's transcription of CWC tables and, for the Kopili at Dharamtul, from CWC's daily flood bulletins; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Assam the tailwater at a town outfall is set not by the tide but by a river held above the town behind an embankment, by a gated channel whose pumps are a tenth of its gravity capacity, by a beel that is already full, by the release of a dam, or by a hill stream in spate, and no document found during research gives a design level or a closure duration for any of them. No design standard for any town drain in the State was found either: the town drainage master plans of DoHUA "were prepared before 2015 as per previous FPS system" and await revision to the CPHEEO guideline of 2015 (DoHUA status sheet); Dibrugarh's DTP drain was designed by a "rainfall based approach … rational method" with no return period stated (ADB IEE, 2017); and the only return period found in an official document is the ADB project's 1-in-5-year target for the Bahini basin (ADB PAM, 2025). The State has no floodplain zoning law and no published 1% AEP level for any reach (Chapter 7).

The first case is the river-locked outfall. Item (a) follows the river-locked form of the plains editions of this series: the operator, the sills, crests, pumps and closing levels, every level tied to a gauge, and a design level never below the highest level recorded at the nearest CWC gauge. All the CWC levels used come from SANDRP's transcription of CWC tables, with no datum stated, so each is "as reported" and the datum is to be confirmed. Where the sources give two highest levels for one gauge (Goalpara, Dhubri, the Manas at Mathanguri), the higher governs until CWC confirms one, because a tailwater set too low floods the town, while one set too high only costs storage. The lock is the heart of the clause. The brief rule, that the gate is shut for the whole 72-hour storm and for as long after it as the river stays above the sill, comes from the case it describes: WRD itself names "back flow and congestion near outfalls" from the high stages of the Brahmaputra and Barak as a cause of "prolonged inundation" (as quoted by the CAG, 2018). Where no stage record has been analysed, the minimum on the main rivers is 7 days, because on this Manual's reading the Brahmaputra at Guwahati reaches its danger level in most monsoons and its highest level is 1.78 m higher, and because Silchar was under water for about 11 days in 2022 (as reported; "about a week" in another report); 7 days is the shorter of the two Silchar figures, and the same minimum lock that another plains edition of this series sets for its river-locked cities. On a tributary, which rises and falls faster, the minimum is 72 hours, the length of the longest design storm, as the hill editions of this series set for their rivers. The receiving beel or pond starts full because the Dibrugarh DPR, the only design of a town outfall found in the State, assumed exactly that, and because a beel that has filled in the first storm of a spell is full for the next. The pump-down of 48 hours with the gate still shut is the drawdown time of Clause 4.7: storage that is still full when the next storm of the same high stage arrives fails in the event that matters more. Pumps are credited only as permanent, working and confirmed, less the largest unit, because the city's own record shows how far they fall short: 7 m³/s of pumps against 72 m³/s by gravity at Bharalumukh (2008, as reported). A designer with an analysed CWC stage record can justify a different lock under Clause 5.10.6.

The second and third cases are Guwahati and the dyke-protected towns. Item (b) names the city's systems because the State's capital drains through them, because their gates and pumps belong to WRD while the channels above them belong to GMC and GMDA, and because the projects that will change them, the ADB Bahini works and the ₹1,459 crore Bharalu and Bahini project, were not commissioned when research was done; the clause counts them only once they are. Deepor Beel is the western city's storage, but it is also a Ramsar site and a sanctuary, so item (b) lets no project take credit for its volume. Item (c) takes the Dibrugarh DPR's own design flood level and its full-beel assumption, and treats Silchar as a breach case: the 2022 flood came through a cut

embankment at a river level 0.25 m below the 1989 record, so a design that checks only the river level and not a breach misses the flood that happened. A cut such as that at Bethukandi is what s.15(ii) of the Embankment and Drainage Act, 1953 punishes; the Manual's breach check does not depend on whether a cut is lawful.

The fourth case is the tributary and the release reach. Item (d) applies the river rule of item (a) to the tributaries and the reservoir and release-reach rule of the hill editions of this series to the dams upstream of the north bank and the hill fringe: the largest recorded release, or the spillway capacity until the operator gives one, placed before, during and after the site storm, with no credit for warnings, drawdown or attenuation. The Ranganadi's release of 2017 is the only release record found for a dam above an Assam town. The Kopili at Dharamtul is given as 58.09 m (21 July 2004), the value printed in CWC's daily flood bulletins of July 2024; the Meghalaya edition uses the same value for the river where it leaves that State.

The fifth case is the beel and the pukhuri. Item (e) treats them as storage that belongs to the drainage system and starts every storm full to its outlet. The law already treats them so: the 2008 Guwahati Waterbodies Act and the 2024 Bill both define a waterbody as land "where the rain water accumulates and act as natural or storm water reservoir" (Chapter 7). No stage–storage relation was found for any beel, so the clause asks for a survey rather than a figure.

The sixth and seventh cases are the hill streams and the consents. Item (f) follows the hill-stream rule of the hill and mountain editions of this series for the streams that come down to Guwahati from the Khasi hills and for the hill districts: a study with the bulking factor, surveyed flood marks, an invert at least 0.5 m above the highest bed level and a lock of at least 24 hours, because these streams fall within hours of the rain stopping. Item (g) asks for WRD's permission and the owner's consent because a design that discharges through an embankment or into another body's drain cannot be checked without them, and because no rule divides the drains of the State's towns (Chapter 6). The lines of item (g) decide where an outfall can be built, not its level: the byelaw setbacks, the water-bodies law, the Hill Land Act and the Master Plan's riverfront strip bind where they apply, and the floor levels follow Clause 6.11 because no local authority has fixed the "highest recorded flood level" that byelaw 45(c) refers to.

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 ≤ 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.

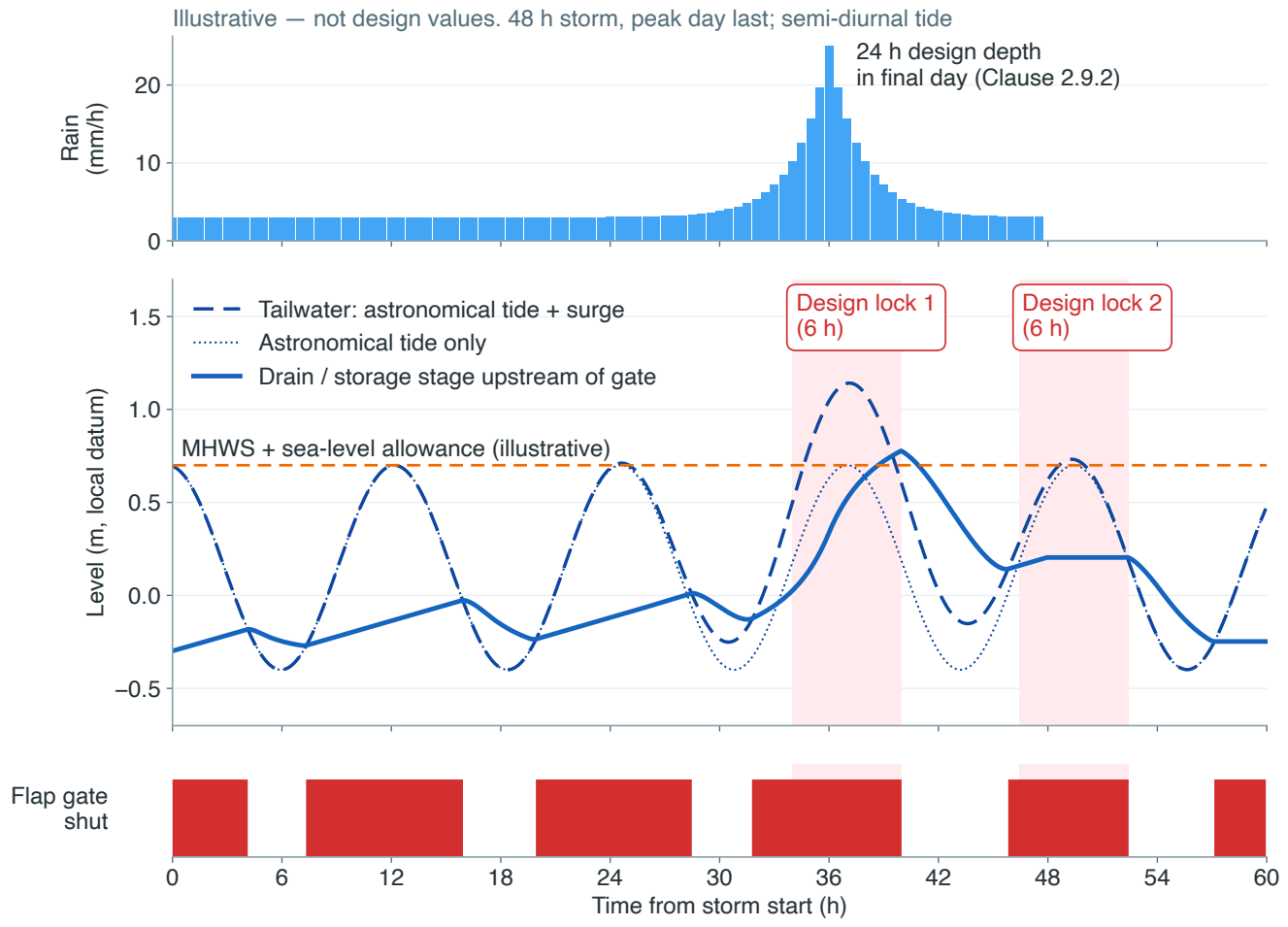

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal 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 Assam requirement in this Manual. In Assam it applies where an outfall is shut not by the tide but by a river held above the town for days or weeks behind an embankment sluice, by a gated channel whose pumps are far smaller than its gravity capacity, by a beel or pond that is already full, by the release of a dam upstream, or by a hill stream in spate. At Guwahati the Brahmaputra reaches its danger level of 49.68 m at the DC Court gauge in most monsoons on this Manual's reading, with its highest flood level of 51.46 m 1.78 m higher (CWC levels as reported), so the city's outfalls are designed for gates closed for days to weeks; and the Bharalu then drains through pumps reported at 7 m³/s against 72 m³/s by gravity (2008, as reported); at Dibrugarh the DTP drain's outfall sluice was designed with "the beel … full and the drain … also flowing full" (ADB IEE, 2017); and Silchar stayed under water for about 11 days in June 2022 (as reported; "about a week" in another report). That is why Clause 5.8.5 replaces the two 6-hour windows described below with a gate closed for the whole 72-hour storm and for as long as the river stays above the sill, not less than 7 days on the Brahmaputra, the Barak and the Kushiyara and not less than 72 hours on a tributary or a release reach where no stage record has been analysed; a beel or pond full to its outlet at the start; a pump-down within 48 hours with the gate still shut; and a lock of at least 24 hours at a hill-stream outfall. 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 **31 March** each year;
- after every event in which they closed against a storm flow; and
- as set in the maintenance plan (Chapter 10).

> Commentary. The requirement for gates below the 1% still-water level is set by this Manual. The construction details follow common coastal-drainage practice. A gate that is jammed open by debris lets the tide into the drain. A gate held shut by a sand bank turns a gravity outfall into a dead end. In Assam the outfalls do not cross a beach, but most town outfalls pass through a sluice in a WRD embankment or a town dyke, and the gates, flap gates and pumps on them are the towns' defence against the rivers. When the Brahmaputra is high the Bharalumukh sluice gates are closed and the Bharalu drains only by its pumps: "the natural discharge capacity of the Bharalu is 72 Cumecs when its Bharalumukh sluice gates are kept open, while the pumps fitted to its sluice gates can discharge only seven Cumecs" (2008, as reported; the present capacity was not found [TBC]). In May 2022 the Barak embankment at Bethukandi, upstream of Silchar, was cut, and in June the river entered the town through the cut (as reported); cutting through an embankment, or opening, shutting or obstructing a sluice, without authority is punishable under s.15(ii) of the Assam Embankment and Drainage Act, 1953. The embankments and sluices are WRD's, while the drains behind them are GMC's, a Municipal Corporation's or Board's, PWD's or GMDA's, and WRD's sluice operating rules and closure durations were not found during research [TBC], so a gate and the drains behind it can belong to different bodies. The 31 March inspection date is set ahead of the 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 **31 March** each year. Private pumped systems shall be covered by a registered maintenance declaration (Chapter 10).

> Commentary. Duty + standby, 72 hours of fuel and flood-immune electrics have no single direct precedent and are set by this Manual. The 72-hour fuel figure matches the longest mandatory design storm (Clause 2.5.2). A pump station that depends only on grid power can stop exactly when it is needed, because supply to flooded areas is often switched off for safety. Singapore's April 2025 amendments added annual maintenance declarations for pumped detention tanks (PUB Addendum No. 3). Clause 5.12.9 and Chapter 10 adopt the same approach. Clause 5.12.3 prevents pumping that simply moves water from one tide-locked drain into a tide-locked river.

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

5.13.2 **Assumption at the start of the monsoon.** The mouth shall be assumed **closed** by a bar at the start of the April–October season, at the crest level of the most recent pre-monsoon survey. This applies unless the Water Resources Department certifies that:

- a mouth-maintenance programme (dredging, bar cutting or training walls) has kept the mouth open at the start of each of the previous three monsoon seasons; and
- the programme is funded for the current season.

5.13.3 **Tailwater with a closed mouth.** With the mouth closed, the tailwater at the outfall shall be the higher of:

- (a) the tidal tailwater of Clause 5.7; and
- (b) the level in the river reach behind the bar, computed with the bar as a weir at its surveyed crest level. That level shall include the river flow of Clause 5.8 and the head needed to pass the flow over or through the bar.

5.13.4 **No credit for emergency cutting.** Bar cutting or breaching during the storm shall not be assumed in design, unless the Water Resources Department has a documented operating procedure, with equipment stationed for it. Where it does, the bar may be assumed lowered to the procedure's target level only after the time the procedure states.

5.13.5 **Outfall-closed check.** Where the closed-mouth level of 5.13.3(b) exceeds the outfall invert for longer than the default lock windows, the lock duration of Clause 5.10 shall be extended to that period.

> Commentary. Assam 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 silt that the Brahmaputra and the hill streams leave at an outfall or a gate, and the chars that the river builds and moves. In Guwahati "Most of the drains directly or indirectly fall into Bharalu River … due to siltation, the bed level of the river has considerably risen", and "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB IEE, 2017); GMC spent ₹32.57 crore on desilting from 2013–14 to 2017–18 (CAG Report No. 4 of 2019); and the char and chapori lands of the river cover about 3,60,927 ha in 2,251 villages (Socio-Economic Survey 2002–03, as quoted). A flap gate held open or shut by silt, sand or waste, an outlet buried by a rising bed, or a sluice that cannot be moved turns a designed outfall into a dead end or a back-flow path. No WRD rule linking the operation of any sluice to the levels of the drains behind it was found during research [TBC]. Clause 5.8.5 deals with this by setting hill-stream outfalls above the range of bed movement, keeping outfall works off active char land, and giving no credit for a gate operation, a pump 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 WRD certification, where relevant (Clause 5.13); and
11. inspection and maintenance requirements for Chapter 10.

Small sites under Clause 5.3.4 shall submit Form 5-2 (Simplified Downstream Statement) instead.

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Annexes and forms

Annex / Form	Content
5A	Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment
5B	Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map
5C	Worked example: outfall-closed check for a site on the hill fringe of south Guwahati draining to the Bahini
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) Assam 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. Assam's drains were not designed against any State or municipal standard: none was found during research, and no document found gives a design return period, runoff coefficient or drain size for any town, apart from the ADB project's target of avoiding inundation "from a 1-in-5-year storm or lower return period" in the Bahini basin (ADB PAM, 2025). The town drainage master plans of DoHUA "were prepared before 2015 as per previous FPS system" and await revision to the CPHEEO guideline of 2015 (DoHUA status sheet), and no design criteria appear in the status documents read. The networks are small: "Assam's stormwater drainage network in ULBs covers only about 30% of the required areas" (ADB RRP, 2025); the CAG found storm-water drainage coverage of "3 to 37 per cent only" in the ULBs it checked, and 14 waterlogging points in Guwahati that flooded six to seven times a year (CAG Report No. 4 of 2019); and "Apart from 17 kilometres of drains built between 1973 and 1997, no other extensive and planned drainage network exists in the Guwahati Metropolitan Area" (as reported). The drains also work in a setting that the other plains editions of this Manual meet only in part. On the plains they end at sluices in embankments, behind rivers that stand above the town for days, and they carry the towns' sewage, because no town has sewers. At Guwahati they also collect water from the Khasi hills of Meghalaya and from the city's own hills, where "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB IEE, 2017). They end in jans (Assamese জান: streams or natural drainage channels, often the outlets of beels, as in Bondajan and Khanajan), juris (Assamese জুৰি: small hill streams) and beels whose margins have been filled. And they are divided among owners: GMC and the other local bodies, GMDA, PWD, NHAI, WRD, the Railways, OIL and the Army all build or hold drains and receiving waters in

> Guwahati, and the ADB names "fragmented institutional responsibilities" as the problem (ADB RRP, 2025; 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 **Drains that carry sewage, and hill and foothill drains.** No town in Assam has a sewerage system, so the public drain that receives storm water from a site or a public drainage project normally also carries sewage and sullage (Clause 8.9); and in the hills and on the hill fringe the drains also carry silt, gravel and debris. This chapter applies to the storm-water system up to the point of connection and to every public drain, with the following additions (all set by this Manual).

Items (a) to (e) apply wherever the receiving drain carries dry-weather flow of sewage or sullage, whatever its owner calls it:

- (a) **Separation on site.** Storm water and sewage shall be collected in separate systems within the site, each with its own last inspection chamber at the site boundary, so that the storm-water system can be connected to a separate public storm drain, without rework on the site, when one is built or when the sewers of the area are commissioned. Where the Authority allows only one connection to the receiving drain, the two systems shall meet only in a final chamber after both inspection chambers. The Commissioner's existing powers to require "an entirely distinct private drain" for rain-water (Gauhati Municipal Corporation Act, 1969, s.237(1)) and "an entirely separate drain for rain water" (Assam Municipal Corporation Act, 2022, s.176) are the hooks for this item. Clause 6.13.7 applies to every storm drain within the site.
- (b) **No rise in the peak inflow.** A development to which Chapter 4 applies shall meet Chapter 4 at each connection to a drain that carries sewage, as at any other site outfall (Clause 4.5.1.3). A development below the thresholds of Clause 1.5.2 shall not raise the peak inflow above that of the site before the development: where it adds impervious area, the roof water of the added area shall pass through a rainwater harvesting or storage tank with a controlled overflow before it reaches the connection.
- (c) **Tailwater and backflow.** The HGL of Clause 6.8 shall be started from the level in the receiving drain at the connection in the coincident event, taken from the owner's model where one exists and otherwise at the drain's obvert or top of bank (Clause 5.6.2). Where the receiving drain ends at a river-locked or pumped outfall, the outfall-closed check of Clause 5.10 applies with the lock of Clause 5.8.5(a). A non-return valve (Clause 6.8.8) shall be fitted on every connection, storm or foul, to a drain that carries sewage wherever the lowest drainage fitting or opening it serves is below the cover or bank level of the receiving drain at the connection.
- (d) **Capacity, velocity, access and odour.** A public drain that carries sewage shall be designed as a combined channel until the sewers of its area are connected: its storm capacity used in Clause 6.3.3 shall be the capacity left after its dry-weather flow, measured or estimated from the population served; it shall reach the minimum velocity of Clause 6.7.3(a) at its dry-weather flow, or have a low-flow channel in its invert that does, so that sewage solids do not settle between storms; where it is covered, it shall have the access openings of Clause 6.13.2, with covers and vents placed so that odour does not reach homes and footpaths; and it shall be cleanable by machine from those openings, without anyone entering it. Flow above its storm capacity, or above what the inlets admit, shall be carried on the surface by the major system (Clauses 6.3.2 and 6.9), and floor levels shall be set under Clause 6.11 with the drain surcharged.

- (e) **Interception and screens before outfalls; separation planned by the Authority.** Every public drain that carries sewage shall have dry-weather-flow interception and a screen before its outfall to a beel, a pukhuri, a scheduled water body, the Bharalu, the Mora Bharalu, the Bondajan or Deepor Beel, designed under Clause 8.9 so that it does not reduce the drain's storm capacity, and no new storm drain shall be brought to a scheduled beel without that treatment. The Authority shall identify in its master plan (Chapter 11) the areas where a separate public storm drain is feasible, among them the zones of the Guwahati sewerage project as they are connected, and elsewhere the storage that will hold back the combined peak; where a separate public storm drain is available at the site boundary, the site's storm-water system shall be connected to it and not to the drain that carries sewage. The Conveyance Design Report (Form 6-1) shall state whether each receiving drain carries sewage, the source of that information, and how items (a) to (e) are met.

Items (f) to (m) apply to every element of the minor and major systems that receives runoff from a hill catchment, which in this Manual means land in the hills and hill fringe of sub-area AS-B (among them the Khanapara, Basistha and Jorabat fringe and the city's hills), land in sub-areas AS-D and AS-D1 of Annex 2A, any catchment whose natural ground slopes more than 10% on average, and every juri or other stream that comes down from the hills, including the streams that rise in Meghalaya and those that cross the bhabar fans of the north bank:

- (f) **Debris racks and traps.** Every inlet, drain or pipe entrance and culvert that receives flow from **1 ha or more** of unbuilt hill land (forest, scrub, cultivated or bare slope, a quarry or a cut slope), or from a juri or other hill stream whatever its catchment, shall have a debris rack or a debris trap upstream of it, designed under Chapter 9 (Clause 9.8), with machine access and a stable place to stockpile what it catches, which shall not be a slope, a juri, a jan or a beel margin. With 50% of the rack blocked, the element it protects shall still pass its design flow, and the overflow route shall not send the flow onto a building or an unprotected slope. Racks and traps shall be cleared by 31 March, again by 31 May after the April–May storms, and after the season by 15 November (Chapter 10). The volume of a debris basin is to be set in Chapter 9 [TBC].
- (g) **Bulking factor.** The design flow of every channel, drain, pipe, culvert and crossing that receives flow from a hill catchment shall be the clear-water peak flow of Chapter 3 multiplied by a bulking factor of **1.25**, for the minor design flow, the check event and the 1% AEP flow; elsewhere the factor is 1.0. The factor applies to capacity, freeboard and velocity; it does not apply to the runoff volume used for storage (Chapter 4). A larger factor shall be used where a sediment study of the catchment gives one. A catchment that the screening of Clause 2.3.6(i) shows to be prone to debris flow or landslides, or that drains a mapped slide, fan or channel-shift path, is not designed by a bulking factor: no building, outfall, pumping station or storage shall be placed in that path, and the drains are designed for the bulked flow only [TBC].
- (h) **Blockage.** The blockage check of Clause 6.12.4 shall assume 50% of the inlet area blocked for every culvert and pipe entrance with a span or diameter below **3.0 m**, and 20% for larger ones, whether or not a debris rack is provided. Grate inlets keep the clogging factor of Table 6.5, and kerb openings on grade take the sag value of 20%.
- (i) **Sediment and minimum velocity.** Drains and pipes that receive flow from a hill catchment shall reach a velocity of at least **1.0 m/s** at the minor design flow, in place of the minimum of Clause 6.7.3(a). Where the gradient does not allow it, a sediment trap shall be provided upstream and the sediment allowance of Clause 6.7.8 doubled (Clause 6.7.4).
- (j) **Steep drains and steep streets.** 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 (g), with the freeboard of Table 6.7 for steep channels and an energy dissipator at every change to a flatter gradient and at the outlet. On a street steeper than 5%, grate-only inlets shall not be used, and inlets shall be placed by the calculation of Clause 6.6.4 with the bypass flows of a steep gutter; on a street steeper than 10%, the flow shall be intercepted by transverse grated channels or kerb inlets at a spacing that keeps the street flow within the limits of Table 6.3 in the check and 1% AEP events, and where the 1% AEP flow cannot be kept within those limits, the excess shall be carried in a lined side channel or stepped drain and the street, unless it is a notified evacuation route, is treated as closed in that event. Steps and footpaths that carry flow shall have a lined side channel.

- (k) **Hill roads as the minor system.** On every road and street in a hill catchment as this clause defines it, the drainage of a road is the minor system for the land above it as well as for the road. Every such road and street shall have, as works of the road's owner, PWD, NHAI, GMC, GMDA, the Municipal Board or the District Council: (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 juri and stream, and culverts or scuppers at intervals such that no side drain exceeds its capacity at the design AEP of Table 6.1 with the factors of items (g) and (h); (iv) at the outlet of every scupper, culvert and side drain on the valley side, a lined chute, cascade or pipe carrying the flow to a stable natural channel or a public drain, with an energy dissipator, so that road runoff is **never discharged onto an unprotected slope**, fill, retaining wall or the land of a building below, by PWD, NHAI or any other owner of a road; (v) culverts of at least the size of Clause 6.12.5, designed under Clause 6.12 and not less than IRC:SP:42-2014 cl. 7.1.4 requires for the road; where the drainage provisions of IRC:SP:48-1998, the Hill Road Manual, which were not read for this Manual [TBC], are stricter than this item, they apply; and (vi) no spoil or excavated material from the construction, widening or maintenance of the road, or from hill cutting beside it, placed in or beside a juri, a jan or another line of natural drainage, or on a slope from which a storm can carry it into one.
- (l) **Sloping sites and hill cutting.** On a site where the land above drains towards a building, its cut or its retaining wall, the runoff of that land shall be intercepted above them by a lined diversion drain sized for the minor design flow of Table 6.1 from the land above it, with the factors of items (g) and (h), with a 1% AEP flow path that does not pass through or against the building. The space between a building and the cut or retaining wall above it shall be paved or lined and drained so that water does not stand against the building or soak into the foot of the cut, and both shall discharge to a public drain or a stable natural channel as item (k)(iv) requires, not onto the slope below. Roof and paved-area runoff on such a site follows the hill rule of Clause 4.11. These items give a design standard to what the Unified Byelaws 2022 already ask on hill sites: drainage "so that rain water and waste water can drain out from the plot without causing soil erosion" (byelaw 110(c)), "special protection measures" on slopes greater than 10° (110(d)), cuts generally of 4 m to 6 m and not over 6 m "ordinarily" (110(e)), a designed dry sump (110(h)) and a silt fence (110(i)); in a Designated Area under the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006, a guard wall or house also needs the prior approval of the Advisory Committee (s.14), and no designated-area notification was found [TBC].
- (m) **The hill–plain break, silt and waste.** Where a juri or hill stream, or a drain that receives one, reaches flatter ground, as the streams of the Khanapara–Jorabat fringe, the Basistha, the Kalmani and the Bahini do on reaching the plain of Guwahati, a silt trap designed under Chapter 9 (Clause 9.8) shall be provided above the point where the gradient falls, with machine access and a stockpile place that is not a jan, a beel margin or a slope, sized for the sediment of item (i) and cleared on the dates of item (f) and after every heavy-rainfall day (Chapter 10). No spoil from hill cutting and no construction and demolition waste shall be placed where a storm can carry it into a drain, a jan, a juri or a beel; the dumping of construction and demolition waste "at road sides, Nalas, Rivers and other water bodies" is already penalised (byelaw 120A, 2024). A trap or screen placed in a stream shall not raise its 1% AEP level at any outfall (Clause 5.8.5(f)) and shall be designed to be overtopped without damage. A trap is not a treatment work: dry-weather flow is intercepted under item (e) and Clause 8.9.

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 Guwahati 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 Assam, and it has two parts because the State's drains fail in two ways that the criteria of this chapter, which assume clear storm water on gentle ground, do not see. The first is sewage. "No ULB in the state has a centralized sewerage system, including Guwahati … about 90% of households have installed septic tanks or leach pits, no ULB has a systematic mechanism for septage collection" (ADB RRP, 2025), so the storm drains are the sewers: the Bharalu "has no natural flow … only the domestic sewage and commercial

sewage are being carried", and the Bahini "now becomes a sewerage drain" (PCBA action plan for the Bharalu); CPCB lists the Bharalu in its first priority for pollution (as quoted), and Deepor Beel is polluted by the "Mora Bharalu channel" (State progress report to the NGT in O.A. 673/2018, August 2020). The law already allows the separation that item (a) asks of each site: the GMC Commissioner may direct an occupier "to make an entirely distinct private drain" for rain-water and unpolluted sub-soil water (Gauhati Municipal Corporation Act, 1969, s.237(1)), and the Commissioner of any other Municipal Corporation may require "an entirely separate drain for rain water or unpolluted sub-soil water" (Assam Municipal Corporation Act, 2022, s.176); both are powers, not duties. Items (a) to (e) follow the combined-sewer rules of the plains editions of this series: a site keeps its storm water separate up to the boundary, so that the town can separate its system street by street as the sewerage zones are connected without going back into every plot; a development does not add to the peak of a drain that carries sewage; a non-return valve guards every connection, because what comes back up a surcharged drain is sewage; the drain is designed as the combined channel it is, with its capacity taken net of its dry-weather flow and a low-flow channel so that sewage solids do not settle in it between storms; and the outfall to a beel or scheduled water body is intercepted and screened, because the beels are the towns' storage and the AMC Act already says that "no sewage shall be discharged into any watercourse until it has been so treated" from a notified date (s.171). Separation itself is for the Authority to plan, not for each site.

The second is the hills. Guwahati's streams rise in the Khasi hills of Meghalaya, and the city's own hills are being cut: "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB IEE, 2017), and the High Court recorded on 26 May 2025 that "hill cutting is still going on" (PIL/14/2024). The slopes fail: four people were killed in a landslide at Nizarapar/Boragaon on 14 June 2022 and three at Bonda on 31 May 2025 (as reported). The streams drop their load where they reach the plain, which is why item (m) puts a silt trap at the hill–plain break and why the research behind this Manual asked for a debris and silt allowance there. No Assam allowance for debris, bulking or blockage was found during research [TBC], and no Indian guidance on bulking factors, debris racks or debris basins [TBC], so each number in items (f) to (m) is the interim value of the hill and mountain editions of this series, with the same reasons. The 1 ha trigger for a debris rack reflects the few minutes' time of concentration on hill slopes. The bulking factor of 1.25 is the factor for a flow that carries a fifth of its volume as sediment (bulking factor = 1 / (1 − sediment fraction by volume)), about the most that a drain can carry and still behave as a water flood; a flow with more behaves as a debris flow, which no drain can be sized for, so item (g) keeps buildings and outfalls out of its path. The 3.0 m limit in item (h) doubles the core's 1.5 m because stones, timber and waste block openings that leaves alone do not. The 1.0 m/s minimum in item (i) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm, because hill drains carry gravel. IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently, with lined side drains and culverts "at closer intervals compared to those in plain areas", and item (k) keeps road runoff off unprotected slopes because water discharged onto a slope raises its pore pressure (Clause 4.11). The Unified Byelaws 2022 already reach towards these rules on hill sites without numbers, and the Master Plan's Hilly Area Zone covers "all the hilly areas and also … adjoining plain areas prone to land slide and soil erosion"; items (l) and (m) give them design standards of this Manual's own. The clause deals with sewage, silt and debris at the drain; it does not ask for the concrete channelisation of the jans and juris, whose capacity has been lost to encroachment and filling, not to roughness.

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: Guwahati, Dibrugarh and Silchar 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) in Guwahati, the localities that the sources name for flooding, Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar (June 2022, as reported), the 14 waterlogging points that the CAG recorded (CAG Report No. 4 of 2019), and the older, densely built core of the city as GMDA identifies it under the Master Plan for Guwahati 2025 [TBC]; and the old towns of Dibrugarh and Silchar [TBC]; with the boundary of each to be confirmed by GMC and GMDA, or by the Municipal Corporation and the Development Authority of the town [TBC];
- (b) in every other Municipal Corporation, Municipal Board and Development Authority area, the area that the applicable Master Plan identifies as the core area, old town or central business district, and the main market of a town; 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:

> $$Q = (K_u / n) \cdot S_x^{5/3} \cdot S_L^{1/2} \cdot T^{8/3}$$

where Q is the gutter flow (m³/s), $K_u = 0.376$ (SI), n is the Manning roughness of the gutter (Table 6.6), S_x is the cross slope (m/m), S_L is the longitudinal slope (m/m) and T is the spread (m). Composite and depressed gutter sections shall be analysed by the methods of FHWA HEC-22 (4th edition, 2024).

6.5.2 **Spread and depth limits.** Street flow shall not exceed the limits of Table 6.2.

Table 6.2 — Street flow limits

Road class	Minor design event (Table 6.1)	Check event and 1% AEP event
Arterial	Spread shall leave at least one through lane in each direction clear of water. No flow across the crown.	Depth ≤ 150 mm at the crown and ≤ 350 mm at the deepest point; hazard limits of Clause 6.5.3
Collector	Spread T ≤ 3 m. No flow across the crown except at a sag intersection.	As above
Local	Spread T ≤ 3 m. Flow shall not overtop the kerb.	As above
All classes, at intersections	Cross-flow over the crown ≤ 0.03 m³/s at sag intersections and superelevation transitions; none at mid-block sags.	As above

6.5.3 **Flow hazard limits.** In the check event and the 1% AEP event, the product of depth (D, m) and velocity (V, m/s) of street and overland flow shall not exceed the limits of Table 6.3.

Table 6.3 — Flow hazard limits for streets and overland flow paths

Location	Required hazard class (Table 6.4)	Limits
Carriageways of all roads	H2 or better	D·V ≤ 0.6 m²/s; D ≤ 0.35 m (Table 6.2); V ≤ 2.0 m/s
Footpaths, pedestrian crossings, school, hospital and transit-stop frontages	H1	D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s
Notified evacuation and emergency routes	H1	D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s
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.

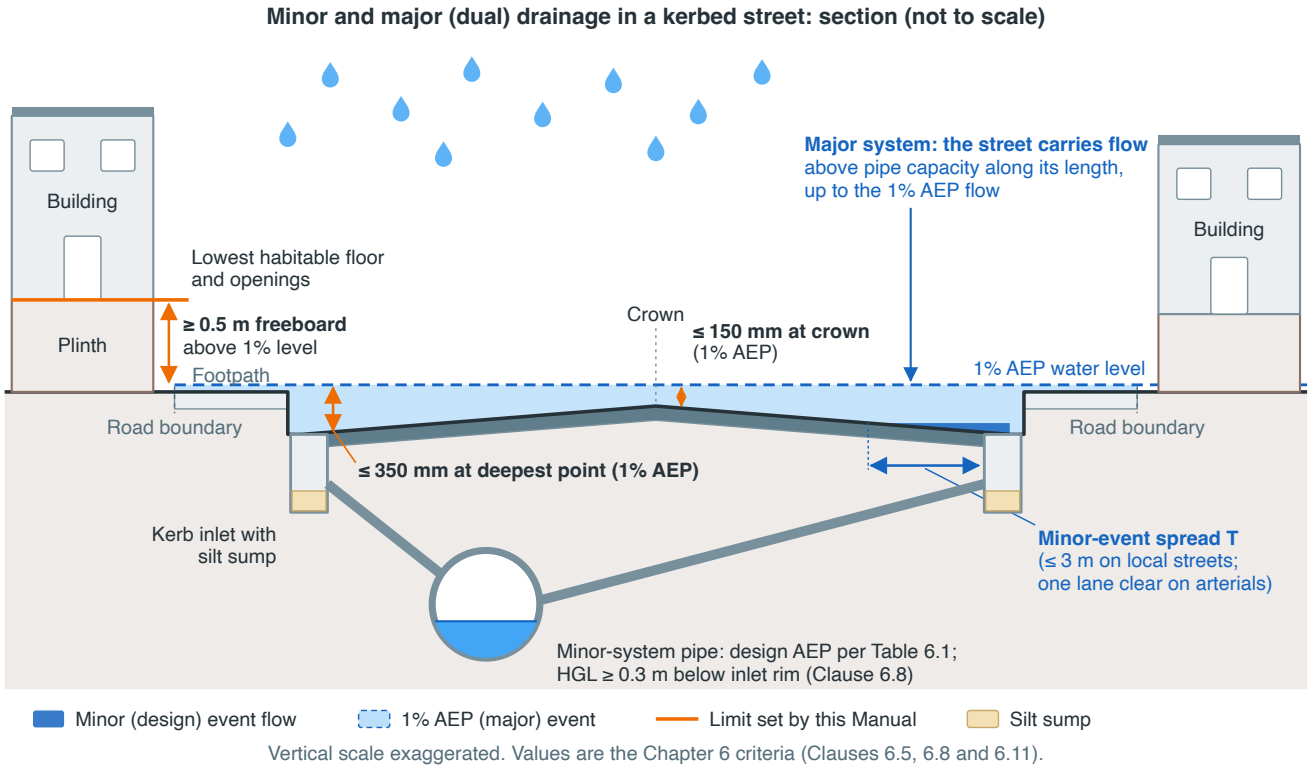


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

> **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 Assam 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:

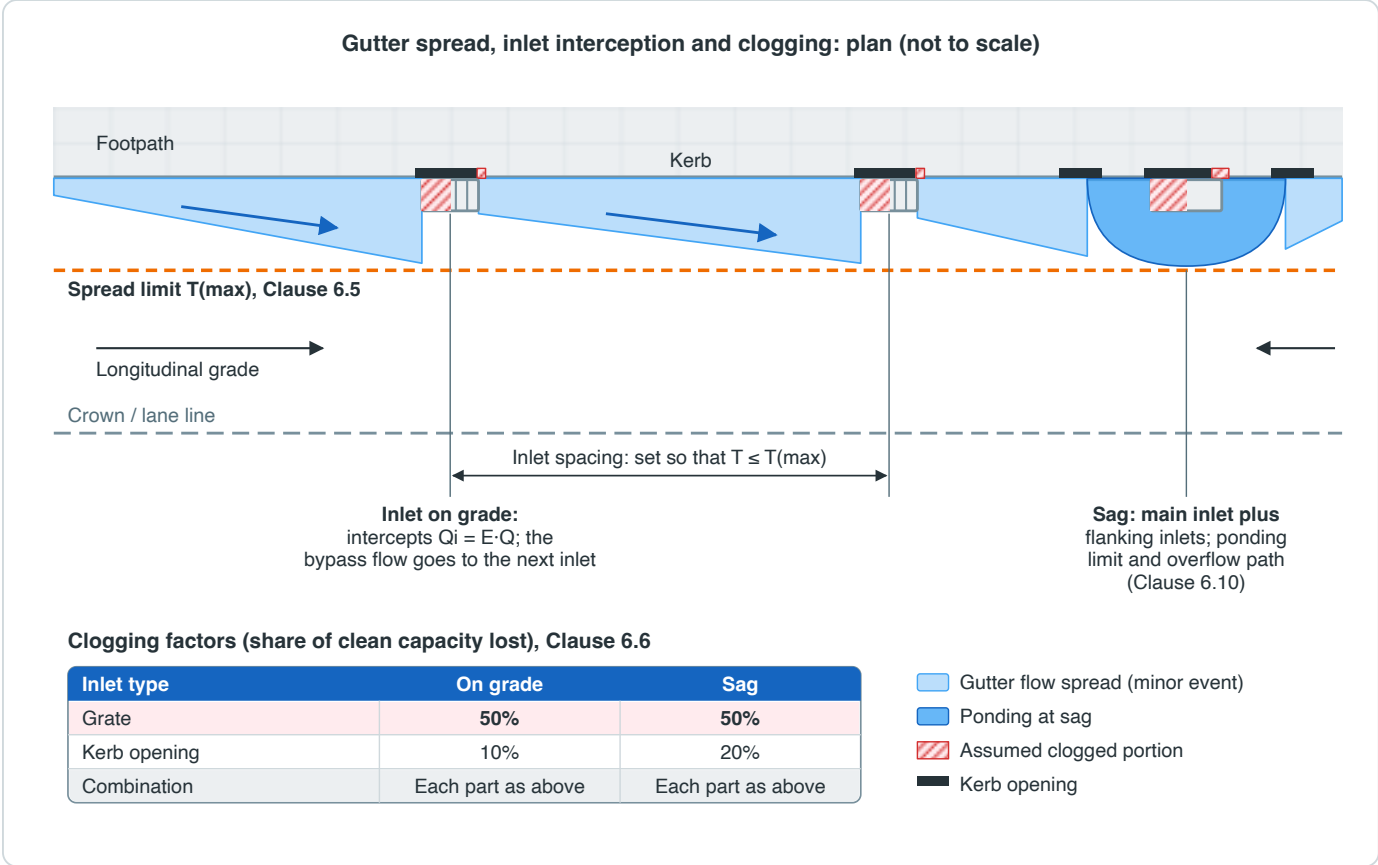
- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass 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 Assam streets are routinely blinded by plastic and leaves. CPHEEO (2019) Part A shows solid waste dumped in drains as a primary cause of drain failure (Figures 1.2 and 2.1). APWA 5600 (2006) allows only kerb-opening inlets on public streets; Clause 6.6.1(a) is less strict because combination inlets are useful on flat roads. No standard inlet, kerb-channel or covered-drain detail of PWD, of GMC or of any other local body in the State was found during research [TBC]; the Unified Byelaws 2022 ask only that the plans show a "Detailed drainage plan for both internal and external required to be constructed upto the available permanent/pucca drain of municipal/other authority" (byelaw 94). 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 flood plains of the Brahmaputra and the Barak are very flat, which shortens the calculated spacing anyway; on the steep streets of the Guwahati hills and of Haflong gutter flow runs fast and passes inlets by, which Clause 6.3.6(j) deals with. A fixed cap stops a single blocked inlet from leaving a long dry gutter run. The 300 mm silt sump is set by this Manual. It matches the 0.3 m sump shown on the CPHEEO catch-basin detail (CPHEEO 2019, Figure 5.9).

6.7 Pipes and open and covered drains

6.7.1 **Uniform flow.** Pipe and drain capacity shall be computed with Manning's equation:

> $V = (1/n) \cdot R^{(2/3)} \cdot S^{(1/2)}$; $Q = A \cdot V$

where V is the mean velocity (m/s), n is the Manning roughness (Table 6.6), R is the hydraulic radius (m), S is the friction slope (m/m), A is the flow area (m²) and Q is the discharge (m³/s). Where backwater from a tailwater, a junction or a structure affects the water level, a gradually varied flow (standard step) or hydraulic network model shall be used, and the HGL requirements of Clause 6.8 apply.

6.7.2 **Manning roughness.** Design values of n shall be taken from Table 6.6. For concrete pipes and masonry or concrete drains, the design value shall be not less than the "fair" or "rough" condition value listed, to allow for sediment, biofilm and ageing.

Table 6.6 — Manning's n for design (from CPHEEO 2019)

Material	Condition	n (CPHEEO)	Minimum design n in this Manual
Cement concrete pipe (collar joints)	Good / fair	0.013 / 0.015	0.015
Spun concrete pipe (RCC, PSC) with S/S joints	Manufacturer's design value	0.011	0.013
HDPE / uPVC pipe	—	0.010	0.011
Plastic (smooth), asbestos cement	—	0.011	0.011
Concrete drain, steel trowelled / wood trowelled	—	0.014 / 0.015	0.015
Sand and cement plaster	—	0.015	0.015
Brick masonry	Good / rough	0.015 / 0.017	0.017
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 the hill areas of Guwahati, Haflong, Diphu, Hamren, Maibang and Umrangso 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

Drain	Minimum freeboard	Source
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.

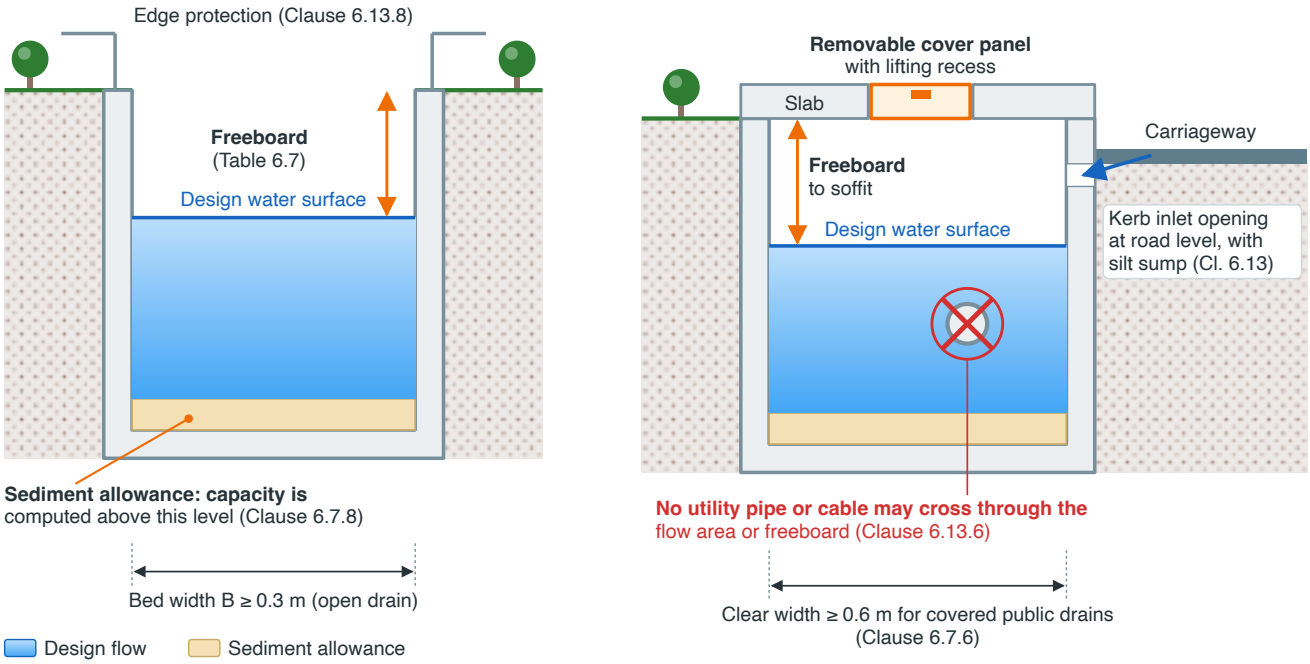


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

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 Assam 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 Guwahati floods of June 2014, which killed seven people in flash floods and four by electrocution, and in a city where GMC's storm-drain data "was not available as it was involved with works of drain desilting only", although ₹32.57 crore had been spent on desilting from 2013–14 to 2017–18, and 14 waterlogging points flooded six to seven times a year (CAG Report No. 4 of 2019), and where narrow, silted drains and the "construction of buildings and roads over the manmade drains" are among the causes of waterlogging (ADB IEE, 2017). 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. Guwahati'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 Assam most town drains end at a sluice in an embankment, behind which the river stands higher than the drain for days in the monsoon, or in a beel or pond that is already full (Clause 5.8.5). At Guwahati the Brahmaputra's danger level at the DC Court gauge is 49.68 m and its highest flood level 51.46 m (CWC levels as reported), and "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB IEE, 2017); Dibrugarh's town "is 1.5 m below the bed level of Bramhaputra", and its DTP drain was designed with backwater at its outfall sluice at 97.50 m and "the beel … full and the drain … also flowing full" (ADB IEE, 2017). No design level for any other outfall in the State was found during research. A drain whose HGL is started from a free outfall, or computed one length at a time without the river, the closed sluice or the full beel at its end, 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 a Water Resources Department channel, the reserve is transferred to the Water Resources Department.
- (b) No building, compound wall, fence, ramp, step, fill or other structure shall be built in the reserve. Compound walls and boundary fences shall stand outside it.
- (c) The access strip in the reserve shall be level and continuous, and connected to a public road. Bollards or posts and chains may be used at entrances to keep out vehicles other than maintenance vehicles.
- (d) Where the reserve is not fenced off, its edge shall be marked with concrete markers at not more than 50 m spacing.
- (e) Services shall cross under the drain, with at least 1.0 m clearance below the invert, or over it on an approved structure. Services shall not run along the reserve inside the drain section.
- (f) A structure within 2 m of the edge of the reserve shall be designed to remain stable when the drain is excavated to 1.0 m below its invert. The design shall be signed by a qualified structural engineer.
- (g) The reserve counts toward the site's open space requirements only where the Approving Authority's rules allow it; it does not reduce any setback required by Chapter 7.

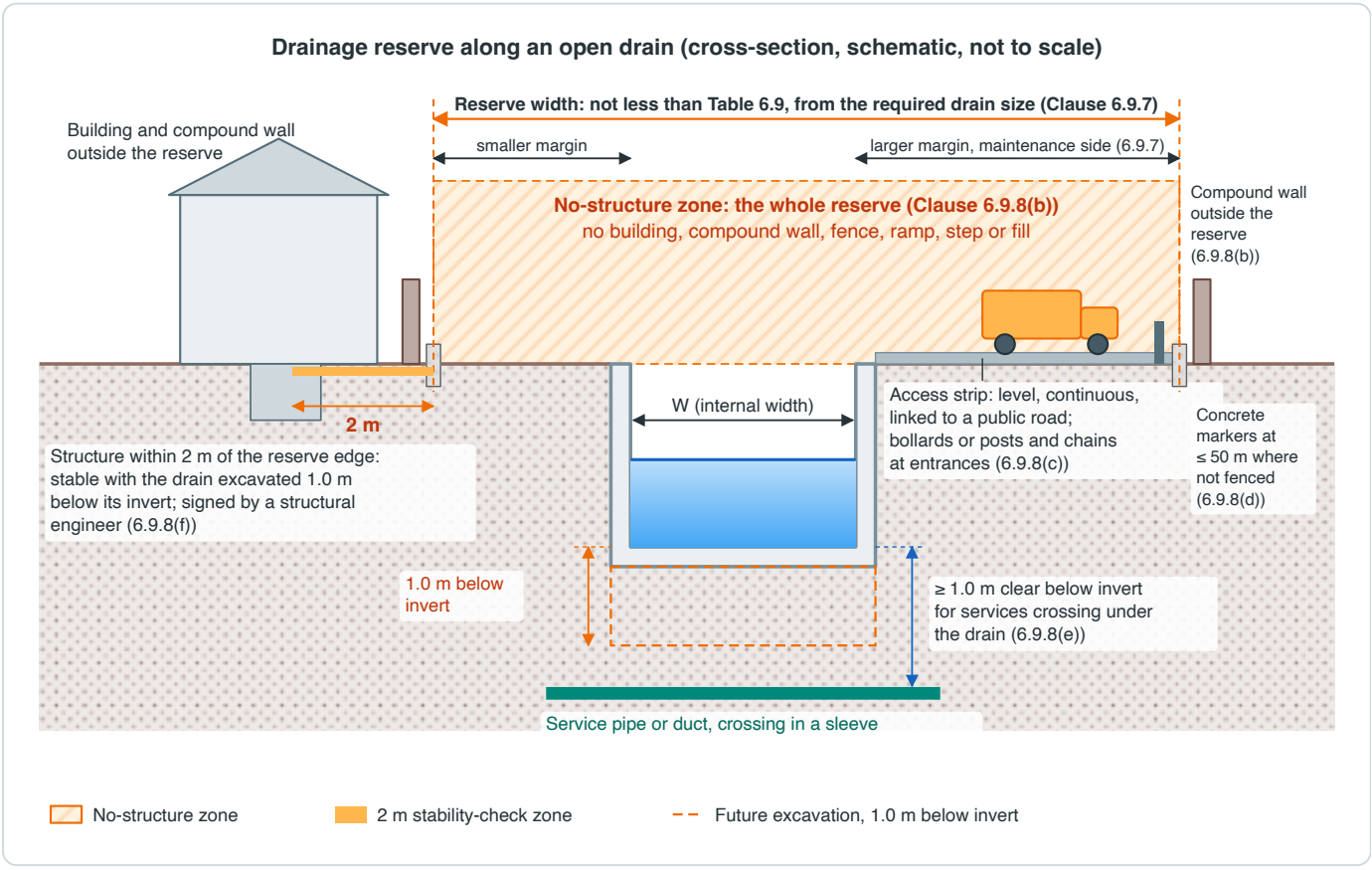


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, Code of Practice on Surface Water Drainage (7th ed., with Addendum No. 3, 2025), clauses 5.1, 5.3, 9.6 and 9.7 and Appendix 1.

Commentary. Drainage reserves follow Singapore, where "the width of a drainage reserve is based on the required drain size" and the reserve is set aside as a separate plot, "kept free of all encumbrances" (PUB Code of Practice on Surface Water Drainage, 7th ed. with Addendum No. 3, 2025, cl. 1.1). Table 6.9 reproduces PUB's Appendix 1 widths. Clauses 6.9.8(b) to (f) follow PUB clauses 5.1 (no structure within a drain or drainage reserve), 5.3 and 5.3.1 (stability for excavation 1.0 m below the invert; engineer's calculations within 2 m of the reserve), 9.6 (level,

continuous access, with bollards or posts and chains) and 9.7 (markers at a maximum of 50 m). The 1.0 m clearance for services crossing under a drain is from PUB's development-plan guidance. In Assam, 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. Assam has statutory building setbacks from rivers, named channels and water bodies, but no reserve width along a drain, and no floodplain zoning law. The setbacks are those of the Unified Byelaws 2022: "The minimum distance of any building from the edge of natural drainage channels shall be as given below" (byelaw 26(ix), repeated as 44(ix) [TBC: numbering read from the OCR layout; confirm against a clean copy]): River (as marked in the plan) 15 m; Bharalu, Mora Bharalu and Bondajan 10 m; other channels 6 m; minor drains not marked in the plan, as the building setbacks of the byelaws; notified water bodies (Deepar Beel, Silsako Waterbody) 15 m; other notified water bodies (Sarusola, Barsola etc.) 6 m; other large ponds and water bodies marked in the plan 10 m; and small ponds not marked in the plan, as the building setbacks. The table names only Guwahati channels and beels, although the byelaws apply in every notified Master Plan area of the State, and "as marked in the plan" ties its rows to the Master Plan maps (NEER reading). The Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 makes the District Level Committee "ensure no construction zone within a buffer around the Water Bodies as prescribed in the Notified Master Plan and Assam Unified Building Construction (Regulation) Bye law, 2022" (s.5 of the Bill), and that buffer is this table; the Bill's waterbody includes "all natural water channels (that are inflow or out flow channels into or from the waterbody)" (s.2(d)), and it repeals the Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (s.22) (the enacted Act's text was not read [TBC]). The Master Plan for Guwahati 2025 adds a no-construction strip of 15 m from the Brahmaputra bank on the riverfront from Sonaram High School to the Kamakhya foothills, and classifies "All notified forest, water bodies, rivers etc." as Eco-Sensitive Zone. The Authority may refuse a site "near a water body or water course" whose development is likely to contaminate it, change the course of the channel or be inundated without satisfactory drainage, or "a filled up tank or low lying" site (byelaw 44(iii) [TBC: numbering from OCR]); multistoreyed buildings are excluded from areas "on or abutting natural drainage channels" and wetlands (byelaw 117). In a notified area, no one may build on, remove or alter an embankment or drain without the permission of the Deputy Commissioner or the Embankment Officer (Assam Embankment and Drainage Act, 1953, s.16), but no setback distance from an embankment was found [TBC]. In Guwahati, the Commissioner may pull down a building erected over a drain vested in GMC (Gauhati Municipal Corporation Act, 1969, s.239); elsewhere, public drains and the subsoil they need vest in the Municipal Corporation (Assam Municipal Corporation Act, 2022, s.173). In a Designated Area under the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006, "a drainage system, feeding channel" is an ecological site that no one may alter (ss.2(d) and 3), but no designated area was found [TBC]. None of these gives a reserve width along a jan or town drain. For this Manual, as its own proposal and not as the meaning of the rules, the bank of a channel is its top of bank, and the edge of a beel or pukhuri is the higher of its full level and its monsoon water line (Chapter 7); every jan, juri and other natural channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whoever maintains it and whether or not it is lined, piped or covered (all set by this Manual). This Manual therefore gives the reserve a width, as its own proposal and not as a statutory width: a **hydraulic corridor** made up of the reserve of Table 6.9, based on the drain size needed to carry the design flow, with the bulking factor of Clause 6.3.6(g) in the hills (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along every natural channel that drains 8 ha or more and round every beel and pukhuri that this Manual covers, the setbacks of Clause 7.4, with a Zone 1 of **not less than 15 m** from top of bank (or from the full level of a beel or pukhuri) and a Zone 2 to the 1% AEP extent plus 10 m, the line that reaches furthest from the water governing; where the byelaw table, the Master Plan, a scheduled water body's buffer or a court sets a wider line, that line applies for as long as it binds, and the widest governs (Clause 7.4.5). Three reference lines are compared (Chapter 7): the byelaws' "edge of natural drainage channels" or of the water body, with the byelaw distance; the top of bank or full level, with Zone 1; and the 1% AEP extent, with 10 m. The corridor equals the byelaw distance for rivers and for Deepor Beel and Silsako (15 m), and is stricter than the byelaws for the Bharalu, the Mora Bharalu and the Bondajan (10 m), for other channels and other notified water bodies (6 m), for large ponds (10 m), and for minor drains and small ponds (the building setbacks). It applies to new development and redevelopment approved under this Manual, not to existing buildings, and Clause 7.4.7 allows no variance below it. Land in Assam is mostly patta land held by dag number, so Zone 1 land and reserve

land that is private is **reserved in the Master Plan or secured by agreement with the owner**, recorded on the layout approval and against the dag and patta in the land records, and not taken; where it is so secured, the transfer of Clause 6.9.8(a) is made by that recorded agreement rather than by a transfer of title; in the Sixth Schedule districts it is secured through the District Council, whose land law was not researched [TBC] (set by this Manual). The corridor should be shown in the Master Plan for Guwahati and in the Master Plans of the other towns as land kept free along drainage lines, and checked at the planning permit and the building permit, where the plans already have to show a "Detailed drainage plan for both internal and external required to be constructed upto the available permanent/pucca drain of municipal/other authority" (byelaw 94), rather than made a new NOC.

The reserve matters because the drains of Assam's towns are divided among owners, and no rule divides them. No notification assigns the Bharalu, the Mora Bharalu or the Bahini to one owner (NEER reading), and the ADB found that "sustainable management of stormwater drainage remains a challenge because of fragmented institutional responsibilities involving multiple institutions, such as the Guwahati Metropolitan Development Authority (GMDA), Public Works Department, and Water Resources Department" (ADB RRP, 2025). In Guwahati GMC cleans and alters the municipal drains and may make them empty into any place (Gauhati Municipal Corporation Act, 1969, ss.231, 232 and 234), but its Act has no duty to provide an outfall like that of the other Municipal Corporations (Assam Municipal Corporation Act, 2022, s.171), which may also make drains over to another authority or take them over (s.174). In 2022 the work was reported split so that GMC desilted the Bharalu, the Mora Bharalu, the Basistha, the Bahini and the Lakhimijan and their feeder drains, WRD desilted the Bondajan and ran the dewatering pumps at the Bharalu, the Mora Bharalu and the Bondajan, and PWD cleaned about 260–263 roadside drains (as reported); GMDA builds the new drainage, is the implementing unit of the ADB Bahini works and has excavated Silsako; and the Railways, OIL, NHAI, CPWD, the Army and BSNL hold their own drains in the city (as reported). The CAG found that GMC's storm-water drainage data "was not available as it was involved with works of drain desilting only" (CAG Report No. 4 of 2019). For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: the municipal drains of Guwahati, with the desilting of the Bharalu, the Mora Bharalu, the Basistha, the Bahini and the Lakhimijan and their feeder drains, to **GMC** (ss.231–252 of the 1969 Act); the public drains of every other Municipal Corporation to the **Corporation** (ss.171–177 of the 2022 Act), and of a Municipal Board to the **Board** (Assam Municipal Act, 1956); roadside drains to **PWD**, and those of the national highways to **NHAI**; embankments, sluices and the channels of WRD drainage schemes, the Bharalumukh sluice and pumps, the dewatering pumps at the Bharalu, the Mora Bharalu and the Bondajan, and the desilting of the Bondajan, to **WRD**; new drainage works, the ADB Bahini works until they are handed over in writing, Silsako and the scheduled water bodies of the GMDA area to **GMDA**; the drains of the Railways, OIL, CPWD, the Army and BSNL to those bodies; and, in an Autonomous District, the drains to the District Council or the body it designates [TBC] (set by this Manual). Each town shall keep a **drain register** that gives every reach its owner under this assignment, its land status (patta, government or Council land), whether it is a scheduled water body or an inflow or outflow channel of one, whether it is an embankment drain under the 1953 Act, and its outfall (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to the Water Resources Department is transferred to, or secured for, the Water Resources Department. Where a channel's status is disputed, the corridor follows the channel and not its name: Guwahati's channels are at once storm drains, carriers of sewage, embankment drains behind a WRD sluice and, under the water-bodies law, inflow and outflow channels of its beels. No approved city drainage master plan with a design return period was found for any town in the State; the comprehensive drainage master plan for Guwahati was under revision when research was done (as reported). A drain sized to fit the land left beside it cannot be enlarged, which is why the reserve is based on the required size. Until a Basin Stormwater Master Plan is adopted (Clause 6.9.6(b)), the required drain size of Clause 6.9.7 is the size computed by the designer under this chapter. This Manual does not prescribe a lined or an unlined section, except where Clause 6.3.6(j) and 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 Assam 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 Assam was found during research [TBC]. The roads already act as the major system: in June 2022 Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar in Guwahati were inundated (as reported), and on the night of 19 April 2026 a woman died after falling into an open roadside drain in the city (as reported). Clause 6.10.5(d) links the 150 mm crown depth limit of Table 6.2 to the point at which traffic should stop.

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.

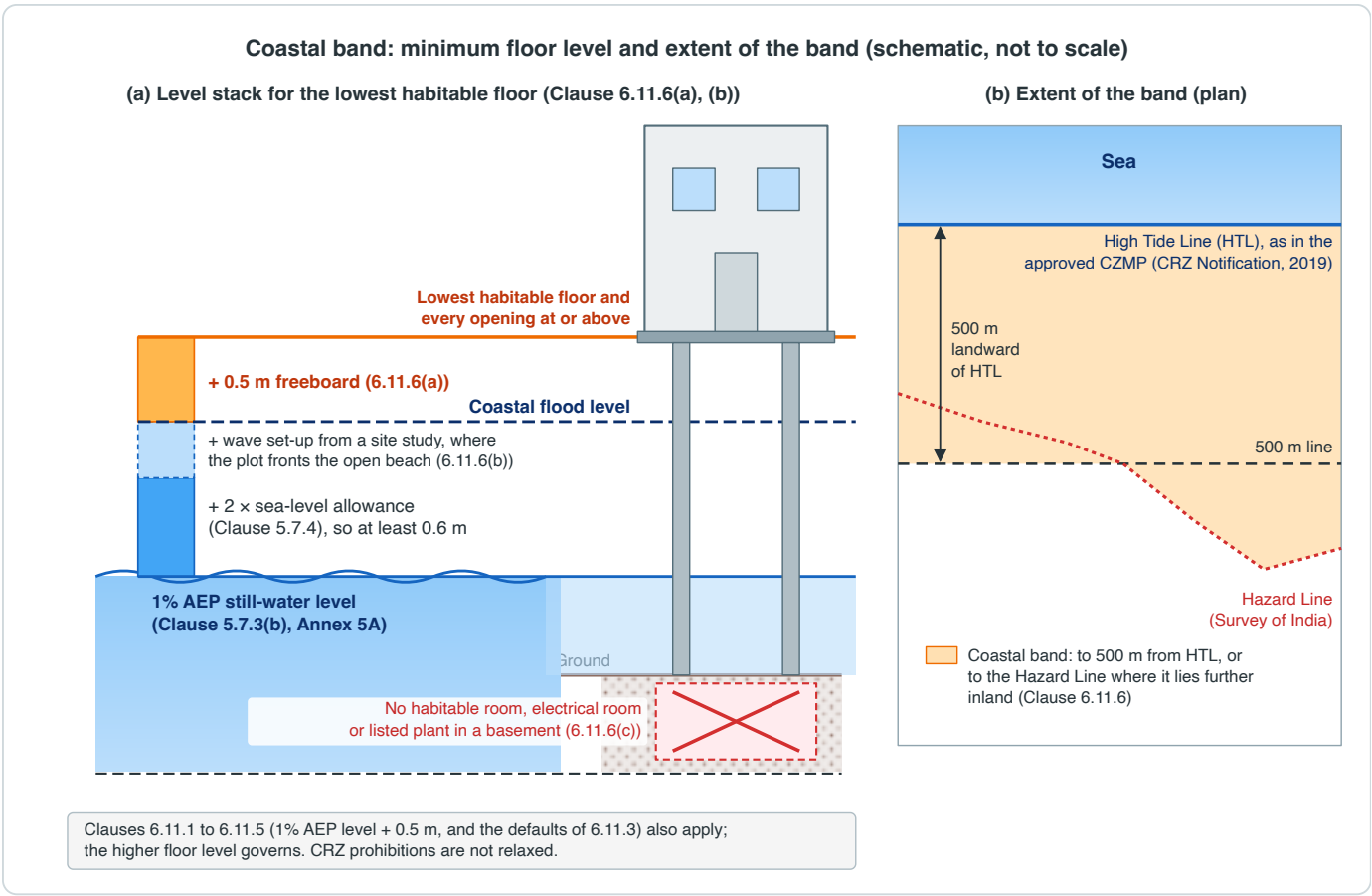


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Assam 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 Unified Byelaws 2022 set the plinth "0.3 m higher than the highest recorded flood level as fixed by the local authority for ordinary buildings and 0.6 higher for lifeline buildings" (byelaw 45(c)), and not less than 0.5 m and not more than 0.75 m above the ground level of the plot, with the ground not raised more than 0.5 m above the nearest street (45(a)); they bar basements "in low-lying areas and areas without adequate drainage facilities" (66(3)) and require that "surface drainage do not enter the basement" (67(c)); and on a site liable to flood they require roof-water harvesting, a designed "dry sump … capable of holding rain water during peak monsoon" in every plot, and a silt fence (74). No local authority's "highest recorded flood level" was found for any town [TBC], so the byelaw gives no level to build to. For this Manual, that level is taken as the 1% AEP flood level of Clause 6.11.2 at the site, computed with the river-locked and breach cases of Clause 5.8.5, or, where none has been computed, the highest flood level surveyed from flood marks with its source stated, and the floor levels of Clause 6.11.1, 0.5 m above the 1% AEP level, govern where they are higher than the byelaw plinth (set by this Manual). Behind an embankment the level is that of the ponded area with its sluices closed, and for a breach, the river level beyond the embankment (Clause 5.8.5(a) and (c)): in June 2022 Silchar lay under up to about 4 m of water behind the Barak embankment (as reported). 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 byelaws; where the byelaws bar a basement, the bar governs. On a hill site 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 Clause 6.3.6(l) in place, and a floor or basement cut into a slope also needs the geotechnical certificate of the hill rule of Clause 4.11. Along the rivers, jans and beels and round the pukhuris, 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 Assam construction-practice requirements

6.13.1 **Covered roadside drains.** Where a roadside drain is covered by slabs that form a footpath:

- (a) it shall be designed as an open channel with the freeboard of Table 6.7 measured to the soffit of the cover slab, and its HGL shall meet Clause 6.8 measured to the footpath and inlet levels;
- (b) road runoff shall enter through openings in the drain wall at road level (Clause 6.6.1(b)), each with a silt sump (Clause 6.6.7), at the spacing of Clause 6.6.4;
- (c) footpath runoff shall enter through slots or grated openings in the cover, not by ponding on the footpath; and
- (d) the clear section shall meet Clause 6.7.6(c).

6.13.2 **Removable covers and access openings.** Covered drains shall have:

- (a) removable cover panels at not more than **10 m** centres, each at least 0.6 m long and spanning the full clear width, with recessed lifting points, liftable by two workers or by a hand-operated lifting device, and flush with the footpath;
- (b) access chambers with a clear opening of at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than **30 m** centres on straight runs; and
- (c) covers rated for the traffic or pedestrian load at their location (Chapter 9, Clause 9.11).

6.13.3 **Silt traps.** In addition to the inlet sumps of Clause 6.6.7, silt trap chambers shall be provided:

- (a) upstream of every culvert under an arterial road;
- (b) upstream of every pump station and detention facility; and
- (c) at every outfall to a tank, river or other waterbody (with the gross pollutant trap required by Chapter 8).

Each silt trap shall be sized to hold the sediment expected between scheduled cleanings, using the sediment yield in Annex 6B, and shall be reachable by a desilting vehicle.

6.13.4 **Garbage and gross pollutant screens.** Screens shall be provided where an open drain enters a covered drain, a pipe or a culvert, and at outfalls under Chapter 8. Each screen shall:

- (a) be designed under Chapter 9, Clause 9.8;
- (b) have a bypass or overflow, so that a fully blinded screen does not flood properties or the road beyond the limits of this chapter; and
- (c) be checked hydraulically with 50% of its area blocked.

6.13.5 **No building over drains.** No structure other than an approved crossing or a removable cover shall be built over a public drain. Shop frontages, ramps and steps that cross a drain shall be removable or shall leave access openings that meet Clause 6.13.2.

6.13.6 **Utilities.** No water main, sewer, power or telecom cable, gas pipe or duct shall be laid along, or pass through, the flow area or freeboard of any drain. A utility that must cross a drain shall:

- (a) cross above the cover soffit or below the drain invert, inside a sleeve; and
- (b) be shown on the drainage plan with its level.

Where an existing utility crossing obstructs a drain, its area shall be deducted from the drain section, with a 50% blockage allowance for the debris it traps, until the utility is relocated. The utility owner shall relocate it when the drain is rebuilt.

6.13.7 **Sewage.** No sewage connection is permitted to a storm drain (Chapter 8). Covered drains shall be built with sealed joints where they run next to sewers.

6.13.8 **Edge protection.** Open drains deeper than 1.0 m beside a footpath, a carriageway or a public open space shall have railings or barriers. Open drains of any depth shall not be left uncovered across a footpath.

6.13.9 **As-built levels.** The as-built invert levels of every public drain, pipe and manhole shall be surveyed and submitted (Chapter 10). Inverts shall be within ±15 mm of design. An HGL re-check shall be submitted where they are not.

6.13.10 **Desilting.** Public drains shall be desilted before the monsoon season each year, as set out in Chapter 10.

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of Assam 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 Assam that date is also the start of the wet season. The south-west monsoon reaches the North East at about 5 June (as reported), and IMD's revised normals are reported to put its onset at Guwahati at 2–4 June (as quoted in a press summary of the IMD release); its withdrawal date for Assam was not obtained [TBC]. But the storms come earlier: Guwahati's April record of 116.5 mm (6 April 2004) was beaten by 117.4 mm at the airport on 20 April 2026, when SIRD Khanapara recorded 215.9 mm the same night (as reported); four of the seventeen Assam station 24-hour records in IMD *Extremes* are May storms, among them Dibrugarh (Mohanbari) 231.5 mm (10 May 1996) and Dhubri (Rupsi) 479.3 mm (28 May 1989); Silchar recorded 245.4 mm on 29 March 1922 (IMD *Extremes*); and the CWC report for subzone 2(b) finds the rainfall "spread over a period of eight months, i.e. from March to October", with "The winter season from December to March … practically dry". Storms also come after the season: Haflong 237.1 mm on 30 October 1959, and Haflong 234.2 mm and Silchar 174.2 mm on 9 November 1955 (IMD *Extremes*). No order with a completion date for desilting town drains was found during research [TBC]: GMC's drain cleaning in 2026 was "expected to begin from mid-February", desilting SOPs "issued in February 2025" are said to have been "largely ignored", and the Mayor said that the work "will be completed before the monsoon" (all as reported); the WRD dates in the press, among them the target of 30 April 2018 for embankment repairs, are for embankment works and are WRD's own calendar. So Clause 6.13.10 refers to the monsoon season as this Manual defines it, 1 April to 31 October, and Chapter 10 requires the desilting of drains, jans and channels and the clearance of inlets, silt traps and screens to be complete by 31 March, with sluice gates, flap gates, pumps and standby power certified ready and test-run on the same date (Clauses 5.11.5 and 5.12.9); a mid-season clearance of inlets, silt traps, screens and hill-stream traps by 31 May, after the April–May storms and before the south-west monsoon sets in; standby from 1 April to 31 October; and a post-season clearance of silt and debris, with a survey of silt depths, by 15 November. A deadline of 30 April for the Brahmaputra valley was considered and not used, because it would leave the April storms uncovered. These dates are set by this Manual. Assam's towns have no snow regime.

Building over drains is already restrained in law. In Guwahati the Commissioner may pull down a building erected over a drain, conduit or water-course vested in GMC (Gauhati Municipal Corporation Act, 1969, s.239), and no building within one hundred feet of a municipal drain may be erected or occupied until a drain to it has been built (s.244); the Unified Byelaws 2022 exclude multistoreyed buildings from areas "on or abutting natural drainage channels" (byelaw 117). Yet the ADB found the "construction of buildings and roads over the manmade drains" among the causes of the city's waterlogging (ADB IEE, 2017). Natural jans and hill streams are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over. 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: on the night of 19 April 2026 a woman died after falling into an open roadside drain in Guwahati (as reported), and petitions on covering open drains and manholes were before the High Court in 2026 (PIL 34 or 36 of 2026, the number given differently in two reports, as reported).

Clause 6.13.7 is not yet the practice, and in Assam it cannot be until sewers exist. "No ULB in the state has a centralized sewerage system, including Guwahati … about 90% of households have installed septic tanks or leach pits" (ADB RRP, 2025); the CAG found that "natural drainage systems of the cities carried the sewage" (CAG Report No. 4 of 2019); the Bharalu "has no natural flow … only the domestic sewage and commercial sewage are being carried", with about 39 outfalls, and the Bahini "now becomes a sewerage drain" (PCBA action plan for the Bharalu); and Dibrugarh's DTP drain "receives sewage flows" (ADB IEE, 2017). The JICA-assisted Guwahati sewerage project, whose loan agreement was signed on 27 February 2015, had barely begun by 2025 ("We have begun with the survey", March 2025, as reported). Clause 6.3.6(a) to (e) sets how a drain that carries sewage is designed meanwhile, and Clause 8.9 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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- *The Assam Building Construction (Regulation) Act, 2010* (Assam Act XVI of 2010), as amended by Assam Act XXVII of 2022, https://prsindia.org/files/bills_acts/acts_states/assam/2010/ActNo16of2010Assam.pdf
- *The Gauhati Municipal Corporation Act, 1969* (Assam Act I of 1973), ss.231, 232, 234, 237, 239, 242, 244 and 250 (Legislative Department scans of Chapters XXI and XXII–XXV); and *the Assam Municipal Corporation Act, 2022* (Assam Act VIII of 2022), ss.171, 173, 174, 176 and 177, https://prsindia.org/files/bills_acts/acts_states/assam/2022/ActNo.8of2022Assam.pdf
- *The Assam Embankment and Drainage Act, 1953* (Assam Act I of 1954), ss.2, 4, 15 and 16, https://www.ielrc.org/content/e5303.pdf
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- *The Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006* (Assam Act V of 2007), ss.2(d), 3, 14 and 19, Assam Gazette Extraordinary No. 20, 20 January 2007.
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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Assam 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, Pukhuris (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 (pukhuri) 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 Assam, a landlocked State, means the beels of the Brahmaputra and Barak floodplains, among them Deepor Beel, the State's only Ramsar site, Silsako, Borsola and Sorusola in Guwahati, Larua Jamira on the Dibrugarh drain, Son Beel, Urpad Beel and Chandubi, the marshes and hola land of the floodplains, the land ponded behind embankments when their sluices close, the water bodies scheduled under the water-bodies law, and any wetland notified under the 2017 Rules (none was found notified);
- (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 Assam Building Construction (Regulation) Act, 2010 and the Assam Unified Building Construction (Regulation) Byelaws, 2022 made under it, the Master Plans and Zoning Regulations under the GMDA Act, 1985 and the Assam Town and Country Planning Act, 1959, the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024 and the Guwahati Waterbodies (Preservation and Conservation) Act, 2008, which it repeals, the Assam Embankment and Drainage Act, 1953, the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006, the Gauhati Municipal Corporation Act, 1969, the Assam Municipal Corporation Act, 2022, the Assam Municipal Act, 1956, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Assam protects its waterbodies through its building rules, its water-bodies law, its embankment law and its Master Plans, with the wetland rules and the courts behind them; no law yet zones its floodplains. The **Assam Unified Building Construction (Regulation) Byelaws, 2022** (Assam Gazette Extraordinary No. 688, 15.10.2022, notification No. DoHUA/ECF No. 236697/2), as amended by the (Amendment) Byelaws, 2024 (Gazette No. 667, 20.11.2024, No. DoHUA/ECF No. 420084/34), are made by DoHUA under section 4 of the Assam Building Construction (Regulation) Act, 2010 (Assam Act XVI of 2010, as amended by Assam Act XXVII of 2022, which renamed it and extended it "to the whole of the State of Assam"). They apply in "the master Plan

areas or notified Planning areas of whole of Assam except for areas under Autonomous Districts", unless a District Council opts in (byelaw 1(2)). They set the minimum distance of a building "from the edge of natural drainage channels" and from notified water bodies and ponds (byelaw 26(ix), repeated as byelaw 44(ix) [sub-item numbers read from the OCR layout; TBC: confirm against a clean copy]); let the Authority refuse a site "near a water body or water course" that the development would contaminate or whose channel it would change, a site likely to be inundated without proper drainage, or "a filled up tank or low lying" site (byelaw 44(iii) [TBC: confirm the numbering]); keep multistoreyed buildings off land "on or abutting natural drainage channels" and "wetlands" (byelaw 117); and fix the plinth above "the highest recorded flood level as fixed by the local authority" (byelaw 45(c)) (Clause 7.4, Disclosure). The **Guwahati Waterbodies (Preservation and Conservation) Act, 2008** (Assam Act XX of 2008) defines waterbodies as "the area or areas of land where the rain water accumulates and act as natural or storm water reservoir and shall include wetland" (s.2(e)) and forbids filling, building and dumping in the four areas of its schedules (s.4). The **Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024**, passed on 29 August 2024 and cited as Assam Act XXV of 2024, keeps that definition, extends it to "all natural water channels (that are inflow or out flow channels into or from the waterbody)" and to all ponds and tanks "irrespective of its size" in every notified Master Plan area outside the Autonomous Districts (s.2(d)), and repeals the 2008 Act (s.22(1)); the enacted text, its gazette date and the Rules of 2025 were not read, so the section numbers given in this Manual are the Bill's [TBC]. The **Assam Embankment and Drainage Act, 1953** (Assam Act I of 1954) counts sluices as part of an embankment and "dongs", culverts, ditches, canals and sluices as drains (s.2), vests the works in the State (s.14), and makes it an offence to cut through an embankment or drain, or to open, shut or obstruct a sluice, without authority (s.15(ii)), and, in a notified area, to build on, remove or alter one without permission (s.16). The **Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006** counts "a drainage system, feeding channel, any water body" and "any marshy land, ponds, lakes and swamp" among its ecological sites (s.2(d)), which it protects once an area is designated (s.4); no designated area was found [TBC]. The **Master Plan for Guwahati 2025** classes "All notified forest, water bodies, rivers etc." as Eco-Sensitive Zone. Within municipal limits the drains that connect to the municipal system vest in the Municipal Corporation (Gauhati Municipal Corporation Act, 1969, s.250(2); Assam Municipal Corporation Act, 2022, s.173). Wetlands are the concern of the **Assam State Wetlands Authority** (Clause 7.12, Commentary), and Deepor Beel is the State's only Ramsar site (as reported). In this chapter **WRD** means the Water Resources Department, which holds the embankments, sluices, drainage channels and dewatering pumps and whose Embankment Officers act under the 1953 Act. A beel or pukhuri has no gate of its own unless it drains through one of WRD's sluices, so WRD is the custodian this chapter names where a clause speaks of levels, a datum, freeboard or an operating rule; the other custodians are recorded one by one in the inventory (Annex 7A). Who regulates where in the Sixth Schedule areas, and who is the competent authority for the area, is set out in Chapter 1.

This Manual treats every recorded waterbody as drainage infrastructure. Five features set Assam apart. The first is the **river behind the embankment**: the towns stand on the floodplains of the Brahmaputra and the Barak behind about 4,474 km of embankments (mothauri, the Assamese word for a river embankment) and drain through sluices (pani-duwar) that close when the river is high, so the outfall is normally shut in the monsoon (Chapter 5). The second is the **beel** (Assamese বিল: a natural floodplain lake or wetland), which in Guwahati is the city's storage: Deepor Beel, whose water spread is reported to range from about 10.1 km² to 40.1 km² in floods; Silsako, which GMDA is excavating as a retention basin; Borsola and Sorusola; and, at Dibrugarh, Larua Jamira on the town's drain. The law already calls such land a "natural or storm water reservoir" (2008 Act, s.2(e); Bill, s.2(d)). The third is the **jan** (a stream or natural drainage channel, often the outlet of a beel), by which the beels drain to the river, as the Khanajan drains Deepor Beel, and whose name survives in the Bondajan and the Lakhimijan; with it goes the **juri** (a small hill stream), which brings water, silt and debris down from the Guwahati hills. The fourth is the **pukhuri** (Assamese পুখুৰী: a dug tank or pond; plural pukhuris), the dug tank of the towns and villages, which this Manual keeps apart from the beel. The fifth is the **char and chapori** land of the rivers, sand and silt that the river builds, floods and erodes, on which no permanent drainage work is relied on (Clause 2.3.6(i)). Assam has no irrigation tank cascades; the tank clauses of this chapter apply to pukhuris and to beels that drain through a jan or a sluice, and storage built under this Manual is a "detention pond", never a pukhuri or a beel. Because the storm drains are also the sewers (Clause 8.9, Commentary), most beels in the towns receive sewage. This chapter gives the design rules that protect the storage and conveyance of these waterbodies. It does not replace the byelaws,

the water-bodies law, the embankment law, the Master Plans, the municipal Acts and the wetland procedures that record and protect them, or the directions of the Gauhati High Court, the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river, such as the Brahmaputra and the Barak and their tributaries and town rivers (the Bharalu, which the Bahini becomes at Jonali, the Mora Bharalu, the Basistha and the Kalmani in Guwahati, the Sessa at Dibrugarh and the Kushiyara at Karimganj); jan (a stream or natural drainage channel, often the outlet of a beel, as in the Bondajan, the Lakhimijan and the Khanajan); juri (a small hill stream); nala (a built drain) or khal (a ditch or channel); beel (a natural floodplain lake or wetland, such as Deepor Beel, Silsako, Borsola and Sorusola in Guwahati, Larua Jamira on the Dibrugarh drain, Son Beel, Urpad Beel and Chandubi); akhat (a natural pond, not dug); pukhuri (a dug tank or pond); hola (a hollow where water lodges in the rains); marsh or swamp; the land ponded behind an embankment (mothauri) when its sluice (pani-duwar) is closed; retention pond or basin built for flood storage; supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (pukhuri)	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 (overflow, outlet or spillway, or the control at the head of the jan or sluice by which a beel drains) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling.
Maximum water level (MWL)	The highest water level in a tank when the surplus weir passes the tank's design flood. For this Manual, it is the greater of the level recorded by the Water Resources Department and the level computed for the 1% AEP (100-yr) inflow with the climate factor of Clause 2.8 (Clause 7.7.4).
Top bund level (TBL)	The crest level of the tank bund.
Waterspread	The area of a tank submerged at FTL.
Foreshore	The land around a tank between the FTL contour and the MWL contour. Foreshore land is flooded whenever the tank surpluses, and is part of the tank's flood storage.
Supply channel (feeder jan, nala or 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 (pani-duwar), regulator or flap gate, including a sluice through a river embankment (mothauri))	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.

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

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

Term	Meaning in this Manual
Pukhuri	A dug tank or pond: পুখুৰী, "a pond; a tank", from Sanskrit পুষ্কৰ, a large dug place to hold water (*Chandrakanta Abhidhan*, 1962, p. 604); "a tank, a reservoir of water" (Bronson, 1867, p. 351) (Annex 7E). First used in this Manual as "pukhuri (Assamese পুখুৰী: a dug tank or pond; plural pukhuris)". Assamese marks the plural with *-bor* or *-hot*, so the English plural "pukhuris" is a convention of this Manual. A pukhuri with an outlet pipe, sluice or overflow is a tank under Clause 7.2, and its FTL is the crest of that outlet or overflow, found by survey; a pukhuri with no outlet has its FTL at the level at which it would spill to the ground around it, found by survey. Historic and temple tanks keep their own names. Engineered storage built under this Manual is a "detention pond", never a pukhuri.
Beel	A natural floodplain lake or wetland: বিল, "a lake", a broad body of water without current (*Chandrakanta Abhidhan*, p. 685); "a lake, a pond" (Bronson, p. 410). First used as "beel (Assamese বিল: a natural floodplain lake or wetland)"; "beel" is also the word of the 2008 Act's schedules and of the byelaws. A beel that drains through a jan or a sluice is a tank under Clause 7.2: its FTL is the crest of the control at the head of its outfall jan, or the sill of its sluice, found by survey, and its MWL is set under Clause 7.2 with the outfall closed where Clause 5.8.5 so requires. A beel with no outlet is a wetland under Clause 7.12. A natural wetland is never called a pukhuri, and storage built under this Manual is never called a beel.
Jan; juri; nala	A jan (জান) is a stream or natural drainage channel, "a ravine; a stream", a small river from a channel or beel (*Chandrakanta Abhidhan*, p. 397), "a drain, a trench, a channel, a creek" (Bronson, p. 225), as in the Bondajan, the Lakhimijan and the Khanajan; a juri (জুৰি) is "a small hill stream" (*Chandrakanta Abhidhan*, p. 407); a nala (নলা) is a built drain (*Chandrakanta Abhidhan*, p. 535). Every jan, juri or other channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whatever its name and whether it is lined, piped or covered; a built nala that carries a jan's flow along the jan's former line is treated as that jan. A juri carries silt, gravel and debris in flood: its inlets and culverts take the racks, bulking and blockage of Clause 6.3.6(f) to (h), and its top of bank is the edge of its active bed where that is wider than the edge of the 50% AEP flow. These readings are set by this Manual.
Embankment (mothauri); sluice (pani-duwar)	An embankment is a river embankment, মথাউৰি (*Chandrakanta Abhidhan*, p. 737), and, for this chapter, an "embankment" under section 2 of the Assam Embankment and Drainage Act, 1953, which includes walls, dams, spillways, groins, sluices, syphons and appurtenant land but not field ridges (ali) or roads. A sluice is a gated outlet through an embankment, পানী-দুৱাৰ, "a water-gate; a sluice" (*Chandrakanta Abhidhan*, p. 594). The word "dong" is used in this Manual only as the 1953 Act uses it, among drains.
Ponded area behind an embankment	The land inside an embankment-protected area that is flooded when its sluices are closed, up to the level reached in the outfall-closed case of Clause 5.8.5(a) for the 1% AEP storm. It is recorded in the inventory (Annex 7A), and that level is part of the 1% AEP flood extent of Clause 7.3.4; Zone 1 applies to the beels, pukhuris and channels within it, not to the ponded area as a whole. This definition is set by this Manual.
Char and chapori land	Char (চৰ) is "high land formed by river by deposit of silt; alluvial land" (*Chandrakanta Abhidhan*, p. 336); chapori or sapori (চাপৰি) is "high land formed by deposit of river sand and silt; high, open grass land" (*Chandrakanta Abhidhan*, p. 346; "an island, high table land", Bronson, p. 196). A site on active char or chapori land, or on an eroding bank, is a hazard-first site under Clause 2.3.6(i): it is treated as within the 1% AEP flood extent unless a hydraulic study shows otherwise, no permanent drainage work on it is relied on in a design elsewhere, and no infiltration is credited on it (Clause 4.11, floodplain rule). This reading is set by this Manual.

Term	Meaning in this Manual
Recorded waterbody	A beel, pukhuri, jan, juri, river, marsh or ponded area shown in any source of Clause 7.3.3(a): a dag-numbered land record, a schedule of the water-bodies law, a Master Plan map, the Fisheries Department's register of beels, WRD's records, the AURA application or a town's drain register. A recorded waterbody is part of the drainage system for this Manual. Where it is proposed to be filled, in whole or part, a drainage assessment under Chapters 3 to 5 shall show the storage and flow paths lost and their effect upstream and downstream, and the lost storage shall be replaced under Clause 7.6.4 before any design relying on the filling is approved. This definition and rule are set by this Manual.
Scheduled water body	A water body listed, by district, mouza, revenue village and dag number, in a schedule of the Guwahati Waterbodies (Preservation and Conservation) Act, 2008, so far as the schedules continue under the saving clause of the 2024 law [TBC], or in a schedule approved by the State Level Committee and published in the Gazette under section 6 of the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024. Since 2024 "No uses shall be permissible in the plots covered under the schedules of the Assam Urban Waterbodies (Preservation and Conservation) Act, 2024 except with permission from the Authority" (Unified Byelaws 2022, land-use table, note (1)). The storage of a scheduled water body is counted in basin and regional models (Clause 7.12.5) and shall not be reduced by any design under this Manual.
Boundary of a beel or pukhuri	For this Manual, the boundary of a beel or pukhuri under Clauses 7.3.3 and 7.13.1 is the largest of its boundary in the land records or schedule, its surveyed FTL, and the outer edge of its water in the season of 1 April to 31 October shown by dated imagery or survey of recent years. This reading is set by this Manual.
Reference lines for setbacks	Three lines are used, and the setback that reaches furthest from the water governs: (a) the byelaw's line, "the edge of natural drainage channels" or of the water body, with the distance of byelaw 26(ix) / 44(ix) measured from it; (b) the FTL of a beel or pukhuri or the top of bank of a channel, with Zone 1 of Clause 7.4.3 measured from it; and (c) the 1% AEP flood extent of Clause 7.3.4, with the 10 m of Clause 7.4.4 added. Where the byelaw's edge cannot be identified on the ground it is taken as the top of bank. This rule is set by this Manual.
Patta land and landholding	Most land in Assam is held as patta land under the land records of the Revenue and Disaster Management Department; some is government land. Zone 1 land that is patta land is reserved in the Master Plan or secured by a written agreement with the owner, and is not taken; in an Autonomous District, it is secured through the District Council (the Councils' land law was not researched [TBC]). This rule is set by this Manual.

7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with the Water Resources Department and the Revenue and Disaster Management Department, shall maintain a GIS layer of every waterbody in its area (Annex 7A). For each waterbody it shall record:

- (a) its type (Clause 7.2), name and survey numbers;
- (b) its custodian (GMC (for the municipal drains of Guwahati under sections 231 to 252 of the Gauhati Municipal Corporation Act, 1969, and for the desilting of the Bharalu, Mora Bharalu, Basistha, Bahini and Lakhimijan and their feeder drains, as reported), another Municipal Corporation (for the public drains that vest in it under section 173 of the Assam Municipal Corporation Act, 2022), a Municipal Board, GMDA (for the water bodies scheduled in its area under the water-bodies law, for Silsako and for new drainage works) or another Development Authority, WRD (for the rivers, embankments, sluices, drainage channels and pumps it holds, which vest in the State under section 14 of the Assam Embankment and Drainage Act, 1953, among them the Bharalumukh sluice and the dewatering pumps of the Bharalu, Mora Bharalu and Bondajan), PWD or NHAI (for the drains and culverts of their roads), the Fisheries Department (for the beels in its register and the ponds of the Government fish farms), the Environment and Forest Department (for Deepor Beel Wildlife Sanctuary and for water in reserved forests, sanctuaries and national parks), the Revenue and Disaster Management Department (for government land recorded as water), the Gaon Panchayat, a religious institution (for its tank), a private owner (for a beel or pukhuri on patta land), the Railways, OIL, the Army or another body for its own drains, the District Council in an Autonomous District (not researched [TBC]), the Assam State Wetlands Authority (for a notified wetland; none was found), 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) land records of the Revenue and Disaster Management Department, kept by district, mouza, revenue village, dag number and patta, including government land recorded as beel or water; the schedules of water bodies by district, mouza, revenue village and dag number, those of the Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (Sorusola, Borsola, Silsako and land near Deepor Beel) and those that the District Level Committees prepare under section 5 of the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 from Bhuvan and the Water Body Census of the Ministry of Jal Shakti; the land-use maps of the Master Plan for Guwahati 2025 and the other Master Plans (the byelaw setbacks apply to rivers and ponds "as marked in the plan"), with their Eco-Sensitive Zone; the Fisheries Department's register of beels (2,072 beels in 2021-22, then 447 registered and 1,625 unregistered, as quoted from the Statistical Handbook); WRD's records of its embankments, sluices and drainage channels; T&CP's AURA application for urban water bodies (as reported); the National Wetland Atlas (2011); in the Autonomous Districts, the land records of the District Councils (not researched [TBC]); and each town's drain register (Chapter 6);
- (b) WRD and Gaon Panchayat tank registers and records of FTL and MWL;
- (c) the Authority's inventory (Clause 7.3.1) and any list published under court directions;
- (d) historical topographic maps and satellite imagery, including the ISRO National Wetland Inventory and Assessment; and
- (e) a site survey by a licensed surveyor, levelled to the datum stated in Clause 7.3.5.

7.3.4 **Flood extent maps.** The Authority may adopt 1% AEP flood extent or flood depth maps for its area. A depth map adopted under this clause also sets floor levels under Clause 6.11. Where a map has been adopted, it shall be used unless a site hydraulic study under Chapters 3 and 5 shows a larger extent. Where no map has been adopted, the Applicant shall determine the 1% AEP extent by a hydraulic study for:

- (a) any site in a flood-sensitive catchment (Chapter 1);
- (b) any site of 1 ha or more adjoining a waterbody; and
- (c) any site where the Authority so requires.

For other sites, the fixed-width setback of Clause 7.4.6 may be used.

7.3.5 **Datum.** All levels in this chapter shall be stated to one datum, stated on every drawing. Where WRD records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

Commentary. Assam has no flood line in law. It has not enacted the Model Flood Plain Zoning Bill (PIB, as cited); a proposed Assam Flood Plain Zoning Bill was reported to have been reviewed by the Chief Minister on 5 November 2026 (a single press source, unverified), and it is not law. The two figures for the flood-prone area conflict: 31.50 lakh ha, 40% of the State, identified by the Rashtriya Barh Ayog (CAG Report No. 5 of 2018), and 31.05 lakh ha, 39.58% (WRD's website, as cited); WRD gives "reasonable protection" to 16.50 lakh ha, 52% of the first figure (CAG, 2018). The byelaws provide that "Natural Hazard Prone Areas … shall be notified and updated by the authority based on Hazard Studies viz. … Flood zonation" (byelaw 2), and since 2024 they require every Master Plan to carry a "Map identifying natural hazard prone areas where construction is not permitted" (byelaw 120); no such map or notification was found [TBC], and ASDMA's flood hazard maps were not obtained [TBC]. The levels that exist are CWC's: at Guwahati (DC Court) a danger level of 49.68 m and a highest flood level of 51.46 m (21 July 2004), and at Annapurnaghat on the Barak, the gauge for Silchar, 19.83 m and 21.84 m (1 August 1989), among others (as transcribed by SANDRP from CWC tables; the datum is as published by CWC and was not stated [TBC]; Chapter 5). The plinth rule fixes floors above "the highest recorded flood level as fixed by the local authority" (byelaw 45(c)), but no such level was found fixed for any town [TBC]. The dag-numbered schedules of the water-bodies law and WRD's records of its embankments and sluices are the best record of where water is meant to be. Clause 7.3.4 lets the Authority adopt 1% AEP maps; a map prepared under this Manual is offered as an input to the hazard maps of byelaw 120 and to the schedules of the water-bodies law, not as a notification under either. Until maps are adopted, the Applicant produces the 1% AEP extent for larger and flood-sensitive sites with the outfall closed as Clause 5.8.5 requires, because inside an embankment the flood extent is set by the ponding behind a shut sluice as often as by the river; and a highest flood level stated in a permission 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) and tied to the CWC or WRD gauge. 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 along every natural channel draining 8 ha or more and round every beel and pukhuri (wider lines govern under Clause 7.4.5 where they bind: the distances of byelaw 26(ix), repeated as byelaw 44(ix), of the Unified Byelaws 2022 [sub-item numbers read from the OCR layout; TBC: confirm against a clean copy], measured from "the edge of natural drainage channels", are 15 m from a river and from Deepor Beel and Silsako, 10 m from the Bharalu, Mora Bharalu and Bondajan and from large ponds, and 6 m from other channels and other notified water bodies, with only the building setbacks for minor drains and small ponds; the Master Plan for Guwahati 2025 keeps construction 15 m from the Brahmaputra bank on one riverfront stretch; no distance from an embankment was found; and no floodplain zoning law has been enacted; 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 Deputy Commissioner or WRD's Embankment Officer under section 16 of the Assam Embankment and Drainage Act, 1953 for any building on, or removal or alteration of, an embankment or drain in a notified area; a condition of the District Level Committee or the State Level Committee for a scheduled water body under the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024 (the Bill as introduced was read, ss.4 to 8 [TBC]); the approval of the Advisory Committee under section 14 of the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006 in a Designated Area; the views or permission of the Assam State Wetlands Authority or the Environment and Forest Department for a work in or next to Deepor Beel, a sanctuary or a notified wetland; a line of the Master Plan for Guwahati 2025 or another Master Plan, such as its 15 m strip from the Brahmaputra bank; or a direction of the Gauhati High Court, the National Green Tribunal or the Supreme Court sets a setback wider than Zone 1 or Zone 2, the wider setback governs for the uses it restricts.

7.4.6 **Fixed-width setback where no 1% AEP extent is available.** Where Clause 7.3.4 does not require a hydraulic study and no map has been adopted, the setback (Zone 1 plus Zone 2) shall be not less than the following, measured as in Clause 7.4.3:

Table 7.1 — Fixed-width setback where no 1% AEP extent is available

Waterbody	Total setback (Zone 1 + Zone 2)	Of which Zone 1
Channel draining 8 ha to 65 ha	25 m	15 m
Channel draining 65 ha to 20 km²	40 m	15 m
Channel draining more than 20 km², and rivers	50 m	20 m
Tank, lake or pond	MWL contour + 25 m	to MWL contour, and not less than 15 m from FTL
Marsh, estuary or backwater	as notified by the Authority, and not less than 50 m	15 m

This table is the alternative S-3 of the Policy Supplement (Annex 1C) and may be adopted under Clause 1.7.

7.4.7 **Minimum in all cases.** No setback under this chapter, and no variance under Clause 1.10, shall reduce Zone 1 below 15 m (Clause 1.10.3(c)).

> **Commentary.** The 15 m minimum is set by this Manual, as the floor of a hydraulic corridor where no wider line binds. Assam's distances from water are in its building rules: byelaw 26(ix), repeated as byelaw 44(ix), of the Assam Unified Building Construction (Regulation) Byelaws, 2022 (Assam Gazette Extraordinary No. 688, 15.10.2022), not amended in this respect in 2024 (NEER reading of the amendment's index [TBC]), sets "The minimum distance of any building from the edge of natural drainage channels" at 15 m from a river "as marked in the plan" and from the notified water bodies Deepar Beel and Silsako, 10 m from the Bharalu, Mora Bharalu and Bondajan and from other large ponds, and 6 m from other channels and other notified water bodies such as Sarusola and Barsola; minor drains and small ponds not marked in the plan take only the building setbacks. The Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 points its "no construction zone within a buffer around the Water Bodies" to the Master Plan and to these byelaws (s.5). The 15 m floor equals the byelaw for rivers and for Deepor Beel and Silsako; it is half as wide again as the 10 m of the Bharalu, Mora Bharalu and Bondajan and of large ponds, two and a half times the 6 m of other channels and other notified water bodies, and

it reaches the minor drains and small ponds that the table leaves to the building setbacks. The byelaw measures from the channel's edge; this Manual measures from top of bank or FTL, or from the 1% AEP extent where that is wider. It applies to new development and redevelopment approved under this Manual, not to existing buildings; and where Zone 1 land is patta land, it is reserved in the Master Plan or secured by agreement with the owner, not taken. It is this Manual's proposal, not a statutory width, and it never reduces a wider line (see the Disclosure below). Extending the setback to the mapped 1% AEP extent plus a margin follows the Kansas City Metro APWA Section 5600 (2025.01) two-zone structure:

- APWA Zone 1 (streamside) is measured from top of bank, and only utility and road crossings are allowed in it.
- APWA Zone 2 is the 1% AEP flood extent plus 10 ft (about 3 m), for streams draining 20–40 acres.
- APWA lowered the trigger for stream setbacks from 40 acres to 20 acres (about 8 ha) in 2025.01.

(MARC, APWA 5600 Policy Supplement, Nov 2025.) Clause 7.4.1(b) adopts the 8 ha trigger. This Manual's 10 m margin is wider than APWA's 10 ft and has no direct precedent. This Manual sets it because Assam flood maps are mostly coarser than US maps, the Brahmaputra and Barak floodplains on which the towns stand are flat and low, and Dibrugarh town is "1.5 m below the bed level" of the Brahmaputra (ADB, 2017) (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).

Assam's setbacks from water are in its building rules. Byelaw 26(ix) of the Unified Byelaws 2022, repeated as byelaw 44(ix) in Part II [sub-item numbers read from the OCR layout; TBC: confirm against a clean copy], reads: "The minimum distance of any building from the edge of natural drainage channels shall be as given below": River (as marked in the plan), 15 m; Bharalu, Mora Bharalu & Bondajan, 10 m; Other channels, 06 m; Minor drains (not marked in the plan), "In accordance with setback requirements for buildings provided in the byelaws"; Notified water bodies (Deepar Beel, Silsako Waterbody), 15 m; Other notified water bodies (Sarusola, Barsola etc.), 06 m; Other large ponds/water bodies (as marked in the plan), 10 m; and Small ponds (not marked in the plan), as for the building setbacks. The same table stood in the Guwahati Building Construction (Regulation) Byelaws, 2014, which also kept "river edge etc." in a "Reserved Forest & Conservation Area" where "No development should normally be allowed"; the 2024 amendment did not change it (NEER reading of the amendment's index [TBC]). The table names only Guwahati's channels and beels although the byelaws now extend to every notified Master Plan area in the State, and "as marked in the plan" ties the river and pond rows to the Master Plan maps (NEER reading). The Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 makes the District Level Committee "ensure no construction zone within a buffer around the Water Bodies as prescribed in the Notified Master Plan and Assam Unified Building Construction (Regulation) Bye law, 2022" (s.5); that buffer is this table. The Master Plan for Guwahati 2025 adds, on the riverfront strip from Sonaram High School to the foothills of Kamakhya, that "No construction shall be allowed within a distance of 15m from river bank" (schedule of modification), and classes "All notified forest, water bodies, rivers etc." as Eco-Sensitive Zone. Byelaw 44(iii) [TBC: numbering] lets the Authority refuse or modify a proposal "if the site is near a water body or water course" and the development is likely to contaminate it or "change the course of the channel", or if the site is likely to be inundated without proper drainage, or "is a filled up tank or low lying"; byelaw 117 excludes multistoreyed buildings from "Areas falling on or abutting natural drainage channels", "Areas falling on or abutting wetlands" and "Government land in the hills and in the water bodies like beels". Under the Assam Embankment and Drainage Act, 1953, no one

may build on, remove or alter an embankment or drain in a notified area without the permission of the Deputy Commissioner or the Embankment Officer, on pain of up to three years and ₹1,000 and removal at the offender's cost (s.16), but **no setback distance from an embankment was found** [TBC]. The Gauhati Municipal Corporation Act, 1969 bars occupying a building "within one hundred feet of a municipal drain" until it is drained to that drain (s.244); that is a duty to connect, not a setback. The rules leave gaps for drainage: the table's distances run from a channel's "edge", which is not defined; the Bharalu, Mora Bharalu and Bondajan, which carry most of Guwahati's storm water and sewage, get 10 m and other channels 6 m; minor drains and small ponds not marked in a plan get only the building setbacks; nothing keeps building back from an embankment; and outside notified Master Plan areas, and in the Autonomous Districts unless a Council opts in, the byelaws do not apply at all. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere the Manual applies.

Disclosure. Assam **has distances from water in its building rules, but they are narrow along the channels that carry most of the towns' water, they name only Guwahati's channels and beels, and they keep nothing back from an embankment**: byelaw 26(ix), repeated as byelaw 44(ix), of the Unified Byelaws 2022 [sub-item numbers read from the OCR layout; TBC: confirm against a clean copy] gives **15 m from a river and from Deepor Beel and Silsako, 10 m from the Bharalu, Mora Bharalu and Bondajan and from large ponds, and 6 m from other channels and other notified water bodies**, measured from "the edge of natural drainage channels", with only the building setbacks for minor drains and small ponds; it applies in notified Master Plan areas and, in the Autonomous Districts, only where a District Council opts in (byelaw 1(2); none has [TBC]); **no distance from an embankment was found**; and **no floodplain zoning law** has been enacted. The **15 m minimum** Zone 1 of Clauses 7.4.3 and 7.4.7, and every value derived from it in Table 7.1, is **set by this Manual** as a hydraulic corridor where nothing wider binds: along every natural channel draining 8 ha or more, jan, juri or river, whether or not a plan marks it, and round every beel and pukhuri. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, this Manual's three reference lines, its reading of the boundary of a beel or pukhuri and of the ponded area behind an embankment, and its rules on char and chapori land (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule**, and no government body, Authority, committee or District Council has adopted or endorsed them. The 15 m Zone 1 **equals the byelaw** for rivers and for Deepor Beel and Silsako, and is **stricter than the byelaw** for the Bharalu, Mora Bharalu and Bondajan and for large ponds (10 m), for other channels and other notified water bodies (6 m), and for minor drains and small ponds (building setbacks only). It applies to **new development and redevelopment approved under this Manual, not to existing buildings**; Clause 7.4.7 allows no variance below it; and where Zone 1 land is patta land, it is **reserved in the Master Plan or secured by agreement with the owner, not taken** (in an Autonomous District, through the District Council [TBC]). The byelaw measures from a channel's "edge"; this Manual measures Zone 1 from top of bank or FTL, and Zone 2 from the 1% AEP extent. The setback is applied as **whichever of the three reference lines and its setback reaches furthest** (definitions after Clause 7.2), so the Manual is **stricter than statute** along the town channels, the jans and the smaller beels and ponds, and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The Unified Byelaws 2022, as amended in 2024.** The distances of byelaw 26(ix) / 44(ix) above, which the Applicant states on Form 7-1; where 10 m or 6 m is narrower than Zone 1 it never governs alone. Byelaw 44(iii) [TBC: numbering] lets the Authority refuse a site near a water body or water course, a site likely to be inundated, or "a filled up tank or low lying" site; byelaw 117 keeps multistoreyed buildings off land on or abutting natural drainage channels and wetlands and off government land "in the water bodies like beels"; byelaw 45(c) sets the plinth 0.3 m (0.6 m for lifeline buildings) above "the highest recorded flood level as fixed by the local authority", and this Manual's floor of the 1% AEP level plus 0.5 m (Clause 7.6.6(b); Chapter 6) governs where it is higher; byelaw 66(3) bars basements "in low-lying areas and areas without adequate drainage facilities".
- **The water-bodies law.** The Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 makes the District Level Committee "ensure no construction zone within a buffer around the Water Bodies as prescribed in the Notified Master Plan and Assam Unified Building Construction (Regulation) Bye law, 2022" (s.5), which is the byelaw table; it bars filling that may "reduce the size of the waterbodies", any structure "either Concrete or RCC or Iron except nature based solutions", and any "obstruction in the natural and normal course of inflow and outflow of water into or from the waterbody" without permission (s.15), with

up to three years or ₹1 lakh or both and restoration (s.16). It repeals the Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (s.22(1)); the enacted text was not read, so these are the Bill's section numbers [TBC]. The 2008 Act set no distance; its Schedule IV is land **near** Deepor Beel, not the beel itself.

- **The Master Plans.** In Guwahati, the 15 m no-construction strip from the Brahmaputra bank between Sonaram High School and the Kamakhya foothills, and the Eco-Sensitive Zone that takes in "All notified forest, water bodies, rivers etc." (Master Plan for Guwahati 2025, Gazette No. 198, 9 July 2009, and its schedule of modification); the draft Master Plan 2045 is not in force. The lines of the other towns' Master Plans were not read [TBC].
- **The embankment law.** Section 16 of the Assam Embankment and Drainage Act, 1953 requires permission for any building on, or removal or alteration of, an embankment or drain in a notified area; it sets no distance [TBC].
- **Wetlands, courts and custodians.** Deepor Beel Wildlife Sanctuary and the Ramsar site, whose denotification the Gauhati High Court has stayed (05.04.2024); its eco-sensitive zone exists **only in draft** (as reported); any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was found); the orders of the Gauhati High Court, the National Green Tribunal and the Supreme Court as they stand; and WRD's lines at its embankments and sluices.

This Manual sets 15 m as the floor because the town channels that carry most of the storm water and sewage get only 10 m or 6 m from an undefined edge, and the jans and ponds not marked in a plan get nothing beyond the building setbacks; because 15 m is the byelaws' own distance for a river and for the two largest notified water bodies, and above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled; and because a town channel needs room for desilting by machine, which is the main maintenance the towns already do. The reasons for the corridor are the record: the drains and channels are silted and built over ("construction of buildings and roads over the manmade drains"; "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels", ADB, 2017); builders blocked channels and filled wetland at Palasbari, causing "artificial floods" (Gauhati High Court, PIL/53/2023, order of 06.09.2024); and Guwahati spent ₹32.57 crore on desilting between 2013-14 and 2017-18 while it had no data on its storm-water drains (CAG Report No. 4 of 2019). Until a byelaw amendment, a Master Plan, a schedule under the water-bodies law or a court adopts it, the 15 m minimum is this Manual's recommended standard, and the byelaws, the Master Plans, the water-bodies law and the orders above remain the only legal minimum. Approving authorities should state in each approval which was applied.

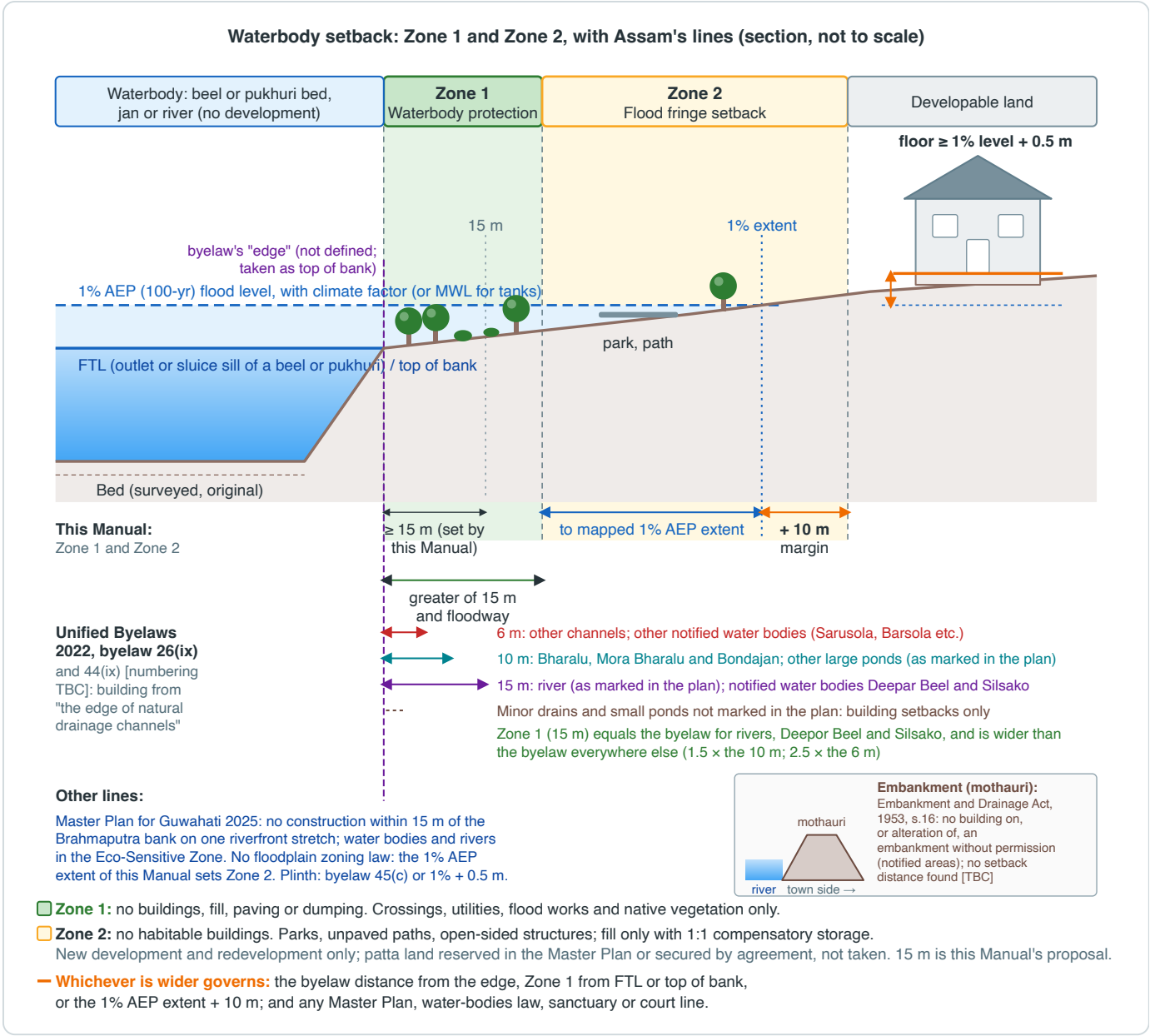

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 Assam Unified Building Construction (Regulation) Byelaws 2022, 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 Assam 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 Brahmaputra and Barak floodplains are flat, the low ground of Guwahati and its beels lies below the high stage of the Brahmaputra, and Silchar is a bowl behind the Barak embankment, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.

In Assam the byelaws measure setbacks from "the edge of natural drainage channels", and the 2008 Act's schedules fix water bodies by dag number, but neither gives a line for the edge of a beel whose water spreads and shrinks through the year. The difference matters because the beels are shrinking: Deepor Beel's water spread is reported at about 10.1 km² in the dry season and up to 40.1 km² in floods, and its loss since 1991 at "about 35%" (figures of 14.1% and about 405 ha in other sources conflict); Urpad Beel's water area is reported to have fallen from 4.84 km² in 2003 to 3.38 km² in 2023, and Chandubi's from 203.2 ha in 1997 to 186.5 ha in 2007 (all as reported). A line drawn from the edge of the water in the dry months would leave the beel's own flood storage open to building, and one drawn from today's edge would give up its lost area for good. This Manual gives every beel and pukhuri a boundary measured from a high level, not from the water's edge on the day of survey: the edge of its water in the season and its recorded dag boundary 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 Guwahati's Bharalu basin, where Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar were inundated in June 2022 (as reported), of Dibrugarh behind the DTP dyke, and of Silchar behind the Barak embankment 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.

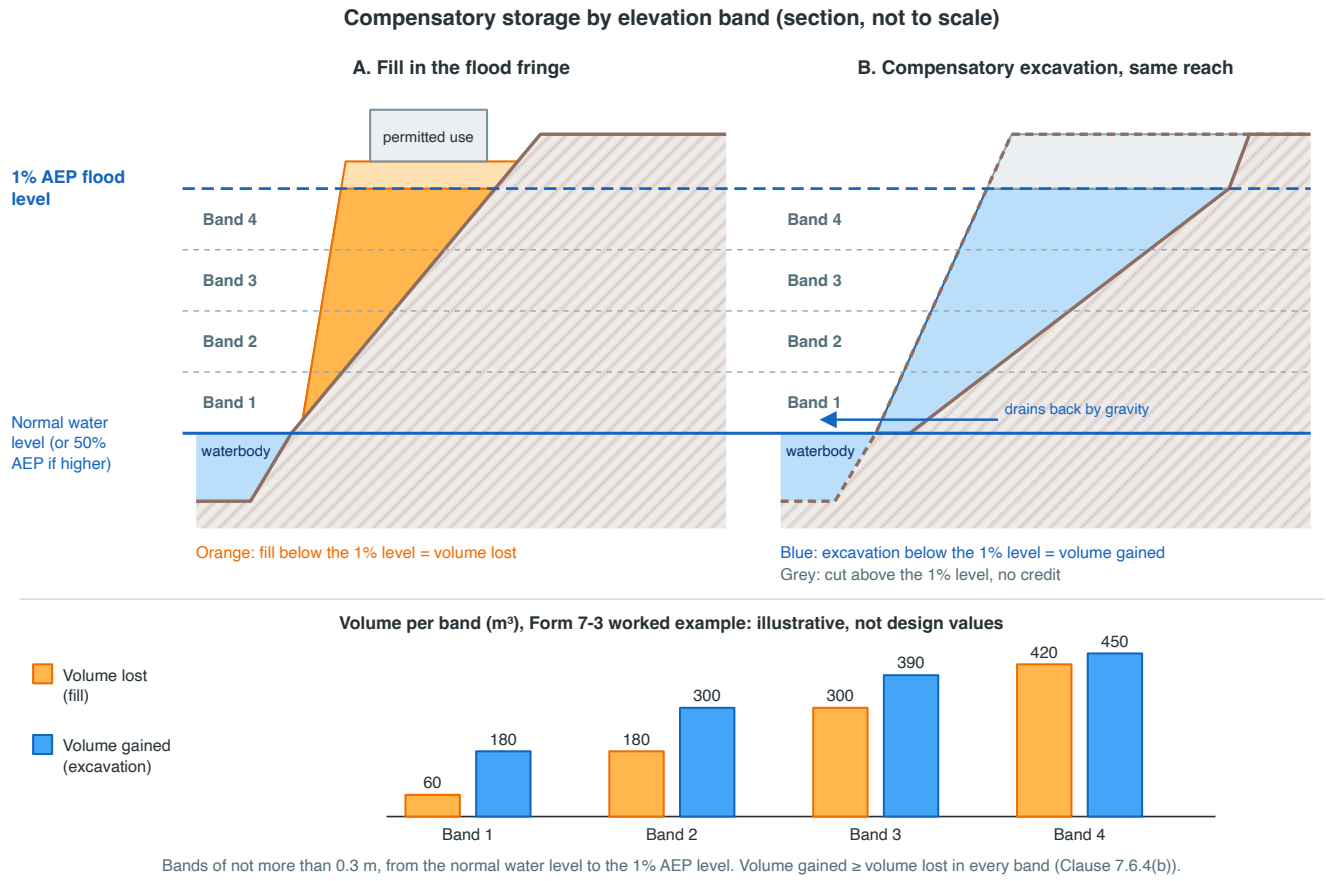

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation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

Assam has no tank Act and no irrigation tank cascades, and its standing waters range from a village pukhuri to Deepor Beel. The storages that matter for urban drainage are of five kinds. The first is the **beels** that receive a town's runoff: in Guwahati, Deepor Beel, whose perennial water spread of about 10.1 km² is reported to reach 40.1 km² in floods (as reported; no stage–storage relation was found [TBC]), fed by the Basistha and the Kalmani and draining to the Brahmaputra by the Khanajan, with the Mora Bharalu a polluting inflow; Silsako, to which part of the Bahini's runoff is to be diverted "to a retention basin in the nearby Silsako Basin and gradually pumped out to the Brahmaputra River" (ADB, 2025); Borsola and Sorusola; and, at Dibrugarh, Larua Jamira beel on the town's drain to the Sessa. Elsewhere Son Beel in Karimganj district, Urpad Beel in Goalpara and Chandubi are among the large beels (their areas conflict and are given in Clause 7.12, Commentary). The second is the **retention ponds** now being built for flood storage, of which the first is the ADB's "nature-based flood retention pond of 59,000 m3 and a pumping station with capacity of 1.6 m3 per second" in the Bahini basin (ADB, RRP, 2025); these are detention ponds, never pukhuris or beels. The third is the **ponded area behind an embankment**, which stores the town's runoff while its sluices are shut (definitions after Clause 7.2). The

fourth is the **pukhuris**, the dug tanks of the towns and villages, among them historic tanks such as Joysagar, Jor Pukhuri and Dighalipukhuri, named here only as examples of the word (not researched [TBC]); no levels, areas or outlet records were found for any of them [TBC], so their storage is modelled as an existing feature and not counted unless Clause 7.7.1 is met. The fifth is the **village beels and hola land**, modelled as existing features where they intercept runoff but never counted as storage, because they are not surveyed, have no controlled outlet and are full by the time of the peak storm. The Fisheries Department's register lists 2,072 beels with 71,843.5 ha in 2021-22, and 447 registered and 1,625 unregistered beels in the next count (as quoted from the Statistical Handbook; the change is in the counting); the National Wetland Atlas (2011) puts the State's wetlands at 764,372 ha, 9.74% of its area. These are the waterbodies for which Figure 7.3 and Clause 7.8 matter: in a floodplain town every drain ends in a jan or a beel, and every beel in a sluice through the embankment that the river closes. Any beel, pukhuri or pond whose storage is to be counted is subject to Clause 7.7.1 in full, with WRD where the outlet is its sluice and with the other custodian where it is not, and the custodian of each shall be confirmed for the inventory (Annex 7A) [TBC].

7.7.1 **When tank storage may be counted.** The storage of a tank or tank cascade may be counted as design storage (in a basin plan, a regional facility or a fee-in-lieu scheme under Clause 7.11) **only** where all of the following are met:

- (a) **Surveyed levels.** FTL, MWL, TBL, the surplus weir crest and length, and the sluice sill levels have been surveyed to the datum of Clause 7.3.5 within the previous 5 years.
- (b) **Stage–storage curve.** A stage–storage curve has been derived from a bathymetric and topographic survey of the waterspread and foreshore within the previous 5 years, or after the last desilting, whichever is later.
- (c) **Operating rule.** A documented operating rule has been agreed with the custodian (Clause 7.8).
- (d) **Maintained structures.** The surplus weir, sluices and bund are maintained under an O&M plan (Chapter 10), and the latest pre-monsoon inspection found them serviceable.
- (e) **Custodian concurrence.** WRD, or the other custodian, concurs in writing.

Storage in a tank that fails any of (a) to (e) shall not be counted, though the tank shall still be modelled as an existing feature (Chapter 3).

7.7.2 **Modelling.** Tank cascades shall be modelled under Clause 3.12.5 (level-pool routing of each tank, with surplus weir and sluice ratings) and Clause 3.13 (continuous simulation). The whole cascade, from the uppermost tank whose surplus can reach the site or facility to the next river, major drain or sea outfall, shall be modelled together, including, for a floodplain town behind an embankment, every beel and pukhuri that stores its runoff, the jans that join them, the outfall sluice and pumps through the embankment, and the river stage at the outfall that closes the sluice (Clause 5.8.5), as shown in Figure 7.3.

7.7.3 **Starting level.** The starting level in every tank shall be **FTL** for the design-storm analysis. A lower starting level may be used only under a flood-cushion operating rule that meets Clause 7.8.

7.7.4 **Design maximum level.** For the 1% AEP inflow with the climate factor, routed through the cascade:

- (a) the computed maximum level shall be not higher than MWL (as defined in Clause 7.2); and
- (b) the freeboard from the computed maximum level to the lowest point of the bund (TBL) shall be not less than WRD's freeboard standard for the tank.

Where (a) or (b) fails, the tank storage above FTL shall not be counted until the surplus weir capacity is increased or the bund raised under Clause 7.7.6.

7.7.5 **Creditable volume.** The creditable design storage of a tank is the volume between the starting level (Clause 7.7.3) and the computed maximum level of Clause 7.7.4, less any volume already committed to another facility or scheme.

7.7.6 **Changes to FTL, weirs and bunds.** No surplus weir crest shall be raised or lowered, no shutters or falling boards shall be added, and no bund shall be raised, cut or breached except under a design approved by the custodian that:

- (a) routes the cascade under Clause 7.7.2;
- (b) shows the effect on flood levels in the foreshore and upstream, and on flows in the surplus course and downstream; and

- (c) checks the bund under Clause 7.14.

Commentary. This Manual allows tank cascades to be used as design storage subject to three basic conditions (surveyed FTL, a documented operating rule and maintained surplus weirs). Clause 7.7.1 adds the stage–storage survey and the custodian's concurrence, because the storage a tank actually offers depends on its silt level and on who controls the sluices. The 5-year survey interval is set by this Manual.

The FTL starting level follows Clause 3.12.5. In Assam the starting level of a beel is its outlet level because the outlet is shut when the river is high. The design of Dibrugarh's drain outfall checks the "backwater affect … at the sluice with a flood level of 97.50 m", "keeping in mind that the beel is full and the drain is also flowing full" (ADB, 2017): this Manual takes the same case as the rule for every beel or pond that drains through a sluice or a gated pumped outfall (Clause 5.8.5(a) and (e)). At Guwahati the Brahmaputra reaches its danger level of 49.68 m at the DC Court gauge in most monsoons, and its highest flood level is 1.78 m higher (CWC levels as transcribed by SANDRP; NEER reading of the gap), so the outfalls are designed for gates closed for days to weeks; with the Bharalumukh sluice gates closed the city's main channel drains only by pumps, reported in 2008 at 7 m³/s against 72 m³/s by gravity (as reported; the present capacity was not found [TBC]). The beels themselves fill and spread through the season: Deepor Beel's water spread is reported at about 10.1 km² in the dry season and up to 40.1 km² in floods (as reported). The Manual's season begins on 1 April because large falls come before the south-west monsoon (Dibrugarh (Mohanbari) 231.5 mm on 10 May 1996 and Dhubri (Rupsi) 479.3 mm on 28 May 1989, IMD) as well as during it, so a beel or pukhuri may be full at any time from April to October. No record of how long any beel stays at or above its outlet level in a wet spell, or of how long any sluice stays closed, was found [TBC]. While a beel is full and its sluice shut, it stores nothing more below FTL, and the drains and jans that flow into it discharge against its level. 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.

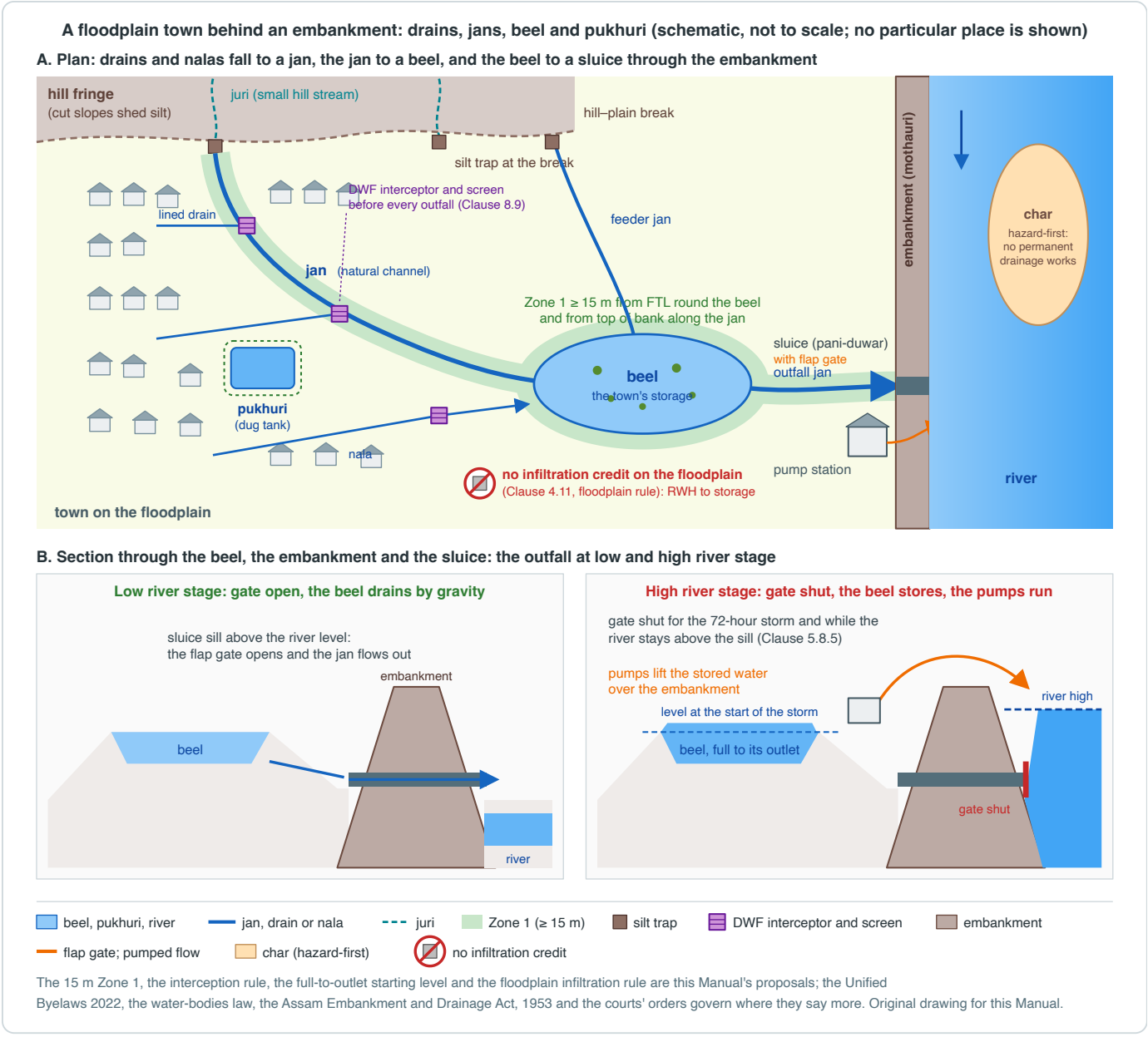

Figure 7.3 — A floodplain town behind an embankment: its drains, jans, beel and pukhuri, and the outfall sluice at low and high river stage (schematic, not to scale; no particular town, beel, sluice or landmark is shown). A: in plan, the town stands on the floodplain behind a river embankment (mothauri). Its lined drains and nalas fall to a jan, a stream or natural drainage channel, which runs to a beel, the natural floodplain lake or wetland that stores the town's runoff; the beel drains by its outfall jan to a sluice (pani-duwar) through the embankment, with a flap gate on the river side and a pump station beside it (Clause 5.8.5; Chapter 9). Every drain outfall to the jan and the beel has a dry-weather-flow interceptor and a screen, because the drains carry sewage (Clause 8.9). A pukhuri, a dug tank, stands in the town; it is modelled as an existing feature and counted as storage only under Clause 7.7.1. On the hill fringe, juri streams from the hills pass silt traps at the break of slope before they reach the town's drains (Clauses 6.3.6(m) and 8.12). Zone 1 is at least 15 m from the top of bank of the jan and from the FTL of the beel and the pukhuri, and Zone 2 runs to the 1% AEP extent plus 10 m (Clause 7.4). No infiltration is credited on the floodplain (Clause 4.11, floodplain rule). A char in the river is marked as hazard-first ground with no permanent drainage works (Clause 2.3.6(i)). B: in section through the embankment, at low river stage the gate is open and the beel drains by gravity; at high stage the gate is shut, the beel starts full to its outlet level and stores the inflow, and the pumps lift it over the embankment (Clauses 5.8.5 and 7.7.3). The 15 m minimum, the interception rule, the starting level and the infiltration rule are this Manual's proposals; the Unified Byelaws 2022, the water-bodies law, the Assam Embankment and Drainage Act, 1953 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, ASDMA alerts, and city forecast systems where available) and the actions taken at each trigger;
- (f) communication with downstream ULBs and residents before any release; and
- (g) the records to be kept: daily levels in the monsoon, releases, and gate settings.

7.8.2 **Flood cushion.** A tank may be operated with a flood cushion (a level below FTL during part of the monsoon), and the cushion counted under Clause 7.7.3, only where:

- (a) the tank has a gated sluice, regulator or other controllable outlet able to draw the tank down to the cushion level in the time stated in the rule;
- (b) the operating rule fixes the cushion level and the dates it applies;
- (c) continuous simulation (Clause 3.13) shows that the cushion is available at the start of a design storm in at least **90%** of monsoon seasons in the record, allowing for the rain that usually comes before the peak storm;
- (d) the custodian accepts any loss of irrigation or water-supply yield, and any agreed compensation is recorded; and
- (e) the release needed to create or restore the cushion meets Clause 7.8.1(d).

7.8.3 **No storage credit without control.** Where a tank has no controllable outlet, no flood cushion shall be assumed, whatever the past practice.

7.8.4 **Coordination.** For tanks under WRD control, the operating rule shall be WRD's rule. This Manual does not authorise any other body to operate a WRD tank.

> **Commentary.** No beel or pukhuri in Assam was found with a written operating rule, and most have no gates to operate. Where a beel drains through an embankment, its only controllable outlet is a sluice that WRD holds, and WRD's sluice operating rules and closure periods were not found [TBC]; the sluices close because the river rises, not because a forecast is issued, and the law makes it an offence to open, shut or obstruct one without authority (Assam Embankment and Drainage Act, 1953, s.15(ii)). The town's pumps at the outfall, where they exist, are the only means of drawing a beel down while the river is high, and they are small for the floods they serve: at Bharalumukh 7 m³/s against 72 m³/s by gravity (2008, as reported), and the ADB's Bahini works add 7.8 m³/s in three stations and a pump of 1.6 m³/s at the new retention pond (ADB, 2025). Without an agreed rule with dates, levels, pumping rates and a named operator, storage in a beel cannot be relied on, and a release made without warning to the land downstream is itself a flood. Clause 7.8.2 turns that principle into a rule that can be checked, with a reliability test, because a cushion that is refilled by the April and May storms gives no protection when a June to August monsoon storm, such as those of June 2022, arrives after weeks of rain. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.
>
> For a beel or pukhuri with no controllable outlet, Clause 7.8.3 is the governing condition: no cushion is assumed, a design that relies on it routes the storm through it from its outlet level, and the outflow is limited by the jan below it and, at the embankment, by the sluice and the river stage. A cushion made by pumping is counted only where the pumps, their standby power and their operator are in the rule and were certified ready by 31 March (Chapter 10). Many beels are fisheries, settled or registered by the Fisheries Department, and some pukhuris belong to

religious institutions or private owners, which is why Clause 7.8.2(d) requires the custodian to accept any drawdown and any loss to the fishery, and why no detention pond built under this Manual is called a pukhuri or a beel.

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 Pollution Control Board, Assam (PCBA) directs.

7.9.7 **Inlet treatment.** Every restoration of a tank that receives urban runoff shall include sediment and gross pollutant control at each inlet: a sediment forebay, a constructed wetland inlet zone, or a gross pollutant trap (Chapter 8), so that the restored storage does not silt up again.

7.9.8 **Timing.** Desilting shall be completed, and the waterbody made safe, by **31 March** each year (Chapter 10).

Commentary. No State or municipal order fixing a date for the pre-monsoon cleaning of drains, jans or beels was found: in Guwahati, drain cleaning was "expected to begin from mid-February" in 2026, desilting SOPs "issued in February 2025" are said to have been "largely ignored", and the Mayor said that "The necessary work will be completed before the monsoon" (all as reported). The cleaning is large and recurrent: GMC spent ₹32.57 crore on desilting from 2013-14 to 2017-18 (CAG Report No. 4 of 2019); "Most of the drains directly or indirectly fall into Bharalu River … due to siltation, the bed level of the river has considerably risen" (ADB, 2017); and GMDA is excavating Silsako as a retention basin (as reported). The date of 31 March in this Manual is set by this Manual, before its season begins on 1 April, because Guwahati's April storms come early (116.5 mm on 6 April 2004, IMD,

and 117.4 mm at the airport on 20 April 2026, as reported) and four of the State's station 24-hour records are May storms (IMD); because storms also follow, the jans, racks and silt traps are cleared again by 31 May, before the south-west monsoon arrives, and after it by 15 November (Chapter 10). WRD's works dates in the press are for embankments, not drains, and remain WRD's. Excavation to "increase capacity" is governed by Clause 7.9.3. In a beel, the clay and silt of the bed hold the water above a water table that is near the surface in the monsoon (Chapter 8), and the silt of a town beel is laden with sewage: every desilting of a beel or pukhuri that receives town drains tests the silt under Clause 7.9.1(c) and disposes of it as the PCBA directs, and no work in Deepor Beel, its sanctuary or a scheduled water body is begun without the permissions of Clause 7.12. The 31 March deadline matches the pre-monsoon inspection date of Chapter 10. The limits on deepening are set by this Manual. Deepening tanks to "increase capacity" is common, but it can breach the silt and clay layer that holds water in the tank, it can let polluted urban water reach the aquifer, it can draw salt water toward the coast, and it creates storage below the sluice sill that never empties and gives no flood benefit. Deep pits with steep sides are also a drowning hazard. The slope and bench values in Clause 7.9.4 are adapted from common pond-safety practice; they have no Assam 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 Assam the municipal drains of Guwahati are the Corporation's to cleanse, alter and close (Gauhati Municipal Corporation Act, 1969, ss.231 and 234), the Commissioner may pull down a building erected "over any drain, conduit, water-course … vested in the Corporation" (s.239), no one may make a drain into a municipal drain without permission (s.242), and a connecting drain vests in the Corporation (s.250(2)); the outfall power is permissive (s.232), and no outfall duty like that of the Assam Municipal Corporation Act, 2022 was found in the 1969 Act [NEER reading]. In the other Municipal Corporations the public drains vest in the Corporation (AMC Act, s.173), which must provide "a safe and sufficient outfall … for effectual drainage and proper discharge of storm-water and sewage" (s.171). Embankments and the drains, sluices and "dongs" of the 1953 Act are WRD's, and vest in the State (s.14). Roadside drains are PWD's or NHAI's, and the Railways, OIL, the Army and others hold their own (as reported). No notification assigning the Bharalu, Mora Bharalu or Bahini to one owner was found [NEER reading], and the ADB names "fragmented institutional responsibilities involving multiple institutions, such as the Guwahati Metropolitan Development Authority (GMDA), Public Works Department, and Water Resources Department" as the problem (RRP, 2025); Chapter 6 gives this Manual's working split and each town's drain register. The record shows a network that is partial and has been built over: storm-water drainage coverage in the test-checked towns was "3 to 37 per cent only" (CAG Report No. 4 of 2019), and "Assam's stormwater drainage network in ULBs covers only about 30% of the required areas" (ADB, 2025); "Apart from 17 kilometres of drains built between 1973 and 1997, no other extensive and planned drainage network exists in the Guwahati Metropolitan Area" (as reported); the causes of waterlogging include "construction of buildings and roads over the manmade drains" and filled swamps (ADB, 2017); at Dibrugarh "The construction of the DTP dyke closed all the drainage channels" of the town (ADB, 2017); and at Palasbari builders blocked channels and filled wetland (Gauhati High Court, PIL/53/2023, 06.09.2024). The law reaches the channels of a beel: the Urban Water Bodies Bill counts "all natural water channels (that are inflow or out flow channels into or from the waterbody)" as part of it (s.2(d)) and forbids "obstruction in the natural and normal course of inflow and outflow" (s.15), and the Hill Land Act counts "a drainage system, feeding channel" as an ecological site once an area is designated (s.2(d)(ii)). None of these keeps a jan or a town channel at its recorded width once it has been lined, covered, built over or narrowed by a culvert, 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 pukhuri 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 Assam no shared form of storage is required by the building rules: the Unified Byelaws 2022 ask for a designed "dry sump … capable of holding rain water during peak monsoon" in each plot on sites liable to flood and in hilly areas (byelaws 74(ii) and 110(h)), which is on-site storage, and for rainwater harvesting, but have no detention, peak-flow or design-storm rule (Chapter 4). The first public storage built for flood control is the ADB's Bahini retention pond of 59,000 m³ with its pump, and the diversion of part of the Bahini's runoff to a retention basin at Silsako (ADB, 2025). The drainage master plans that T&CP "has started preparing … for all major towns" (ADB, RRP, 2025), and the court-supervised Comprehensive Drainage Master Plan for Guwahati (under revision, not final, as reported), are the natural home for basin storage targets (Chapter 11). 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 Assam State Wetlands Authority;
- (b) any wetland notified under the 2017 Rules, to its notified boundary (none was found notified), and Deepor Beel, Ramsar site No. 1207 (designated 19 August 2002, as listed), to the larger of its Ramsar boundary and the boundary of Deepor Beel Wildlife Sanctuary;
- (c) every beel, and the other marshes and hola land of the Brahmaputra and Barak floodplains, within the 1% AEP extent of Clause 7.3.4, among them Silsako, Borsola and Sorusola in Guwahati, Larua Jamira on the Dibrugarh drain, Son Beel, Urpad Beel and Chandubi, and every water body scheduled under the water-bodies law (a river, jan or pukhuri itself is a waterbody under the rest of this chapter); and
- (d) any other beel, marsh or wetland that the Authority notifies, that the Assam State Wetlands Authority lists, or that the Gauhati High Court, the National Green Tribunal or the Supreme Court directs to be protected.

7.12.2 **No drainage of wetlands.** No drain, channel, cut or pump shall be designed to drain a wetland, to lower its normal water level, or to reduce the period for which it is wet, except under a plan approved by the wetland authority.

7.12.3 **Inflows.** Every drain discharging into a wetland in Clause 7.12.1 shall:

- (a) meet Clause 7.10.6;
- (b) pass through water quality treatment for the WQv of its catchment (Chapter 8) before entering the wetland; and
- (c) where practicable, spread its flow across a vegetated margin rather than discharge at one point.

7.12.4 **Hydraulic connectivity.** Roads, embankments and utility corridors across or along a wetland shall have openings that:

- (a) pass the 1% AEP flow without raising the 1% AEP water level by more than the limit in Clause 7.6.2; and
- (b) keep the wetland's normal water exchange, including tidal exchange in estuaries, with openings spread along the crossing so that no part of the wetland is cut off.

7.12.5 **Storage counted at basin scale only.** Wetland storage shall be included in basin and regional models. It shall not be counted as detention for any individual development.

7.12.6 **Tidal wetlands and estuaries.** For estuaries and tidal wetlands:

- (a) tailwater shall be taken from Chapter 5 (Clause 2.12 joint cases);
- (b) works shall also comply with the Coastal Regulation Zone Notification in force; and
- (c) mouth-opening works, training walls and dredging are outside the scope of this Manual and need their own studies.

7.12.7 **No dumping.** No solid waste, construction debris or dredged material shall be placed in a wetland or its setback.

> Commentary. Assam's wetlands are the concern of the **Assam State Wetlands Authority**, constituted by notification No. FRM.10/2010/Pt/16 of 1 November 2018 under the Wetlands (Conservation and Management) Rules, 2017 (as listed; the notification was not read [TBC]); no wetland notified under rule 4 of the Rules was found. The State's wetlands cover 764,372 ha, 9.74% of its area (National Wetland Atlas, 2011, as cited; the counts in that and other inventories conflict and are not used). Its one Ramsar site (as reported) is **Deepor Beel**, site No. 1207, designated on 19 August 2002 (as listed). Deepor Beel was notified as a wildlife sanctuary in 2009; the notification was set aside in 2017 and restored on appeal in 2023, an appeal to the Supreme Court is pending, and when the Cabinet decided on 27 March 2024 to denotify it, the Gauhati High Court directed the State "not to issue any notification de-notifying" it (PIL 18/2023, I.A.(C) 924/2024, 05.04.2024). Its eco-sensitive zone exists only in draft: about 148.9 km² in 2021 and about 38.84 km² in 2025 (as reported); no final notification was found. The beel is fed by the Basistha and the Kalmani and drains to the Brahmaputra by the Khanajan (as cited in research), and the Mora Bharalu brings it the city's sewage (Clause 8.9, Commentary); the National Green Tribunal heard the dumping of waste at Boragaon beside it (O.A. 472/2018, order of 11.02.2020), and a later suo motu case (O.A. 99/2025/EZ) records a CPCB finding of faecal coliform (as reported; the outcome was not found). No source was found for any direct link between the Bharalu and Deepor Beel other than the Mora Bharalu. Elsewhere, Son Beel in Karimganj district, the largest in the State, is given as 3,458 ha in a study of 2024 and as 4,388 ha dry and 9,800 ha full in another source (the figures conflict); Urpad Beel in Goalpara and Chandubi are shrinking (Clause 7.6, Commentary); Rowmari–Donduwa is reported to be proposed as a Ramsar site and the Borjuli wetland to have been declared a Biodiversity Heritage Site in 2026 (both as reported). A drain outfall, desilting, diversion or gate operation in or next to Deepor Beel, a sanctuary or a notified wetland therefore needs the views or permission of the Assam State Wetlands Authority or the Environment and Forest Department where the Rules or the wildlife law reach it, and, for a scheduled water body, the permission that the water-bodies law requires, as well as compliance with this chapter; for the beels and marshes they do not reach, this chapter and the byelaws 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 Assam's beels through the drains (Clause 8.9, Commentary). The State's report to the National Green Tribunal placed Borsola Beel and Silsako Beel in Priority I, Sorusola in Priority II and Deepar Beel in Priority III, polluted by the "Mora Bharalu channel" (O.A. 673/2018, August 2020), and the Bharalu has "no natural flow" but sewage (PCBA). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by most existing outfalls in Guwahati. In Assam they apply in full to every new outfall, and every existing outfall to a beel, a pukhuri, a jan or a scheduled water body is taken to carry dry-weather flow and comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed. Where a drain falls from the hills, every drain that enters a beel also passes a silt trap at the hill–plain break first (Figure 7.3; Clause 6.3.6(m)), because the beel is the end of the slope's drainage and loses its storage to the silt of hill cutting.

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. Assam's controls on building and filling in its waterbodies have come mostly from the courts. On Silsako the Gauhati High Court held in 2023 that the 2008 Act "is not prospective, it [only] declares", and told the occupants of the beel, "Once it is a water body you have to move out" (writ appeals, 19 June 2023, as reported). In PIL/53/2023, *Khanindra Kalita and others*, it found that builders had blocked channels and filled wetland at Palasbari, causing "artificial floods", and appointed an Advocate Commissioner (06.09.2024). In PIL/14/2024, on the flooding of Guwahati, it recorded the engagement of Haskoning DHV for a "GIS-based Comprehensive Drainage Master Plan and Detailed Project Report (DPR) for Guwahati City" (23.09.2024) and found that "hill cutting is still going on" (26.05.2025). It stayed the denotification of Deepor Beel sanctuary (PIL 18/2023, 05.04.2024), and PWD was told in February 2025 to stop earth filling and construction near the beel (as reported). The National Green Tribunal heard the State say that "no encroachment exists in the notified area" of Deepor Beel and that dumping at Boragaon was to end (O.A. 472/2018, 11.02.2020). Eviction drives along drains and rivers were carried out in Guwahati from January 2023 under "Mission Flood Free Guwahati", for which no formal order was found (as reported). The statutes' penalties are up to three years or ₹50,000 under the 2008 Act (s.6), up to three years or ₹1 lakh with restoration under the Bill of 2024 (s.16), up to three years and ₹1,000 for cutting an embankment or obstructing a sluice under the 1953 Act (s.15(ii)), and up to six months or ₹5,000 under the Hill Land Act (s.19). The CAG found that GMDA was "not functioning as per the spirit" of its Act, with "very few technical staff" (Report No. 2 of 2024). The encroachment of low-lying land and the filling of swamps are among the causes of waterlogging that the ADB lists for Guwahati (2017). 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 monsoon (by 31 March) and after every heavy-rainfall event (Chapter 10) for seepage, slips, cracks, animal burrows, trees on the bund, and blockage of the weir and sluices.

7.14.5 **No unauthorised cutting.** No person shall cut, lower or breach a tank bund or surplus weir during a flood except under the custodian's emergency procedure.

> Commentary. The definition of a specified dam is quoted from the Dam Safety Act, 2021 (Act 41 of 2021). The Act defines a "dam" as an artificial barrier constructed across rivers or tributaries to impound or divert water. It excludes flood embankments, dikes and guide bunds. Assam's embankments along the Brahmaputra and the Barak, given as 4,474.42 km by the CAG (March 2017) and 4,473.82 km by WRD (as cited), and as about 4,800 km in a later ministerial reply (as reported), are flood embankments, which the Act excludes; the dams of the hydroelectric projects upstream of Assam's towns (NEEPCO's Ranganadi and Kopili projects and NHPC's Lower Subansiri) are dams across rivers under the Act, and their heights were not obtained [TBC]. No beel or pukhuri in Assam was found to be held by a bund high enough to be a specified dam, though no bund or outlet was surveyed for this Manual [TBC]; each shall be screened under Clause 7.14.1. Where the storage of a beel or pukhuri is counted under Clause 7.7, the embankment or bund that holds it, with its sluice, is a tank bund for Clause 7.14.2 unless the Act applies. Whether a tank bund that is not across a river or tributary is a "dam" under the Act is not clear from its text. In Assam the embankment hazard is the breach. In May 2022 the Barak embankment at Bethukandi, upstream of Silchar, was cut, and in June the river entered the town through it (FIR for a breach of 23 May and one arrest, as reported); Silchar was under water for about 11 days, up to about 4 m deep in places ("about a week" in another report; both as reported), although the Barak at Annapurnaghat peaked at 21.59 m on 21 June, 0.25 m below its 1989 highest flood level (as quoted from the Cachar district report; NEER reading of the

gap). Cutting an embankment without authority is an offence under section 15(ii) of the Assam Embankment and Drainage Act, 1953. In the Barak valley 450 km of the 731 km of embankments are reported to be "extremely vulnerable", and 71 breaches were reported in the State between mid-June and 20 July 2024 (both as reported). Releases from the dams upstream are the other hazard: in 2017 the Ranganadi project released 1,412.57 m³/s (as quoted in a report of IIT Guwahati for ASDMA). No breach map or emergency action plan for any embankment, dam, beel or pukhuri was read for this Manual. A failed embankment floods the land behind it, and a breach closes no sluice, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments counted under this Manual, and why Chapter 5 treats embankment-protected towns and release reaches as flood-sensitive outfalls. 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.

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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 Assamese waterbody terms and regional variants
Form 7-1	Waterbody Sheet
Form 7-2	Tank Storage Credit Sheet
Form 7-3	Compensatory Storage Calculation (by elevation band)

CHAPTER 8

Water Quality and Recharge

8.1 Purpose and scope

8.1.1 This chapter sets the requirements for the quality of stormwater leaving a site or a public drainage system, and for groundwater recharge. It covers:

- (a) the water quality volume (WQv) and the water quality design flow;
- (b) the treatment train, and the selection and design of best management practices (BMPs);
- (c) the criteria for infiltration and recharge;
- (d) the exclusion of sewage and dry-weather flow from storm drains;
- (e) gross pollutant traps, first-flush treatment and screens at outfalls to waterbodies;
- (f) how rainwater harvesting (RWH) fits with retention and detention;
- (g) erosion and sediment control during construction; and
- (h) monitoring.

8.1.2 This chapter applies to every development and public work to which Chapter 4 applies (Chapter 1). Clauses 8.9 (sewage) and 8.12 (construction erosion and sediment control) apply to every development that needs a building permit or layout approval, and to every public drainage work, whatever its size.

8.1.3 Retention under Chapter 4 is the first and preferred form of water quality control. Runoff retained on site is treated in full. The rest of this chapter applies to the part of the WQv that is not retained.

> Commentary. CPHEEO (2019) is the only Indian manual that covers stormwater quality in any detail. Its Chapter 9 reproduces US event mean concentrations, but cautions that "in an Indian context the values would be much higher" because drains receive night soil, urine and food waste, and it sets no Indian numeric criteria (CPHEEO 2019, Part A §9.5). Its Chapter 10 describes water-sensitive urban design, LID and SuDS treatment trains (CPHEEO 2019, Part A Ch. 10). This chapter turns that guidance into requirements. It follows the treatment approach of the MARC/APWA BMP Manual (2012), now merged into APWA 5600 (2025.01), with the Malaysian 3-month ARI water quality storm (MSMA 2, 2012) and the Georgia water quality volume (GSMM, 2016) as tropical and US benchmarks.

8.2 Definitions

Term	Meaning in this Manual
Water quality volume (WQv)	The runoff volume that must be retained or treated, from the water quality rainfall depth (Clause 8.4).
Water quality rainfall depth (P_wq)	The greater of the retention depth (Annex 2E, Clause 2.10) and the 24-hour 3-month ARI depth (Annex 8A).

Term	Meaning in this Manual
3-month ARI depth	The 24-hour rainfall depth equalled or exceeded on average four times a year, from a partial-duration series of the long-term daily record.
Water quality design flow (Q_wq)	The peak flow from the 3-month ARI storm, used to size flow-through devices and diversion structures (Clause 8.4.5).
Runoff coefficient for WQv (Rv)	The volumetric runoff coefficient for small storms, Rv = 0.05 + 0.009·I.
BMP	A best management practice: a structural or non-structural measure that reduces pollutant loads or runoff volume.
Treatment train	Two or more BMPs in series, from source to site to regional scale (Clause 8.5).
Pretreatment	A BMP that removes coarse sediment, litter and oil before runoff reaches a filter or infiltration BMP.
First flush	The early part of a runoff event, which usually carries the highest concentrations of sediment, litter and oil.
Gross pollutant trap (GPT)	A device that captures litter, plastics, vegetation and coarse sediment, typically above about 5 mm.
Dry-weather flow (DWF)	Flow in a storm drain when it has not rained for at least 72 hours. In a separate storm system, DWF is evidence of sewage, sullage, groundwater infiltration or illicit discharge.
Cross-connection	Any pipe, channel or opening that lets sewage or sullage (grey water from kitchens, bathrooms and laundries) enter a storm drain.
Infiltration facility	A facility designed to store runoff below the ground surface, or in a depression, and let it soak into the soil: infiltration trenches and basins, unlined bioretention, permeable pavement with an open base, soakaways, recharge pits and recharge wells.
Seasonal high groundwater table	As defined in Clause 3.10.2: the highest level in the monsoon season.
Hotspot	A land use with a high risk of spills or contaminated runoff (Clause 8.8.8).
Level of Service (LoS) / Value Rating (VR)	The scoring system of Clause 8.6, from the MARC/APWA BMP Manual (2012).

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 Assam 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 Assam 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 Assam, 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 m^3;
- A = the contributing area, m^2;
- $Rv = 0.05 + 0.009 \cdot I$; 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 (m^3) = 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 Assam 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 Assam, 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.

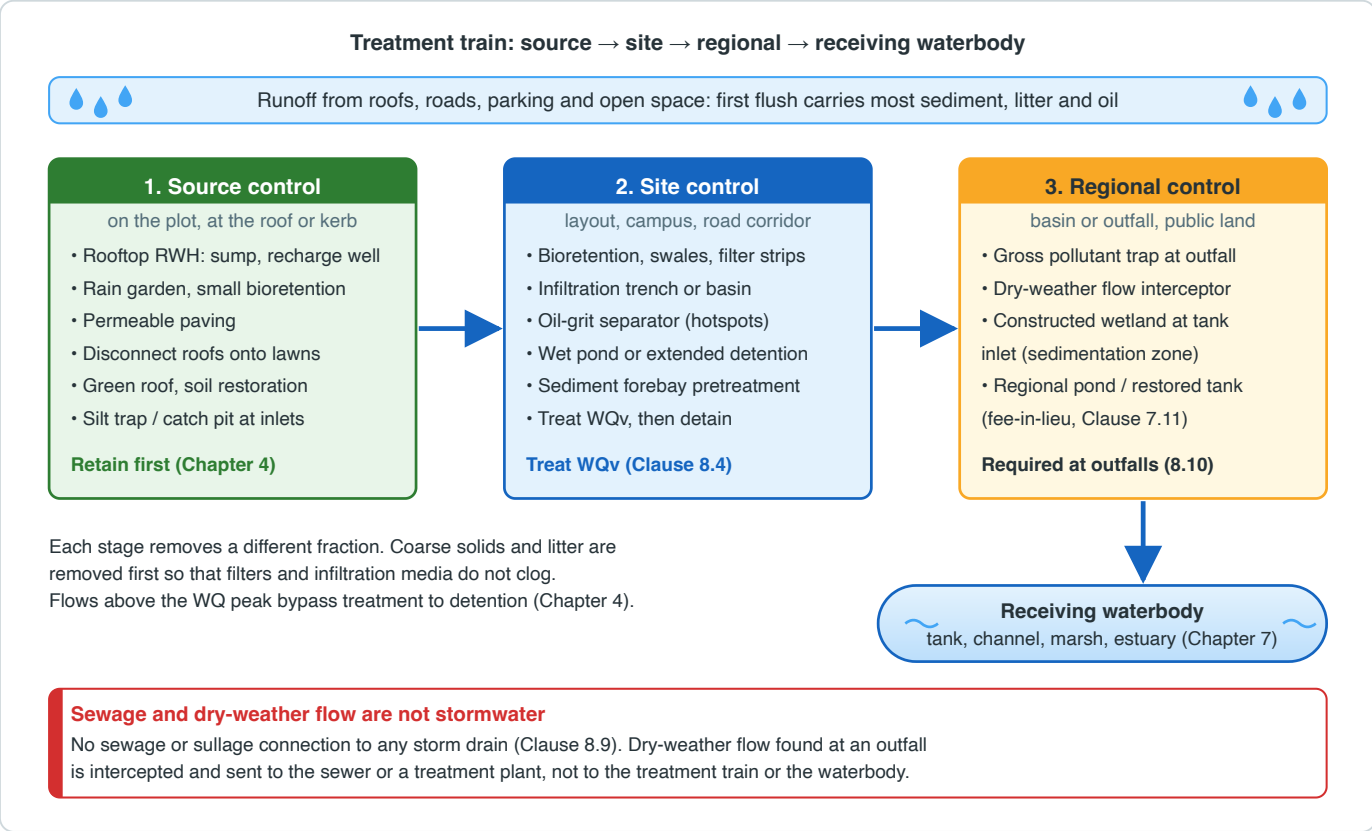


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater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

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Bhabar fans, river terraces and tested hill-foot colluvium (recharge rule)	Laterite / hard rock	Floodplain alluvium, char, beel and pukhuri margins / high water table	Assam 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	Bhabar fans, river terraces and tested hill-foot colluvium (recharge rule)	Laterite / hard rock	Floodplain alluvium, char, beel and pukhuri margins / high water table	Assam 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 Assam 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. Assam 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.**

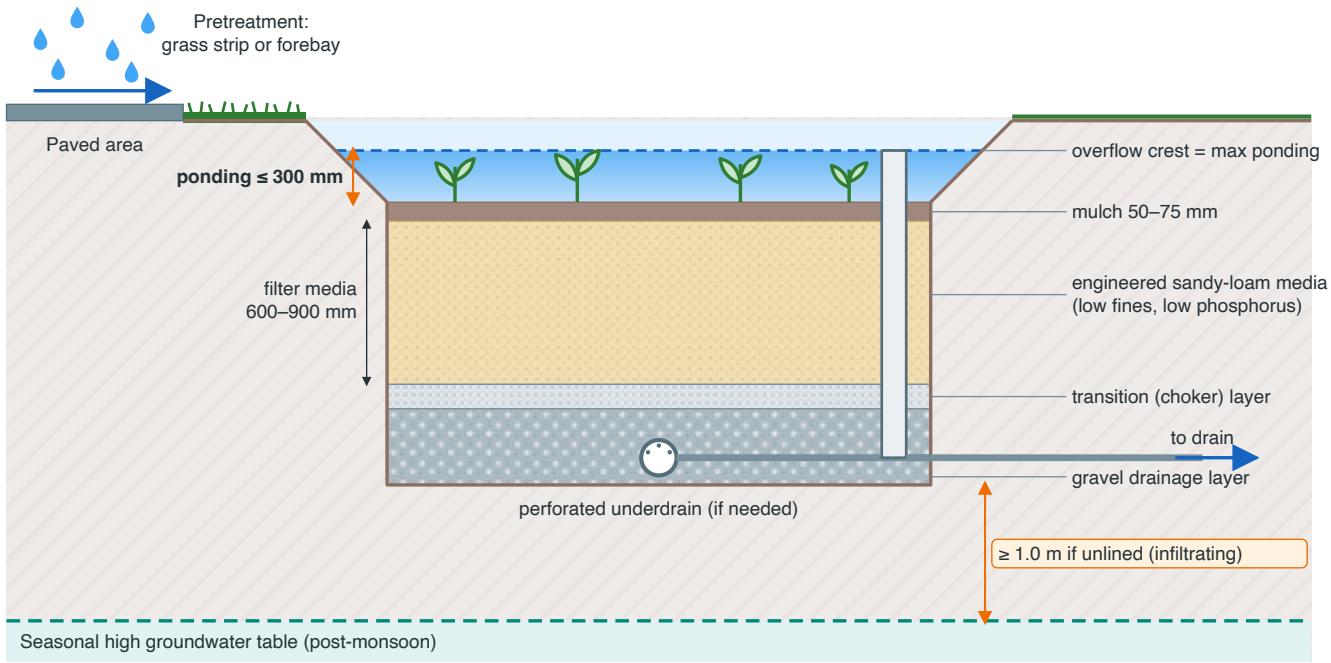
- (a) At every inlet that receives runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody.
- (b) A sump at least 300 mm below the outlet invert.
- (c) Silt traps are pretreatment only and earn no VR.

> 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 Assam. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Assam. 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 Assam's rain falls in the monsoon season of 1 April to 31 October: the CWC report for subzone 2(b) describes rain "generally spread over a period of eight months, i.e. from March to October", with "about 90 percent of the total rainfall" from May to October, and says that "The winter season from

December to March is practically dry"; the State's normal is given as 2,262.95 mm on 144 rainy days (CGWB, 2007). From November to March the beels shrink (Deepor Beel from up to 40.1 km² in floods to about 10.1 km², as reported) and pukhuris fall, though on the floodplains the water table stays within a few metres of the ground (Clause 8.8.1). In the towns the dry-weather feed of a drain, jan or beel is sewage, because the drains carry it (Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool from December to March on its own catchment's runoff is not to be used, and none is kept full with dry-weather flow; on the floodplain, where Clause 4.11 bars infiltration, the practical forms are lined bioretention with an underdrain, swales, storage for use and lined extended dry detention. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; beels, pukhuris 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 Assam drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

The 50-space threshold for oil-grit separators, the 5 mm GPT capture size, the 0.3 m/s swale velocity and the other dimensions in this Clause have no direct precedent and are set by this Manual.



Lined version (no infiltration): impermeable liner below the gravel layer. Required at pollution hotspots and wherever the 1.0 m separation to seasonal high groundwater cannot be met.

Dimensions as set in Clause 8.7.2.

Figure 8.2 — Bioretention cell (rain garden) in section: pretreatment, surface ponding, filter media, transition and gravel layers, underdrain, overflow, and the 1.0 m separation to seasonal high groundwater for an unlined cell. Original drawing for this Manual, adapted from MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012, and CIRIA, The SuDS Manual (C753), 2015.

8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Assam, which has no coastal sand areas (Clause 8.8.9). For this Clause the seasonal high groundwater table is the highest level found from April to November, which covers the season of 1 April to 31 October and the month after it (Clause 3.10.2). Assam needs the three rules of Clause 4.11 here, and Clause 8.8.1 applies with the following. **(i) No infiltration on the floodplain (Clause 4.11, floodplain rule).** No deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, unlined bioretention, or permeable paving with an exfiltrating base) shall be built or credited on char or chapori land; on land below the 1% AEP flood level of a river or stream; inside an embankment-protected area that ponds when its sluices close; on the margins of a beel or pukhuri (its Zone 1 and Zone 2 under Chapter 7); or wherever the seasonal high water table is less than 2.0 m below ground. The last condition alone may be set aside where a piezometer record of at least one full April–November season shows that the water table stays at least 2.0 m below ground and at least 1.0 m below the base of the practice; the others may not. On such land the exception for roof water in Clause 8.11.3(c) does not apply; roof water goes to storage for use, retention is met by storage for use and by surface measures that do not infiltrate below ground, and detention under Chapter 4 is lined. The CGWB found the water in March 2022 "mostly in the range of 2-5 mbgl (57.43%)" and within 2 m at 20.27% of its Assam wells, and in November 2022 "within 5 mbgl (89.13%)" and within 2 m at 45.96%, with water-logged (under 2 m) and prone (2 to 3 m) ground after the monsoon in "almost all the districts of Assam"; in Kamrup (Metro) the wells read 1.39 to 4.08 m in March, 0.2 to 2.76 m in August and 1.29 to 2.64 m in November (Ground Water Year Book, North Eastern Region, 2022-23). **(ii) No infiltration on hill slopes (Clause 4.11, hill rule).** In the Guwahati hills, in sub-areas AS-D and AS-D1 and on any natural slope steeper than 10° elsewhere, no deliberate infiltration practice shall be built or credited on natural ground sloping more than 10°, on colluvium, fill or slide debris, in a mapped landslide zone (including the Hilly Area Zone of the Master Plan for Guwahati 2025 and land declared landslide-prone), or upslope of a cut slope or retaining wall within twice its height, unless a geotechnical certificate shows that the added water will not destabilise the slope; roof runoff goes to storage, with its overflow, and all other runoff, by a lined drain through a silt trap and an energy dissipator to a stable channel. The 10° threshold is the byelaws' own: "In hilly areas with slope greater than 10° special protection measures shall have to be provided" (byelaw 110(d)). **(iii) Recharge only on tested ground outside both rules (Clause 4.11, recharge rule).** Recharge is allowed, with pretreatment, the field test of Clause 8.8.3 and the separation of this Clause, with the seasonal high water table at least 2.0 m below ground, only on the bhabar fans of the northern foothills (a belt 11 to 15 km wide, CGWB), where debris and the shifting of channels govern siting, on river terraces above the 1% AEP level, and on Guwahati's hill-foot colluvium on slopes of 10° or less where the hill rule's certificate is given. Recharge is a choice, not a duty: the stage of groundwater extraction was 12.61% in the assessment of 2024 (as quoted, columns unlabelled) and 22%, with no over-exploited unit, in 2007 (CGWB). **(iv) No recharge or injection well in the arsenic and fluoride districts.** In the districts in which groundwater with arsenic above the limit has been found (isolated pockets in Barpeta, Goalpara, Golaghat, Karbi Anglong, Kokrajhar, Lakhimpur, Sibsagar, Nalbari and Karimganj, as quoted from a Lok Sabha answer of February 2025) or fluoride above 1.5 mg/L (parts of Goalpara, Kamrup, Karbi Anglong, Nagaon, Golaghat and Karimganj, as quoted), no recharge well, recharge shaft, borewell or injection well shall receive runoff of any kind, including roof water, and the exception for recharge wells in Clause 8.11.3(c) does not apply. **(v) Quality.** No runoff from roads with heavy traffic, fuel stations, workshops, industrial yards or solid-waste sites is led to any recharge structure, and a recharge structure on the bhabar or a terrace takes only roof water or runoff that has passed a filtering BMP. The 2.0 m limit, the April–November record, the districts rule and these conditions are set by this Manual; no Assam rule on infiltration near the water table 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. Assam has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The char and chapori sands of the Brahmaputra and Barak and the bhabar fans of the northern foothills are not coastal sand areas: Clause 8.8.1 applies there in full, with the floodplain rule and the recharge rule of Clause 4.11, and the reduced separation of item (d) does not. In coastal sand areas:

- (a) infiltration is the preferred means of meeting retention and the WQv wherever Clause 8.8.1 is met;
- (b) storm drains shall not be designed to lower the groundwater table: inverts below the seasonal high groundwater table shall be watertight, with no weep holes or subsoil drains that discharge groundwater to the outfall, unless a hydrogeological report shows no harm to the freshwater aquifer;

- (c) no long-term pumping of groundwater into storm drains shall be approved (for example basement dewatering); and
- (d) in notified coastal sand areas, **roof-only runoff** may be infiltrated with a separation of not less than **0.5 m** to the seasonal high groundwater table, provided a groundwater mounding check shows that the mound stays at least 0.3 m below the facility base and does not reach adjacent foundations or basements. No other runoff may use this reduced separation;
- (e) where neither the 1.0 m separation nor clause (d) can be met, the site shall use surface retention that does not infiltrate below ground (for example shallow vegetated depressions, disconnection of roofs onto lawns, and reuse), and detention under Chapter 4.

8.8.10 **Laterite and hard-rock areas.** In laterite and hard-rock terrain (for example the granite-gneiss of the Guwahati hills under thin red loams, and the gneiss, laterite and red loams of the Karbi hills and the Dima Hasao hills, for which no primary geological source was read for this Manual [TBC]; on any slope in these areas the hill rule of Clause 4.11 applies first under Clause 8.8.1):

- (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.

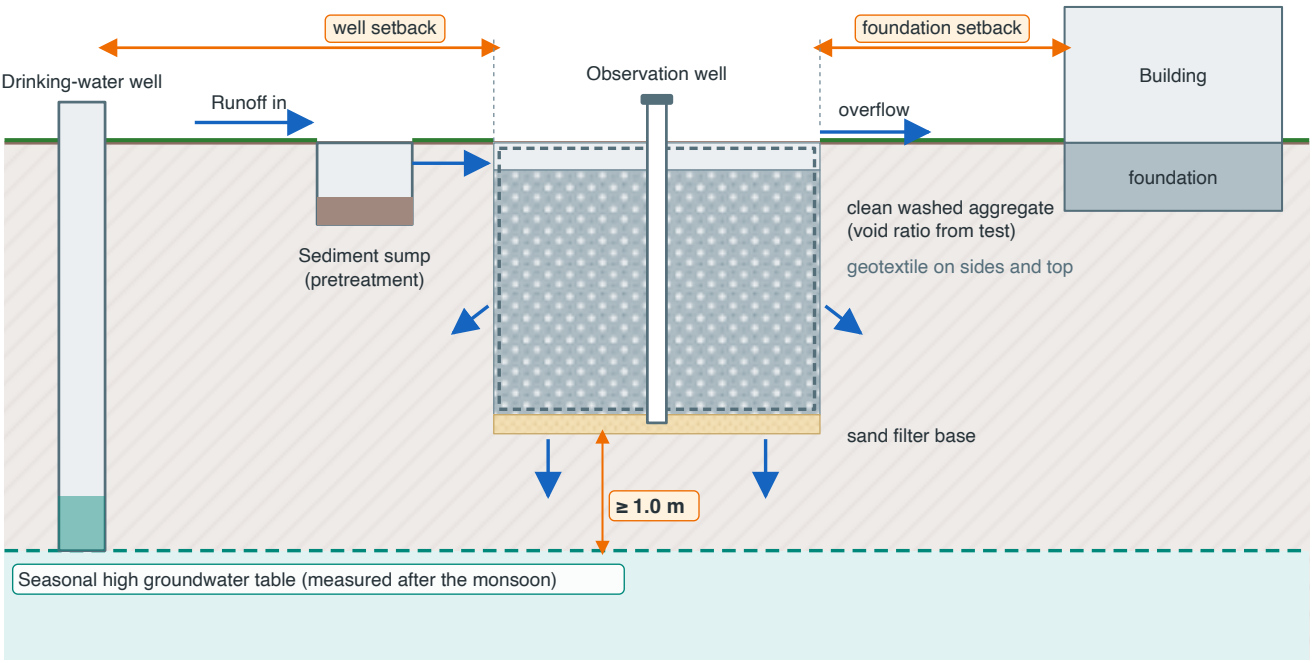
8.8.11 **Delta clays and black cotton soils.** In the silty clays and clays of the Brahmaputra and Barak floodplains, the clay beds of the beels, the low terraces and the Silchar bowl, and the silted beds of pukhuris, and in expansive black cotton soils:

- (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 Assam precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Assam RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.
>
> No map of hydrologic soil groups for Assam, no soil series of NBSS&LUP and no measured infiltration rate anywhere in the State was found [TBC]; every infiltration design needs the tests of Clause 8.8.3. "More than 75% of the state is underlain by unconsolidated formations comprising of clay, silt, sand, gravel, pebble and boulders"; along the northern foothills a bhabar belt 11 to 15 km wide gives way to the terai, and the Brahmaputra floodplains and the semi-consolidated formations of Cachar make up most of the rest (CGWB, 2007). "The flood plains covering the Dibrugarh, Mariani, Nowgong, Guwahati and Goalpara districts represent alluvial soils of recent origin" (CWC, FER 2(b)). The water is shallow almost everywhere on the plains: in March 2022 it stood "mostly in the range of 2-5 mbgl (57.43%)" and within 2 m at 20.27% of the CGWB's Assam wells, in November 2022 "within 5 mbgl (89.13%)" and within 2 m at 45.96%, and in Kamrup (Metro) at 1.39 to 4.08 m in March, 0.2 to 2.76 m in August and 1.29 to 2.64 m in November; water-logged (under 2 m) and prone (2 to 3 m) ground was found after the monsoon in "almost all the districts of Assam", and "Occurrence of water logging conditions in the region is due to high rainfall, shallow water level and a poor ground water draft in the vast flood plains" (CGWB, Ground Water Year Book, North Eastern Region, 2022-23). At Guwahati the rising Brahmaputra "reduces the rate of percolation" (ADB, 2017). The loss rates of the CWC reports, 0.35 cm/h in subzone 2(b) and 0.24 cm/h in 2(a), are low, as the saturated alluvium would lead one to expect (Chapter 3). Groundwater is not short: the stage of extraction was 12.61% in the assessment of 2024 (as quoted, columns unlabelled) and 22%, with no over-exploited unit, in 2007 (CGWB). Quality is the constraint: arsenic above the limit is reported in isolated pockets in Barpeta, Goalpara, Golaghat, Karbi Anglong, Kokrajhar, Lakhimpur, Sibsagar, Nalbari and Karimganj (as quoted from a Lok Sabha answer of February 2025), fluoride above 1.5 mg/L in parts of Goalpara, Kamrup, Karbi Anglong,

Nagaon, Golaghat and Karimganj (as quoted), and iron on the north bank of the Brahmaputra (CGWB, 2007). This Manual's interim soil groups follow from these (Chapter 3): the recent floodplain alluvium C to D, and D in the beels, the low terraces and the Silchar bowl; the char and chapori sands A or B by texture but D in design through the monsoon, when the water is at or near the surface; the bhabar fans A, where debris and the shifting of channels govern; the terai B to C with a high water table; the Guwahati hills C to D, and cut slopes and fill D; the laterite and red loams of the Karbi and Dima Hasao hills C; and urban fill C (D if clayey or compacted). **The State therefore needs three rules, not one** (Clause 4.11). On the floodplain, which is most of the State, no water is put into the ground on purpose, under the floodplain rule, because in the storms that matter it would go into saturated ground. On hill slopes, on colluvium and fill and in landslide zones, no water is put into the ground on purpose, under the hill rule. On the bhabar fans, the river terraces above the 1% AEP level and Guwahati's hill-foot colluvium, recharge is allowed after testing, under the recharge rule, as a choice rather than a duty, and never through a well in the arsenic and fluoride districts. Everywhere, runoff from roads and open land goes to surface systems and never directly to a recharge well, borewell or shaft (Clause 8.11.3(b)). Clause 8.8.9 has no effect in Assam, which has no coast.

Infiltration trench: section, not to scale



Test infiltration at the proposed base level. Design rate = measured rate ÷ safety factor. Empty within 72 h.
Setback distances and test methods: Clauses 8.8.3 to 8.8.6. Road and parking runoff is never piped into a well.
Sandy coastal soils: high rates, shallow groundwater. Laterite, hard rock: low rates. Delta clay: usually unsuitable.

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 Pollution Control Board, Assam (PCBA) and the drain owner.

8.9.4 **Public drains: DWF survey.** Every ULB in a Tier A area shall survey its storm drain outfalls to waterbodies for dry-weather flow at least once a year, before the monsoon, and record:

- (a) the outfalls with DWF;
- (b) the estimated DWF rate; and
- (c) the upstream sources found by tracing, CCTV, dye or smoke testing.

The results shall be published in the register of Clause 10.17.

8.9.5 **DWF interception.** Until the sources are removed, every outfall to a waterbody that carries DWF shall have a DWF interceptor that:

- (a) diverts the DWF to a sewer or a treatment plant;
- (b) does not reduce the capacity of the storm drain for the minor or major event (Chapter 6), with its weir or diversion head losses included in the hydraulic design (Chapter 9);
- (c) has a screen ahead of the diversion; and
- (d) is not a substitute for removing the source connections.

8.9.6 **Sewage overflows.** No new sewage overflow, emergency bypass or pumping station overflow shall be designed to discharge into a storm drain or waterbody, except where the sewerage agency shows that no alternative exists, and then only with screening and with the overflow frequency stated.

> **Commentary.** The prohibition of sewage connections and the removal of existing cross-connections as a condition of approval are core requirements of this Manual, and Clause 1.10.3 allows no variance from them. Sewage in storm drains is the single largest water quality problem of urban drainage in Assam. 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 Assam the storm drains are the sewers, and this Clause is the normal case, not the exception. "No ULB in the state has a centralized sewerage system, including Guwahati … about 90% of households have installed septic tanks or leach pits, no ULB has a systematic mechanism for septage collection" (ADB, RRP, 2025); in the towns the CAG test-checked, "natural drainage systems of the cities carried the sewage" (CAG Report No. 4 of 2019). In Guwahati "un-treaded or semi-treated sewage is disposed in to nearby drains and low-lying areas", with a drain BOD of "90 mg/l in 2013" (JICA, 2015). The Bharalu "has no natural flow of the river at present and only the domestic sewage and commercial sewage are being carried"; the Bahini, cut off by a sluice at Natun Bazar, "now becomes a sewerage drain"; about 39 outfalls discharge 70,740 KLD of untreated sewage (at 135 lpcd), expected to reach 75,060 KLD by 2030, and the BOD ranged from 6.0 to 54 mg/L between 2016 and April 2019, when it was 54 mg/L with a COD of 98 mg/L and no dissolved oxygen (PCBA, action plan for the Bharalu, Priority I). The State's report to the National Green Tribunal in O.A. 673/2018 placed the Bharalu, Borsola Beel and Silsako Beel in Priority I, Sorusola in Priority II and Deepar Beel in Priority III, polluted by the "Mora Bharalu channel", and found "no suitable land available" for a 75 MLD plant (August 2020); the CPCB's data for 2022–23 are reported to keep the Bharalu in Priority I and to list the Pamohi, the Digboi, the Mora Bharali at Tezpur and the Bega in Priority V and

the Dhansiri in Priority IV (as reported), and a CPCB report of 18 July 2025 found faecal coliform in Deepor Beel (as reported). Outside Guwahati, Dibrugarh's DTP drain "receives sewage flows through secondary drain from a major part of the town" (ADB, 2017). Sewers are coming slowly. The JICA-assisted Guwahati Sewerage Project (loan agreement of 27 February 2015) was appraised at 187 MLD (189 MLD in a State report of 2024; the figures conflict); its first phase, of ₹1,460.37 crore with sewage treatment plants of 65 MLD at Silsako, 62 MLD at Borsola and 60 MLD at Paschim Boragaon and about 872 km of sewers, was approved in January 2024 (as reported; ₹1,178.75 crore and ₹2,365 crore in other sources, which conflict), and in March 2025 an official said "We have begun with the survey" (as reported). Against a sewage gap of about 435 MLD the State reported 338.5 MLD of plants planned for 435.5 MLD (report of 9 October 2024, as cited); GMDA treats 15 MLD at Silsako "with bacterial dosing" before release to the Brahmaputra, and a 20 KLD faecal sludge plant has run at Belortol since August 2024 (as cited). The law already points the same way: from a notified date "no sewage shall be discharged into any watercourse until it has been so treated" (Assam Municipal Corporation Act, 2022, s.171), and the Commissioner may require "an entirely separate drain for rain water" (s.176) or, in Guwahati, "an entirely distinct private drain" for rain-water (Gauhati Municipal Corporation Act, 1969, s.237(1)); but Appendix VI of the Unified Byelaws 2022 routes "All Rain water outlets/drains and waste water drains" to the road drain "through the percolation pit only", which mixes sullage with storm water on every plot that follows it. In Assam, therefore: **(i)** every storm-drain, nala and jan outfall to a beel, a pukhuri, the Bharalu, the Mora Bharalu, the Bondajan, the Bahini, any other town river or a water body scheduled under the water-bodies law is taken to carry dry-weather flow until the survey of Clause 8.9.4 shows that it does not, and has a DWF interceptor and a screen under Clause 8.9.5 before it reaches the water, and before any detention or retention pond; **(ii)** no new storm drain shall discharge into a scheduled beel, Deepor Beel or any other wetland of Clause 7.12.1 unless its dry-weather flow is intercepted and its first flush treated under Clause 8.10; **(iii)** no septic tank or leach pit overflow and no sullage pipe is connected to a storm drain, nala or percolation pit on any site approved under this Manual (Clauses 8.9.1 and 8.9.2): where no sewer exists, sullage goes with the sewage to the on-site system of Clause 8.9.3, and where Appendix VI asks for the waste-water drains to pass through the percolation pit, this Manual states the conflict and leaves the Applicant to seek the Authority's relaxation; **(iv)** until sewers connect, a drain that receives sewage is designed as a combined channel under Clause 6.3.6(d): for velocities that keep sludge moving in dry weather as well as for the storm flow, with access for cleaning, and with covers or screens where it passes homes; **(v)** where no sewer or treatment plant exists to receive the intercepted flow, the interceptor delivers it to an interim treatment unit that the PCBA approves, never to a beel, pukhuri or pond; and **(vi)** a retention pond, beel or basin that stores storm water mixed with sewage, as Silsako does and as the retention pond of the ADB's Bahini works and the diversion to Silsako will, has the dry-weather flow of its inflows intercepted ahead of it; keeps no permanent pool fed by dry-weather flow; is drawn down to its normal level, by gravity or by its pumps, as soon as the river stage allows and within the pumping period of Clause 5.8.5; has its inlets screened and set so that they do not stand exposed as the level falls; is cleared of sludge in the post-season clearance by 15 November, with the sludge tested under Clause 7.9.1(c) and disposed of as the PCBA directs; and leaves no isolated pool standing more than 72 hours after drawdown, because of mosquitoes. Every interceptor is sized from the measured dry-weather flow of its drain and does not reduce the drain's capacity for the minor and major events (Clause 8.9.5(b)); at an outfall that a sluice closes when the river is high, it and its chamber are placed above the 1% AEP level or made watertight, and work with the gate shut. These conditions are 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 Assam 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 Assam Unified Building Construction (Regulation) Byelaws 2022 (byelaw 114: "Every building shall provide one or more rainwater harvesting structures to collect the roof top run-off", with recharging or percolating pits or trenches of "at least 5 cubic metres dimension for every 100 sq. metres. of roof area"; byelaws 38(i) and 104(i) and Appendix VI, with percolation pits of 1.2 m by 1.2 m by 1.5 m for every 100 m² of plot area and "rain water harvesting storage and reuse" for every plot of 134 m² and above; byelaw 110(g) in hilly areas; byelaw 111, which keeps 20% of every plot for trees and greenery; and byelaw 92, as amended in 2024, which leaves half the landscaped open space unpaved; and, in a notified area under section 19 of the Assam Ground Water Control and Regulation Act, 2012, the directions of the State Ground Water Authority for premises of 100 m² or more, though no notified area was found) continues to apply, subject to the limits of Clause 8.8.1: where a percolation pit or recharge trench that the byelaws ask for falls on a site where Clause 4.11 bars infiltration, this Manual states the conflict, requires storage for use in its place, and leaves the Applicant to seek the Authority's relaxation of the byelaw, which this Manual does not override (Chapter 1). This Clause sets how RWH structures are counted under this Manual.

8.11.2 **Three different functions.** The designer shall keep apart, on the drawings and in the calculations:

- (a) **harvesting**: storage for use (sumps and tanks);
- (b) **recharge**: recharge pits, trenches, shafts and wells that put water into the ground; and
- (c) **detention**: storage with an orifice outlet that is empty at the start of a storm (Chapter 4).

8.11.3 **Recharge structures.**

- (a) Roof runoff may be led to recharge wells, open wells, recharge pits and shafts after a filter or settling chamber.
- (b) Runoff from roads, parking and other paved areas shall not be led directly into any well, borewell or recharge shaft. It may be recharged only through an infiltration facility that meets Clause 8.8, with pretreatment.

- (c) Recharge structures shall meet the groundwater separation of Clause 8.8.1, measured from the base of the pit or the bottom of the filter media, except recharge wells that receive filtered roof water only.

8.11.4 **Credit toward retention and WQv.** A recharge structure counts toward the retention volume of Chapter 4 and the WQv only where:

- (a) its infiltration rate has been tested under Clause 8.8.3;
- (b) it empties within 72 hours at the design rate; and
- (c) it has pretreatment.

A harvesting sump counts toward retention only where its contents are used, by a demand stated in the drainage report, within 72 hours (Chapter 4).

8.11.5 **No credit as detention.** RWH storage does not count as detention unless it is a dedicated volume that is empty when a storm arrives, with an outlet. RWH sumps are assumed **full** at the start of every monsoon (April–October) design storm (Chapter 4).

8.11.6 **Overflow.** Every RWH structure shall have an overflow that discharges at grade to the site drainage, never onto a neighbouring plot or into a sewer.

8.11.7 **Surface-runoff recharge in public spaces.** Recharge trenches, shafts and percolation pits in roads, medians, parks and other public spaces shall meet Clause 8.8 in full, including the hotspot rules for roads with heavy traffic, and shall have a GPT or silt trap at each inlet.

> Commentary. The rule that RWH storage does not count as detention is set in Chapter 4. Assam's building rules make rainwater harvesting compulsory for every building, but they size it by pits and set no storm, volume for use or detention rule. Byelaw 114 of the Unified Byelaws 2022 reads: "Every building shall provide one or more rainwater harvesting structures to collect the roof top run-off. The total dimension of recharging/percolating pits/trenches should be at least 5 cubic metres dimension for every 100 sq. metres. of roof area"; byelaws 38(i) and 104(i) require the provisions "as prescribed in the Appendix-VI", which asks for "percolation pits of size 1.2m x 1.2m x 1.5m … at the rate of 1 nos. such pit for every 100 sq.m. of Plot area", routes "All Rain water outlets/drains and waste water drains" to the road drain "through the percolation pit only", and, since 2022, requires that "All buildings with plot area 134sq m and above shall have the provision of rain water harvesting storage and reuse"; and the structures are "shown in plans while applying for planning permission". The pit rate gives about 2.16 m³ per 100 m² of plot and byelaw 114 asks for 5 m³ per 100 m² of roof; the two are not reconciled in the text, and neither is sized to a storm (NEER reading). Roof-water harvesting is "mandatory in hilly areas" (byelaw 110(g)); byelaw 111 keeps "at least 20% of the land" of every plot for trees and greenery (10% where 25% of the FAR is affordable housing); and byelaw 92, as amended in 2024, leaves half the landscaped open space unpaved and lets the rest be laid with permeable pavers "to allow rain water to percolate to underground". The Assam Ground Water Control and Regulation Act, 2012 defines rainwater harvesting as "collection and storage of rainwater at surface or in sub-surface aquifer" (s.2(f)) and lets the State Authority direct it for premises of 100 m² or more in a notified area (s.19); no notified area was found, and the "100 m² plot" threshold quoted elsewhere is that section's, not a byelaw's. In practice GMC began inspections for rainwater harvesting and green cover from 20 June 2025, with penalties up to the revocation of the occupancy certificate; builders are reported to "conveniently flout" the rules, and the builders' association says the Appendix VI structures "have proved to be faulty" (all as reported). In Assam a percolation pit on the floodplain, receiving grey water and standing in ground that is saturated through the monsoon, is a soakaway, not storage. This Manual therefore treats rainwater harvesting as **storage for use** for the dry months from December to March, and as storage on floodplain sites: where the floodplain or hill rule of Clause 4.11 bars infiltration, byelaw 114's 5 m³ per 100 m² of roof (about 50 mm over the roof) is provided as storage, credited as retention only through reuse, emptied within 72 hours by a continuous non-potable use (Clauses 4.4.3 and 8.11.4), assumed full at the start of every storm (Clause 4.11.2), and never counted as detention (Clause 8.11.5). On the bhabar fans, the river terraces and the tested hill-foot colluvium, recharge may be one function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); where the byelaws' percolation pit

falls on a site where Clause 4.11 bars infiltration, this Manual states the conflict and requires storage in its place (Clause 8.11.1). The byelaws' dry sump on flood-liable and hilly plots is a detention facility under Chapter 4, empty before each storm, and is never an RWH tank. RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a June to August monsoon storm, such as those of June 2022, 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 monsoon (April to October) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **31 March**; and
- (c) any area exposed between 1 April and 31 October has sediment controls in place before it is cleared.

8.12.3 **Measures.**

- (a) **Silt fences** along the downslope edge of disturbed areas receiving sheet flow, with the area draining to each fence limited as set in Annex 8E.
- (b) **Sediment traps** for concentrated flow from disturbed areas of up to 2 ha.
- (c) **Sediment basins** for disturbed areas of more than 2 ha. The storage volume below the outlet shall be at least the greater of the runoff from the 50% AEP (2-yr) 24-hour storm and **250 m³ per hectare** of drainage area, with a dewatering outlet that draws water from the surface.
- (d) **Inlet protection** at every existing drain inlet that receives runoff from the site.
- (e) **Stabilised construction exits**, with wheel washing where vehicles enter public roads.
- (f) **Stockpiles** outside Zone 1 of any waterbody setback (Chapter 7), at least 10 m from any drain, and covered during the monsoon.
- (g) **Dewatering** discharges passed through a sediment basin, settling tank or filter bag, never pumped directly into a drain or waterbody.
- (h) **Concrete washout** in a lined pit, never into a drain.

8.12.4 **Design storm for temporary works.** Temporary ESC measures use the rainfall of Chapter 2 with a climate factor of 1.0 (Clause 2.8.2).

8.12.5 **Inspection.** ESC measures shall be inspected weekly and within 24 hours after every heavy-rainfall event (as defined in Chapter 10), repaired within 48 hours, and cleaned when half full of sediment.

8.12.6 **Removal.** Temporary measures shall be removed only after the area draining to them is stabilised. Sediment shall be removed from any permanent facility used for sediment control before its as-built survey (Chapter 10).

> Commentary. The 0.1 ha threshold is the applicability threshold of Chapter 1. The sediment basin volume of 250 m³/ha is the US EPA Construction General Permit minimum of 3,600 ft³ per acre drained, converted to SI (US EPA, 2022 CGP); the CGP allows the alternative of the 2-year, 24-hour runoff. This Manual requires the greater of the two, because Assam's 2-year 24-hour depths are high and construction sites are commonly left exposed through the monsoon. The 2 ha division between traps and basins, the 31 March stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 31 March date matches the pre-monsoon deadline of Chapter 10. Construction sediment is a direct flood hazard as well as a pollutant: it fills drains, culverts and tanks, and in Assam the silt of hill cutting travels with it: "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels", and the Bharalu's bed "has considerably risen" with silt (ADB, 2017); the Gauhati High Court found in 2025 that "hill cutting is still going on" (PIL/14/2024, 26.05.2025); and GMC spent ₹32.57 crore on desilting in five years (CAG Report No. 4 of 2019). The Unified Byelaws 2022 already ask for a "silt fence along plot boundary to prevent soil wasting into another's plot or into a common drainage network" on sites liable to flood (byelaw 74(iii)) and make one "mandatory" in hilly areas (byelaw 110(i)), with drainage "without causing soil erosion" (byelaw 110(c)); and since 2024 they penalise the dumping of construction and demolition waste "at road sides, Nalas, Rivers and other water bodies" (byelaw 120A). They give no size, area, date or inspection, which Clause 8.12 supplies. The stabilisation date of 31 March is set by this Manual, before its season begins on 1 April, because Guwahati's April storms and the State's May storms come before the south-west monsoon (Chapter 2). The reason given above for the larger basin volume, that the 2-year 24-hour depths are high, holds against the US basis it compares with: the CWC plates give no 2-year value, but the NIH-DHAARA reanalysis gives about 113 to 317 mm across the State (123 mm at Guwahati; comparison values only, not design values; Chapter 2), falls of 111 mm on 31 May 2025 and 117.4 mm on 20 April 2026 at the airport flooded Guwahati (as reported), and AMC III applies through much of the season (Chapter 3); the rule of Clause 8.12.3(c) is kept unchanged everywhere. In Assam 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; no sediment basin or trap is designed to infiltrate where Clause 4.11 bars infiltration, which includes the whole floodplain and every slope steeper than 10°; no spoil, silt or debris from a site is placed in a beel, pukhuri, jan or juri, within its Zone 1, or on an embankment; and a site on the hill fringe of Guwahati keeps its sediment behind a silt trap at the hill–plain break (Clause 6.3.6(m)) before any drain reaches a beel.

8.13 Monitoring

8.13.1 **Outfall monitoring.** Each Tier A authority shall monitor water quality at a representative set of its outfalls to waterbodies, including every outfall to a drinking-water tank or notified wetland. Monitoring shall include:

- (a) dry-weather sampling (Clause 8.9.4), at least once a year before the monsoon; and
- (b) wet-weather sampling of at least three events each monsoon at a set of index outfalls.

8.13.2 **Parameters.** At minimum: TSS, BOD, COD, faecal coliform, total nitrogen, total phosphorus, oil and grease, and, for industrial catchments, heavy metals. Results shall be compared with the CPCB water quality criteria for the designated best use of the receiving waterbody.

8.13.3 **Gross pollutant records.** The mass or volume of material removed from each GPT and screen at each cleaning shall be recorded in the O&M records (Chapter 10).

8.13.4 **BMP performance monitoring.** The State Stormwater Technical Committee shall run a BMP performance calibration programme and shall revise Table 8.3 and Annex 8C from its results.

8.13.5 **Publication.** Monitoring results shall be published in the register of Clause 10.17.

> Commentary. No Assam 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.

References (chapter)

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- Government of Assam. *Assam Ground Water Control and Regulation Act, 2012* (Assam Act XVI of 2012), Assam Gazette Extraordinary No. 226, 19 May 2012, ss. 2(f), 3, 5, 6 and 19, https://legislative.assam.gov.in/sites/default/files/swf_utility_folder/departments/legislative_medhassu_in_oid_3/menu/document/The%20Assam%20Ground%20Water%20Control%20and%20Regulation%20Act%2C%202012..pdf (Wayback 20220810194637)
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- Parliament reply AU1419 on AMRUT 2.0 admissible components. https://eparlib.sansad.in/bitstream/123456789/2988692/1/AU1419_tzClvw.pdf

Annexes and forms

Annex / Form	Content
8A	3-month ARI 24-hour depth and IDF by zone
8B	Redevelopment LoS table and treatment-train composite VR
8C	Assam 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, a jan (Assamese জান: a stream or natural drainage channel, often the outlet of a beel), a beel, a pukhuri or another water body 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 upstream, such as the Ranganadi and Lower Subansiri projects on the north bank, the Kopili hydroelectric project of NEEPCO, New Umtru on

the Umtru above Byrnihat and Kurichu in Bhutan on the Manas; the outfall-closed check of Clause 5.10 wherever the river can rise above the outfall invert, which in the monsoon is the normal case, not the exception, for the drains of Guwahati that reach the Brahmaputra through the sluice at Bharalumukh and through the Bondajan and the Khanajan (Clause 5.8.5(b)), for Dibrugarh's DTP drain, which reaches the Sessa through an outfall sluice, and for Silchar behind the Barak embankment (Clause 5.8.5(c)), and for every town whose drains reach a river through a sluice in an embankment of WRD (Clause 5.8.5(a)); for an outfall to a beel or retention pond, its level full to its outlet at the start of the storm, as Dibrugarh's drainage design assumes (Clause 5.8.5(e)); the level held in a drain by any sluice, flap gate or pumping station downstream of the outfall, taken as a fixed control at its gate-closed level, its sill or the start level of its pumps; and the joint case of Clause 2.12. At the CWC sites that govern the larger towns the high flood levels stand well above the danger levels: the Brahmaputra at Guwahati (DC Court), danger level 49.68 m and high flood level 51.46 m (21 July 2004), at Dibrugarh 105.70 m and 106.48 m (3 September 1998), at Tezpur 65.23 m and 66.59 m (27 August 1988) and at Dhubri 28.62 m and 30.36 m (28 August 1988; 30.37 m on 17 July 2019 in a later bulletin, a conflict); the Barak at Annapurnaghat, the Silchar gauge, 19.83 m and 21.84 m (1 August 1989); and the Kushiyara at Karimganj 14.94 m and 16.57 m (10 June 2010) (CWC levels as transcribed by SANDRP, as reported; the datum of none is stated [TBC]). No document found sets a design river level at any outfall in Assam; 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

Barrel and inlet	ke
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.

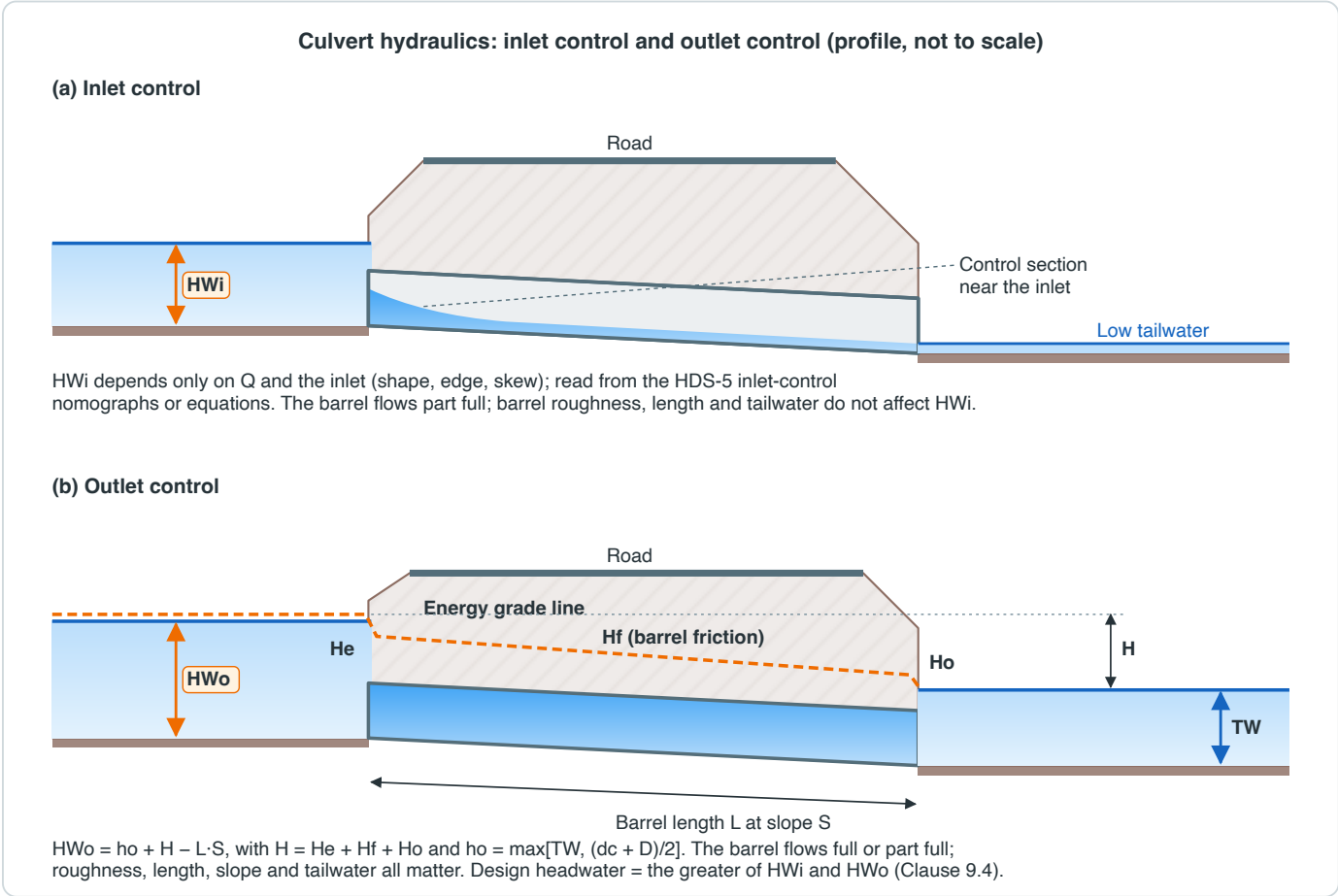

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

> **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 Assam 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 Guwahati, Dibrugarh, Silchar and the other embanked towns that reach the Brahmaputra, the Barak, the Kushiyara or a tributary through sluices or by pumping, on the drains

to beels and retention ponds that a closed sluice holds full, and on the flat jans of the floodplains is the normal case, as it is on the steep drains of the Guwahati hills and the hill districts and on every juri (Assamese জুৰি: a small hill stream) there, stepped by drop structures and chutes and passing through critical depth at every step.

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 Assam (the recent flood-plain alluvium of the Brahmaputra and Barak valleys, silty clay loams with clays in the beel basins, the char and chapori sands, the boulder and gravel fans of the bhabar and the terai belt below them along the northern foothills, the thin red loams over the granite-gneiss of the Guwahati hills with their cut slopes and fills, and the laterite and red loams of the Karbi and Dima Hasao hills (this Manual's reading of the CWC Flood Estimation Reports and of CGWB; no soil series of NBSS&LUP was obtained [TBC])). 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 Assam 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

Class	D50 (mm)	Apron length	Apron thickness
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.

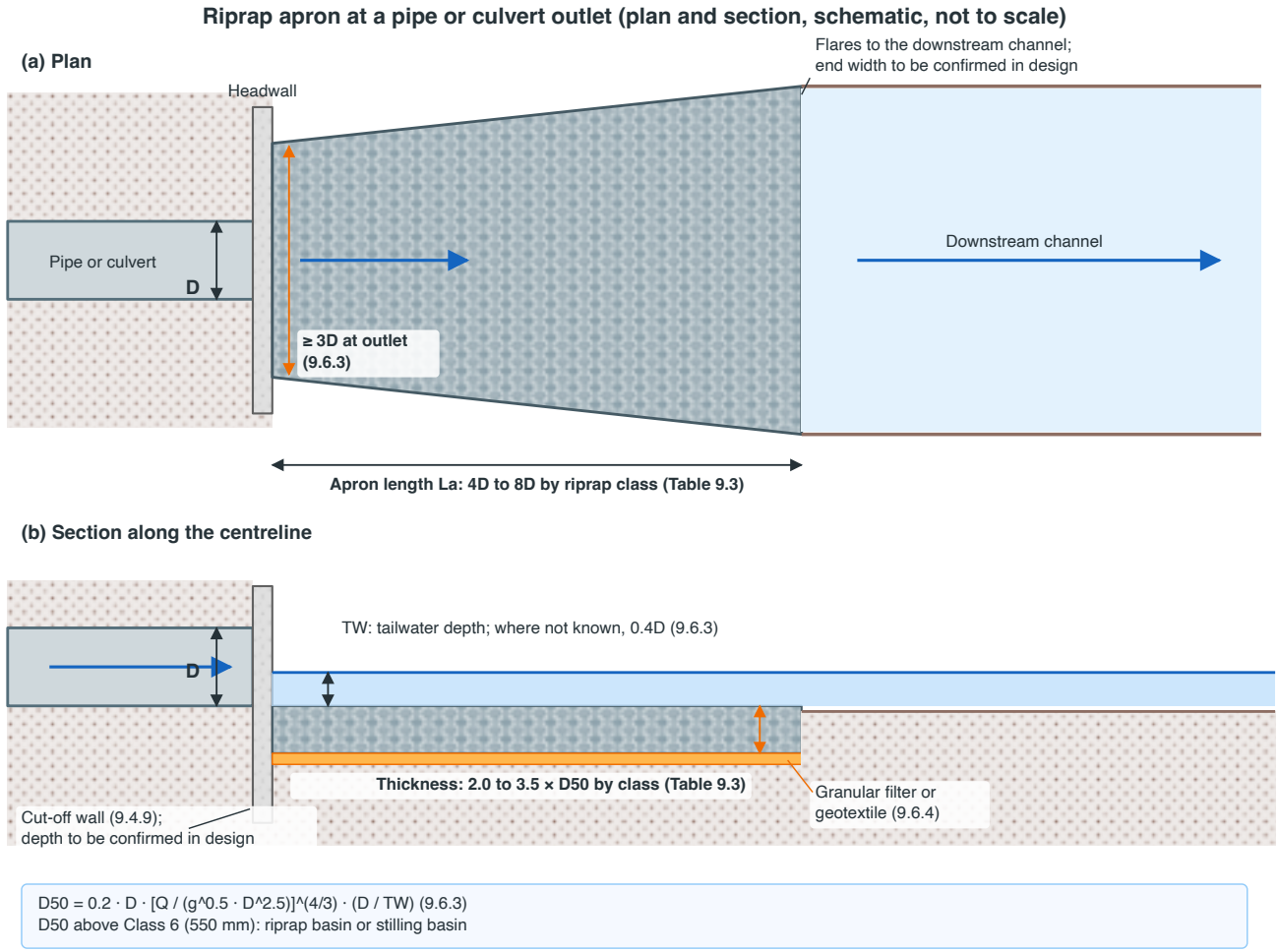

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design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

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

where A is the orifice area (m²) and h is the head (m) on the centroid of the orifice, or the difference between the upstream and downstream water levels where the orifice is submerged. 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 $Q = C_w \cdot L \cdot H^{1.5}$, 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: $Q = 1.38 \cdot \tan(\theta/2) \cdot H^{2.5}$ (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 m^3/s.

9.8.7 **Safety.** Racks at the entrance to long conduits shall prevent people from being drawn in. They shall be designed for the hydrostatic load of a fully blocked rack.

> Commentary. CPHEEO (2019, §8.3.1.3) describes pump-station bar screens with a spacing of "approximately 58 mm", built in modules, with an emergency overflow in case of clogging. Clause 9.8.6 follows that approach but links the spacing to the pump's solids-passing size, which varies by pump. The 50% blockage check matches the grate clogging factor of Chapter 6. The Kirschmer equation and its shape factors are standard (Kirschmer 1926, as reproduced in hydraulic handbooks). The rack spacing, area ratio, through-velocity, the 30 m conduit length trigger, the 10× screen area for orifices and the 1 m^3/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.

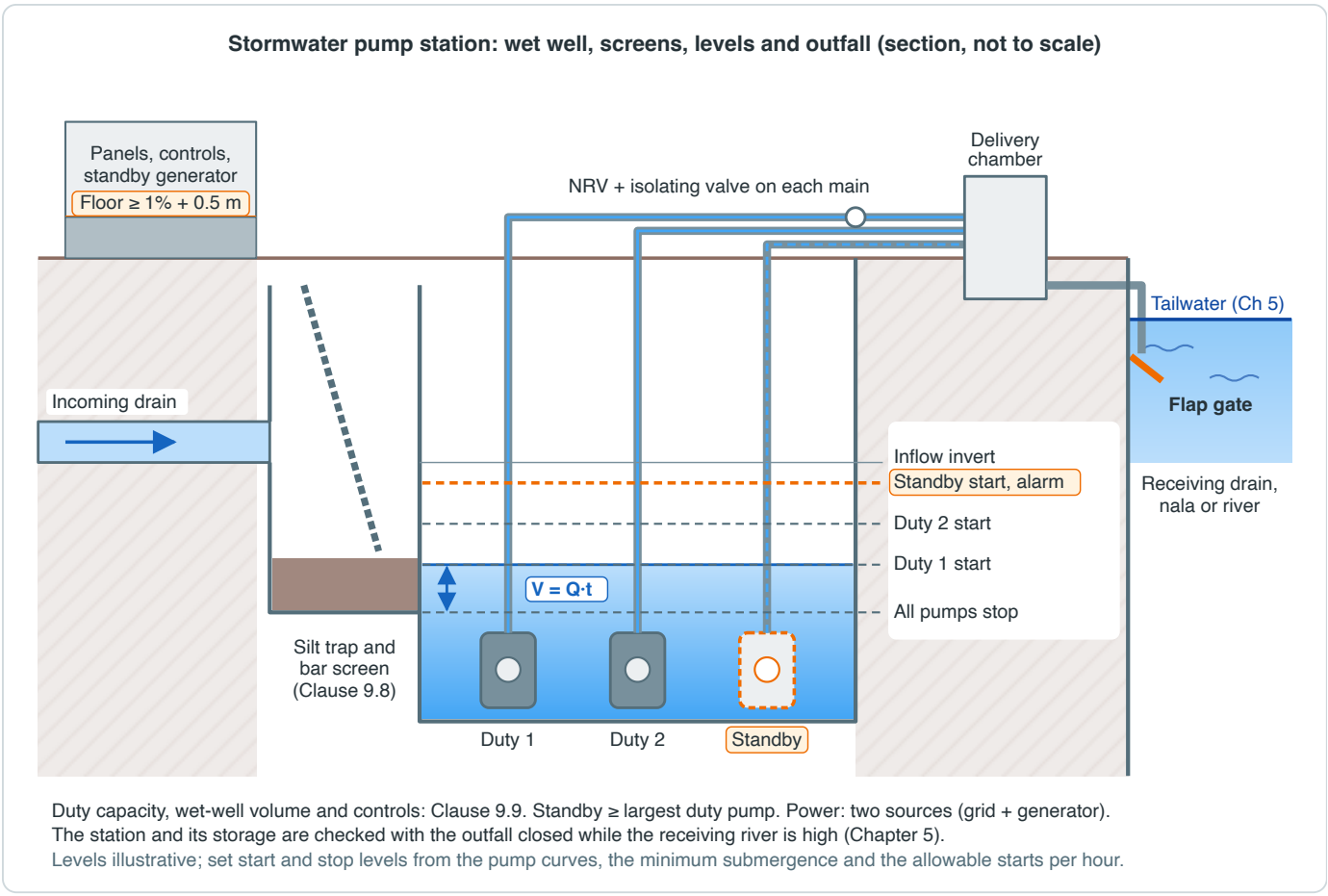

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **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". Assam 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, beel or ponded level of Chapter 5. The river closes the outfalls instead. Assam's towns sit below the high stage of the Brahmaputra or the Barak, behind about 4,474 km of embankments, and most of their drains reach the river only through sluices in those embankments, which close when the river rises: "High stages of river Brahmaputra and Barak obstruct free discharge of tributaries causing back flow and congestion near outfalls. Inadequate countryside drainages through sluices in embankment system … cause prolonged inundation" (WRD, as quoted by the CAG, Report No. 5 of 2018), and at Guwahati "the water level of the Brahmaputra River sometimes, is higher than the ground level of the city areas" (ADB, initial environmental examination, 2017). Pumps, sumps and gates under Clauses 9.9 and 9.10 are therefore the normal monsoon case of this Manual, and the outfall-closed check of Chapter 5 sizes them. **Guwahati.** The Bharalu reaches the Brahmaputra through the sluice at Bharalumukh; "the natural discharge capacity of the Bharalu is 72 Cumecs when its Bharalumukh sluice gates are kept open, while the pumps fitted to its sluice gates can discharge only seven Cumecs" (2008, as reported; the present installed capacity was not found [TBC]), so with the gates closed the city drains at about a tenth of its gravity capacity. WRD installs and runs the dewatering pumps at the Bharalu, the Mora Bharalu and the Bondajan (as reported), and the Noonmati pump house diverts the Noonmati basin towards the Bondajan with four pumps of 1,000 L/s each (as reported). The ADB-funded Bahini works add pumping capacity of 7.8 m³/s in three stormwater pumping stations and a nature-based retention pond of 59,000 m³ with a pumping station of 1.6 m³/s, and divert part of the runoff "to a retention basin in the nearby Silsako Basin and gradually pumped out to the Brahmaputra River" (ADB, report and recommendation of the President and project administration manual, 2025), and a project of ₹1,459 crore for the Bahini and the Bharalu with an automated pumping station at Bharalumukh was announced in May 2026 (as reported). The Brahmaputra at Guwahati (DC Court) reaches its danger level of 49.68 m in most monsoons, and its high flood level is 51.46 m (21 July 2004) (CWC levels as transcribed by SANDRP, as reported; the datum is not stated [TBC]), so these gates stay closed for days or weeks at a time. **Dibrugarh** is the model for the sluice-locked case. "To protect the town, the 8.62-km DTP dyke was constructed in 1955. The construction of the DTP dyke closed all the drainage channels"; "At present, Dibrugarh town is 1.5 m below the bed level of Bramhaputra"; its drain runs 32.053 km to the Sessa past the Larua Jamira beel, with capacities of 105.50, 142.97 and 61.11 m³/s by reach, and its outfall sluice is to be rebuilt as "two numbers of radial automatic sluice", designed against a backwater "at the sluice with a flood level of 97.50 m" and "keeping in mind that the beel is full and the drain is also flowing full" (ADB, initial environmental examination for the Dibrugarh drain, 2017). **Silchar** is a bowl behind the Barak embankment; in June 2022 the river entered it

through a cut at Bethukandi and the town was under water for about 11 days, or "about a week" in another account (as reported), with the Barak at Annapurnaghat peaking at 21.59 m on 21 June, 1.76 m above its danger level and 0.25 m below the high flood level of 1989 (as quoted from the Cachar district report; differences computed for this Manual); its outfall channels and any pumps were not researched [TBC]. Across the State the counts of sluices conflict: 98 major and 545 minor (CAG, March 2017), 94 and 545 (WRD's website, as quoted) and 122 and 545 (a Lok Sabha reply of December 2024, as quoted); the embankments are 4,474.42 km (CAG), 4,473.82 km (WRD, as quoted) or about 4,800 km (a later ministerial reply, as reported).

In Assam the following are set by this Manual, for every outfall that passes through an embankment, sluice or drain under the Assam Embankment and Drainage Act, 1953, whose "embankment" includes sluices and whose "drain" includes "dongs", culverts, sluices and any device for "excluding, regulating or retaining" rain, flood or sub-soil water (s.2), and for every pumped outfall: (a) the outfall shall have a flap gate and, behind it, a penstock or stop-log slot (Clause 9.10.3) whatever its size, because WRD closes the sluice in the embankment for the whole of a river flood and the flap gate is the only closure the town controls; (b) the sill, the gate-closing level and the embankment crest at the sluice shall be surveyed on a named datum and tied to the governing CWC or WRD gauge (Clause 10.4.4(d)); (c) the storage and pumping behind the gate shall meet the outfall-closed check of Chapter 5 for the durations that Chapter 5 sets for gated outfalls (Clause 5.8.5), with the receiving beel or retention pond full to its outlet at the start of the storm, as Dibrugarh's design assumes, and the pumps selected for the full range of static head up to the high flood level at the governing CWC site; (d) a station behind an embankment shall have fuel on site for the 72 hours of Clause 9.9.9(b) and a written arrangement, agreed with the owner of the station, for resupply by road or boat for the rest of the closure, which Chapter 5 takes as not less than 7 days on the Brahmaputra, the Barak and the Kushiyara where no stage record has been analysed (Clause 5.8.5(a)), and the 1% AEP level of Clause 9.9.10 at a station inside an embankment shall be taken as the higher of the local 1% AEP ponding level and the level reached inside the embankment in a recorded breach or cut, such as the flood marks of June 2022 in Silchar, because the stations must keep running when the land around them floods; and (e) the work needs the permission of WRD, through its Embankment Officer, under ss.15 and 16 of the 1953 Act, and the gate is operated only by the body that runs it, since opening, shutting or obstructing a sluice without authority is an offence under s.15(ii) (up to three years and ₹1,000). Gates are also required where an outfall reaches a river reach below a dam: the Ranganadi project released 1,412.57 m³/s in 2017 (as quoted from a report of IIT Guwahati for ASDMA), of an inflow of about 1,511 m³/s (as reported), the release rules of the Lower Subansiri, the Kopili hydroelectric project of NEEPCO and Kurichu in Bhutan on the Manas were not found [TBC], and New Umtru on the Umtru above Byrnihat has a maximum water level of 132.78 m and a spillway of 3,820 m³/s, with a release reach of 9.80 km to Byrnihat (MePGCL); an outfall to such a reach is checked against the largest recorded release, or, until the operator gives one, the spillway capacity, and below that level needs a flap gate and storage. These dams are designed to dam-safety standards, not to this chapter, but their releases are this chapter's boundary conditions.

The hill streams set the other half of this chapter. The Bahini rises at Umtyrnga in Meghalaya and the Basistha and the Kalmani in the same hills, and they cross the hill fringe of south Guwahati, at Khanapara, Basistha and Jorabat, before the plain; "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas results in sheet wash and blockage of channels" (ADB, initial environmental examination for Guwahati, 2017), and on 26 May 2025 the Gauhati High Court recorded that "hill cutting is still going on" (PIL/14/2024). The Unified Byelaws 2022 ask for "special protection measures" on slopes greater than 10° (byelaw 110(d)), cuts of "generally … 4 m. to 6m" (110(e)), drainage "without causing soil erosion" (110(c)) and silt fences that are "mandatory" (110(i)), and ban the dumping of construction and demolition waste in "Nalas, Rivers and other water bodies" (byelaw 120A, added in 2024), but set no design for a structure. In Assam the following are therefore set by this Manual, as in the mountain editions of this series, for a structure on a drain whose catchment includes an undeveloped hill slope, a cut slope, a juri or a stream from the hills, in the Guwahati hills, in sub-areas AS-D and AS-D1 and on the bhabar fans of the northern foothills: (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, with the sediment bulking and blockage factors that Chapter 6 sets (Clause 6.3.6(g) and (h)), a debris rack, inclined so that the flow lifts debris onto it, shall stand upstream of the inlet, with a clear bar spacing chosen from a survey of the gravel, boulders and garbage in the bed and not less

than that of Clause 9.8.2(a), and a silt trap or debris basin upstream of the rack, sited at the hill–plain break, where the streams drop their load (Clause 6.3.6(m)); the basin volume shall be estimated from the silt and debris deposited at the site in past floods and a stated sediment-yield method, counting every hill cut, quarry, slide scar and building site in the catchment as a source, because no Indian or Assam guidance on sizing debris basins and no Assam silt or bulking allowance was found [TBC]; its spillway shall pass the 1% AEP inflow with the basin full, as for Clause 9.7.6, and it shall have a ramp for the machines that empty it; (c) a culvert on a hill stream shall have a single barrel where possible (Clause 9.4.8(a)), an armoured headwall and apron at the inlet, an invert that follows the bed (Clause 9.4.8(c)), and an outlet protected under Clause 9.6 and led to a stable channel, never onto an unprotected slope, as Clause 6.3.6(k) requires of hill roads; (d) every lined drain that receives runoff from cut slopes, hill roads, quarries or building sites shall have a silt trap before it joins a public drain, a jan or a beel; 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. On the bhabar fans the boulders a flood carries and the shifting of the channel govern more than the hydraulics, and a structure is sited out of the active fan where it can be. No structure of this chapter is designed to pass a debris flow or a landslide, or to hold a channel on active char and chapori land: there, and on any drain below a mapped landslide zone, in a breach path behind an embankment or in a dam-release reach, the screening of Clause 2.3.6(i) comes first, and a structure is sited out of the hazard.

No structure of this chapter is built to exfiltrate on the floodplain, on char and chapori land, on beel and pukhuri margins, behind an embankment that ponds when its sluices close or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, floodplain rule), or on natural slopes over 10°, colluvium or fill without a geotechnical certificate (Clause 4.11, hill rule): no soakaway, exfiltrating chamber, perforated pipe or open-jointed drain. Screens matter as much as gates, because the drains also carry sewage and garbage: no town in Assam has a centralised sewerage system (ADB, report and recommendation of the President, 2025), the Bharalu carries about 70,740 kL of untreated sewage a day from about 39 outfalls and is in Priority I of CPCB's polluted river stretches (PCBA action plan), and Dibrugarh's drain "receives sewage flows" (ADB, 2017), so a screen on a pump sump or a gate in Assam is checked in the blocked case of Clause 9.8.4, cleaned mechanically where the sump serves more than one drain, and placed with the interception of dry-weather flow before every outfall to a beel or scheduled water body (Chapter 6, Clause 6.3.6(e); Chapter 8, Clause 8.9.5). No inventory of the sluices, flap gates, screens and pumping stations on the drains of any Assam town, with their sills, capacities and operating rules, no rule of WRD linking the closing of a sluice to a river stage or stating how long its sluices stay closed, and no design river level at any outfall was found in the public domain. Clauses 9.10.3 and 9.10.5 are set by this Manual because a flap gate or sluice that fails, or is jammed open by silt, garbage or debris, lets the Brahmaputra, the Barak or a tributary in flood back into the drain network, and one jammed shut blocks it. The drains of Assam towns carry silt, garbage and sewage to their outfalls: the Bharalu "has no natural flow of the river at present and only the domestic sewage and commercial sewage are being carried" to Bharalumukh, where its sluice blocks the backflow of the Brahmaputra, and the Bahini, cut off by a sluice at Natun Bazar, "now becomes a sewerage drain" (PCBA action plan for the Bharalu); "due to siltation, the bed level of the river has considerably risen" (ADB, initial environmental examination for Guwahati, 2017); and GMC spent ₹32.57 crore on desilting from 2013–14 to 2017–18 while holding no data on its storm drains (CAG Report No. 4 of 2019), so a gate, its screen and the pump sump behind it are exposed to the same load and must be kept clear together; and because the Brahmaputra at Guwahati reaches its danger level in most monsoons, with its high flood level 1.78 m higher (CWC levels as transcribed by SANDRP, as reported; difference computed for this Manual), a gate that leaks or jams can be exposed for days or weeks, and opening, shutting or obstructing a sluice without authority is an offence under s.15(ii) of the Assam Embankment and Drainage Act, 1953, so only the body that runs the gate may operate it.

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 Assam 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 Assam 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 Assam 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 Assam 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 Assam the failure is one of missing criteria and of drains split among many hands. No document of DoHUA, T&CP, GMDA, GMC, any other Municipal Corporation or Board, PWD or WRD stating a design return period, intensity or runoff coefficient for the storm drains of any town was found. The CAG found storm-water drainage in the test-checked ULBs covering "3 to 37 per cent only" of the need, and GMC's data on storm-water drainage "not available as it was involved with works of drain desilting only", although it spent ₹32.57 crore on desilting from 2013–14 to 2017–18 (Report No. 4 of 2019); it found GMDA "not functioning as per the spirit" of its Act, with "very few technical staff", and no action against the consultants for "defective DPRs for Storm Water Drainage Project for Guwahati City" (Report No. 2 of 2024). ADB puts the stormwater drainage of the State's ULBs at "only about 30% of the required areas" and names the cause: "fragmented institutional responsibilities involving multiple institutions, such as the Guwahati Metropolitan Development Authority (GMDA), Public Works Department, and Water Resources Department" (report and recommendation of the President, 2025). The approval route shapes this chapter. Since the Assam Building Construction (Regulation) (Amendment) Act, 2022 (Assam Act XXVII of 2022), one Act and one set of byelaws cover every notified Master Plan area: GMDA or another Development Authority grants the planning permit "as per the provisions of Master Plan and Zoning Regulations", and GMC, another Municipal Corporation, a Municipal Board or a Gaon Panchayat the building permit under the byelaws (s.6, amending s.2); the occupancy certificate follows, and GMC already checks rainwater harvesting there, with penalties up to its revocation (as reported); the time for a permit was cut from 45 to 30 days in 2024 (as reported). The Unified Byelaws 2022 already ask for much of what a drainage submittal needs: a "Detailed drainage plan for both internal and external required to be constructed upto the available permanent/pucca drain of municipal/other authority" and the "detail provisions made for conservation and harvesting of rain water" on the plans (byelaw 94); the rainwater structures of Appendix VI "shown in plans while applying for planning permission"; on hill sites a topographic survey with proposed ground levels and erosion measures (110(a)) and

earthwork and slope-stability calculations vetted by an approved third party (110(f)); on sites liable to flood and in hilly areas a "dry sump (including design calculation) in all individual plots, capable of holding rain water during peak monsoon" (byelaws 74(ii) and 110(h)); a plinth "0.3 m higher than the highest recorded flood level as fixed by the local authority" (45(c)), although no local authority's level was found for any town [TBC]; and the "Improvement of drains up to the nearest outlet point … as directed by the Authority", with an "Additional 25% of the cost of improvement at PWD rate" as a penalty if it is not done (101(vi)). The Act defines a "drain-surface water" as one "used or constructed to use solely for conveying to any drain any rain water" (s.2(20)). An outfall through an embankment or sluice needs the permission of WRD under the Assam Embankment and Drainage Act, 1953 (ss.15 and 16); a scheduled water body, the committees of the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024; a guard wall or house on hill land in a Designated Area, the Advisory Committee under s.14 of the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006; and a well in a notified area, the State Ground Water Authority under the Assam Ground Water Control and Regulation Act, 2012, under which no area has yet been notified. The byelaws do not extend to the Autonomous Districts unless a District Council notifies that they apply (byelaw 1(2)), and no such notification was found [TBC]. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a design storm, and the dry sump's "design calculation" has no method to follow. 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 competent authority for the area can check it with the drawings the Unified Byelaws 2022 already require: the drainage plan of byelaw 94 to the pucca drain, the Appendix VI plans and the dry-sump calculation, which Chapter 4 supplies, at the planning permit; the hill-site survey and third-party slope checks of byelaw 110 at the building permit; the permission of WRD for any outfall through an embankment or sluice; and the occupancy certificate at completion. 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 Assam Unified Building Construction (Regulation) Byelaws 2022 (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.

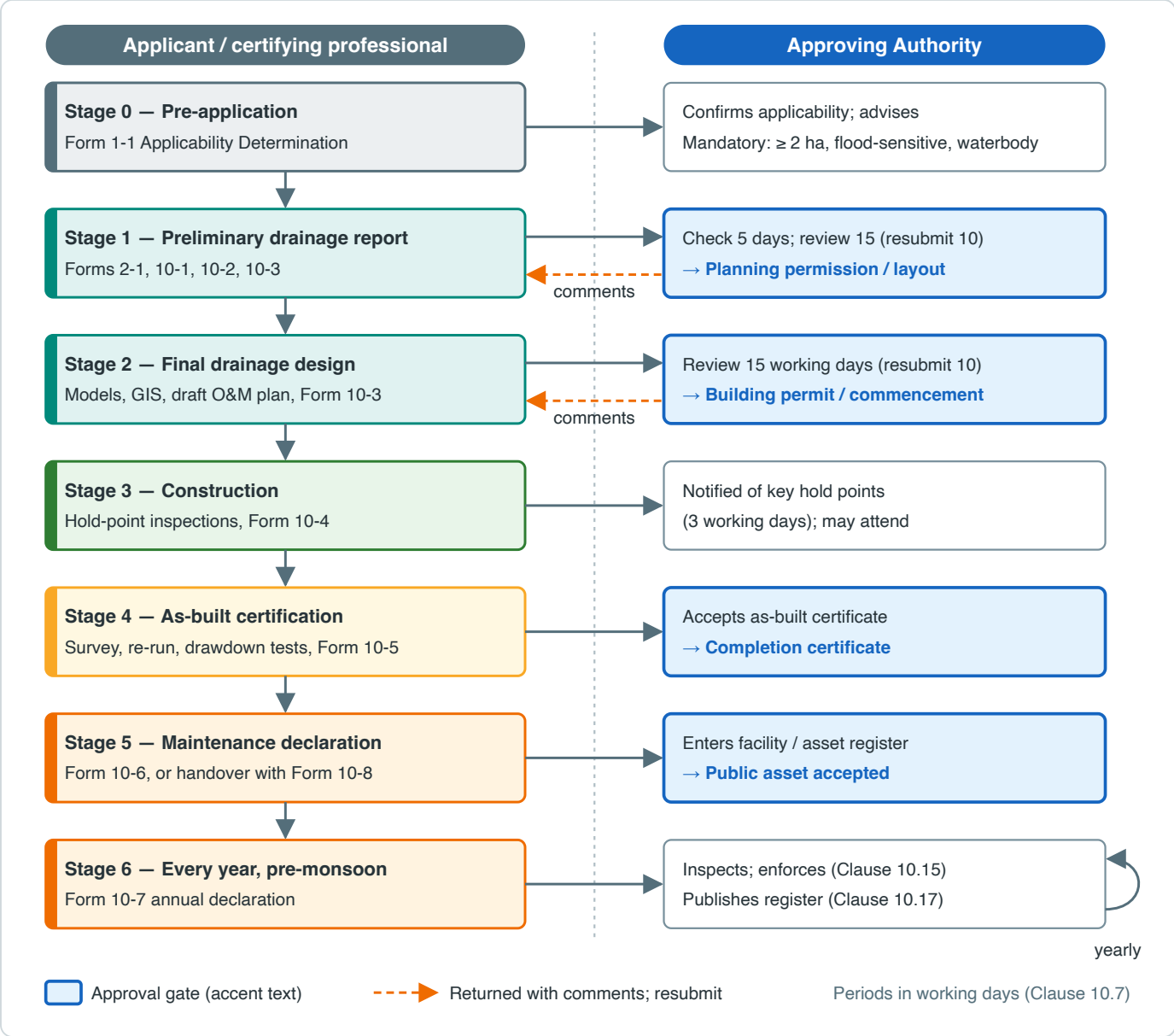

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **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 Unified Byelaws 2022 steps an Assam 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 (46N for State-wide work and nearly every project, and 45N only for a project wholly west of 90° E, a strip of Dhubri, South Salmara-Mankachar and western Kokrajhar and Goalpara districts that includes Dhubri town at about 89.98° E (this Manual's reading; district boundaries and coordinates to be confirmed against Survey of India data [TBC]); at most a sliver of Tinsukia district east of 96° E would fall in 47N [TBC] and is mapped in 46N, and a project 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 flood-forecasting and level-monitoring sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries (not stated in any source found [TBC]), of the gauges of WRD and of its embankment crests, sluice sills and gate-closing levels, and of the flood marks surveyed on ungauged channels, beels and pukhuris 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

Form	Title	Stage
1-2	Variance / Waiver Request	1
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. Assam has no notified design return period or design storm for its urban drains. The town drainage master plans of DoHUA were "prepared before 2015 as per previous FPS system" and await revision to the CPHEEO guideline of 2015 (DoHUA, status of drainage master plans, c. 2016), and no design criteria appear in any of their documents read; Guwahati's storm-drainage report by Tahal (2008) was not built (as reported); the comprehensive drainage master plan that Haskoning DHV is preparing for GMDA was under revision, not final, in November 2026 (as reported); and Dibrugarh's DTP drain was designed by a "rainfall based approach … The peak discharge computed by rational method", with no return period given (ADB, 2017). The first design values found in an official Assam document are those of the ADB-funded Bahini works: inundation "from a 1-in-5-year storm or lower return period avoided in 434 ha of frequently flooded areas of Bahini Basin", with "Inundation areas of 693 ha during the design storm of 65.72 mm hour" (ADB, project administration manual, 2025); the duration behind 65.72 mm per hour and its return period are not stated, and the 616-ha baseline of the same table differs from the 693 ha [TBC]. A 1-in-5-year target is below the 10% AEP that Table 2.1 sets for minor drains in high-density areas, so a design that uses it reports it on Form 2-1 and meets this Manual's AEPs. A research model has simulated about 34 m³/s for a 2-hour, 5-year storm in a proposed outfall system for Guwahati (EGU abstract, 2026), research only. The rainfall studies do not supply a design storm either. No intensity–duration–frequency relation with published constants was found for any Assam station; IMD's national study (Das et al., 2022) prints panels for Guwahati and Dibrugarh (Mohanbari), but both repeat a generic curve and are not used; NIH-DHAARA's depths exceed every IMD 24-hour record at Guwahati, Dibrugarh, Tezpur, North Lakhimpur and Silchar and are reported for comparison only; and the two CWC Flood Estimation Reports that cover the State disagree, the report for subzone 2(a) giving a 1-hour ratio of 0.260 on the north bank and the report for subzone 2(b) 0.48 on the south bank, while the Barak valley lies in subzone 2(c), for which CWC has published no report. The storms on record exceed the screening values: Guwahati's self-recording gauge took 163 mm in 3 hours and 179 mm in 6 hours on 18 July 1978, above the 3- and 6-hour depths that the 2(b) ratios give on the city's 50-year plate value, and Nowgong's 427 mm in 24 hours on 3–4 September 1978 (CWC, Flood Estimation Report for subzone 2(b), Annex 4.2), and SIRD Khanapara recorded 215.9 mm overnight on 20 April 2026 (as reported). The State's design values are therefore those of Chapter 2: the plates and ratios of the two reports by sub-area (Clause 2.3.6(c) and (f)), the Guwahati catchment rule of Clause 2.3.6(c)(i), the Barak valley rule of Clause 2.3.6(c)(ii) and the short-storm floors of Clause 2.3.6(g), 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 Assam 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 Unified Byelaws 2022 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 WRD, through its Embankment Officer, for any work that cuts, crosses, alters or discharges through an embankment, sluice or drain under the Assam Embankment and Drainage Act, 1953 (ss.15 and 16), or for a work on a river in its charge, the permission of the Commissioner to make or alter a drain leading into a drain vested in the Corporation (Gauhati Municipal Corporation Act, 1969, s.242) or of the Municipal Corporation or Board under the Assam Municipal Corporation Act, 2022 (ss.173–177) or the Assam Municipal Act, 1956, the permission of the Authority for any use of a plot scheduled under the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024 (Unified Byelaws 2022, land-use note added in 2024) and the approval of the State Level Committee for any change that diminishes a water body or alters its character (ss.3 and 15 of the Bill; the enacted section numbers [TBC]), the prior approval of the Advisory Committee for a guard wall or a house on hill land in a Designated Area (Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006, s.14), the permit or direction of the State Ground Water Authority in an area notified under the Assam Ground Water Control and Regulation Act, 2012 (none has been notified), the consent of PWD or NHAI for a discharge to a side drain or culvert of one of their roads, the consent of PCBA for a discharge that carries effluent, and the consent of the body that owns or runs the receiving drain where that body is not the Authority (in Guwahati, GMDA, GMC, PWD, WRD, the Railways or another owner of drains), 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.

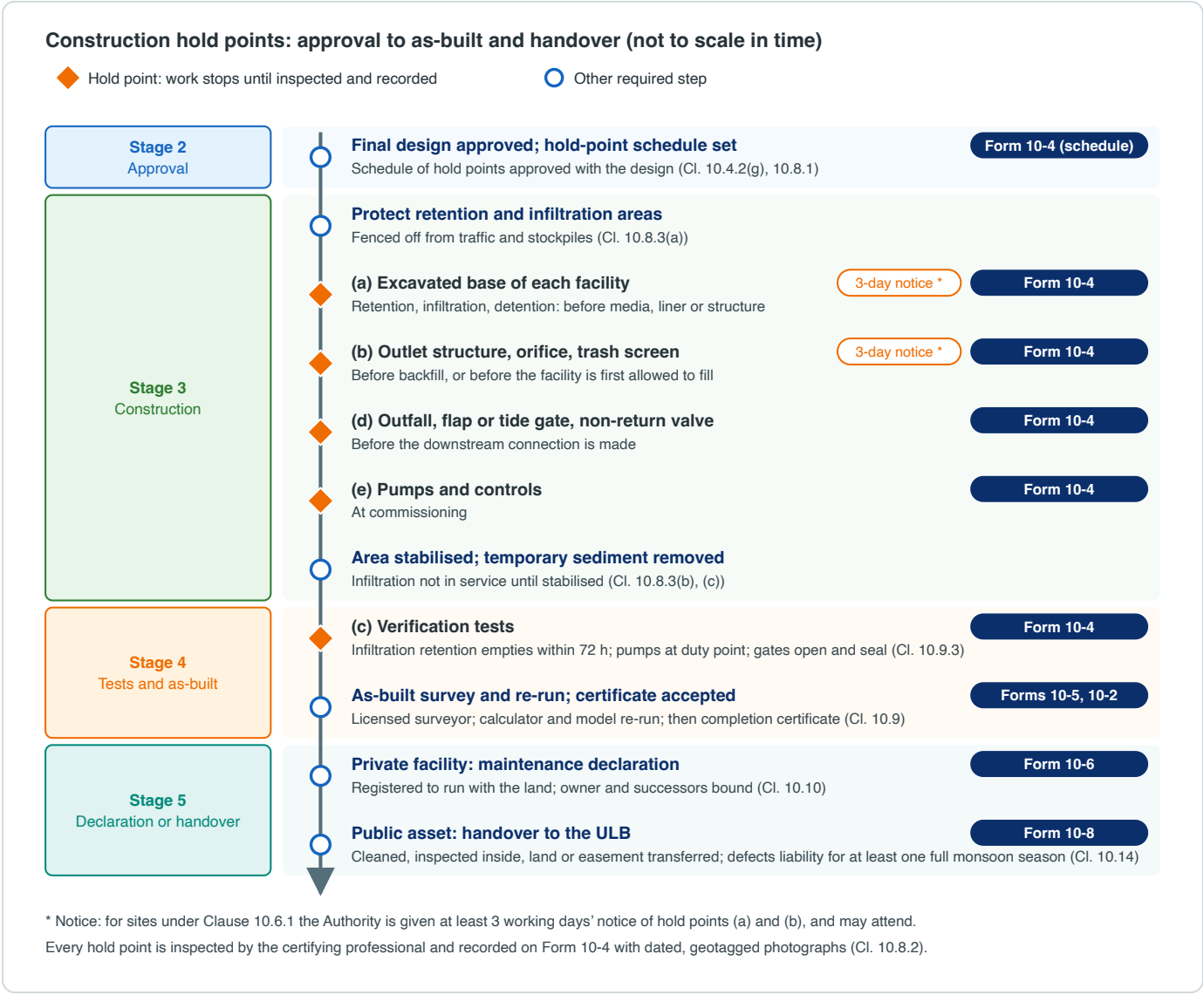

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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 March** each year. The report shall be signed by the owner and, for facilities under Clause 10.6.1(c) and (d), by an empanelled professional. It shall state that the pre-monsoon inspection of Clause 10.12 has been done and any defects corrected.

10.10.4 **Transfer.** On sale or transfer, the seller shall disclose the declaration and the latest Form 10-7. The purchaser takes on the obligations from the date of transfer.

> Commentary. Singapore requires owners of pumped detention systems to file yearly declarations and documents with PUB (PUB Detention Tank Guide, citing Code of Practice §13.2). Addendum No. 3 to the Code of Practice (16 Apr 2025) introduced annual maintenance declarations for flood barriers and pumped detention tanks, following amendments to the Sewerage and Drainage Act. APWA 5600 (2006, §5608) required easements and maintenance provisions for detention facilities. A registered declaration matters in Assam because detention

tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 31 March date is set by this Manual to fall before the monsoon season (April–October), when most Assam 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. Assam has no dated State or municipal order fixing pre-monsoon desilting. In Guwahati, GMC's cleaning of nearly 550 drains was "expected to begin from mid-February" in 2026, desilting procedures "issued in February 2025" are said to have been "largely ignored", and the Mayor said that the work "will be completed before the monsoon" (all as reported). The drains are run by several hands, and no notification divides them: under a working split of 2022, GMC desilts the Bharalu, the Mora Bharalu, the Basistha, the Bahini and the Lakhimijan with their primary and secondary drains; WRD desilts the Bondajan and installs and maintains the dewatering pumps at the Bharalu, the Mora Bharalu and the Bondajan; and PWD cleans about 263 roadside drains (all as reported); GMDA builds new drainage, excavates Silsako and is the project implementation unit of the ADB-funded Bahini works (ADB, 2025); and the Railways, OIL, NHAI, the Army and others keep their own drains (as reported). In March 2025, 21 monitoring committees of the District Disaster Management Authority were reported to oversee the desilting in Guwahati (as reported). GMDA treats about 15 MLD at Silsako "with bacterial dosing" before release to the Brahmaputra (State report to the National Green Tribunal, 9 October 2024, as quoted), so the retention ponds that hold storm water mixed with sewage need their own operating rules. In the other Municipal Corporations the public drains vest in the Corporation, which must provide "a safe and sufficient outfall … for effectual drainage and proper discharge of storm-water and sewage" (Assam Municipal Corporation Act, 2022, ss.171 and 173); the Gauhati Municipal Corporation Act, 1969 lets the Commissioner set up "reservoirs, sluices, engines and other works" (s.231(2)) but sets no comparable outfall duty (s.232 is permissive). The gates that matter most are WRD's: the sluices in its embankments, 98 major and 545 minor in March 2017 (CAG), are closed and opened by its staff, but no operating rule of WRD for any sluice, linking it to a river stage, and no record of how long its sluices stay closed in a monsoon were found [TBC]; Dibrugarh's outfall sluice is to be rebuilt as "two numbers of radial automatic sluice" (ADB, 2017), whose operating rule was not found. The dams upstream are operated for power: the Ranganadi project released 1,412.57 m³/s in 2017 (as quoted from a report of IIT Guwahati for ASDMA), and the release rules and warning procedures of the Ranganadi, the Lower Subansiri and

> the Kopili projects were not found [TBC]. No operating rule for any sluice, flap gate or pumping station in an Assam town, linking it to a river stage, a dam release or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

10.12 Inspection frequencies

10.12.1 **Owner inspections.** Owners shall inspect facilities at least as set out in Table 10.3:

Table 10.3 — Minimum owner inspection frequencies

Facility type	Routine	Pre-monsoon (by 31 March)	After a heavy-rainfall event
Retention / infiltration (soakaways, trenches, bioretention, permeable paving)	Every 6 months	Yes	Yes
Surface detention basin or multi-use open space area	Every 6 months	Yes	Yes
Underground or podium detention tank, gravity outlet	Every 6 months	Yes	Yes
Pumped detention, pumps and controls	Monthly test run	Yes, with full duty test	Yes
Flap / tide gate, non-return valve	Every 3 months	Yes, with seal test	Yes
Gross pollutant trap / first-flush device	Every 3 months	Yes	Yes
Private drains and inlets	Every 6 months	Yes	—

A heavy-rainfall event, for this Clause, is a day on which the nearest approved gauge records rainfall at or above the IMD "heavy rainfall" category, or a day for which a red alert is issued for the district. In Assam, the pre-monsoon inspection of sluice gates, flap gates, non-return valves, screens, silt traps and pumped facilities, including the gates and pumps on outfalls through the embankments of WRD and to the Brahmaputra, the Barak and the beels, with the desilting of every drain, nala (a built drain) and jan (Assamese জান: a stream or natural drainage channel, often the outlet of a beel), the clearance of inlets, silt traps, screens and hill-stream traps, and the pump duty and gate seal tests, shall be completed by **31 March**; sluice gates, flap gates and pumped facilities, with their standby power and fuel, shall be certified ready on the same date, with every gate on an outfall to a river or beel operated through its full travel, by or with WRD where the gate is in its charge, because the season of this Manual begins on 1 April and the storms of April and May are among the State's largest. Pumps, their standby power, gates and screens shall then be kept on standby, with the monthly test run, from **1 April to 31 October**, and at an outfall to a river until the river at the governing CWC site has fallen below its danger level and the gates have been reopened, if that is later. Inlets, silt traps, screens and hill-stream traps shall be cleared again by **31 May**, of the silt, debris and garbage of the April and May storms, before the south-west monsoon arrives, and every public drain, nala and jan, inlet, trap and screen in every town shall be cleared of the silt and debris of the season, and its silt depths surveyed, by **15 November**.

10.12.2 **Authority inspections.** The Authority shall inspect:

- (a) every facility on a site of 1,000 m² or more, or under Clause 10.6.1(c) or (d), at least once every 2 years, and every year in a flood-sensitive catchment; and
- (b) a random sample of at least 10% of other facilities each year.

10.12.3 The results of Authority inspections shall be entered in the facility register (Clause 10.17).

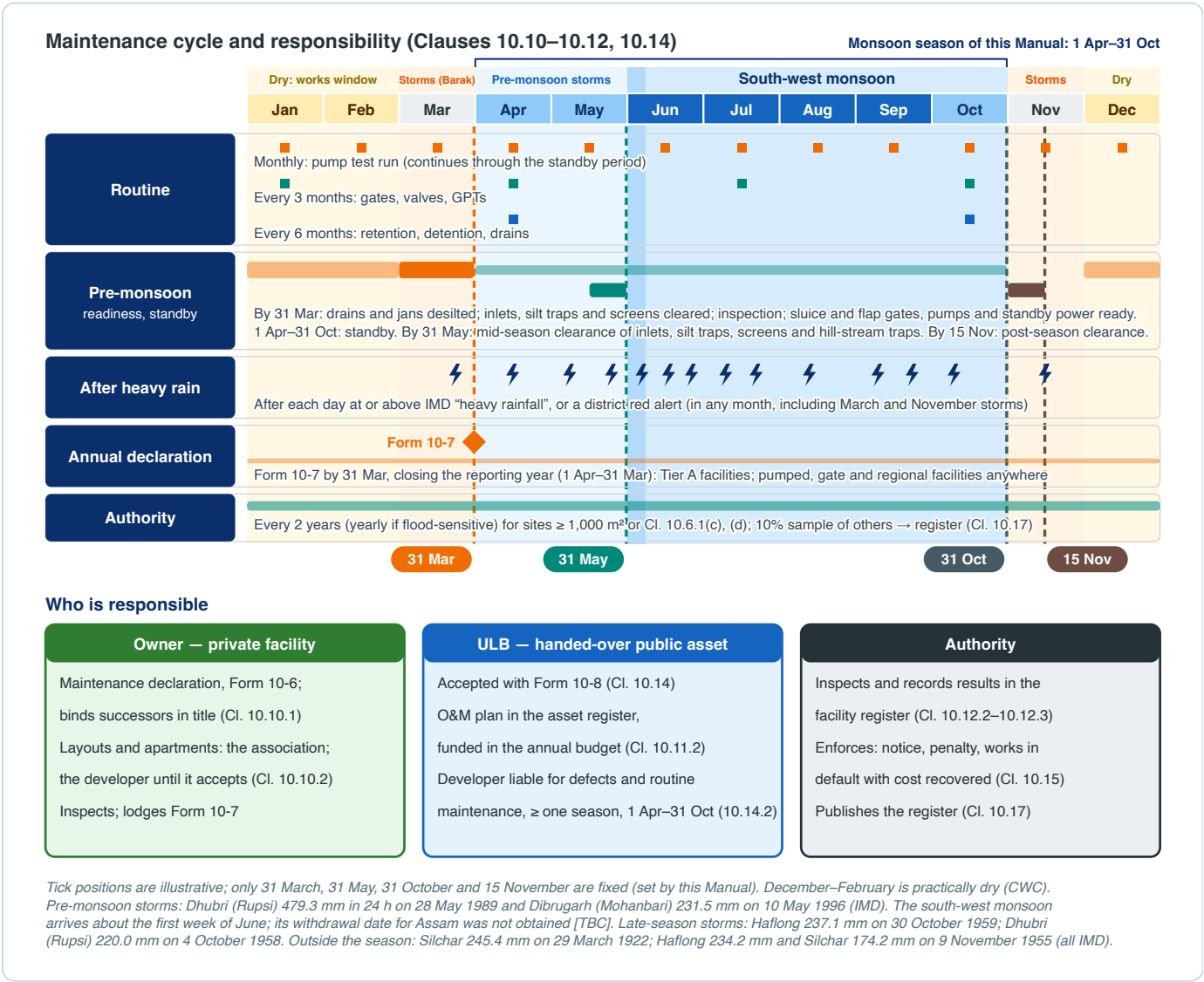

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 March) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the monsoon season (April–October); tick positions within the year are illustrative.

Commentary. The split in Clause 10.12.2 follows the MBBL 2016 inspection regime for RWH, which requires 100% monitoring of buildings over 1,000 m² and a 10% random check below that (MBBL 2016, §9.6). The inspection intervals in Table 10.3 are set by this Manual. The 31 March deadline is set by this Manual for a wet season that begins before the south-west monsoon. In this Manual the monsoon season runs from 1 April to 31 October, and its first two months bring some of the State's largest storms: four of the seventeen Assam station records of 24-hour rainfall in IMD's *Extremes* are May storms, Dibrugarh (Mohanbari) 231.5 mm (10 May 1996), Dhubri (Rupsi) 479.3 mm (28 May 1989), Rangia 217.0 mm (29 May 1977) and Silchar 290.3 mm (30 May 1893), Haflong's May value of 248.2 mm (10 May 1958) is 80% of its record (ratio computed for this Manual), and Silchar's wettest month on record is May (1,314.2 mm in 1883) (IMD). April brings storms too: Guwahati's April record of 116.5 mm (6 April 2004, IMD) was beaten on 20 April 2026, when the airport recorded 117.4 mm, SIRD Khanapara 215.9 mm, Gauhati University 134 mm and the City ARG 126.5 mm overnight, and a woman died after falling into an open roadside drain on the night of 19 April (all as reported); Chaparmukh's pre-monsoon record is 193.2 mm on 23 April 1982 (IMD). The CWC Flood Estimation Report for subzone 2(b) finds that "The rainfall is generally spread over a period of eight months, i.e. from March to October", that at Guwahati and Nowgong "May rainfall is more

than the September rainfall. Similarly, April rainfall is more than October rainfall", and that "The winter season from December to March is practically dry"; December to February is the works window. NDMA (2010) sets 31 March for pre-monsoon desilting nationally, and this Manual keeps that date. A deadline of 30 April, which the research for this edition first suggested for the Brahmaputra valley, would leave the April storms uncovered, and the Barak valley has storms in March (Silchar 245.4 mm on 29 March 1922, IMD); one date applies statewide, the same as in the neighbouring North-East edition of this series, because Guwahati's hill streams rise across the State's southern border and the catchments that cross it are cleared and inspected on one calendar. No Assam order fixes a date for drains (Clause 10.11, Commentary). The dates of WRD in the press are for embankment works, not for drains: the Chief Minister's target of 30 April 2018 for embankment repairs, which was missed, "no permanent work … from May 15 to October, only temporary work", and works to be "concluded before the month of May" (2021) (all as reported); that calendar is WRD's for its embankments, while this Manual's 31 March covers the drains, sluice gates, flap gates and pumps of the drainage system. This Manual therefore takes 31 March for desilting, the clearance of inlets, silt traps and screens, the pre-monsoon inspection, the annual declaration and the readiness of gates, pumps and standby power, with no later readiness date. The south-west monsoon arrives about the first week of June: its normal onset over the North East is about 5 June (as reported), and IMD's revised normals are reported to put Guwahati at 2–4 June (as quoted in a summary of IMD's press release). Inlets, silt traps, screens and hill-stream traps are therefore cleared again by 31 May, after the April and May storms and before the onset. The date of the monsoon's withdrawal from Assam was not obtained [TBC], but storms continue to the end of October: Haflong 237.1 mm (30 October 1959), Dhubri (Rupsi) 220.0 mm (4 October 1958), Dhubri 186.2 mm (2 October 2012) and Guwahati 160.9 mm (15 October 1991) (IMD); pumps, gates and screens are therefore kept on standby to 31 October (Figure 10.3), and the research's suggestion of a post-monsoon check by 30 September is not used, because standby and the after-event inspections run to 31 October. Large falls also come outside the season, Haflong 234.2 mm and Silchar 174.2 mm on 9 November 1955 (IMD), and the drains fill with silt during the season, so every town clears its drains a second time, and surveys their silt depths, by 15 November. The post-event inspections of Table 10.3 cover storms at any time of year. The reporting year runs from 1 April to 31 March, so that the annual declaration of 31 March closes it.

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 Assam 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 1 April to 31 October,** after handover. The ULB may hold a security deposit for this period.

10.14.3 **Asset register.** On acceptance, the ULB shall enter the asset in its GIS drainage asset register and in the facility register of Clause 10.17.

10.14.4 **Private facilities.** A private facility remains the owner's responsibility under its maintenance declaration unless the ULB formally accepts it under this Clause.

> Commentary. NDMA (2010) calls for a GIS inventory of drains. Requiring the developer's GIS data at handover builds that inventory as the city grows, at no cost to the ULB. The defects period spans one monsoon because many defects in Assam drainage show up only in the first 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.

Step	Action
4	Works in default by the Authority, with the cost recovered from the owner.
5	Disconnection of the private drain connection to the public system, where this causes no hazard to others.
6	Report of the certifying professional to the registering authority, and suspension from the empanelled list.

10.15.3 **Immediate action.** Where a contravention puts life or property at risk during a monsoon, the Authority may carry out works in default at once and recover the cost later.

10.15.4 **Security deposits.** For sites under Clause 10.6.1, the Authority may require a security deposit or bank guarantee, released after the as-built certificate is accepted, to cover works in default.

10.15.5 **Record.** Every notice and action under this Clause shall be entered in the facility register.

> Commentary. Penalties are referred to generically. This Manual cannot itself create offences or fines, and the powers come from the Acts under which the Assam Unified Building Construction (Regulation) Byelaws 2022 are made and from the municipal Acts. The graduated steps are set by this Manual. In Assam the courts and the National Green Tribunal have become the working regulators of the city's drains and beels. The Gauhati High Court, in PIL/14/2024 on Guwahati's waterlogging, recorded the engagement of Haskoning DHV by order of 21 August 2024 to prepare a "GIS-based Comprehensive Drainage Master Plan and Detailed Project Report (DPR) for Guwahati City" within nine months (order of 23 September 2024) and found on 26 May 2025 that "hill cutting is still going on"; in PIL/53/2023 it appointed an Advocate Commissioner after builders were said to have blocked channels and filled wetland at Palasbari, causing "artificial floods" (6 September 2024); in PIL 18/2023 it directed the State not to denotify the Deepor Beel sanctuary (5 April 2024); and in the Silsako eviction appeals it was reported to say "Once it is a water body you have to move out" (2023, as reported). The Tribunal has dealt with dumping near Deepor Beel (O.A. No. 472 of 2018, order of 11 February 2020), the polluted river stretches, among them the Bharalu (O.A. No. 673 of 2018), and the State's sewage gap (O.A. No. 606 of 2018). The statutes carry real terms of imprisonment but mostly nominal fines. Under the Assam Embankment and Drainage Act, 1953, cutting through an embankment or drain, or opening, shutting or obstructing a sluice without authority, is punishable with up to three years and ₹1,000 (s.15(ii)), and so is building on, removing or altering an embankment or drain in a notified area without permission, with removal at the offender's cost (s.16); the fine is nominal by today's values, the imprisonment is not, and the cut at Bethukandi in 2022, for which a police case was registered and one arrest made (as reported), is such an offence (this Manual's reading). Under the Assam Hill Land and Ecological Sites (Protection and Management) Act, 2006, earth cutting on a hill or altering an ecological site in a Designated Area is punishable with up to six months or ₹5,000 (s.19), nominal, and no Designated Area was found [TBC]. The water-bodies law is the strongest: the Guwahati Waterbodies (Preservation and Conservation) Act, 2008 provided up to three years or ₹50,000 (s.6), and the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024, which repeals it (s.22), provides up to three years or ₹1 lakh or both, with restoration of the water body "to its original status and shape" (s.16); the enacted text of the Act of 2024 was not read [TBC]. Under the Gauhati Municipal Corporation Act, 1969 the Commissioner may pull down any building erected over a drain vested in the Corporation (s.239), no one may make or alter a drain leading into one without permission (s.242), and no building within one hundred feet of a municipal drain may be occupied until it is drained to it (s.244); the fines under the Act were not read [TBC]. The Unified Byelaws 2022 add their own lever, the 25% penalty on the cost of drain improvement not carried out (byelaw 101(vi)), and GMC's drive on rainwater harvesting from 20 June 2025 threatened the revocation of occupancy certificates and the sealing of premises, while builders were reported to "conveniently flout" the rules and their association to call the Appendix VI structures "faulty" (all as reported). The CAG found that the State "relied on short term measures to avert flood problems without adopting long term solutions" (Report No. 5 of 2018), that GMC had no storm-drainage data (Report No. 4 of 2019) and that GMDA was "not functioning as per the spirit" of its Act (Report No. 2 of 2024).

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 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 stage of the receiving river (the Brahmaputra, the Barak, the Kushiyara or a tributary) at the nearest CWC site, against its warning, danger and high flood levels, and, where it is gauged, at the outfall and inside the embankment, each on a named datum, with any reading of a WRD or local gauge kept apart from the CWC levels; the times at which each sluice and flap gate on the outfall and on the drain upstream of it closed and reopened, the level in the receiving beel or retention pond, the hours each pump ran, any loss of power and the fuel used; any breach or cut of an embankment, with its time and the level the water reached inside it; and the releases of any dam that set the receiving level, such as the Ranganadi, Lower Subansiri or Kopili projects, with the times of the warnings given;
- (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), ASDMA, 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. Assam's floods have been counted more often than they have been reviewed, and the counts conflict, differing in whether landslides, storms and lightning are included. In 2022, the worst flood season in a decade, more than 88 lakh people were affected, with 54.57 lakh in 32 districts on 23 June, and the deaths are given as about 181, 195 or 197 (all as reported); Silchar was under water for about 11 days, or "about a week" in another account, after the Barak entered through the cut embankment at Bethukandi, and a police case was registered over the breach of 23 May (as reported). In Guwahati, the floods of June 2014 caused seven flash-flood deaths and four electrocutions (CAG, Report No. 4 of 2019); on 14 June 2022 four people died in a landslide at Nizarapar and Boragaon; on 31 May 2025 three died in a landslide at Bonda; and on 19 April 2026 a woman died after falling into an open roadside drain (all as reported). The season of 2024 affected 24,20,722 people in 30 districts at its peak about 5 July and killed 117 by 27 July, that of 2025 111 by 30 August, and that of 2026 105 by 17 August, with 11,45,109 people affected in 25 districts between 29 April and 3 August (all as reported). ASDMA's daily flood reports list the rivers above their danger levels (on 4 July 2024, the Brahmaputra at Neamatighat, Tezpur, Guwahati, Goalpara and Dhubri, the Barak, the Kushiyara at Karimganj and others, none above its high flood level), but ASDMA's official tolls for these seasons were not obtained [TBC]. No review of any flood in an Assam town, and no record of flood extents, depths or durations kept by GMC, GMDA, another Municipal Corporation or Board, or ASDMA, was found. The rainfall record

shows why reviews need more than one gauge: on 14 June 2022 the gauges of WRD at Chandmari and Beltola recorded 84.6 mm and 88 mm while Borjhar recorded about 10 mm (as reported), and on 20 April 2026 the gauges of one city ranged from 117.4 mm to 215.9 mm (as reported). 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. Much of Assam's drainage record is public: the Unified Byelaws 2022 and their amendment of 2024, the Guwahati Building Construction (Regulation) Byelaws, 2014 and the gazette of the Master Plan for Guwahati 2025 with its zoning report and modification schedule, on GMDA's website; the Acts on the website of the Legislative Department and in PRS's copies, among them the building Act and its amendment of 2022, the Gauhati Municipal Corporation Act, 1969, the Assam Municipal Corporation Act, 2022, the Assam Embankment and Drainage Act, 1953, the Hill Land Act of 2006, the groundwater Act of 2012 and the Urban Water Bodies Bill, 2024; the CAG's reports of 2018, 2019 and 2024; the High Court's orders in PIL/14/2024, PIL/53/2023 and PIL 18/2023 and the Tribunal's orders on Deepor Beel; ADB's report and recommendation, project administration manual and environmental examinations for Guwahati and Dibrugarh; PCBA's action plan for the Bharalu; JICA's evaluation of the Guwahati sewerage project; CGWB's Ground Water Year Book for the North Eastern Region; DoHUA's status sheet of the town drainage master plans; ASDMA's daily flood reports; and IMD's station extremes and the two CWC Flood Estimation Reports. Several of these were read only from archived copies, because the State's websites refused connections while this edition was prepared. Much else could not be found in the public domain: the comprehensive drainage master plan for Guwahati and the project reports for the Bahini and the Bharalu; Tahal's report of 2008; the town drainage master plans themselves; the modification of the Master Plan 2025 of 25 March 2025 and the drainage and wetland chapters of the draft Master Plan 2045; the enacted Urban Water Bodies Act, its schedules and its Rules of 2025; the Designated Areas under the Hill Land Act; the constitution of the State Ground Water Authority; the text of the GMDA Act, 1985; any notification by a District Council applying the byelaws; CWC's site sheets and gauge datums; an inventory of WRD's sluices with their sills and operating rules; the present capacity of the pumps at

> Bharalumukh; the stage–storage of Deepor Beel; the archives of the Guwahati city gauges; and ASDMA's official tolls. 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.

References (chapter)

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Annexes and forms

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10B	GIS data specification and attribute schema
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Annex / Form	Content
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Form 10-6	Maintenance Declaration
Form 10-7	Annual Maintenance Declaration and Inspection Report
Form 10-8	Asset Handover Certificate
Form 2-1	Design Rainfall Sheet (Chapter 2)

CHAPTER 11

Basin and City Stormwater Master Plans

11.1 Purpose and scope

11.1.1 Chapters 2 to 10 control one project at a time. This chapter sets the requirements for the plan that ties those projects together: the **Basin Stormwater Master Plan (BSMP)**. A BSMP is prepared for each drainage basin of a city or urban area. A city's set of BSMPs makes up its **City Stormwater Master Plan**.

11.1.2 A BSMP shall:

- (a) map flood hazard for the basin under existing and future conditions;
- (b) set the level of service each part of the drainage system must achieve (Clause 11.6);
- (c) identify the works, storage and land needed to reach that level of service, and rank them (Clauses 11.7 and 11.8);
- (d) reserve land for regional storage, pukhuri 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. Assam's towns have master plans, drainage projects and court-supervised studies, but no published storm-drainage master plan with a design storm. The Master Plan for Guwahati 2025 and its Zoning Regulations, published by GMDA in Assam Gazette Extraordinary No. 198 of 9 July 2009 "for operation with effect from 07/07/2009", cover 328 km² (the old metropolitan area of 262 km² and 66 km² added), put "All notified forest, water bodies, rivers etc." in an Eco-Sensitive Zone and, in a later modification, take their slope classes "from a conceptual guideline derived from a study by IIT(G) in the planning and design of drainage in hilly areas" (the study was not seen), but set no design storm and size no drain; the draft Master Plan 2045, released early in 2024, has not been finally notified (as reported). Guwahati is on its second drainage master plan. The storm-drainage report prepared by Tahal in 2008 was not built (as reported), and the CAG found no action taken against the consultants for "defective DPRs for Storm Water Drainage Project for Guwahati City" (Report No. 2 of 2024). Under the supervision of the Gauhati High Court, GMDA engaged Haskoning DHV by order of 21 August 2024 to prepare a "GIS-based Comprehensive Drainage Master Plan and Detailed Project Report (DPR) for Guwahati City" within nine months (PIL/14/2024, order of 23 September 2024); the State told the Court in February 2026 that it was "expected to be completed by April 2026", and the minister later directed the consultants to revise the plan and the project report for the Bahini–Bharalu basin (both as reported), so in November 2026 the plan is under revision, not final. Outside Guwahati, DoHUA's town drainage master plans were "prepared before 2015 as per previous FPS system" and await revision to CPHEEO's guideline of 2015, with drafts for Tinsukia (11 May 2015), Silapathar and Margherita, Sonari's finalised, Dibrugarh's held up by a "shortage of fund" and Goalpara's "Final hydraulic design work … in progress" (DoHUA, status sheet, c. 2016); a later undated sheet puts Dibrugarh and Silchar at the "final stage" and Jorhat's as "prepared" (as quoted); "The Directorate of Town and Country Planning

has started preparing drainage master plans for all major towns in the state" (ADB, 2025); no design criteria appear in any of these documents read. At basin scale, the Brahmaputra Board's master plans for the Brahmaputra (Part I) and the Barak (Part II) were approved in 1997 (as quoted), for the rivers rather than the towns. The first funded works with storage are the ADB-funded Bahini works in Guwahati, with 4.1 km of diversion channels, 4.7 km of drains, 7.8 m³/s of added pumping in three stations and a retention pond of 59,000 m³ with a pumping station of 1.6 m³/s, against a target of avoiding inundation "from a 1-in-5-year storm or lower return period" in 434 ha of the Bahini basin (ADB, 2025), and a project of ₹1,459 crore for the Bahini and the Bharalu was announced in May 2026 (as reported). "Assam's stormwater drainage network in ULBs covers only about 30% of the required areas" (ADB, 2025). 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 DoHUA, T&CP, GMDA, GMC, any other Municipal Corporation, Municipal Board or Development Authority, any District Council, WRD, ASDMA, the Brahmaputra Board or any other body, and it does not replace the plan that Haskoning DHV is preparing for GMDA. A site-level manual cannot fix basin-level problems: lost tank storage, beels and low land filled for building, as round Deepor Beel and Silsako in Guwahati and in the wetland at Palasbari, hill streams that bring the silt of cut hill slopes down into the Bharalu and the other city channels, drains that are the sewers of towns without sewerage and carry their sewage to the beels and the rivers, outfalls that a sluice closes for days or weeks when the river is high, so that the town drains only as fast as its pumps run, and single channels split between GMC, GMDA, PWD, WRD and other owners, 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 Assam, the first floodplain-river State of the North East in the series: to towns that sit below the high stage of the Brahmaputra or the Barak, behind about 4,474 km of embankments, and drain through sluices and pumps into rivers that are often higher than the town, so that the outfall is normally closed in the monsoon; to beels, pukhuris and jans (jan, Assamese জান: a stream or natural drainage channel, often the outlet of a beel) that the law already treats as storm-water reservoirs and channels, and that are being filled; to a city, Guwahati, whose hill streams, each a juri (Assamese জুৰি: a small hill stream) at its head, rise across the State's southern border and bring down the silt of cut hill slopes; to drains that are the sewers of towns with no sewerage; to two CWC subzones that read the rainfall differently across one river and a third, the Barak valley, that no CWC report covers; to a water table near the surface on the floodplains, where infiltration is not credited; to char and chapori land, eroding banks, embankment breach paths and dam-release reaches, where no drain is the answer; to drains split among GMC, GMDA, PWD, WRD and others with no notification dividing them; and to the Sixth Schedule districts, where the byelaws do not apply unless a District Council chooses, so that a BSMP begins with the river and the hazard, not the storm alone (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.

Term	Meaning in this Manual
Lead Authority	The body responsible for preparing a BSMP (Clause 11.4).
Level of service (LoS)	The flood performance a part of the drainage system must achieve, expressed as an AEP and an outcome (Clause 11.6).
Flood hazard map	A map of flood extent, depth, velocity and hazard class (H1–H6, Chapter 6) for a stated AEP and scenario.
Regional facility	A storage, conveyance or outfall work serving more than one development, identified in a BSMP.
Capital Improvement Programme (CIP)	The ranked, costed list of works in a BSMP (Clause 11.8.4).

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 Assam town; the comprehensive drainage master plan for Guwahati, which is to cover six river basins surveyed by DGPS and drone (State affidavit, February 2026, as reported), is under revision. For the urban areas where the evidence identifies them, the basins are at least the following, in the order of the flood-sensitive catchments of Clause 4.5.3.2:

- **Guwahati, Bharalu–Bahini:** the catchment of the **Bahini** from its head in Meghalaya to Jonali and of the **Bharalu** from Jonali to the sluice at **Bharalumukh**, with the Noonmati basin and its diversion by pumping to the **Bondajan**, the whole catchment modelled with the design rainfall of the Guwahati catchment rule (Clause 2.3.6(c)(i)), the sluice at Natun Bazar, the ADB pumping stations and retention pond and the outfall-closed case at Bharalumukh as a design case (Clause 5.8.5(b)), the drains carrying sewage to the Bharalu's outfalls in the 1D network, and the Brahmaputra at Guwahati (DC Court), danger level 49.68 m and high flood level 51.46 m (CWC, as transcribed by SANDRP, as reported; datum not stated), as the boundary;
- **Guwahati, Mora Bharalu–Deepor Beel–Khanajan and Silsako:** the catchments of the **Basistha** and the **Kalmani** and of the **Mora Bharalu** to **Deepor Beel** and on through the **Khanajan** to the Brahmaputra, with the beel's stage–storage, once surveyed [TBC], its perennial spread of about 10.1 km² and up to 40.1 km² in floods (as reported) and its draft eco-sensitive zone shown; and the **Silsako** basin, with the retention basin to which part of the Bahini's runoff is to be diverted and pumped out (ADB, 2025);
- **Guwahati, the other ADB basins:** the **Dipar**, **Foreshore**, **North Guwahati** and **Kalmoni** basins (ADB, initial environmental examination, 2017), North Guwahati on the north bank under the 2(b) rainfall of Clause 2.3.6(b), each to its outfall on the Brahmaputra;
- **Guwahati hill fringe:** the streams that come down from the hills to the south at **Khanapara** and **Jorabat**, with their silt traps at the hill–plain break (Clause 6.3.6(m)) and the cut slopes, quarries and landslide ground above them mapped, and the hazard-first rule below;
- **Dibrugarh, DTP drain to the Sessa:** the town behind the **DTP dyke** and its drain of 32.053 km past the **Larua Jamira** beel to the **Sessa**, with the beel full and the drain flowing full at the start of the storm and the flood level of 97.50 m at the outfall sluice (ADB, 2017) as the boundary, and the Brahmaputra at Dibrugarh, danger level 105.70 m and high flood level 106.48 m (as reported), on the dyke side;
- **Silchar, behind the Barak embankment:** the bowl of the town, with its outfall channels and any pumps, once surveyed [TBC], the Barak at Annapurnaghat, danger level 19.83 m and high flood level 21.84 m (as reported), and the breach path of the Bethukandi cut of 2022 and its flood marks as calibration evidence;

- **Karimganj, Hailakandi and Badarpur:** the towns on the **Kushiyara** and the Barak, with the Kushiyara at Karimganj, danger level 14.94 m and high flood level 16.57 m, and the Barak at Badarpurghat, 16.85 m and 18.48 m (as reported), as boundaries, under the Barak valley rule of Clause 2.3.6(c)(ii);
- **Palasbari–Mirza:** the channels and wetland whose blocking and filling the High Court has examined as "artificial floods" (PIL/53/2023);
- **North-bank towns on release and flash-flood reaches: North Lakhimpur** on the **Ranganadi**, **Dhemaji**, the **Subansiri** reach and **Tezpur** on the **Jia Bharali**, with the largest recorded release, or the spillway capacity until the operator gives one, as the boundary (Clause 5.8.5(d)), and the bhabar fans above them mapped;
- **Dhubri and Goalpara:** the towns on the lower Brahmaputra, with the Brahmaputra at Dhubri (high flood level 30.36 m in 1988, or 30.37 m in 2019, a conflict) and at Goalpara (37.43 m in 1954 or 37.35 m in 2004, a conflict) (as reported), and, at Dhubri, the record check of Clause 2.3.6(h);
- **Majuli and the char lands:** under the hazard-first rule below; and
- **Haflong and Diphu:** the hill towns, Haflong on the 2(b)/2(c) line, with landslide ground mapped and the hazard-first rule below.

Hazard first (set by this Manual). On active char and chapori land and eroding banks, in the breach path of an embankment, in a reach below a dam, on the bhabar fans and avulsing streams of the northern foothills, on the landslide ground of the Guwahati hills and the hill districts and on cut hill slopes, the BSMP begins with a hazard screening (Clause 2.3.6(i)), made with the flood and landslide maps of ASDMA where they exist [TBC], the Hilly Area Zone of the Master Plan for Guwahati 2025, the hazard maps that byelaw 120 asks the Master Plans to carry once they are made, and WRD's records of its embankments, sluices and breaches, and states whether each part of the basin lies in the path of the hazard. The scale is large: riverbank erosion is reported at more than 4.27 lakh ha since 1950 or about 3.86 lakh ha since 1954 (both as reported, a conflict); the Ranganadi released 1,412.57 m³/s in 2017 (as quoted from a report of IIT Guwahati for ASDMA); and landslides killed four at Nizarapar and Boragaon on 14 June 2022 and three at Bonda on 31 May 2025 (as reported). 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 hold a channel on active char land or to carry a breach, a debris flow or a landslide. Other Tier A bodies and the other Municipal Corporations and Boards define their basins in the first BSMP that covers them. Where CWC, WRD, a master plan, an operator of a dam or a court has a high flood level, a gate-closing level, a flood line or an operating rule for a dam, sluice or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

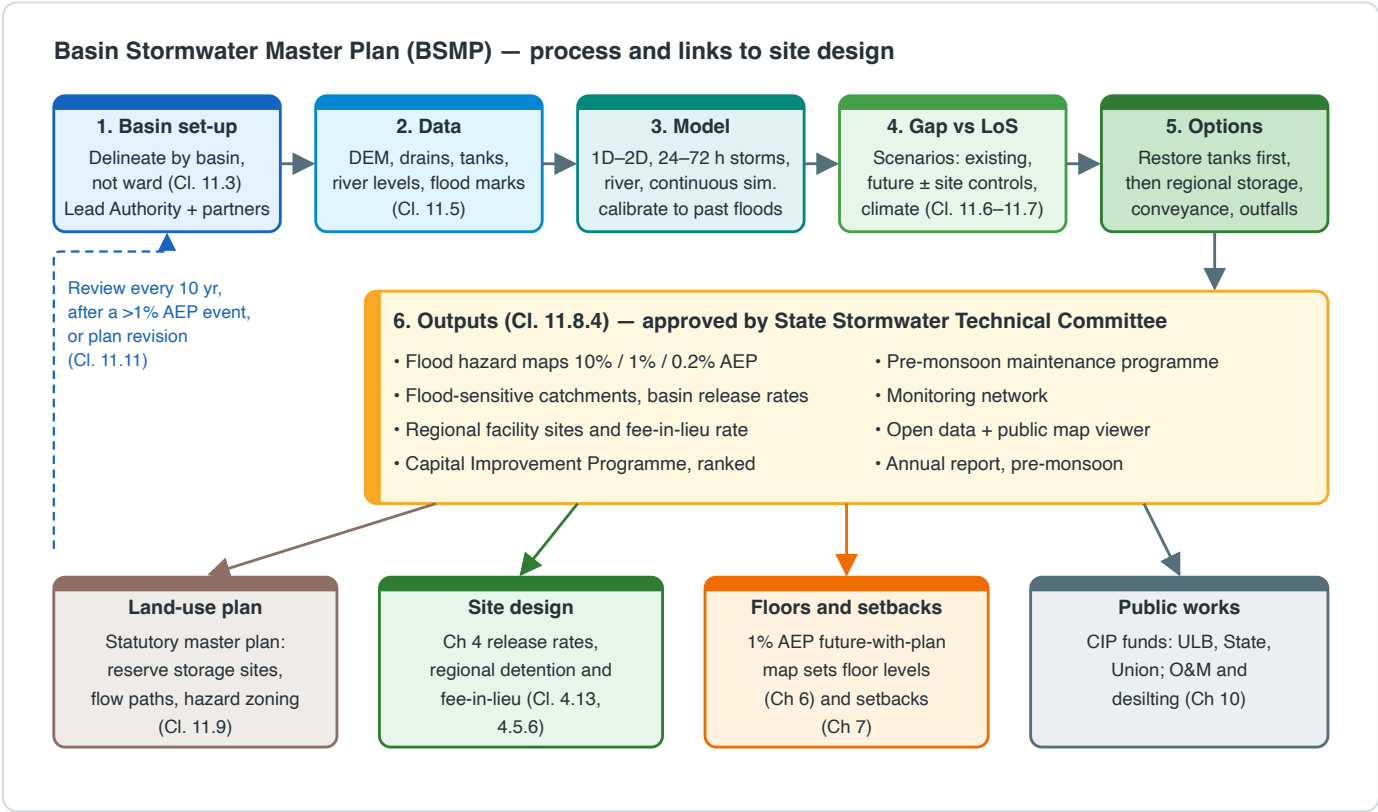

Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

> **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 Assam a single channel passes through many hands, and often across the State's border, on its way to a river. The Bahini rises at Umtyrnga in Meghalaya and runs 9.29 km to Jonali, where it becomes the Bharalu, which runs 6.2 km to the Brahmaputra at Bharalumukh; the catchment is about 120 km², roughly half hills and half plains, of which about 10.94 km² drains the city (PCBA action plan for the Bharalu, as quoted; about 11 km² in a press account, a conflict); the Bahini is "cut off by a sluice at Natun Bazar" (the same plan), and the Mora Bharalu, a channel "abandoned by the Bharalu river" (Assam's progress report to the National Green Tribunal, August 2020), carries water and sewage to Deepor Beel, which drains to the Brahmaputra through the Khanajan. ADB divides the city into "six drainage basins … Bharalu Basin, Dipar Basin, Silsako Basin, Foreshore Basin, North Guwahati Basin, and Kalmoni Basin" and finds that "The wetlands and other water bodies in GMA collectively act as the receptors of storm water during the monsoons" (initial environmental examination, 2017). No notification assigns the Bharalu, the Mora Bharalu or the Bahini to one owner (this Manual's reading of the record): GMC desilts them, WRD runs the sluice and the pumps at their outfalls, PWD holds the roadside drains, GMDA builds new drainage and protects the scheduled water bodies, and the Railways, OIL, NHAI and the Army keep their own drains (ADB, 2025; press reports), and ADB names "fragmented institutional responsibilities" as the core problem. The law already treats the channels as part of the water bodies: the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 defines a water body to include "all natural water channels (that are inflow or out flow channels into or from the waterbody)" (s.2(d)), and the Hill Land Act of 2006 counts "a drainage system, feeding channel" among its ecological sites (s.2(d)(ii)). Dibrugarh shows the same at town scale: its DTP drain runs 32.053 km past the Larua Jamira beel to the Sessa, receiving the town's sewage on the way (ADB, 2017). This clause makes the basin the planning unit, so that one model carries each channel from its head in the hills, across the State's border where it rises there, to the river, through every sluice and pump, whoever owns each reach.

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of the Guwahati Metropolitan Area (the area of the Master Plan for Guwahati 2025, 328 km², on both banks): **GMDA**, which plans the area, builds new drainage, protects the scheduled water bodies and is the project implementation unit of the ADB-funded Bahini works, jointly with **GMC**, which keeps the municipal drains and desilts the Bharalu, the Mora Bharalu, the Basistha, the Bahini and the Lakhimijan (as reported); the BSMP is taken into the Master Plan and its Zoning Regulations (Clause 11.9). For Dibrugarh and Silchar: the **Dibrugarh Municipal Corporation** and the **Silchar Municipal Corporation**, in which the public drains vest and which must provide a safe and sufficient outfall for storm water (Assam Municipal Corporation Act, 2022, ss.171 and 173), each jointly with the **Development Authority** of its Master Plan area (names [TBC]) and with **T&CP**, which prepares the Master Plans and the drainage master plans of the towns outside the Guwahati Metropolitan Area. Each role is the one the body would have if the Manual were adopted. Where a basin extends beyond the Corporation's limits or the Master Plan area, the other local bodies and Gaon Panchayats in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the city's channels among GMC, GMDA, PWD and WRD was found; until one is made, this Manual assigns the reaches within each BSMP as follows, each body being Lead Authority for the reaches and works it owns or runs and for the parts of the CIP on them: **WRD**, through its Embankment Officers, for the rivers, the embankments and the sluices in them, the drainage schemes, the sluice and pumps at Bharalumukh, the dewatering pumps at the Bharalu, the Mora Bharalu and the Bondajan and the desilting of the Bondajan (as

reported); **GMC** and the other **Municipal Corporations and Boards** for the municipal drains and the channels they desilt; **GMDA** for new drainage, the Bahini works, the Silsako retention basin and the scheduled water bodies in its area; **PWD** for the roadside drains, and **NHAI** for those of the national highways; the **Railways**, **OIL**, the **Army** and the other owners of drains for their own; and, for the scheduled water bodies outside the GMDA area, the **District Level Committee** under the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024. Each town keeps the drain register of Chapters 1 and 6, which gives every reach its owner.

- **ASDMA**, with the District Disaster Management Authority, for the flood, erosion and landslide hazards that a BSMP must show (Clause 11.3.3).
- In the other Municipal Corporations and Boards, the Development Authorities and Tier B bodies: the Lead Authority is named by DoHUA. In an Autonomous District (the Bodoland Territorial Region, Karbi Anglong and West Karbi Anglong, and Dima Hasao), the Lead Authority is the District Council or the authority it designates, only where the Council has notified that the byelaws or this Manual apply (none has). Basins draining to a common river reach or sluice may be grouped into one district-level plan.

WRD shall also be a partner in every BSMP whose outfall passes through one of its embankments or sluices; ASDMA and the Deputy Commissioner shall be consulted on every BSMP; the State Level Committee under the Act of 2024, and in the GMDA area GMDA as chair of the District Level Committee, on every BSMP that proposes works in or next to a scheduled water body; the Environment and Forest Department and the Assam State Wetlands Authority on every BSMP whose basin drains to Deepor Beel or another wetland; PCBA on every BSMP that proposes works on a drain that carries sewage, among them the Bharalu; the Guwahati Jal Board on every BSMP in the area of its sewerage project; the operator of any dam that sets the receiving level, NEEPCO for the Ranganadi and the Kopili and NHPC for the Lower Subansiri, on every BSMP whose outfall lies on a release reach; and, for a basin whose streams rise across the State's border, such as the Bahini, the Basistha and the Kalmani, the authorities of the neighbouring State through WRD, since the rain on the part of the catchment beyond the border is part of the design storm (Clause 2.3.6(c)(i)).

The Water Resources Department (WRD) shall be a partner in every BSMP that includes a river, canal or tank under its control.

11.4.2 **When a BSMP is required.**

- (a) Every Tier A body shall approve BSMPs covering its whole area within **3 years** of this Manual taking effect.
- (b) A BSMP is required before:
  - any regional detention or fee-in-lieu is accepted under Clause 4.13;
  - a fee held under Clause 4.5.6.3 is spent; and
  - a basin-specific release rate is applied under Clause 11.8.3.
- (c) A Tier B body shall prepare a BSMP where its Lead Authority, or the State Stormwater Technical Committee, finds recurrent flooding of buildings or arterial roads.

11.4.3 **Preparation.** BSMPs shall be prepared by, or under the direction of, an engineer empanelled as a Stormwater Design Professional (Chapter 10) with experience in basin-scale modelling.

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

Data	Minimum requirement
Waterbodies	Survey of every tank, pukhuri, 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, embankments, sluices and pumps	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 (for example the Brahmaputra at Guwahati (DC Court), danger level 49.68 m and high flood level 51.46 m, and the Barak at Annapurnaghat, 19.83 m and 21.84 m; CWC levels as transcribed by SANDRP, as reported, with the datum not stated) and its recorded peaks, with any WRD or local gauge kept as a separate series and any conflict between published values stated; embankment crest levels and the location of every sluice in the embankments of WRD, with its sill, gate type, closing level and operating rule; the pumping stations on the outfalls, with their installed and working capacities, sump volumes and standby power; the stage–storage of every beel and retention pond that receives the outfall, starting full to its outlet; past breaches and cuts of the embankments and the land they flooded; the release records of any dam that sets the receiving level; and the char and chapori land, eroding banks and bhabar fans in and below the basin
Rainfall and levels	All available rain gauges (IMD, including the Regional Meteorological Centre Guwahati and its stations in *Extremes*, among them Guwahati (Borjhar) (42410), Dibrugarh (Mohanbari) (42314), Tezpur (42415), North Lakhimpur (Lilabari) (42309), Dhubri (42404) and Dhubri (Rupsi) (42406), Silchar (42619) and Silchar (Kumbhigram) (42620), Haflong (42522), Lumding (42523), Chaparmukh, Golaghat, Goalpara, Gohpur, Rangia, Tangla and Majbat; the self-recording gauges at Guwahati, Nowgong (Nagaon), Dibrugarh, Chabua and Jorhat used for the CWC Flood Estimation Report for subzone 2(b); the river gauges of CWC; the rain gauges of WRD, among them Chandmari and Beltola in Guwahati; the Guwahati city gauges reported in 2026, the City ARG, AAU-HRS, Gauhati University and SIRD Khanapara (owners, logging intervals and archives [TBC]); and any gauges or sensors kept by GMC, GMDA, ASDMA or Guwahati Smart City Ltd [TBC]) and water-level records, including those for the 31 May 2025 (111 mm in 24 hours at Guwahati (Borjhar), the highest May day on record there, with 120 mm and 99.6 mm given in other outlets, and three deaths in a landslide at Bonda, as reported), 14 June 2022 (84.6 mm at Chandmari and 88 mm at Beltola, gauges of WRD, against about 10 mm at Borjhar and 46 mm for the city, so that the gauges of one city differed about nine-fold in one storm, and four deaths in the landslide at Nizarapar and Boragaon, as reported), 20 April 2026 (117.4 mm at the airport, the April record, 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG overnight, as reported, with no hourly values found), June 2022 at Silchar (the Barak entering the town through the cut in its embankment at Bethukandi, with the Barak at Annapurnaghat peaking at 21.59 m on 21 June and 251.20 mm in Cachar on 19 June, both as quoted from the Cachar district report, and no hourly rainfall in the town found) and June 2014 (the Guwahati floods, with seven flash-flood deaths and four electrocutions, CAG Report No. 4 of 2019, and no rainfall value found) 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 floodplains of the Brahmaputra and the Barak, behind the embankments of Dibrugarh, Silchar and the other embanked towns, on the char and chapori land and in the beel basins, where slopes are gentle, the rivers back up and a closed sluice ponds the land behind it, and where a raised road, an embankment or a dumped fill can turn an overflow from one part of a town to another, 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 31 May 2025 (111 mm in 24 hours at Guwahati (Borjhar), the highest May day on record there, with 120 mm and 99.6 mm given in other outlets, and three deaths in a landslide at Bonda, as reported), 14 June 2022 (84.6 mm at Chandmari and 88 mm at Beltola, gauges of WRD, against about 10 mm at Borjhar and 46 mm for the city, so that the gauges of one city differed about nine-fold in one storm, and four deaths in the landslide at Nizarapar and Boragaon, as reported), 20 April 2026 (117.4 mm at the airport, the April record, 215.9 mm at SIRD

Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG overnight, as reported, with no hourly values found), June 2022 at Silchar (the Barak entering the town through the cut in its embankment at Bethukandi, with the Barak at Annapurnaghat peaking at 21.59 m on 21 June and 251.20 mm in Cachar on 19 June, both as quoted from the Cachar district report, and no hourly rainfall in the town found) and June 2014 (the Guwahati floods, with seven flash-flood deaths and four electrocutions, CAG Report No. 4 of 2019, and no rainfall value found) events are the best calibration data Assam 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
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 pukhuri 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. Assam's storage is in its beels and wetlands more than in tanks; it has no irrigation tank cascades, and its pukhuris are mostly the dug tanks of towns and villages. The National Wetland Atlas puts the State's wetlands at 764,372 ha, 9.74% of its area (SAC, 2011, as quoted; the counts of wetlands in different sources conflict and are not used); the Fisheries Department's register listed 2,072 beels of 71,843.5 ha in 2021–22, and later 447 registered and 1,625 unregistered beels, a change in the way they are counted (as quoted). Deepor Beel is the State's only Ramsar site (site 1207, designated 19 August 2002, as listed), its sanctuary of 2009 was restored on appeal and its denotification stayed by the High Court (5 April 2024), and its eco-sensitive zone has been notified only in draft (about 148.9 km² in 2021 and 38.84 km² in 2025, as reported). The Son Beel in Karimganj, the largest in the State, is given as 3,458 ha in a study of 2024 and as 4,388 ha dry and 9,800 ha full elsewhere, a conflict; the Chandubi is reported to have shrunk from 203.2 ha in 1997 to 186.5 ha in 2007. The Assam State Wetlands Authority was constituted by Notification No. FRM.10/2010/Pt/16 of 1 November 2018 (as listed), but no wetland has been found notified under rule 4 of the Wetlands Rules, 2017. Guwahati's scheduled water bodies, Sarusola, Borsola, Silsako and land near Deepor Beel, are listed by dag number in the schedules of the 2008 Act, which the Bill of 2024 repeals (s.22; the enacted text was not read [TBC]); the Bill extends scheduling to all notified Master Plan areas. No survey of the stage–storage of Deepor Beel or of any other beel or pukhuri in a town was found [TBC].

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 Assam has been adopted with a design factor; the Assam State Action Plan on Climate Change 2.0 is reported to project that "extreme rainfall events will increase by 5–38 per cent", and a minister to have given 38% by about 2050 relative to 1971–2000 (as reported; the plan text was not read [TBC]); the NAPCC portal lists a change in annual rainfall of +0.97 to +3.04% for 2011–2040 (RCP 4.5 and 8.5, as quoted); IMD's analysis for 1989–2018 is reported to find decreasing trends in each month from June to September, while a study of 26 locations for 1981–2017 found increasing pre-monsoon and monsoon trends, a conflict; and Guwahati set new April (2026) and May (2025) daily records (as reported), which is a reason to keep the factors, not to reduce them; and on the hill fringe of Guwahati, in the hill districts and below the dams the hazard screening of Clause 11.3.3 is made in every scenario.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the 31 May 2025 (111 mm in 24 hours at Guwahati (Borjhar), the highest May day on record there, with 120 mm and 99.6 mm given in other outlets, and three deaths in a landslide at Bonda, as reported), 14 June 2022 (84.6 mm at Chandmari and 88 mm at Beltola, gauges of WRD, against about 10 mm at Borjhar and 46 mm for the city, so that the gauges of one city differed about nine-fold in one storm, and four deaths in the landslide at Nizarapar and Boragaon, as reported), 20 April 2026 (117.4 mm at the airport, the April record, 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG overnight, as reported, with no hourly values found), June 2022 at Silchar (the Barak entering the town through the cut in its embankment at Bethukandi, with the Barak at Annapurnaghat peaking at 21.59 m on 21 June and 251.20 mm in Cachar on 19 June, both as quoted from the Cachar district report, and no hourly rainfall in the town found) and June 2014 (the Guwahati floods, with seven flash-flood deaths and four electrocutions, CAG Report No. 4 of 2019, and no rainfall value found) events where data exist.

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and pukhuris 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:** pukhuris, 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:** sluices, flap gates and penstocks on the outfalls through the embankments of the Brahmaputra, the Barak and their tributaries, with the storage and pumping behind them sized for the outfall-closed durations of Chapter 5, among them the sluice and pumps at Bharalumukh, the Noonmati–Bondajan diversion and the pumping stations and retention pond of the Bahini works in Guwahati, the outfall sluice of Dibrugarh's DTP drain

to the Sessa and the outfalls of Silchar behind the Barak embankment; standby power and fuel for the whole closure; screens and silt traps where drains that carry sewage and garbage enter a pump sump, a gate or a beel; silt traps and debris racks at the hill–plain break, where the streams of the Guwahati hills and the hill districts enter the towns; the interception and screening of dry-weather flow before every outfall to a beel or scheduled water body (Chapter 8, Clause 8.9); and the operating rules of the sluices of WRD, agreed with WRD;

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 from the Regional Meteorological Centre Guwahati, CWC flood forecasts and river stages at its sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries against their warning and danger levels, the daily flood reports of ASDMA, level gauges with alarms in the Bharalu, the Mora Bharalu and the other city channels at their sluices and pumping stations, and warnings before releases from the dams on the Ranganadi, the Subansiri and the Kopili, whose release rules and warning procedures were not found [TBC]), 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, which is credited only on tested ground outside the floodplain and hill rules, the bhabar fans, the river terraces above the 1% AEP level and the hill-foot colluvium of Guwahati (Clause 4.11, recharge rule), waterlogging where the water table lies within 2 m of the surface, as CGWB found after the monsoon in almost every district, the stability of the Guwahati hills and the hill districts, where water put into colluvium or fill raises the pore pressure, and the quality of the shallow aquifer in the districts with arsenic or fluoride above the limits (Chapter 8);
- effect on downstream basins and the receiving river, jan or beel; 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 Assam's town outfalls are closed for days or weeks when the river is high, and the storage left is in beels and low land that the towns are filling. When the sluice at Bharalumukh is closed, the Bharalu's pumps were reported in 2008 to pass 7 m^3/s against 72 m^3/s by gravity, so the city's drains can empty only as fast as the pumps run, and every cubic metre that cannot be pumped must be stored; Dibrugarh's drainage design accordingly assumes "that the beel is full and the drain is also flowing full" at its outfall sluice (ADB, 2017), and the ADB-funded Bahini works build a retention pond of 59,000 m^3 and divert runoff to a retention basin at Silsako to be "gradually pumped out to the Brahmaputra River" (ADB, 2025). The

beels are the towns' storage, and the law already says so: a water body is "the area or areas of land where the rain water accumulates and act as natural or storm water reservoir" (Guwahati Waterbodies (Preservation and Conservation) Act, 2008, s.2(e); kept in s.2(d) of the Bill of 2024 that repeals it). They are being lost: Deepor Beel spreads over about 10.1 km² all year and up to 40.1 km² in floods, and is reported to have shrunk by "about 35% since 1991", though other figures conflict (as reported); the water area of the Urpad Beel in Goalpara fell from 4.84 km² in 2003 to 3.38 km² in 2023 (as reported); and among the causes of Guwahati's waterlogging ADB lists the "encroachment of low-lying land", filled swamps and "indiscriminate cutting and quarrying of hill slopes for filling up of low lying areas" (2017). On the floodplain, where the water table is near the surface in the monsoon, storage means a lined pond or a beel kept at its outlet level, never a pond that soaks into the ground (Clause 4.11, floodplain rule); the 5 m³ of storage for every 100 m² of roof that byelaw 114 asks for, held as storage under Clause 4.11, and the dry sump of byelaws 74(ii) and 110(h), designed as detention under Chapter 4, are the first of it. Conveyance upgrades on their own move water faster to an outfall that the Brahmaputra, the Barak or a tributary in flood closes at its sluice for days or weeks, to a beel or retention pond that a closed sluice holds full, or to an outfall limited by the capacity of its sluice or pumping station, as at Bharalumukh, where the pumps were reported in 2008 to pass 7 m³/s against 72 m³/s by gravity with the gates open. Groundwater in Assam calls for storage and restraint, not recharge. It is not short: the stage of extraction was 22% in CGWB's assessment for 2007, with no over-exploited, critical or semi-critical unit, and is quoted at 12.61% for 2024 (as quoted; the columns of the source are unlabelled). It is shallow: in March 2022, before the monsoon, the water level in Assam was "mostly in the range of 2-5 mbgl (57.43%)", with 20.27% of wells within 2 m, and in November 2022 89.13% of wells were within 5 m and 45.96% within 2 m; in Kamrup (Metro) the range was 1.39–4.08 m in March, 0.2–2.76 m in August and 1.29–2.64 m in November; waterlogged and waterlogging-prone areas were found after the monsoon in "almost all the districts of Assam", "due to high rainfall, shallow water level and a poor ground water draft in the vast flood plains" (CGWB, Ground Water Year Book, North Eastern Region, 2022-23). The rising Brahmaputra "reduces the rate of percolation" (ADB, 2017). Its quality limits what can be put into it: arsenic above the limit in isolated pockets of Barpeta, Goalpara, Golaghat, Karbi Anglong, Kokrajhar, Lakhimpur, Sibsagar, Nalbari and Karimganj (as quoted from a Lok Sabha answer of February 2025), fluoride above the limit in parts of Goalpara, Kamrup, Karbi Anglong, Nagaon, Golaghat and Karimganj (as quoted from CGWB), and iron on the north bank (CGWB, 2007). The Assam Ground Water Control and Regulation Act, 2012 allows the State Ground Water Authority to notify areas and direct rainwater harvesting there on premises of 100 m² or more (ss.5(2) and 19), but no area has been notified and the Authority's constitution was not confirmed [TBC]. The percolation pits of Appendix VI of the Unified Byelaws 2022 therefore sit in saturated ground for much of the season they are meant to serve. This is why waterlogging, recharge only on the ground that can take it (Clause 4.11, recharge rule), slope stability 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 Plan for Guwahati 2025 and its Zoning Regulations under the GMDA Act, 1985, and the Master Plan 2045 once it is notified; the Master Plans and Zoning Regulations of the other towns under the Assam Town and Country Planning Act, 1959; the hazard maps that byelaw 120 of the Unified Byelaws 2022, as amended in 2024, asks the Master Plans to carry; the schedules of water bodies under the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024; in an Autonomous District, the plans and rules of the District Council, if the District Council adopts the Manual; and the layouts and buildings permitted under them. In particular:

- (a) regional facility sites, restored tank flood storage, and major flow paths shall be reserved in the plan;
- (b) the 1% AEP hazard map shall be shown, and Chapter 7 setbacks applied to it;
- (c) land in hazard classes H5–H6 in the 1% AEP event shall not be zoned for new habitable development; and
- (d) the open space of layouts within a basin should be located, where possible, to form part of the major flow paths or regional storage shown in the BSMP.

11.9.2 Where a land-use plan is revised before a BSMP is approved, the planning authority shall use the best available flood mapping and record the BSMP as pending.

Commentary. Assam draws its water lines in its byelaws and Master Plans, and has no floodplain zoning law. The Unified Byelaws 2022 set the minimum distance of any building "from the edge of natural drainage channels": 15 m from a river "as marked in the plan"; 10 m from the Bharalu, the Mora Bharalu and the Bondajan; 6 m from other channels; 15 m from the notified water bodies "Deepar Beel, Silsako Waterbody"; 6 m from "Other notified water bodies (Sarusola, Barsola etc.)"; 10 m from other large ponds and water bodies "as marked in the plan"; and, for minor drains and small ponds not marked in the plan, the ordinary building setbacks (byelaw 26(ix), repeated as byelaw 44(ix) [numbering read from the OCR layout; TBC: confirm against a clean copy]). The table names only Guwahati's channels and beels although the byelaws are statewide, and "as marked in the plan" ties its rows to the Master Plan maps (this Manual's reading). The Authority may refuse a site "near a water body or water course" that the development may contaminate or divert, or a site "likely to be inundated" without satisfactory drainage, or "a filled up tank or low lying" site (byelaw 44(iii) [TBC]); multistoreyed buildings are excluded from areas "on or abutting natural drainage channels" and "wetlands" (byelaw 117); and since 2024 the Master Plans are to map the "natural hazard prone areas where construction is not permitted" (byelaw 120). The Master Plan for Guwahati 2025 classifies "All notified forest, water bodies, rivers etc." as Eco-Sensitive Zone, and its modification schedule forbids construction "within a distance of 15m from river bank" on the riverfront from Sonaram High School to the Kamakhya foothills. The Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 asks the District Level Committee to "ensure no construction zone within a buffer around the Water Bodies as prescribed in the Notified Master Plan and Assam Unified Building Construction (Regulation) Bye law, 2022" (s.5); that buffer is the byelaw table. The plinth is to be "0.3 m higher than the highest recorded flood level as fixed by the local authority" (byelaw 45(c)), but no such level was found for any town [TBC]. Under the Assam Embankment and Drainage Act, 1953 no one may build on, remove or alter an embankment or drain in a notified area without permission (s.16), but no setback from an embankment was found [TBC]. Assam has not enacted a floodplain zoning law (as quoted from PIB); a proposed Assam Flood Plain Zoning Bill was reported to have been reviewed by the Chief Minister on 5 November 2026 (a single report, unverified), and is not law. The flood-prone area is 31.50 lakh ha, 40% of the State, by the figure of the Rashtriya Barh Ayog as quoted by the CAG (Report No. 5 of 2018), or 31.05 lakh ha, 39.58%, on WRD's website (as quoted); both figures are in use. Where a byelaw line, a Master Plan line or a scheduled water body governs, it applies; this Manual adds the hydraulic corridor and setback zones of Chapter 7, with a Zone 1 of at least 15 m from the top of bank on every natural channel draining 8 ha or more and round every beel and pukhuri, and a Zone 2 to the 1% AEP extent plus 10 m, the line that reaches furthest from the water governing, as this Manual's proposal; it equals the byelaw for rivers, Deepor Beel and Silsako and is stricter elsewhere (Chapter 7), and Zone 1 land that is patta land is reserved in the Master Plan or secured by agreement, not taken. A BSMP gives the Master Plans the 1% AEP drainage-flood map and the buffer widths of Chapter 7 as an input to the hazard maps of byelaw 120, not as a notification under it. Using open space land as storage or flow path has no direct precedent; this Manual adopts it because the Unified Byelaws 2022 already reserve 20% of every plot for trees and greenery (byelaw 111) and 30% of a plot in hilly areas for vegetation (byelaw 110(k)), require 60% of the open space to be landscaped, half of it unpaved and the rest in permeable pavers "to allow rain water to percolate" (byelaw 92, as amended in 2024), and ask for rainwater harvesting on every building (byelaw 114) and a dry sump "capable of holding rain water during peak monsoon" on flood-liable and hilly plots (byelaws 74(ii) and 110(h)), 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 the floodplain, where the water table is near the surface in the monsoon, it is a shallow lined storage that drains to the outfall, never an infiltration basin (Clause 4.11). Placing it on the flow path costs the developer nothing extra and gives the basin storage it would otherwise have to buy.

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 monsoon (by 31 March). The report shall show:

- CIP progress;
- the fee-in-lieu ledger (Clause 4.13.4);
- maintenance completed; and
- any flooding against the levels of service.

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.

References (chapter)

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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 Assam 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 Guwahati Metropolitan Area of the Master Plan for Guwahati 2025 and of the Dibrugarh and Silchar Municipal Corporations and their Master Plan areas

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

1A.1 Clause 1.6.1 defines Tier A by class of authority. Table 1A.1 sets out the classes, and the authorities named in the clause, as Chapter 1 defines them. Every authority not in Table 1A.1 is Tier B (Clause 1.6.2).

Table 1A.1 — Tier A authorities as defined in Clause 1.6.1

Item	Tier A authority	Clause
(a)	The Guwahati Municipal Corporation (GMC)	1.6.1(a)
(b)	GMDA and every other Approving Authority within the Guwahati Metropolitan Area, the area of the Master Plan for Guwahati 2025 (328 km²), whichever has jurisdiction over a site	1.6.1(b)
(c)	The Dibrugarh Municipal Corporation, with the Development Authority of the Dibrugarh Master Plan area, and the Silchar Municipal Corporation, with the Development Authority of the Silchar Master Plan area (the names of the two Development Authorities are to be confirmed [TBC])	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 Approving Authority within the Guwahati Metropolitan Area and the Master Plan areas of Dibrugarh and Silchar, with the date from which each is Tier A, and the boundaries of those areas and of the three Municipal Corporations as a map and as a GIS layer. It needs the notified Master Plan for Guwahati 2025 and its modifications, with Schedule I of the 328 km² area (GMDA); the Master Plans of Dibrugarh and Silchar and the names and areas of their Development Authorities (T&CP, DoHUA) [TBC]; the limits of the GMC and of the Dibrugarh and Silchar Municipal Corporations, whose dates of constitution are to be confirmed (DoHUA) [TBC]; the Gaon Panchayats and other local bodies that fall within those Master Plan areas; and the district, mouza and revenue village boundaries (Revenue and Disaster Management Department, Survey of India). Until it is published, the tier is decided by the classes in Clause 1.6.1 and recorded on Form 1-1, and the Authority confirms it at the pre-application stage (Clause 1.5.9).

Table 1A.2 — Register of Tier A authorities (layout)

No.	Authority	Class (Municipal Corporation / Municipal Board / GMDA / Development Authority / Gaon Panchayat / District Council / 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 Municipal Corporation, Municipal Board and Master Plan area boundary map shall be published as open data in a machine-readable format (Clause 10.17.4), with the date of the notification it shows.

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)	Guwahati's Bharalu–Bahini basin to Bharalumukh, with the Noonmati–Bondajan diversion	The catchment of the Bahini, which rises at Umtyrnga in Meghalaya and becomes the Bharalu at Jonali, and of the Bharalu down to its gated outfall to the Brahmaputra at Bharalumukh, about 120 km², about half of it hills (PCBA, as quoted), with the diversion from Noonmati to the Bondajan. The localities inundated in June 2022 lie here, among them Anil Nagar, Nabin Nagar, Rajgarh Link Road, Rukminigaon, Hatigaon and Krishna Nagar (as reported), with the 14 waterlogging points that the CAG found flooding six or seven times a year (CAG, Report No. 4 of 2019). "The natural discharge capacity of the Bharalu is 72 Cumecs when its Bharalumukh sluice gates are kept open, while the pumps fitted to its sluice gates can discharge only seven Cumecs" (2008, as reported; present capacity [TBC])
(b)	The Mora Bharalu–Deepor Beel–Khanajan system, with the Basistha and the Kalmani, and the Silsako basin	The land that drains by the Mora Bharalu, the Basistha and the Kalmani to Deepor Beel and from it by the Khanajan to the Brahmaputra, and the basin of Silsako, the retention basin to which part of the Bahini's runoff is to be diverted (ADB, RRP, 2025). Deepor Beel holds about 10.1 km² of water in winter and up to about 40.1 km² in floods (as reported); its stage–storage relation was not found [TBC]

Item	Catchment	Extent as described in Chapter 4
(c)	The hill streams of the Guwahati fringe from Meghalaya	The catchments of the streams that come down from the hills of Meghalaya to Khanapara, Jorabat and Basistha, where Plate 9 of the 2(b) report reads about 280–320 mm at 50 years against about 200–240 mm in the city (Clause 2.3.6(c)(i)) and SIRD Khanapara recorded 215.9 mm on the night of 19–20 April 2026 (as reported)
(d)	Dibrugarh behind the DTP dyke	The town behind the 8.62 km DTP dyke of 1955, which "closed all the drainage channels", "1.5 m below the bed level of Bramhaputra", and its drain of 32.053 km past Larua Jamira beel to the Sessa, whose outfall sluice is designed for a flood level of 97.50 m with "the beel … full and the drain … also flowing full" (ADB, IEE, 2017)
(e)	Silchar behind the Barak embankment	The bowl of Silchar inside the Barak embankment, flooded from 19 June 2022 for about 11 days after the cut at Bethukandi (as reported); the Barak at Annapurnaghat has a danger level of 19.83 m and a highest level of 21.84 m (1 August 1989) (CWC data as transcribed by SANDRP). Its outfall channels were not researched [TBC]
(f)	Karimganj on the Kushiyara, with Hailakandi and Badarpur	The towns of the lower Barak valley on the Kushiyara and the Barak; the Kushiyara at Karimganj has a danger level of 14.94 m and a highest level of 16.57 m (10 June 2010), and the Barak at Badarpurghat 16.85 m and 18.48 m (11 September 2007) (CWC data as transcribed by SANDRP)
(g)	Palasbari–Mirza	The land of the Palasbari–Mirza area, where builders blocked channels and filled wetland, causing "artificial floods" (Gauhati High Court, PIL/53/2023, order of 06.09.2024)
(h)	The north-bank towns on dam-release and flash-flood reaches	North Lakhimpur on the Ranganadi, below the NEEPCO project that released 1,412.57 m³/s in 2017 (as quoted); Dhemaji; the reach of the Subansiri below the Lower Subansiri project (release rules [TBC]); and Tezpur on the Jia Bharali
(i)	Dhubri and Goalpara on the lower Brahmaputra	The towns of the lower Brahmaputra, where the river has a danger level of 28.62 m at Dhubri and 36.27 m at Goalpara (CWC data as transcribed by SANDRP) and Dhubri (Rupsi) recorded 479.3 mm in 24 hours on 28 May 1989, the largest qualifying day in the State (IMD; Clause 2.3.6(h))
(j)	Majuli and the char lands	Majuli and every char and chapori in the Brahmaputra and the Barak, where Clause 2.3.6(i) makes the design hazard-first and the floodplain rule of Clause 4.11 bars infiltration; Majuli's area is given as 733.79 km² in 1940 and 524.29 km² in 2016 (as quoted), and as 1,246 km² in 1951 and 487 km² in 2024 in another source (conflict)
(k)	Haflong and Diphu	The hill towns of Dima Hasao and Karbi Anglong, where slopes, slides and debris govern (Clause 2.3.6(i))
(l)	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 GMC, GMDA, PWD, the Dibrugarh and Silchar Municipal Corporations and the Municipal Boards, Survey of India), including the parts of the Guwahati catchments that lie in Meghalaya; the drains with their outfalls, the sluices, flap gates and pumping stations with their sills, closing levels and capacities, and the dry-weather interceptions on them, with levels on a stated datum (the WRD, GMDA, the Corporations); the flood marks of June 2014, June 2022, 31 May 2025 and 20 April 2026 in Guwahati and of June 2022 in Silchar, and the waterlogging points recorded by the CAG (the GMC, GMDA, ASDMA, the Deputy Commissioners); the stage records of the CWC sites at Guwahati (DC Court), Dibrugarh, Tezpur, Goalpara, Dhubri, Annapurnaghat, Badarpurghat and Karimganj with their datum (CWC); the release records of the Ranganadi, Lower Subansiri and Kopili projects (NEEPCO, NHPC); the stage–storage relations of Deepor Beel, Silsako and Larua Jamira beel [TBC]; and the char and chapori lands as mapped (the Directorate of Char Areas Development, WRD). Jorhat, Nagaon, Tezpur town, Tinsukia, Bongaigaon and the other Master Plan towns are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The setbacks of the Unified Byelaws 2022 from rivers, channels and water bodies, and the corridors of Chapter 7, 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 (k), 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 Assam 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 Deputy Commissioner and the District Disaster Management Authority, ASDMA, the Water Resources Department or GMDA (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 pukhuri or tank storage identified in the basin plan (Clause 4.13.1).

S-5.3 *Eligibility:* sites in a basin for which a basin plan has been notified (Table 1.2).

S-5.4 *Conditions:*

- (a) the conditions of Clause 4.13.2 apply, including interim on-site detention until the regional facility or restored tank is operational, and retention and WQv treatment on site;
- (b) the fee is computed under Clause 4.13.3 and held in the ring-fenced basin account;
- (c) the volume credited and the fee are entered in the public ledger of Clause 4.13.4; and
- (d) in a flood-sensitive catchment, fee-in-lieu is available only as allowed by Clause 1.10.3(d).

Part 3 — Model council resolution

> **Model text for consideration by a competent authority. Not in force.**

Resolution No. _____ of _____ (name of Municipal Corporation / Municipal Board), dated _____

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

The Council, having considered the report of the Commissioner / Executive Officer dated _____, and noting that:

- (i) the Assam 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: _____ Commissioner / Executive Officer: _____ Date: _____

Annex 1D — Model Unified Byelaws 2022 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 Assam Unified Building Construction (Regulation) Byelaws 2022 at which the new rule and the conditions would be inserted, and the enabling sections of the Assam Town and Country Planning Act, 1959 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 Assam Unified Building Construction (Regulation) Byelaws 2022

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

- (1) These rules may be called the Assam Unified Building Construction (Regulation) (Stormwater Management) (Amendment) Byelaws, _____.
- (2) They shall come into force on the date six months after their publication in the Assam Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building byelaws made by the Government under section 4 of the Assam Building Construction (Regulation) Act, 2010, the following rule shall be inserted:

> **Rule [_____]. Stormwater management.**
>
> (1) *Definitions.* In this rule, "the Manual" means the Assam 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 Assam 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 — Assam 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 Assam Unified Building Construction (Regulation) Byelaws 2022 — 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 (Unified Byelaws 2022, byelaw 114 and Appendix VI: every building in a notified Master Plan area, with storage and reuse on plots of 134 m² and above; Assam Ground Water Control and Regulation Act, 2012, s.19: premises of 100 m² or more in a notified area (none found)) — 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 — Assam 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 gauges of the Water Resources Department, among them Chandmari and Beltola in Guwahati, the Guwahati city gauges (the City ARG, AAU-HRS, Gauhati University and SIRD Khanapara), whose owners, logging intervals and archives are to be confirmed, and the rainfall data of ASDMA's daily flood reports and its Flood Reporting and Information Management System (FRIMS) [TBC]), and district and basin boundaries (Survey of India, WRD). Until it is published, design depths are taken from NIH-DHAARA under Clause 2.3.1, the cross-checks of Clause 2.3.3 are reported on Form 2-1, and the zone of a site is the one agreed with the Authority and recorded on Form 2-1.

Table 2A.1 — Benchmark comparison of design depths (layout)

Benchmark point	IMD station ID	Latitude, longitude	Years of record	Duration (h)	AEP	NIH-DHAARA (mm)	IMD station analysis (mm)	IMD gridded, point value (mm)	NIH-DHAARA / IMD station	Remarks
				24						
				48						
				72						

2A.1 The zone names below are the working names used in the Tier B table template of Chapter 4 (Clause 4.14.2). Their boundaries, and whether further zones are needed, are to be set by the analysis of this annex.

Table 2A.2 — Rainfall zones (layout)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AS-Z1 North bank	The north bank of the Brahmaputra from the Sankosh to the Arunachal foothills, in CWC subzone 2(a), North Brahmaputra (Clause 2.3.6(b)); within 5 km of the river's banks, including Majuli and every char, the 5-km rule of Clause 2.3.6(b) applies; catchments that cross a zone line take the higher zone value	Dhubri (42404) and Dhubri (Rupsi) (A) (42406); Tezpur (42415); North Lakhimpur (Lilabari) (42309); Rangia (42408), Tangla (42409) and Majbat (42413); Gohpur (42419, suspect January value)	FER 2(a) 50-yr 24-h from about 200 mm at Tezpur and Amingaon to more than 440–480 mm at the Bhutan foothills (Plate 9; NEER reading); 2(a) ratios, 1-h ratio 0.260 (Clause 2.3.6(f)), with the short-storm floors of Clause 2.3.6(g). Bhabar fans and the terai belt below the foothills; dam-release reaches of the Ranganadi and the Subansiri
AS-Z1 North bank: AS-A Lower north bank and Bhutan foothills (Dhubri–Kokrajhar–Bongaigaon–Barpeta–Nalbari–Rangia)	Also Gossaigaon, Kajalgaon (Chirang), Mushalpur (Baksa), Tamulpur, Pathsala (Bajali) and Abhayapuri; the Manas, Beki, Aie and Pagladiya plains; bhabar–terai fans; Dhubri town lies on the north bank. The strip west of 90° E (Dhubri) lies in UTM zone 45N; boundaries [TBC]	Dhubri (42404, 1901–2012); Dhubri (Rupsi) (A) (42406, 1957–2003); Rangia (42408, 1957–2012)	FER 2(a) 50-yr 24-h about 280–320 mm at Dhubri, 280–360 mm at Barpeta, 360–400 mm at Bongaigaon, 240–280 mm at Rangia–Nalbari and more than 440–480 mm at Kokrajhar and the Bhutan foothills (low to medium confidence). Records: Dhubri (Rupsi) 479.3 mm (28 May 1989), which raises the 1% AEP depth within 25 km to at least 479.3 mm (Clause 2.3.6(h)); Dhubri 368.3 mm (11 June 1909); Rangia 217.0 mm (29 May 1977). FER-only flags: Lakhipur 490.3 mm, Bijni 486.4 mm, Patacharkuchi 406.4 mm, Kachugaon and Mankachar 366.0 mm (2(a), Table 7). Annual normals about 2,400–3,200 mm (Bini 3,176 mm; Dhubri 2,587 mm, 2(b) Annex 4.1). NIH-DHAARA 50-yr 24-h 789 mm (Dhubri) and 641 mm (Bongaigaon), comparison only
AS-Z1 North bank: AS-A1 Central and upper north bank (Mangaldoi–Udalguri–Tezpur–Biswanath Chariali–North Lakhimpur–Dhemaji)	Also Gohpur and Silapathar; the Jia Bharali, Ranganadi and Subansiri release and flash-flood reaches; boundaries [TBC]	Tezpur (42415, 1901–2012); North Lakhimpur (Lilabari) (42309, 1951–2012); Tangla (42409) and Majbat (42413), 1954–2012; Gohpur (42419, 1957–2009)	FER 2(a) 50-yr 24-h about 200 mm at Tezpur, 240–280 mm at North Lakhimpur and 320 to more than 400 mm at Dhemaji (Plate 9). Records: North Lakhimpur 261.6 mm (12 July 1971); Tezpur 184.9 mm (30 June 1986); Majbat 235.0 mm (9 June 1962); Tangla 224.4 mm (16 June 1973); Gohpur 312.7 mm (16 January 1971), suspect and excluded (Clause 2.3.6(h)). The 2(a) ratio gives Tezpur about 52 mm in 1 hour at 50 years, against NIH-DHAARA's 99 mm, so the floors of Clause 2.3.6(g) govern there. Ranganadi release of 1,412.57 m³/s in 2017 (as quoted)
AS-Z2 Guwahati	The Guwahati Metropolitan Area of the Master Plan for Guwahati 2025, 328 km² on both banks, in subzone 2(b) with North Guwahati and Amingaon in 2(a) (Clause 2.3.6(b)); for rainfall, the parts of the catchments of its streams in Meghalaya (Clause 2.3.6(c)(i))	Guwahati (Borjhar) (A) (42410, rainfall data 1902–2012); the Guwahati recording gauge of the 2(b) report; the city gauges (City ARG, AAU-HRS, Gauhati University, SIRD Khanapara) and the WRD gauges at Chandmari and Beltola (owners, logging intervals and archives [TBC])	FER 2(b) 50-yr 24-h about 200–240 mm in the city, 280–320 mm at the Khanapara–Jorabat foothills and 400 mm at the Meghalaya border; 2(b) ratios on both banks (Clause 2.3.6(f)); Guwahati catchment rule (Clause 2.3.6(c)(i)). A spatial IDF from the city gauges is the first task of this annex for AS-B

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AS-Z2 Guwahati: AS-B Guwahati metropolitan area (Guwahati–Dispur–North Guwahati–Amingaon)	The Master Plan 2025 area on both banks, with its hill fringe at Khanapara, Basistha and Jorabat; the basins of the Bharalu, Dipar, Silsako, Foreshore, North Guwahati and Kalmoni (ADB, IEE, 2017); boundaries as notified	Guwahati (Borjhar) (A) (42410); the city gauges [TBC]	FER 2(b) 50-yr 24-h about 200–240 mm at the city (25-yr about 180–200 mm, 100-yr about 240 mm), rising south; 2(a) Plate 9 about 200 mm at Amingaon. Records: Guwahati (Borjhar) 194.3 mm (5 June 1956), below the plate; recording-gauge maxima 93 mm in 1 hour (17 May 1970) and 163, 179, 186 and 187 mm in 3, 6, 12 and 24 hours (18–19 July 1978) (CWC, 2(b), Annex 4.2), against which the 2(b) ratios fall short at 3 and 6 hours, hence the floors of Clause 2.3.6(g). Storms of 14 June 2022, 31 May 2025 and 20 April 2026 (as reported). NIH-DHAARA 50-yr 24-h 307 mm and 1-h 104 mm, comparison only. Kamrup (Metro) water table 1.29–2.64 m below ground in November 2022 (CGWB)
AS-Z3 South bank	The south bank of the Brahmaputra from the Meghalaya border at Goalpara and South Salmara-Mankachar to Tinsukia and Margherita, in subzone 2(b) (Clause 2.3.6(b)); the 5-km rule applies along the river	Goalpara (42407; 712.1 mm suspect); Chaparmukh (42414); Golaghat (42420); Lumding (42523); Dibrugarh (Mohanbari) (A) (42314); the Nowgong, Dibrugarh, Chabua and Jorhat recording gauges of the 2(b) report	FER 2(b) 50-yr 24-h about 180–240 mm on the valley floor from Nagaon to Jorhat, rising to about 280–320 mm at Dibrugarh and about 320 mm at Goalpara; 2(b) ratios (Clause 2.3.6(f)). Annual normals 1,250–2,500 mm over most of the subzone, Lanka "barely 1,242 mm" (CWC, 2(b))
AS-Z3 South bank: AS-C Lower and central south bank (Goalpara–Palasbari–Morigaon–Nagaon–Hojai–Golaghat)	Also South Salmara-Mankachar, Dudhnoi, Jagiroad, Lumding and Numaligarh; the Kopili, Kolong and Dhansiri plains; boundaries [TBC]	Chaparmukh (42414, 1954–2012); Lumding (42523, 1912–2012); Golaghat (42420, 1954–2012); Goalpara (42407, 1954–2012); the Nowgong recording gauge (2(b) report)	FER 2(b) 50-yr 24-h about 200 mm at Nagaon (100-yr about 200–240 mm), about 180–200 mm at Lumding and about 320 mm at Goalpara. Records: Lumding 410.0 mm (3 August 1981) and Chaparmukh 295.5 mm (17 July 1980) raise the 1% AEP depth within 25 km (Clause 2.3.6(h)); Golaghat 147.0 mm (30 August 1996); Goalpara 712.1 mm (8 June 1970), suspect and excluded; the Nowgong recording gauge took 427 mm in 24 hours on 3–4 September 1978, twice the 50-year plate value. FER-only flags: Kampur 385.0 mm, Lumding 360.0 mm, Goalpara 357.4 mm, Lanka 471.9 mm. Kopili at Kampur DL 60.50 m, HFL 61.79 m (20 July 2004) (CWC data as transcribed by SANDRP)
AS-Z3 South bank: AS-C1 Upper Assam (Jorhat–Sivasagar–Charaideo–Dibrugarh–Tinsukia–Margherita)	Also Moran, Naharkatia and Digboi; the Dikhow, Burhidihing and Disang plains; Majuli is treated under the 5-km rule of Clause 2.3.6(b); boundaries [TBC]	Dibrugarh (Mohanbari) (A) (42314, 1901–2012); the Dibrugarh, Chabua and Jorhat recording gauges (2(b) report); no IMD station at Jorhat or Tinsukia in *Extremes*	FER 2(b) 50-yr 24-h about 200 mm at Jorhat, 240–280 mm at Sivasagar and Tinsukia and 280–320 mm at Dibrugarh (low confidence; probably high at Dibrugarh). Records: Dibrugarh (Mohanbari) 231.5 mm (10 May 1996), below the plate; recording-gauge maxima at Dibrugarh 95 mm in 1 hour (3 August 1970) and 207 mm in 24 hours (26–27 August 1977) (CWC, 2(b), Annex 4.2). FER-only flag: Moran 381.0 mm. Dibrugarh DL 105.70 m, HFL 106.48 m (3 September 1998) (CWC data as transcribed by SANDRP)
AS-Z4 Hill districts	Karbi Anglong, West Karbi Anglong and Dima Hasao, in subzone 2(b) with the south of Dima Hasao in 2(c) (Clause 2.3.6(b)); a separate domain for the record check (Clause 2.3.6(h)); the hill rule of Clause 4.11 applies	Haflong (Halflong) (42522, 1901–2012); no IMD station at Diphu in *Extremes*	FER 2(b) 50-yr 24-h from about 180–200 mm in the Karbi rain shadow to about 320–400 mm at Haflong; 2(b) ratios in AS-D and 2(a) ratios in AS-D1 (Clause 2.3.6(f)). Landslides, debris and cut slopes govern (Clause 2.3.6(i))

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AS-Z4 Hill districts: AS-D Karbi hills (Diphu–Hamren–Bokajan–Donkamokam)	Karbi Anglong and West Karbi Anglong; low hills and plateau, a rain shadow on the Lumding–Diphu side; boundaries [TBC]	None in *Extremes*; Lumding (42523), in AS-C, is outside the domain for the record check	FER 2(b) 50-yr 24-h about 180–200 mm at Diphu, inside the 200 mm loop (25-yr below 180 mm east of Lumding; 100-yr about 200–240 mm). NIH-DHAARA 50-yr 24-h 300 mm and 1-h 82 mm at Diphu, comparison only. Kopili at Kheronighat HFL 74.07 m (19 July 2004) (CWC data as transcribed by SANDRP). Arsenic and fluoride above the limits reported in parts of Karbi Anglong (as quoted)
AS-Z4 Hill districts: AS-D1 Dima Hasao hills (Haflong–Maibang–Umrangso–Jatinga)	The Barail ridge on the 2(b)/2(c) line; south of the line the Barak valley rule of Clause 2.3.6(c)(ii) also applies; boundaries [TBC]	Haflong (Halflong) (42522, 1901–2012)	FER 2(b) 50-yr 24-h about 320–400 mm at Haflong (low confidence; on the subzone line); 2(a) ratios on the plate depth (Clause 2.3.6(f)). Records: Haflong 309.5 mm (27 June 2012), below the plate; 248.2 mm in May (1958) and 237.1 mm in October (1959). Jatinga Valley's annual normal is 4,767 mm (CWC, 2(b), Annex 4.1, OCR) and Haflong's wettest month 1,428.5 mm (June 2012). NIH-DHAARA 50-yr 24-h 289 mm and 1-h 82 mm at Haflong, comparison only
AS-Z5 Barak valley	Cachar, Karimganj (district renamed Sribhumi, as reported [TBC]) and Hailakandi, in subzone 2(c), for which CWC has published no report (Clause 2.3.6(b)); a separate domain for the record check (Clause 2.3.6(h))	Silchar (42619, 1901–2012); Silchar (Kumbhigram) (A) (42620, 1957–1990); no IMD station at Karimganj or Hailakandi in *Extremes*	No CWC plate, ratio or unit hydrograph. Barak valley rule of Clause 2.3.6(c)(ii): Gumbel of the two Silchar stations, not less than 320 mm at 2% and 351 mm at 1% AEP; 2(b) ratios (Clause 2.3.6(f)). The Barak study of Basumatary and Sil is the first document to obtain (Clause 2.3.6(a))
AS-Z5 Barak valley: AS-E Barak valley (Silchar–Karimganj–Hailakandi–Badarpur)	The Barak, Kushiyara, Longai and Katakhal plains; the Silchar bowl behind the Barak embankment; boundaries [TBC]	Silchar (42619); Silchar (Kumbhigram) (A) (42620)	Records: Silchar (Kumbhigram) 350.6 mm (2 June 1974), the 1% AEP floor; Silchar 290.3 mm (30 May 1893), before 1901 and excluded; Silchar 245.4 mm in March (1922) and 174.2 mm in November (1955); Silchar's wettest month 1,314.2 mm (May 1883). NIH-DHAARA 50-yr 24-h 450 mm (Silchar) and 513 mm (Karimganj), and 1-h 106 mm and 117 mm, comparison only. Barak at Annapurnaghat DL 19.83 m, HFL 21.84 m (1 August 1989); Kushiyara at Karimganj DL 14.94 m, HFL 16.57 m (10 June 2010) (CWC data as transcribed by SANDRP)

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 Assam are those of Clause 2.3.6 for the site's sub-area in Table 2B.1 (the 2(a) ratios in AS-A and AS-A1 and, on the 2(b) plate depth, in AS-D1; the 2(b) ratios in AS-B on both banks, AS-C, AS-C1, AS-D and AS-E), applied to the 24-hour depth before the record check of Clause 2.3.6(h), with the short-storm floors of Clause 2.3.6(g) at 1, 3 and 6 hours in every sub-area (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
AS-Z1 (AS-A Lower north bank and Bhutan foothills; AS-A1 Central and upper north bank) and AS-Z4 (AS-D1 Dima Hasao hills, on the 2(b) plate depth)	CWC FER 2(a), NB/18/1991, §3.1.2 and Fig. 10, 50-yr basis, partial-duration analysis of 12 IMD recording gauges (interim design ratios, Clause 2.3.6(f))	0.260	0.370	0.457	0.615	0.805	1.000
AS-Z2 (AS-B Guwahati metropolitan area, both banks), AS-Z3 (AS-C Lower and central south bank; AS-C1 Upper Assam), AS-Z4 (AS-D Karbi hills) and AS-Z5 (AS-E Barak valley, which has no CWC report)	CWC FER 2(b), Table 4.1, 10-yr basis, six recording gauges (Shillong, Nowgong, Dibrugarh, Guwahati, Chabua and Jorhat) (interim design ratios, Clause 2.3.6(f); 2-h value interpolated on logarithmic axes)	0.48		0.62	0.74	0.87	1.00
All sub-areas, 10% AEP and rarer	Short-storm floors of Clause 2.3.6(g), set by this Manual, in mm, not ratios: 1 h 70 / 85 / 95 / 105 mm, 3 h 120 / 145 / 165 / 185 mm and 6 h 130 / 160 / 180 / 200 mm at 10% / 4% / 2% / 1% AEP; 2 h interpolated on logarithmic axes						
AS-Z2 (AS-B): Guwahati	CWC FER 2(b), Annex 4.2: the recording-gauge maxima as ratios to the 24-h maximum of 187 mm (18–19 July 1978); the 1-h value, 93 mm, is from another storm (17 May 1970); record length not printed; comparison only	0.50		0.87	0.96	0.99	1.00
AS-Z3 (AS-C1): Dibrugarh	CWC FER 2(b), Annex 4.2: maxima as ratios to the 24-h maximum of 207 mm (different storms; comparison only)	0.46		0.58	0.64	0.91	1.00
AS-Z3 (AS-C): Nowgong	CWC FER 2(b), Annex 4.2: maxima as ratios to the 24-h maximum of 427 mm (3–4 September 1978; different storms; comparison only)	0.21		0.25	0.43	0.66	1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
AS-Z2 (AS-B), AS-Z1 (AS-A1), AS-Z5 (AS-E), AS-Z4 (AS-D1), AS-Z1 (AS-A): Guwahati, Tezpur, Silchar, Haflong and Dhubri cells	NIH-DHAARA, IMDAA, 50-yr (queried 14 Nov 2026; comparison only)	0.34 / 0.25 / 0.24 / 0.28 / 0.16					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 gauges of the Water Resources Department, among them Chandmari and Beltola in Guwahati, the city gauges of Guwahati and the daily flood-report gauges of ASDMA [TBC]), the benchmark points of Annex 2A, and a stated method for deriving the factors. Until it is published, design depths are taken as point values from NIH-DHAARA or an approved station IDF (Clauses 2.3.1 and 2.3.2). Grid-average values are not used as design depths unless a conversion agreed with the Authority is recorded on Form 2-1 (Clause 1.11.5).

2C.1 The commentary to Clause 2.7 shows why the factors matter. In Assam NIH-DHAARA was queried at 15 points for this Manual, and its reanalysis cells give 24-hour depths higher than the CWC plates everywhere and higher than every IMD record at the stations compared: the Dhubri cell gives 789 mm at 50 years against about 280–320 mm on the 2(a) plate and 479.3 mm, the highest day at Dhubri (Rupsi); the Goalpara cell 674 mm, against 357.4 mm in the 2(a) report; the Tezpur cell 404 mm against about 200 mm on the plate and 184.9 mm at the station; and the Guwahati cell 307 mm against about 200–240 mm on the plate and the 194.3 mm record (NIH-DHAARA, queried 14 Nov 2026; CWC; IMD, *Extremes*). Their 1-hour depths are closer: 104 mm at 50 years in the Guwahati cell, against the 93 mm hour of the Guwahati recording gauge (CWC, 2(b), Annex 4.2). The gauges within one city show the size of the point-to-point gap: on 20 April 2026 the airport recorded 117.4 mm and SIRD Khanapara 215.9 mm, and on 14 June 2022 Beltola 88 mm against about 10 mm at the airport (as reported). Values of this kind are grid- or area-average values and need these factors before any use as point depths; under Clause 2.3.6 NIH-DHAARA is not used as a design depth in Assam until this annex and Annex 2A are published, and is reported for comparison only (Clause 2.3.6(m)).

Table 2C.1 — Grid-to-point factors (layout)

Zone	Grid product and cell size	Duration (h)	AEP	Factor (point / grid)	Stations used	Years of record
		24				
		48				
		72				

Annex 2D — Assam 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 Assam 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 Regional Meteorological Centre Guwahati, the six recording gauges used by the CWC 2(b) report and the 12 used by the 2(a) report, and any recording gauges of the Water Resources Department, ASDMA and the Guwahati city network [TBC]), separated into independent storms by a stated rule, and the storms recorded by the Guwahati recording gauge of the CWC 2(b) report on 17 May 1970 (93 mm in its largest hour) and 18–19 July 1978 (163 mm in 3 hours), by the Dibrugarh gauge on 3 August 1970 (95 mm in an hour) and by the Nowgong gauge on 3–4 September 1978 (427 mm in 24 hours), the Guwahati storms of June 2014, 14 June 2022, 31 May 2025 and 19–20 April 2026, the Barak valley storm of June 2022 and the Dhubri (Rupsi) storm of 28 May 1989 among them. Until it is published, design storms use the alternating-block pattern of Clause 2.9.1 and the 48- and 72-hour pattern of Clause 2.9.2; for catchments of 25–5,000 km², the CWC Flood Estimation Report curves may be used with a sensitivity run under Clause 2.9.1 (Clause 2.9.4). SCS Type distributions are not used (Clause 2.9.3). For the disaggregation of daily records in continuous simulation (Clause 11.7.3), the method is agreed with the Authority and recorded (Clause 1.11.5).

Table 2D.1 — Cumulative fraction of storm depth against cumulative fraction of storm time (layout, one table per zone, duration class and quartile)

Fraction of storm time	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10% probability curve	0										1.0
50% probability curve	0										1.0
90% probability curve	0										1.0

2D.1 Each table shall state the zone, the duration class, the quartile (the quarter of the storm in which most rain fell), the number of storms analysed and the period of record.

Reference: Huff, F.A. (1967). Time distribution of rainfall in heavy storms. *Water Resources Research* 3(4), 1007–1019.

Annex 2E — Retention percentile depths by zone

Supports Clauses 2.8.3 and 2.10.1 to 2.10.2 of Chapter 2, Clause 4.4 of Chapter 4 and Chapter 8.

To be prepared. This annex will give, for each zone of Annex 2A, the retention design depth P_R: the 24-hour rainfall depth not exceeded on 90% of days with rain (≥ 2.5 mm) in the long-term record (Clause 2.10.1). It needs long daily records at stations in each zone (IMD, the gauges of the Water Resources Department, among them Chandmari and Beltola in Guwahati, the city gauges of Guwahati and the daily flood-report gauges of ASDMA [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
AS-Z1 North bank					
AS-Z2 Guwahati					
AS-Z3 South bank					
AS-Z4 Hill districts					
AS-Z5 Barak valley					

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 — Assam Stormwater Design Manual, Draft v1.0. One sheet for each hydrologic submittal. The steps follow Figure 2.3 of Chapter 2.

Table 2F.1 — Form 2-1: site, source and storms

No.	Item (clause)	Entry
	A. Site (Clause 2.13, item 1)	
A1	Project and site	_____
A2	Site coordinates (latitude, longitude, decimal degrees)	_____
A3	Rainfall zone (Annex 2A, or as agreed with the Authority)	_____
A4	Contributing catchment area (km²) (Clause 2.7)	_____
A5	Design life: more than 25 years / temporary works, 5 years or less (Clause 2.8.2)	_____
A6	Outfall under tidal or river backwater influence: Yes / No (Clauses 2.5.3, 2.12)	_____
	B. Source (Clauses 2.3, 2.3.5; item 2)	
B1	NIH-DHAARA: version or access date	_____
B2	Coordinates queried	_____
B3	Screenshot or export of the values extracted attached: reference	_____
B4	Station IDF used (Clause 2.3.2): No / Yes — station, ID, distance from site (km)	_____
B5	Station IDF: years of recording-gauge data (30 or more); published or approved by	_____
B6	Station IDF: change of terrain or coastal exposure between gauge and site: None / describe	_____
	C. AEPs and durations (Clauses 2.4, 2.5)	
C1	Elements designed and their AEPs (Table 2.1)	_____
C2	Conveyance: Tc and design duration (not less than 10 min) (Clause 2.5.1)	_____
C3	Storage: durations checked from {1, 2, 3, 6, 12, 24, 48, 72 h}; 24, 48 and 72 h included (Clause 2.5.2)	_____
C4	Critical duration found for each storage element	_____
	D. Conversions	
D1	Sub-daily depths: read directly / from Annex 2B ratios / from ratios agreed with the Authority (Clauses 2.6.1, 2.6.2)	_____
D2	Fixed-interval factor applied: none (true-interval source) / 1.13 / 1.04 / 1.02 (Clause 2.6.3)	_____
D3	Grid-to-point factor: not needed (point source) / Annex 2C / agreed value (Clause 2.7.1)	_____
D4	ARF: 1.0 (10 km² or less; single-site storage) / CWC curve / interpolated (Clauses 2.7.2–2.7.4)	_____
D5	Climate factor: 1.20 (≤ 6 h) and 1.10 (> 6–72 h) / 1.0 temporary works / projected depths under Clause 2.8.4	_____
	E. Cross-checks (Clause 2.3.3; item 4)	
E1	IMD Das et al. (2022) values for 1–24 h: reported in Table 2F.2	_____

No.	Item (clause)	Entry
E2	CWC subzone 2(a) or 2(b) 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 June–30 September in sub-areas AS-A, AS-A1, AS-B, AS-C, AS-C1 and AS-D1 and of 1 May–31 October in AS-E, whatever its duration; III for every design storm of 1 April–31 October on floodplain land below the 1% AEP level, char and chapori land, beel and pukhuri margins and land behind embankments; III at any time in catchments draining to a reservoir, its backwater or a release reach; at any other site or time (including AS-D), 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 — Assam 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 Assam to its hydrologic soil group (HSG), in both the drained and the undrained state, and (b) a map of the depth to the seasonal high groundwater table in the monsoon season (April–October). It needs NBSS&LUP and Agriculture Department, Assam (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 flood plains of the Brahmaputra and the Barak, where nearly half the CGWB wells stood within 2 m of the surface in November 2022, the Silchar bowl, the char and chapori lands and Majuli, the beel basins and the margins of the beels and pukhuris, the land behind the embankments of the riverside towns, the terai belt of the northern foothills, and the valley floors and hill-foot land of Guwahati. Until it is published, use the interim rules of Chapter 3: assign HSG from measured saturated hydraulic conductivity and depth to an impermeable layer or water table by the criteria of NEH Part 630, Ch. 7 (Clause 3.7.2); verify it by site infiltration tests wherever retention relies on infiltration (Clause 3.7.3); take the seasonal high water table from site piezometers, trial pits or the nearest observation well (Clause 3.10.2); and assign HSG D wherever that level is within 0.6 m of the ground surface (Clause 3.10.1).

Table 3A.1 — Soil series to HSG lookup (layout)

Soil series	District(s)	Taxonomic class	Surface texture	Saturated hydraulic conductivity (mm/h)	Depth to impermeable layer (m)	HSG, drained	HSG, undrained	Source map and scale

Table 3A.2 — Seasonal high water table, by mapping unit (layout)

Mapping unit or grid cell	Observation wells used	Years of April–October record	Highest April–October level below ground (m)	Within 0.6 m of ground (Clause 3.10.1)?	Data source

Mapping unit or grid cell	Observation wells used	Years of April–October record	Highest April–October level below ground (m)	Within 0.6 m of ground (Clause 3.10.1)?	Data source

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Annex 3B — Assam CN calibration and supplementary land covers (hill forest, bunded rice fields, char and chapori land, beel beds and margins, bhabar boulder fans, cut hill slopes and fills, hola hollows)

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 Assam catchments, compared with the TR-55 values of Table 3.5, and (b) curve numbers for land covers that Table 3.5 does not list: the forest that covers most of the hills, about 85% of the land of the CWC subzone 2(b) area by the report's land use; the rice fields of the plains, divided by field ridges (ali, আলি, a ridge across a rice field, which the Assam Embankment and Drainage Act 1953 excludes from "embankment"), and the riverbank grass and scrub that the subzone 2(b) report records as now cultivated; the char and chapori lands, river-deposited sand and silt with grass, bare at low water and submerged or saturated in floods; the beds and margins of beels, which are much smaller at the start of the season than in flood (Deepor Beel about 10.1 km² against up to 40.1 km² in floods, as reported); the boulder and gravel fans of the bhabar belt below the Bhutan and Arunachal foothills; the cut hill slopes, quarries and fills of the Guwahati hills; and hola (হোলা), hollow land where water lodges in the rains (Chandrakanta Abhidhan, p. 920). It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from WRD gauging sites, agricultural research stations and tank gauges, analysed by event and by antecedent moisture. Until it is published: the pre-development reference stays open space in good condition for every site (Clause 3.3.2), so these covers do not enter the pre-development run; for off-site existing conditions, use the nearest Table 3.5 or TR-55 cover row, including the cultivated rows (Clause 3.8.3(c)), and state the row chosen and the reason on Form 3-1; land under standing water at the start of the design storm is modelled as water surface with no losses (Table 3.5; Clause 3.10.4(b)). Any departure from these defaults requires calibration under Clause 3.15 (Clause 3.15.1(d)).

Table 3B.1 — Supplementary land covers, AMC II (layout)

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Forest of the hills (Guwahati hills; Karbi and Dima Hasao hills; northern foothills), with the litter recorded						
Rice fields of the plains, bunded by field ridges (ali), ponded or dry at the start of the storm						
Char or chapori land, sand and silt with grass, above the river level at the start of the storm						
Beel bed or margin, dry or shrunken at the start of the storm						
Bhabar fan of boulders and gravel, northern foothills; losses to the fan credited only after a field test						
Cut hill slope, quarry or fill (Guwahati hills), bare or newly vegetated						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Hola: hollow land where water lodges in the rains, dry at the start of the storm						
Other (state)						

Table 3B.2 — CN calibration catchments (layout)

Catchment	District	Area (km²)	Dominant HSG and cover	Events used	Table 3.5 CN	Calibrated CN	Calibrated ÷ Table 3.5

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 Assam.** Assam is landlocked, 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 flood plains of the Brahmaputra and the Barak, the char lands, the beel basins and the land behind the embankments are flat and slow to drain, but they are not coastal plain; their slow response is represented by storage, pumping and backwater (Clauses 3.10.4, 3.12.1 and 3.12.4) and by the outfall-closed check of Chapter 5, not by a lower peak rate factor. 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 subzones 2(a) and 2(b), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzones 2(a) (North Brahmaputra) and 2(b) (South Brahmaputra), the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs the two CWC Flood Estimation Reports that cover Assam: the North Brahmaputra subzone 2(a) report (Design Office Report No. NB/18/1991), which covers the north bank of the Brahmaputra from Dhubri to Dhemaji, North Guwahati and Amingaon, and of which only the unit hydrograph relationships, the ratio table, Table 7 and Plate 9 were checked against the page images, its Plates 8 and 10 not being read for this draft; and the South Brahmaputra subzone 2(b) report (Revised; Design Office Report No. SB-2(b)/R-4/44/99, March 2000), which covers the south bank, Guwahati, the Karbi hills and the north of Dima Hasao, and of which Annexes 4.1 to 4.3 (heaviest rainfall and areal reduction) were read only by optical character recognition, the time distribution of Annex 4.4 was seen only through its worked example, and the positive Lc exponent of the simplified 100-year formula is to be checked with CWC (see the References of Chapter 3) [TBC]; written confirmation from CWC that no report for subzone 2(c) (Barak and others), which covers the Barak valley and the south of Dima Hasao, exists or is in preparation [TBC]; and the line between subzones 2(b) and 2(c) near Haflong, which is read by eye from the 2(b) plates and is still to be confirmed [TBC], transcribed and checked against the published reports, and a catchment with physiographic parameters measured from survey or a DEM. Until it is published, take all SUH inputs directly from the applicable Flood Estimation Report (Clause 3.11.4(a)), apply the 24-hour design rainfall of Clauses 2.3.3(b) and 2.7.3 with the climate factor of Clause 2.8 (Clause 3.11.4(b)), report the SUH result alongside the HEC-HMS or SWMM result for the existing natural condition (Clause 3.11.4(c)), and, where the hydrograph model gives a lower 1% AEP peak, either justify it by calibration under Clause 3.15 or adopt the SUH peak (Clause 3.11.4(d)).

Table 3E.1 — SUH relationships by subzone (layout)

Parameter	Symbol	Unit	Subzone 2(a) (North Brahmaputra) relationship	Subzone 2(b) (South Brahmaputra) relationship
Peak discharge per unit area	qp	m³/s per km²	qp = 2.272 (L·Lc/S)^−0.409, with S as printed (not √S)	qp = Qp / A
Peak discharge of the 1-hour unit hydrograph	Qp	m³/s	Qp = qp · A	Qp = 0.905 A^0.758 (Eq. 3.4.3.2); the peak depends on the catchment area alone
Time from centre of unit rainfall to peak	tp	h	tp = 2.164 qp^−0.940	tp = 2.87 qp^−0.839
Width of UH at 50% of peak	W50	h	W50 = 2.084 qp^−1.065	W50 = 2.304 qp^−1.035
Width of UH at 75% of peak	W75	h	W75 = 1.028 qp^−1.071	W75 = 1.339 qp^−0.978
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.856 qp^−0.865	WR50 = 0.814 qp^−1.018
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.440 qp^−0.918	WR75 = 0.494 qp^−0.966 (confirmed by the errata)

Parameter	Symbol	Unit	Subzone 2(a) (North Brahmaputra) relationship	Subzone 2(b) (South Brahmaputra) relationship
Base width of UH	TB	h	TB = 5.428 tp^0.852	TB = 2.447 tp^1.157
Time to peak from start of rise	Tm	h	Tm = tp + tr/2	Tm = tp + tr/2
Unit duration	tr	h	1	1
Design storm duration	TD	h	TD = TB (it gave the higher peak on 16 of the 21 catchments)	TD = 1.1 tp, "rounded off to nearest full hour", or any value that gives the maximum discharge
Design loss rate	—	mm/h	2.4 (printed "0.24 cm/hr", the modal value); for rural SUH runs only	3.5 (printed "0.35 cm/hr", the modal value of 100 flood events, kept from the report of 1984); for rural SUH runs only
Design base flow	—	m³/s per km²	0.05	0.05 (68 of 100 events in the range 0.01–0.09)
Ratio of t-hour to 24-hour rainfall	—	—	50-yr, 12 self-recording gauges: 1 h 0.260; 3 h 0.457; 6 h 0.615; 9 h 0.720; 12 h 0.805; 15 h 0.875; 18 h 0.930; 24 h 1.000. Used in this Manual in sub-areas AS-A, AS-A1 and AS-D1 (Clause 2.3.6(f))	10-yr, partial duration, mean of 6 self-recording gauges (the Shillong recording gauge and five in the Assam valley: Nowgong, Dibrugarh, Guwahati, Chabua and Jorhat), "beyond T = 5 years … comparable": 1 h 0.48; 3 h 0.62; 6 h 0.74; 9 h 0.81; 12 h 0.87; 15 h 0.91; 18 h 0.95; 24 h 1.00 (Table 4.1). Used in this Manual in sub-areas AS-B, AS-C, AS-C1, AS-D and AS-E (Clause 2.3.6(f))
Time distribution of rainfall	—	cumulative fraction by hour	[TBC]	1,040 storms in five duration groups (2–3 h: 229; 4–6 h: 286; 7–12 h: 322; 13–18 h: 116; 19–24 h: 87); for a 13-hour storm 0.26, 0.43, 0.56, 0.64, 0.70, 0.76, 0.82, 0.87, 0.90, 0.94, 0.96, 0.98, 1.00 (worked example); the tables of Annex 4.4 not read [TBC]
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	1.15
Areal reduction factor	ARF	% of point rainfall	[TBC]	Annex 4.3, read by optical character recognition only [TBC]: at 50 km², 93.75 (1 h), 94.25 (3 h), 95.50 (6 h), 97.00 (12 h), 98.00 (24 h); at 100 km², 88.00, 90.00, 91.75, 94.50, 96.50; at 200 km², 78.50, 82.00, 85.50, 90.00, 94.00; at 300 km², 71.00, 75.50, 80.00, 87.50, 92.00; at 500 km², 64.50 (3 h), 71.25, 83.00, 88.50; at 1,000 km², 76.00 (12 h), 83.00; at 2,000 km², 77.50 (24 h); the errata correct the 24-hour value at 1,500 km² from 79.50 to 79.00
Simplified formulae	—	m³/s	Given in the report, within ±15% of the detailed method; not transcribed for this draft [TBC]	A km², S m/km, L and Lc km, R the 24-hour point rainfall in cm: Q25 = 1.9194 A^0.4240 S^0.0917 L^0.9965 Lc^−0.5092 R25^0.3789; Q50 = 1.1368 A^0.4846 S^0.0540 L^0.8915 Lc^−0.5012 R50^0.6107; Q100 = 0.5160 A^0.5226 S^0.0552 L^0.7010 Lc^+0.3961 R100^0.9286, with the Lc exponent printed positive, unlike Q25 and Q50, probably a sign error [TBC]; not used for design in this Manual
Catchment area for which the relationships apply	A	km²	25–2,500; up to 5,000 with judgement	more than 50 to 1,500; up to 5,000 "judiciously"

Parameter	Symbol	Unit	Subzone 2(a) (North Brahmaputra) relationship	Subzone 2(b) (South Brahmaputra) relationship
Report reference	—	—	NB/18/1991: the unit hydrograph relationships, the loss rate and the ratio table	SB-2(b)/R-4/44/99: §§3.4–3.7, Table 3.3, the simplified formulae (p. 17), Table 4.1 (p. 20), §4.3, Annexes 3.1, 3.2, 4.1–4.3, the errata and the worked example

Note: relationships as printed in the two CWC reports that cover Assam (References of Chapter 3), read from scanned copies; Table 3.3 of the 2(b) report, its simplified formulae, its ratio table and its errata, and the 2(a) relationships and ratios, were checked against the page images. A is the catchment area in km², L the length of the main stream in km, Lc the length to the point nearest the catchment centroid in km and S the equivalent slope in m/km. **Coverage.** Assam is covered by two reports, not three. Subzone 2(a), North Brahmaputra, covers the north-bank tributaries of the Brahmaputra, among them the Manas (4,056.39 km²), the Pagladiya (1,702.68 km²) and the Subansiri (17,427.47 km²) (areas as read by optical character recognition), and the north-bank towns from Dhubri, which stands on the north bank, through Kokrajhar, Bongaigaon, Barpeta, Nalbari, Rangia, Mangaldoi and Tezpur to North Lakhimpur and Dhemaji, with North Guwahati and Amingaon. Subzone 2(b), South Brahmaputra, covers 73,556 km² of south-bank catchments, among them the Kulsi (5,007.90 km²), the Burhidihing (13,671.55 km²), the Dhansiri (S) (14,162.33 km²) and the Kopili (18,679.45 km²) (areas as read by optical character recognition), and the towns of Guwahati, Nagaon, Lumding, Diphu, Jorhat, Golaghat, Sivasagar, Dibrugarh, Tinsukia and Goalpara, with Haflong on its southern edge; it is bounded "on the south by Barak Subzone 2 (c)". The boundary between 2(a) and 2(b) is the Brahmaputra itself, so riverside towns straddle it (NEER's reading); Clause 2.3.6(b) deals with the rainfall, and where a catchment drains across the boundary this Manual requires the SUH to be computed with the parameters of each subzone and the higher 1% AEP peak to be adopted, unless calibration under Clause 3.15 supports the other (set by this Manual, as in the plains editions of this series). The subzone is chosen by the catchment's outfall, not by its district. **No SUH in subzone 2(c).** Subzone 2(c), "Barak and others" (the Barak, Kaladan and Manipur rivers), is listed in Annexure 1.1 of the 2(b) report, but no report was published: the 2(b) report's foreword lists 21 reports covering 24 of the 26 subzones, its back-page list has none for 2(c), and the Internet Archive index of CWC's downloads has none. **Assam is the first edition of this series in which a plain, not only a hill slope, has no CWC report.** In sub-area AS-E (the Barak valley: Silchar, Karimganj, Hailakandi, Badarpur) and in the south of Dima Hasao no CWC unit hydrograph applies; every cross-drainage structure and outfall of more than 1 km² there needs a site-specific hydrology study with the design rainfall of Clause 2.3.6(c)(ii), the AMC of Clause 3.8.4 and the routing of multi-day storms against the Barak or the Kushiyara behind its embankment (Chapter 5); the 2(b) relationships are not carried south of the line, because the Barak valley is a separate region whose moisture comes from the Bay of Bengal through Bangladesh and the Cachar and Mizo hills (NEER's reading of the rainfall notes). **Basis.** The 2(b) unit hydrograph rests on 14 catchments with 100 bridge-years of record, from 25 catchments of more than 25 km² collected by the Northeast Frontier Railway and RDSO in 1961–83 and 4 catchments gauged by CWC at Ministry of Surface Transport bridges since 1981 (71 bridge-years earlier and 29 added at bridges 463 and 414 and at MOT-3, MOT-4 and MOT-6); the 50-yr peaks it reproduces err by "+40.72% to −57.84%", "very small catchments have larger variation", and the steep MOT-4 and MOT-6 catchments (6.5 m/km against an average of 2.5 m/km) and bridges 184 and 186 are the outliers. The 2(a) relationships rest on 21 gauged catchments. **Neither report rests on an urban, embanked or pumped catchment**: every gauged site is a railway or road bridge on a rural stream. **Area only.** The 2(b) peak depends on A alone; slope enters nowhere, so the SUH gives the same unit hydrograph to a steep hill stream above Guwahati and a flat catchment of the same area on the valley floor, while the 2(a) peak uses L·Lc/S. At the same catchment the two can therefore differ greatly; that difference is a property of the reports, not of the river. **Worked example.** The 2(b) report's example is railway bridge 160 (mile 370/8-9 on the Lumding–Guwahati line, near Longpher, 25°47'N 93°04'48"E): A 470 km², L 56.35 km, Lc 31.40 km, S 2.02 m/km; Qp = 96 m³/s, qp = 0.20 m³/s per km², tp = 11.07 h, adjusted to 11.5 h, TB = 41 h and TD = 1.1 tp = 12.65 h, rounded to 13 h; 50-yr 24-hour point rainfall 22.5 cm (25-yr 19.0 cm; 100-yr 26.0 cm), 13-hour ratio 0.88, giving 19.80 cm, and ARF 0.8406, giving 16.64 cm; loss 0.35 cm/h and base flow 0.05 × 470 = 23.5 m³/s; Q50 = 1,094.81 m³/s. The simplified formulae give 815.18, 1,008.28 and 1,186.82 m³/s for Q25, Q50 and Q100, within 8.02%, 7.90% and 9.63% of the detailed method. The errata correct the example's loss rate from "0.36 cm/hr" to 0.35 cm/h. **Use in the State.** The SUHs apply only to the rural rivers of more than 25 km² (2(a)) or 50 km² (2(b)) that enter or pass the towns, and are computed only as the benchmark of their natural condition (Clause 3.11.4). The urban catchments of Guwahati, Dibrugarh, Silchar and the other towns behind embankments are designed by the Rational Method or SWMM under Clause 3.4, with storage–pump routing behind the sluice and the river

level at the sluice as the tailwater (Chapter 5), and the hill streams of Guwahati, of about 10–120 km², by a hydrograph model with the segment Tc, the 2(b) SUH being only a check above 50 km² (Commentary to Clause 3.7). Below a dam the flood is set by releases (Chapter 5). The design loss rates of 2.4 and 3.5 mm/h are φ-indices fitted to floods of rural catchments; each is used only in rural SUH runs within its own subzone, is not a soil infiltration capacity and is not used to assign HSG (Clause 3.7), in urban SCS-CN or SWMM models, or to size infiltration practices (Chapter 4). The ratio tables are not used outside the sub-areas that Clause 2.3.6(f) assigns them, because the two reports disagree: for the same 24-hour depth the 2(b) 1-hour depth is about 1.8 times the 2(a) depth (NEER's computation), a step across the river at Guwahati that is an artefact of the reports, not of the climate.

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 — Assam 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 Assam 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 — Assam Stormwater Design Manual, Draft v1.0. One form for each point of comparison (POC). Flows in m^3/s, volumes in m^3.

A. Point of comparison (Clause 3.14.2)

Table 3F.10 — Form 3-2: point of comparison

Field	Entry
A1. POC identifier and location	
A2. Area draining to the POC: site (ha) and off-site run-on (ha)	
A3. Off-site run-on passes through site storage? (Clause 3.14.2(c))	
A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3)	
A5. Tailwater applied, including joint cases of Clause 2.12 (Clause 3.14.9(c))	
A6. Flood-sensitive only: largest 10% AEP pre-development peak over all durations, the cap of Clause 2.11.3 (Clause 3.14.7)	
A7. Flood-sensitive only: 50% AEP pre-development peak at the pre-development critical duration (Clause 2.11.3)	

B. Peak flows (Clauses 3.14.7–3.14.10)

Limit: standard catchments 0.9 × Q_pre for the same AEP and duration (Clause 3.14.10(a)); flood-sensitive catchments the caps A6 (for 1% AEP) and A7 (for 50% AEP) (Clause 3.14.10(b)).

Table 3F.11 — Form 3-2: peak flows by AEP and duration

AEP	Duration (h)	AMC	Q_pre	Q_post, uncontrolled	Q_post, routed	Limit	Met?
50% (2-yr)	1	II					
50% (2-yr)	2	II					
50% (2-yr)	3	II					
50% (2-yr)	6	II					
50% (2-yr)	12	III					
50% (2-yr)	24	III					
50% (2-yr)	48	III					
50% (2-yr)	72	III					
10% (10-yr)	1	II					
10% (10-yr)	2	II					
10% (10-yr)	3	II					
10% (10-yr)	6	II					

AEP	Duration (h)	AMC	Q_pre	Q_post, uncontrolled	Q_post, routed	Limit	Met?
10% (10-yr)	12	III					
10% (10-yr)	24	III					
10% (10-yr)	48	III					
10% (10-yr)	72	III					
1% (100-yr)	1	II					
1% (100-yr)	2	II					
1% (100-yr)	3	II					
1% (100-yr)	6	II					
1% (100-yr)	12	III					
1% (100-yr)	24	III					
1% (100-yr)	48	III					
1% (100-yr)	72	III					

C. Volumes and storage (Clauses 3.14.8–3.14.10)

Table 3F.12 — Form 3-2: volumes and storage

AEP	Governing duration (h)	Runoff volume, pre	Runoff volume, post uncontrolled	Retention volume	Detention storage required	Peak water level in storage (m)
50% (2-yr)						
10% (10-yr)						
1% (100-yr)						

C1. Governing duration for storage, and the 24, 48 and 72 h results (Clause 3.14.10): _____

D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

Table 3F.13 — Form 3-2: sensitivity runs

Run	Governing storm (AEP, duration)	Change in Q_post, routed (%)	Change in required storage (%)	Retention volume or WQv governing (Clause 3.8.5(c))
Ia = 0.05S				
Standard peak rate factor (only where a lower factor is used)				—

E. Associated checks (Clause 3.14.12)

Table 3F.14 — Form 3-2: associated checks

Check	Result	Reference in submittal
Drawdown times (Chapter 4)		
Minimum orifice and trash screen (Chapter 4)		
Emergency spillway (Chapter 4)		
Outfall-closed storage check (Chapter 5)		
Downstream analysis (Chapter 5)		

F. Statement by the responsible engineer

I state that this comparison has been made by the procedure of Clause 3.14, with the same design storms in the pre- and post-development runs, and that no runoff has been diverted from one natural catchment to another to meet the criterion (Clause 3.14.2(b)).

Table 3F.15 — Form 3-2: statement by the responsible engineer

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Assam 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 flood plains of the Brahmaputra and Barak valleys, where most CGWB wells stand within 5 m of the surface before and after the monsoon and nearly half within 2 m after it, the Silchar bowl, the char and chapori lands, the beel and pukhuri margins, the land behind embankments, the terai belt of the northern foothills, and the valley floors and hill-foot land of Guwahati, and any area where the groundwater table lies within 3 m of the surface at any time of year (Clause 4.12.1).

To be prepared. This annex will contain (a) the boundaries of the flood-sensitive catchments as a GIS layer and as maps at a scale fit for deciding whether a plot lies inside them, and (b) a map of the shallow-groundwater zone of Clause 4.12.1, with the seasonal high groundwater depth during and after the monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (WRD, NRSC, Survey of India), the embankments, sluices, drainage schemes and gauges of WRD, with their closing levels where they exist [TBC], the warning, danger and highest flood levels of the CWC flood-forecast and level-monitoring sites, with their datum [TBC], the natural-hazard maps that byelaw 120 of the Unified Byelaws 2022 (as amended in 2024) requires in the Master Plans (none yet made [TBC]), the Hilly Area Zone and Eco-Sensitive Zone of the Master Plan for Guwahati 2025, the water bodies scheduled under the Assam Urban Water Bodies (Preservation and Conservation) Act, 2024 and the four schedules of the Guwahati Waterbodies (Preservation and Conservation) Act, 2008, which the 2024 Bill repeals (the enacted text is to be confirmed [TBC]), the boundary of the Deepor Beel Ramsar site, the char areas surveyed by the Directorate of Char Areas Development, and the release records of the operators of the Ranganadi, Lower Subansiri, Kopili and New Umtru projects [TBC], town boundaries (DoHUA and T&CP for the notified Master Plan areas, GMDA for the Guwahati Metropolitan Area, the Municipal Corporations and Municipal Boards, the Development Authorities, and the District Councils of the Autonomous Districts [TBC]), flood maps held by ASDMA, observation-well records of the CGWB and the Irrigation Department, and the extent of the recent alluvium of the Brahmaputra and Barak flood plains, the clays of the beel basins and the Silchar bowl, the char and chapori sands, the bhabar and terai belts of the northern foothills, the thin red loams over the gneiss of the Guwahati hills and the laterite and red loams of the Karbi and Dima Hasao hills, with the land to which the floodplain rule of Clause 4.11 applies and the slopes of more than 10° to which its hill rule applies from soil survey maps (NBSS&LUP, the Agriculture Department, Assam (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 April–November season or, failing that, from the nearest CGWB or State observation well plus 0.5 m and the design flood level of any adjacent river, jan, beel or pukhuri, or of the water ponded behind any embankment that encloses the site (Clause 4.12.1(b)). For the flotation check in the flood plains of the Brahmaputra and Barak valleys, the char and chapori lands, the beel and pukhuri margins and the land behind embankments 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	Brahmaputra flood plain; Barak flood plain (Silchar bowl or other); char or chapori land (Majuli or other); beel or pukhuri margin (Deepor Beel, Silsako or other); land behind an embankment (the DTP dyke at Dibrugarh, the Barak embankment at Silchar or other); terai belt; Guwahati valley floor or hill-foot land; other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, monsoon season	m
shgw_basis	Wells or piezometers used, and period of record	text
tidal_influence	Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b))	yes / no
source	Source agency and date of the data	text
geometry	Zone boundary	polygon

Annex 4B — Tier B tables: PSD and SSR (Table 4.3), retention credit factor C_R, standard outlet sizes; confirmed fixed release coefficients (Table 4.3A)

Supports Clauses 4.4.6.3, 4.14.1, 4.14.2 and 4.14.4 to 4.14.6 of Chapter 4.

4B.1 This annex will hold four tables. Their status in this draft is:

Table 4B.1 — Contents of Annex 4B and their status

Table	Content	Clause	Status in this draft
4B.2	Tier B permissible site discharge (PSD) and site storage requirement (SSR), the values of Table 4.3	4.14.2	To be prepared
4B.3	Retention credit factor C_R	4.4.6.3	To be prepared; C_R = 0 until published
4B.4	Standard outlet sizes	4.14.2 step 4, 4.14.6	Computed in this annex from the orifice equation of Clause 4.6.5.2
4B.5	Fixed release coefficients C_10 and C_2 (Table 4.3A)	4.14.4	Provisional values of Table 4.3A; confirmed values to be prepared

4B.2 PSD and SSR (Table 4.3)

To be prepared. This table will give, for each rainfall zone, hydrologic soil group and post-development imperviousness, the PSD for the 2-yr and 100-yr stages and the SSR, for standard and flood-sensitive catchments, in the layout of Table 4.3. It needs NIH-DHAARA design depths with the climate factor for each zone (Chapter 2, Annex 2A), the sub-daily ratios of Annex 2B, and routing of a set of standard sites by the full method of Clause 4.6 for every AEP and duration of Table 4.1. Each PSD shall be the governing release cap and each SSR the governing storage per hectare, with a margin so that the simplified method is never cheaper than routing. Until it is published, Tier B sites use Clause 4.6, or the fixed-coefficient route of Clause 4.14.3 where the site is 1 ha or less (Clauses 4.14.1 and 4.14.3).

Table 4B.2 — Tier B PSD and SSR (layout of Table 4.3)

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
AS-Z1 North bank: AS-A Lower north bank and Bhutan foothills (Dhubri–Kokrajhar–Bongaigaon–Barpeta–Nalbari–Rangia)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
AS-Z1 North bank: AS-A1 Central and upper north bank (Mangaldoi–Udalguri–Tezpur–Biswanath Chariali–North Lakhimpur–Dhemaji)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
AS-Z2 Guwahati: AS-B Guwahati metropolitan area (Guwahati–Dispur–North Guwahati–Amingaon)	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
AS-Z3 South bank: AS-C Lower and central south bank (Goalpara–Palasbari–Morigaon–Nagaon–Hojai–Golaghat)	C / D	50% / 70% / 90%	—	—	—	—	—
AS-Z3 South bank: AS-C1 Upper Assam (Jorhat–Sivasagar–Charaideo–Dibrugarh–Tinsukia–Margherita)	C / D	50% / 70% / 90%	—	—	—	—	—
AS-Z4 Hill districts: AS-D Karbi hills (Diphu–Hamren–Bokajan–Donkamokam)	C / D	50% / 70% / 90%	—	—	—	—	—
AS-Z4 Hill districts: AS-D1 Dima Hasao hills (Haflong–Maibang–Umrangso–Jatinga)	C / D	50% / 70% / 90%	—	—	—	—	—
AS-Z5 Barak valley: AS-E Barak valley (Silchar–Karimganj–Hailakandi–Badarpur)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(ii))	—	—	—	—

4B.3 Retention credit factor C_R

To be prepared. This table will give C_R for each rainfall zone, hydrologic soil group and design infiltration or drawdown rate of the retention practice (Clauses 4.4.3 and 4.4.6.3). It needs routing of the full duration set of Clause 2.5.2 with NIH-DHAARA depths, with the retention practice modelled as in Clause 4.4.6.2, and the credit expressed as the reduction in governing storage per cubic metre of retention provided. Until it is published, **C_R = 0** (Clause 4.4.6.3).

Table 4B.3 — Retention credit factor C_R (layout)

Zone (Annex 2A)	HSG	Design infiltration or drawdown rate (mm/h)	C_R (–)

4B.4 Standard outlet sizes

4B.4.1 Table 4B.4 gives the largest circular orifice, in 5 mm steps, whose discharge does not exceed a stated permissible discharge at a stated head. It is computed from the orifice equation with the discharge coefficient of Clause 4.6.5.2:

$$Q = 0.60 \times (\pi d^2 / 4) \times \sqrt{(2 g H)}$$

where Q is the discharge (m³/s), d the orifice diameter (m), g = 9.81 m/s² and H the head from the water level to the centre of the orifice (m). Sizes are rounded **down**, so that the orifice never passes more than the permissible discharge. Where the computed size is below 50 mm, the 50 mm minimum of Clause 4.8.2 is shown; it is deemed to comply under Clause 4.5.5.1.

4B.4.2 The table assumes free discharge. Where the tailwater can rise above the orifice (Clause 4.6.6), H is the difference between the upstream and downstream water levels and the orifice shall be checked by routing. The State Stormwater Technical Committee may replace this table when it issues Annex 4B.

Table 4B.4 — Largest orifice diameter (mm) for a permissible discharge at a given head (Cd = 0.60, free discharge)

Permissible discharge (L/s)	H = 0.5 m	H = 1.0 m	H = 1.5 m	H = 2.0 m
5	55	50	50	50
10	80	65	60	55
15	100	80	75	70
20	115	95	85	80
30	140	115	105	100
50	180	150	135	130
75	225	185	170	155
100	260	215	195	180
150	315	265	240	225
200	365	305	275	260
300	450	375	340	315

Check: for 50 L/s at H = 1.0 m, the area is 0.050 / (0.60 × √(2 × 9.81 × 1.0)) = 0.0188 m², so d = √(4 × 0.0188 / π) = 0.155 m, rounded down to 150 mm.

4B.5 Fixed release coefficients (Table 4.3A)

4B.5.1 Table 4B.5 repeats the provisional coefficients of Table 4.3A. They may be used now under the fixed-coefficient route (Clause 4.14.4).

Table 4B.5 — Fixed release coefficients C_10 and C_2 (provisional, Table 4.3A)

Hydrologic soil group	C_10	C_2	Clause	Status
A (sandy, well drained)	0.05	0.02	4.14.4	Provisional
B	0.08	0.03	4.14.4	Provisional
C	0.15	0.08	4.14.4	Provisional
D (clay, poorly drained)	0.25	0.15	4.14.4	Provisional

To be prepared. The confirmed coefficients will replace Table 4B.5. They need NIH-DHAARA depths for each zone and the greenfield curve numbers of Clause 3.3, as described in the commentary to Clause 4.14. Until they are published, the provisional values of Table 4.3A apply.

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 hill-fringe colony in south Guwahati draining to the Bahini; 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 the Bahini in south Guwahati, which reaches the Brahmaputra through the Bharalu and the gated outfall at Bharalumukh is in Annex 5C.

Part 1 — Inputs, hydrographs and routing (Clauses 4.6.1 to 4.6.4)

4C.1 **Inputs.**

Table 4C.1 — Inputs (Illustrative — not design values)

Item	Value	Basis
Site area A	2.0 ha (0.02 km²), one outfall	Clause 4.6.7
Catchment class	Flood-sensitive (Clause 4.5.3)	Clause 4.6.7
Land cover and curve numbers, AMC II	Pre-development: all pervious, CN 70. Post-development, as two sub-areas: directly connected impervious 1.57 ha at CN 98, and pervious open space 0.43 ha at CN 70 (same soil as pre-development). Impervious fraction f = (92 − 70) / (98 − 70) = 0.786, so the area-weighted CN is 92	Clauses 3.9.2, 4.6.7
AMC III conversion	Pervious areas only, for storms of 12 h and longer: CN_III = 23·CN / (10 + 0.13·CN) = 84.3. The impervious CN 98 is not converted	Clause 3.8.4
Initial abstraction	Ia = 0.2S; Ia = 0.05S as a sensitivity run	Clause 3.8.5
Time of concentration Tc	45 min pre-development; 15 min post-development, used for both sub-areas, because the open space is small and drains through the same site system	Clause 4.6.7
Unit hydrograph	SCS triangular; tL = 0.6 Tc; tp = Δt/2 + tL; base 2.67 tp	Clauses 3.6.5, 3.11.2
Time step Δt	5 min (= Tc/3 of the post-development site)	Clause 4.6.2, step 8
24-h depths, 2-, 10-, 100-yr	110, 200, 350 mm, taken as including the climate factor	Clause 4.6.7
Shorter durations	P(t) = P24 · (t/24)^0.40 (assumed ratio set, not Annex 2B)	Clause 4.6.7
48-h and 72-h depths	1.25 and 1.40 × P24, with the 24-h depth on the last day	Clauses 4.6.7, 2.9.2
Storage	Open, vertical-walled, 2,500 m² plan area, excavated, no embankment, not publicly accessible	Clause 4.6.7
Trial outlet	Stage 1: 120 mm orifice at the floor. Stage 2: 470 mm orifice, invert 0.533 m above the floor. No Stage 3	Trial for this annex; Part 2 revises it
Outfall	Free outfall to a receiving drain whose level stays below the outlet invert	Illustrative input

The example follows Clauses 3.8.4 and 3.9.2: the runoff of each sub-area is computed separately and the two are added before routing.

4C.2 **Design rainfall.** Table 4C.2 gives the depths. For example, the 100-yr 6-hour depth is 350 × (6/24)^0.40 = 350 × 0.574 = 201.0 mm.

Table 4C.2 — Design rainfall depths, mm (Illustrative — not design values)

Duration (h)	1	2	3	6	12	24	48	72
50% AEP (2-yr)	30.9	40.7	47.9	63.2	83.4	110.0	137.5	154.0
10% AEP (10-yr)	56.1	74.0	87.1	114.9	151.6	200.0	250.0	280.0
1% AEP (100-yr)	98.2	129.5	152.3	201.0	265.3	350.0	437.5	490.0

4C.3 **Hyetographs.** Storms up to 24 h use the alternating-block method in 5-minute blocks with the peak block at mid-storm (Clause 2.9.1). The 48- and 72-hour storms spread the depth in excess of the 24-hour depth uniformly over the first 24 or 48 h and place the 24-hour alternating-block storm on the last day (Clause 2.9.2). For the 100-yr 72-hour storm: (490.0 − 350.0) / 576 blocks = 0.243 mm per 5 minutes for the first 48 h; the peak 5-minute block on the last day is 350 × (5/1440)^0.40 = 36.3 mm, at 60:00–60:05 h.

4C.4 **Losses.** Table 4C.3 gives S = 25,400/CN − 254 (mm) and Ia = 0.2S. The runoff depth for a rainfall depth P is Q = (P − Ia)² / (P − Ia + S) for P > Ia, and zero otherwise.

Table 4C.3 — Curve numbers and abstractions (Illustrative — not design values)

Condition	AMC	CN	S (mm)	Ia = 0.2S (mm)
Pre-development	II (durations ≤ 6 h)	70	108.9	21.8
Pre-development	III (durations ≥ 12 h)	84.3	47.3	9.5
Post-development pervious open space (0.43 ha)	II (durations ≤ 6 h)	70	108.9	21.8
Post-development pervious open space (0.43 ha)	III (durations ≥ 12 h)	84.3	47.3	9.5
Post-development directly connected impervious (1.57 ha)	All durations (not converted)	98	5.2	1.0

Check: 100-yr 24 h, post-development. Impervious: Q = (350.0 − 1.0)² / (350.0 − 1.0 + 5.2) = 343.9 mm. Pervious, AMC III: Q = (350.0 − 9.5)² / (350.0 − 9.5 + 47.3) = 299.0 mm. Site: 0.786 × 343.9 + 0.214 × 299.0 = 334.2 mm. The post-development columns of Table 4C.4 are these area-weighted site depths.

Table 4C.4 — Storm runoff depth Q, mm (Illustrative — not design values)

Duration (h)	AMC	2-yr pre	2-yr post	10-yr pre	10-yr post	100-yr post
1	II	0.7	20.1	8.2	41.3	79.2
2	II	2.8	28.2	16.9	57.2	108.5
3	II	5.1	34.2	24.5	69.0	130.2
6	II	11.4	47.5	42.9	94.7	177.1
12	III	45.0	70.5	106.6	137.2	249.9
24	III	68.4	96.4	152.6	185.1	334.2
48	III	93.5	123.3	201.0	234.7	421.5
72	III	108.9	139.6	230.3	264.5	473.9

The runoff volume is 10 × Q × A = 20 × Q m³ for this 2.0 ha site: for example 9,478 m³ for the 100-yr 72-hour storm. The routed hydrographs carry up to 0.5% less, because the 5-minute alternating-block storm places 349.5 mm rather than 350.0 mm on the last day.

4C.5 **Unit hydrographs.** The runoff in each 5-minute block (for the post-development site, the sum of the two sub-areas) is convolved with the triangular unit hydrograph of Table 4C.5. The peak is qp = 0.208 × A × Q / tp, with A in km² and Q = 1 mm (Clause 3.11.2).

Table 4C.5 — Unit hydrograph parameters (Illustrative — not design values)

Condition	Tc (h)	tL = 0.6 Tc (h)	tp = Δt/2 + tL (h)	Base 2.67 tp (h)	qp (L/s per mm of runoff)
Pre-development	0.75	0.45	0.492	1.313	8.5
Post-development	0.25	0.15	0.192	0.512	21.7

4C.6 **Release caps (Clause 4.5.3).** The site is flood-sensitive, so the mixed-frequency rule applies. The 100-yr cap is the largest pre-development 10-yr peak over all durations: **356 L/s** (72 h; Table 4.2). The 2-yr cap is the largest pre-development 2-yr peak: **180 L/s** (72 h). Each cap applies to every post-development duration (Clause 4.5.3.1).

4C.7 **Stage–storage–discharge.** The basin is vertical-walled, so storage S = 2,500 × h (m³), where h is the stage above the floor (m). Outlet discharge follows Clause 4.6.5.2 with Cd = 0.60:

- Stage 1, for h ≥ d: Q1 = 0.60 × A1 × √(2g (h − d/2)). For h < d (orifice part-full), the head is taken as d/2 and the result is multiplied by h/d.
- Stage 2 is counted once the water is above its centre: Q2 = 0.60 × A2 × √(2g (h − z2 − d2/2)), where z2 is its invert. Below its centre its flow is ignored, which slightly over-states storage.

Table 4C.6 — Stage–storage–discharge, trial outlet (Illustrative — not design values)

Stage h (m)	Storage (m³)	Stage 1, 120 mm (L/s)	Stage 2, 470 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
0.06	150	3.7	0.0	3.7
0.12	300	7.4	0.0	7.4
0.20	500	11.2	0.0	11.2
0.30	750	14.7	0.0	14.7
0.40	1,000	17.5	0.0	17.5
0.50	1,250	19.9	0.0	19.9
0.60	1,500	22.1	0.0	22.1
0.70	1,750	24.0	0.0	24.0
0.80	2,000	25.9	83.0	108.9
0.90	2,250	27.5	167.8	195.3
1.00	2,500	29.1	222.3	251.4
1.10	2,750	30.7	265.8	296.5
1.20	3,000	32.1	303.2	335.3
1.30	3,250	33.5	336.4	369.9
1.40	3,500	34.8	366.7	401.5

Check at h = 1.00 m: Q1 = 0.60 × 0.01131 × √(19.62 × 0.94) = 0.0291 m³/s; Q2 = 0.60 × 0.1735 × √(19.62 × (1.00 − 0.533 − 0.235)) = 0.2223 m³/s.

4C.8 **Routing.** Each storm is routed by level-pool continuity (Clause 4.6.1): over each 5-minute step, the change in storage equals inflow volume minus outflow volume. The computation used six 50-second sub-steps per 5-minute step. Each row of Table 4C.7 can be checked by hand as 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

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
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
0.085	213	8.8	0.0	8.8
0.17	425	17.6	0.0	17.6
0.30	750	28.0	0.0	28.0
0.40	1,000	33.9	0.0	33.9
0.50	1,250	38.9	0.0	38.9
0.60	1,500	43.3	0.0	43.3
0.70	1,750	47.3	0.0	47.3
0.76	1,900	49.6	0.0	49.6
0.80	2,000	51.0	88.3	139.3
0.90	2,250	54.5	165.3	219.7
1.00	2,500	57.7	216.4	274.1
1.10	2,750	60.8	257.5	318.3
1.17	2,925	62.8	282.8	345.6
1.20	3,000	63.7	293.0	356.7
1.30	3,250	66.5	324.6	391.1

Table 4C.11 — Results for the revised outlet (170 mm and 460 mm orifices) (Illustrative — not design values)

Duration (h)	2-yr detained (L/s)	2-yr max stage (m)	10-yr detained (L/s)	10-yr max stage (m)	10-yr storage (m³)	100-yr detained (L/s)	100-yr max stage (m)	100-yr storage (m³)	10-yr 90% drawdown, 50% blocked (h)
1	15	0.14	28	0.29	734	42	0.57	1,426	31.3
2	20	0.19	34	0.40	990	79	0.76	1,911	32.1
3	22	0.22	37	0.46	1,147	139	0.80	1,999	32.8
6	25	0.26	41	0.56	1,386	194	0.86	2,154	34.2
12	30	0.33	46	0.68	1,692	276	1.01	2,512	39.0
24	32	0.37	49	0.75	1,870	320	1.11	2,766	45.3
48	34	0.40	82	0.77	1,913	343	1.17	**2,913**	44.8
72	34	0.41	84	0.77	1,915	343	1.16	2,911	44.7

Findings:

- **100-yr cap:** largest detained peak 343 L/s ≤ 356 L/s. Met.
- **2-yr cap:** largest detained peak 34 L/s ≤ 180 L/s. Met.
- **Drawdown:** longest blocked drawdown 45.3 h ≤ 48 h (Clause 4.7.1). Met.
- **Governing storage: 2,913 m³** (100-yr, 48 h), at a maximum stage of **1.17 m**. The larger low-flow orifice releases more water early in the long storms, so the revised outlet needs about 220 m³ less storage than the trial outlet. Table 4.2 in Clause 4.6.7 reports this revised design.
- **Governing storms (Clause 4.6.2, step 12):** storage, the 100-yr 48-hour storm; Stage 1, the 10-yr 24-hour storm (drawdown); Stage 2, the 100-yr 48-hour storm (cap).

Part 3 — Sensitivity, retention, spillway, outlet details and safety

4C.13 **Ia = 0.05S sensitivity (Clause 3.8.5).** With S converted as S0.05 = 25.4 × 1.33 × (S0.20 / 25.4)^1.15, the governing 100-yr 48-hour run gives 2,898 m³ of storage and a 341 L/s peak, slightly below the default run. The pre-development 10-yr peak, and so the 100-yr cap, falls to 344 L/s. The design is based on the default run (Clause 3.8.5(c)); the sensitivity results are reported on Form 3-2.

4C.14 **Retention and retention credit (Clauses 4.4.2 and 4.4.6).** With an illustrative retention depth P_R = 40 mm, Q_R is computed for each sub-area at AMC II, because a composite CN is not used for retention (Clause 3.9.4). Impervious, CN 98: S = 5.2 mm, Ia = 1.0 mm, Q_R = (40 − 1.0)² / (40 − 1.0 + 5.2) = 34.4 mm. Pervious, CN 70: S = 108.9 mm, Ia = 21.8 mm, Q_R = (40 − 21.8)² / (40 − 21.8 + 108.9) = 2.6 mm. RRV = 10 × (34.4 × 1.571 + 2.6 × 0.429) = **552 m³**. The retention is modelled as a store that is empty at the start of the storm and captures all runoff until full, with no infiltration during the storm (Clause 4.4.6.2).

Table 4C.12 — Retention credit by routing, revised outlet (Illustrative — not design values)

100-yr storm	Storage without retention (m³)	Storage with retention (m³)	Reduction (m³)
24 h	2,766	2,628	138
48 h	2,913	2,906	7
72 h	2,911	2,911	0

The governing storage falls from 2,913 to 2,906 m³, so the retention credit is 7 m³, about 1% of the RRV. The retention is still required in full for its own purposes (Clause 4.4.1, Chapter 8).

4C.15 **Emergency spillway (Clause 4.9).** The facility is excavated, with no embankment, so Clause 4.9.7 applies: the overflow route is treated as the spillway and must meet Clause 4.9.1.

- Design flow: the 1% AEP peak inflow, 1,089 L/s, with the outlet blocked and the basin full to the crest.
- Crest: the 1% AEP maximum water level with the outlet working is 1.17 m; with the recommended 0.15 m clearance (Clause 4.9.3) the crest is set at **1.35 m**.
- Crest length: a broad-crested weir with Q = C × L × H^1.5, C = 1.7 (an illustrative coefficient for a broad-crested weir in SI units; Clause 4.6.5.2 requires a coefficient suited to the shape). With L = 4.0 m: H = (1.089 / (1.7 × 4.0))^(2/3) = 0.295 ≈ **0.30 m**.
- Maximum level with the spillway flowing: 1.35 + 0.30 = 1.65 m. With 0.3 m freeboard (Clause 4.9.1), the top of the walls is at least **1.95 m** above the floor.
- The spillway discharges to the 1% AEP overland flow path, away from buildings (Clause 4.9.4).

4C.16 **Outlet details (Clause 4.8).**

Table 4C.13 — Outlet checks, revised outlet (Illustrative — not design values)

Item	Requirement	Value	Result
Minimum orifice	≥ 50 mm (Clause 4.8.2)	170 mm	Met
Rack bar spacing	≤ half the smallest opening and ≥ 25 mm (Clause 4.8.3)	≤ 85 mm	Set at 75 mm
Rack open area	≥ 10 × area protected (Clause 4.8.3)	10 × (0.0227 + 0.1662) m² = 1.89 m² for one rack around both orifices	Provide ≥ 1.89 m²
Anti-vortex, Stage 1	Needed if head > 1.5 d (Clause 4.8.4)	Head up to 1.08 m > 0.26 m	Required
Anti-vortex, Stage 2	Needed if head > 1.5 d (Clause 4.8.4)	Head above centre up to 0.41 m < 0.69 m	Not required
Isolation	Facility serving > 1 ha (Clause 4.8.6)	Serves 2.0 ha	Stop-log slot or penstock, normally open
Outlet barrel	≥ 300 mm (Clause 4.8.5)	Sized under Chapter 9 for 343 L/s	To be designed

4C.17 **Safety (Clause 4.15).** The 10-yr depth (0.77 m) exceeds the 0.45 m limit for publicly accessible storage (Clause 4.15.1(a)), so the facility is not open to the public. It has vertical walls higher than 0.6 m and a depth of more than 1.2 m when the spillway flows, so a non-climbable fence at least 1.2 m high with a lockable gate is required (Clause 4.15.3). Signs and a depth marker are provided (Clause 4.15.5).

4C.18 **Summary of the design (Illustrative — not design values).**

Table 4C.14 — Summary of the revised design (Illustrative — not design values)

Item	Value
Storage	2,500 m² plan area; 2,913 m³ at the 1% AEP maximum level of 1.17 m
Stage 1	170 mm orifice at the floor, with trash rack and anti-vortex plate
Stage 2	460 mm orifice, invert 0.53 m
Spillway	Crest 1.35 m, length 4.0 m, maximum level 1.65 m
Top of walls	≥ 1.95 m above the floor
100-yr peak release	343 L/s (cap 356 L/s)
2-yr peak release	34 L/s (cap 180 L/s)
10-yr drawdown, 50% blocked	45.3 h (limit 48 h)
Retention	RRV 552 m³ provided in addition; credit 7 m³
Still to be checked	Outfall-closed check on an outfall to the Bahini in south Guwahati, which reaches the Brahmaputra through the Bharalu and the gated outfall at Bharalumukh (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 — Assam 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 Assam 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 — Assam 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 — Assam Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for Tier B sites using Clause 4.14.2. It can be used only after Table 4.3 is published in Annex 4B; until then, Tier B sites use Clause 4.6 or, for sites of 1 ha or less, the fixed-coefficient route (Clauses 4.14.1 and 4.14.3).

A. Eligibility (Clause 4.14.1)

Table 4F.12 — Form 4-2: eligibility

Field	Entry
A1. Local body (Tier B)	
A2. Site area A (ha): 2 ha or less outside flood-sensitive catchments; 0.5 ha or less inside them	
A3. Catchment class: standard or flood-sensitive (Annex 4A)	

B. Table 4.3 values (Clause 4.14.2, step 1)

Table 4F.13 — Form 4-2: values read from Table 4.3

Field	Entry
B1. Rainfall zone (Annex 2A)	
B2. Hydrologic soil group	
B3. Post-development imperviousness (%)	
B4. PSD 2-yr (L/s/ha)	
B5. PSD 100-yr (L/s/ha), for the catchment class	
B6. SSR (m³/ha), for the catchment class	

C. Storage and release (Clause 4.14.2, steps 2 and 3)

Table 4F.14 — Form 4-2: storage and release

Line	Quantity	Computation	Value
C1	RRV provided (m³)	Clause 4.4	
C2	C_R	Annex 4B; 0 until published	
C3	V_credit (m³)	C2 × C1 (Clause 4.4.6.3)	
C4	Required storage V (m³)	B6 × A − C3	
C5	Storage provided (m³)	From drawings	
C6	Q_PSD,2 (L/s)	B4 × A	
C7	Q_PSD,100 (L/s)	B5 × A	

D. Outlet and other provisions (Clause 4.14.2, steps 4 and 5)

Table 4F.15 — Form 4-2: outlet and other provisions

Field	Entry
D1. Low-flow orifice: diameter (mm) from the Annex 4B outlet table, head (m), at least 50 mm	
D2. Upper control: type, size and level	
D3. Spillway or overflow (Clause 4.9)	
D4. RWH accounting (Clause 4.11)	
D5. Safety provisions (Clause 4.15)	

E. Statement

I state that the values above are taken from Annex 4B for the site's zone, soil group, imperviousness and catchment class, and that the storage and outlets shown on the drawings match them.

Table 4F.16 — Form 4-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Assam 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 — Assam 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 — Assam 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 Assam. Assam has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Assam 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 a river-locked outfall, row F10 records the sluice, the CWC gauge and its datum, the lock and the pump-down of Clause 5.8.5(a), and for an outfall to a beel, pukhuri or pond, its starting level and surveyed stage–storage relation under Clause 5.8.5(e).

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
Brahmaputra at Dibrugarh, Neamatighat (Jorhat), Tezpur, Guwahati (DC Court), Goalpara and Dhubri	Brahmaputra valley	Riverine outfall reaches through WRD embankment sluices; highest levels 106.48 m (Dibrugarh, 3 September 1998), 87.37 m (Neamatighat, 11 July 1991), 66.59 m (Tezpur, 27 August 1988), 51.46 m (Guwahati, 21 July 2004), 37.43 m or 37.35 m (Goalpara, 1954 or 2004; 37.43 m applies) and 30.36 m or 30.37 m (Dhubri, 1988 or 2019; 30.37 m applies); danger levels 105.70, 85.04, 65.23, 49.68, 36.27 and 28.62 m; CWC levels as reported, datum [TBC]; lock the 72-hour storm and while the river stays above the sill, not less than 7 days without a stage record	5.8.1, 5.8.5
Bharalu and Bahini to the Bharalumukh sluice	Guwahati (Bharalu basin)	Major drain and river-locked outfall; the Bahini rises in Meghalaya at Umtyrnga and becomes the Bharalu at Jonali; catchment ≈120 km² (≈10.94 km² or ≈11 km² of city drainage, conflict); 72 m³/s by gravity, 7 m³/s of pumps (2008, as reported; present capacity [TBC]); Natun Bazar sluice on the Bahini; carries sewage (Clause 8.9)	5.2, 5.8.1, 5.8.5
Mora Bharalu, Deepor Beel and the Khanajan, with the Basistha and the Kalmani	Guwahati (Dipar basin)	Major drains and receiving storage; Deepor Beel ≈10.1 km² all year, up to ≈40.1 km² in floods (as reported), stage–storage [TBC]; starts full; Ramsar site and sanctuary, no project credit for its storage; outlet by the Khanajan to the Brahmaputra; Mora Bharalu reported at 45 m³/s	5.2, 5.8.1, 5.8.5
Silsako basin and the ADB Bahini works	Guwahati (Silsako basin)	Receiving storage; 59,000 m³ retention pond with a 1.6 m³/s pump station and +7.8 m³/s in three pumping stations (ADB, 2025), counted only when commissioned and confirmed by GMDA; starts full	5.8.5
Bondajan with the Noonmati pump house; the Lakhimijan	Guwahati	Major drains; Noonmati 4 × 1,000 L/s and an older 2 × 1,700 L/s (as reported), pumped inflow included; WRD dewatering pumps credited only where confirmed permanent	5.2, 5.8.5
DTP drain past Larua Jamira beel to the Sessa sluice	Dibrugarh	Major drain and river-locked outfall; 32.053 km; capacities 105.50, 142.97 and 61.11 m³/s by reach; tailwater not less than 97.50 m at the sluice, beel full and drain flowing full (ADB IEE, 2017; datum [TBC]); carries sewage	5.2, 5.8.1, 5.8.5
Barak at Annapurnaghat (Silchar) and Badarpurghat	Barak valley	Riverine outfall reaches behind the Barak embankment; highest levels 21.84 m (1 August 1989) and 18.48 m (11 September 2007), danger levels 19.83 and 16.85 m (as reported); 2022 peak 21.59 m after the Bethukandi cut; breach check; Silchar's outfall channels [TBC]	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Kushiyara at Karimganj; the Dhaleswari and the Katakhal (Hailakandi)	Barak valley	Riverine outfall reaches; Karimganj highest level 16.57 m (10 June 2010), danger level 14.94 m (as reported); Hailakandi levels [TBC]	5.8.1, 5.8.5
Jia Bharali, Subansiri, Burhidihing, Dikhow, Kopili, Beki, Manas, Puthimari and Pagladiya at their CWC sites	Brahmaputra valley	Riverine outfall reaches; levels as listed in Clause 5.8.5(d) (as reported), the Kopili at Dharamtul 58.09 m (21 July 2004, CWC bulletins); Manas at Mathanguri 100.28 m or 102.28 m (102.28 m applies) [TBC]; lock not less than 72 hours without a stage record; Kopili outfalls designed for the river's pH	5.8.1, 5.8.5
Digaru at Sonapur, Kulsi and Krishnai (Dudhnai)	Kamrup, Goalpara (from Meghalaya)	Riverine outfall reaches; level-monitoring sites with no published level (as reported) [TBC]; modelled or surveyed flood level required; the Meghalaya edition governs the reaches in Meghalaya	5.8.1, 5.8.5
Ranganadi, Subansiri, Kopili, Manas and Umtru below their dams	North bank; Kopili and Umtru basins	Release reaches; Ranganadi release 1,412.57 m³/s (2017, as quoted); Umtru 3,820 m³/s (New Umtru spillway); Lower Subansiri, Kopili HEP and Kurichu releases [TBC]; release before, during and after the storm; lock not less than 72 hours	5.8.3, 5.8.5
Ranganadi (NEEPCO), Lower Subansiri (NHPC), Kopili (NEEPCO, Khandong), Kurichu (Bhutan) and New Umtru (Meghalaya) dams	Upstream of Assam's reaches	Releases and gate operation to be included in river levels (operating rules and release records [TBC]); no credit for warnings, drawdown or attenuation	5.8.3, 5.8.5
Beels, pukhuris, jans and retention ponds that receive town drains, among them Borsola, Sorusola and the scheduled water bodies of every Master Plan area	Statewide	Receiving storage; full to the outlet at the start; surveyed stage–storage [TBC]; storage belongs to the system; interception and screens before any outfall that carries sewage	5.8.5
Juris and hill streams of the Guwahati fringe (Bahini above Jonali, Basistha, Kalmani, Khanapara–Jorabat streams), of the Karbi and Dima Hasao hills and of the north-bank bhabar fans; the Jinjiram from the Garo hills	Guwahati fringe; hill districts; north bank	Hill streams; ungauged; 1% AEP study with bulking and blockage and surveyed flood marks; invert at least 0.5 m above the highest surveyed bed; silt trap at the hill–plain break; lock not less than 24 hours	5.2, 5.8.1, 5.8.5
Drains of GMC, GMDA, the Municipal Corporations and Boards, the Development Authorities, PWD and NHAI 1.0 m wide or more; WRD drainage-scheme channels	Assam	Major drains; WRD permission under the 1953 Act through an embankment or sluice; owner's consent, design water level and flap gate	5.2, 5.8.5
River mouths subject to sand-bar closure	None in Assam	Not applicable (Clause 5.1.4)	5.13.1

To be prepared. This annex will list and map (a) the major drains of each basin plan, (b) the riverine outfall reaches where backwater shall be modelled, with their upstream and downstream limits and the source of their design flood levels, and (c) the river mouths and creek inlets subject to seasonal sand-bar closure, with the most recent pre-monsoon bar crest levels and any WRD mouth-maintenance programme. It needs WRD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (WRD), the drain inventories of GMC and other local bodies, basin stormwater master plans (Chapter 11), and base mapping from the Survey of India and NRSC. Until it is published: every river, WRD canal, the Bharalu and the Bahini, the Mora Bharalu, the Basistha, the Kalmani, the Khanajan, the Bondajan and the Lakhimijan in Guwahati, the DTP drain of Dibrugarh to the Sessa, every channel of a WRD drainage scheme and every drain that discharges through a sluice in an embankment, any drain built or held by GMC, GMDA, a Municipal Corporation, a Municipal Board, a Development Authority, PWD or NHAI with an internal width of 1.0 m or more, and every jan, juri or other natural channel 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 Assam) are assumed closed at the start of the monsoon unless the Water Resources Department certifies otherwise (Clause 5.13.2).

Table 5B.2 — Attributes of the Annex 5B layers (layout)

Field	Content	Unit or format
feature_id	Unique identifier	text
name	Name of the drain, river, canal, creek or mouth	text
category	Major drain; riverine outfall reach; mouth subject to sand-bar closure	text
clause	Clause of Chapter 5 under which it is listed	text
reach_limits	Upstream and downstream limits of the reach	text
design_flood_level_source	WRD design or highest recorded flood level, or hydraulic model (Clause 5.8.2)	text
reservoir_release	Upstream reservoir or tank and its operating rule, where any (Clause 5.8.3)	text
bar_crest_level	Most recent pre-monsoon bar crest level, for mouths	m (Survey of India datum)
mouth_programme	WRD mouth-maintenance programme and certification (Clause 5.13.2)	text
source	Source agency and date	text
geometry	Line (drains and reaches) or point (mouths)	line / point

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Annex 5C — Worked example: outfall-closed check for a site on the hill fringe of south Guwahati draining to the Bahini

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, on the hill fringe of south Guwahati. It discharges through its own outlet chamber and a flap gate to a public storm drain that joins the Bahini, whose level rises when the stream comes down from the Khasi hills in spate and stays up while the Bharalu below it is held behind the closed Bharalumukh sluice, 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 Assam an outfall to a hill stream whose invert is below its design level is closed for the storm and the stream's recession, and for not less than 24 hours; a river-locked outfall, such as every outfall in the Bharalu basin at Bharalumukh, is closed for the whole 72-hour storm and for as long as the Brahmaputra stays above the sill, not less than 7 days where no stage record has been analysed, and its stored volume is pumped down within 48 hours with the gate still shut; an outfall to a release reach is closed for not less than 72 hours; and an outfall below the design level of a full beel, pukhuri or pond is closed for the whole storm, under Clause 5.8.5. In each of those cases the facility must store or pump the volume of the longer closure, up to the whole storm volume (Clause 5.9.4); that needs more storage, or pumping, than this example shows. The routing, the volume balance of Clause 5.10.4 and the assessment are the same. The public drain's own outfall to the Bahini would also need the debris rack, the bulking factor and the silt trap of Clause 6.3.6 and an invert above the range of bed movement of Clause 5.8.5(f); and on a natural slope of more than 10° the facility itself would be a lined tank, not an infiltrating basin (Clause 4.11 (hill rule)).

Table 5C.1 — Inputs (Illustrative — not design values)

Item	Value	Basis
Facility	Revised facility of Annex 4C: 2,500 m² plan area, vertical walls; 170 mm orifice at the floor; 460 mm orifice, invert 0.53 m	Annex 4C, Table 4C.14
Storm	1% AEP, 48 h, peak day last, AMC III; 72 h also run	Clause 5.10.2
Inflow	Post-development 1% AEP hydrographs of Annex 4C (48 h: 8,420 m³; 72 h: 9,468 m³)	Annex 4C
Receiving drain levels at the connection, J1, J2 and J3	Below the site outlet invert (from the drain owner's model)	Illustrative input
Receiving drain during each lock window	Backs up above the site outlet invert, so the site cannot discharge	Illustrative input; Clause 5.10.3(b)
Flap gate on the site outlet	Set 0.15 m below the orifice inverts in the outlet chamber, so that outside the lock windows its opening head and head loss do not affect the orifice control	Illustrative input; to be confirmed from the certified curve (Clause 5.11.2)
Lock windows	Two of 6 h each, starts 12.4 h apart (semi-diurnal tide)	Clause 5.10.3(a)
Pumps	None	—

5C.2 **Cases of Table 5.2.** Because the receiving drain stays below the site outlet in J1, J2 and J3 (Table 5C.1), those cases give the free-outfall results of Annex 4C: in J2 the 1% AEP maximum water level is **1.17 m** (2,913 m³), and in J3 (10% AEP, 48 h) it is 0.77 m. R1 and R2 do not apply, because the site does not drain to a river. J4, the outfall-closed check, is worked below.

Lock windows (Clause 5.10.3)

5C.3 The peak 1-hour block of the final 24 hours of the 48-hour storm is 35:35–36:35 h, with 98.2 mm (the 1-hour depth of Table 4C.2). Two runs are made:

- **Run A:** the first window is centred on that block: 33:05–39:05 h; the second starts 12.4 h later: 45:29–51:29 h.
- **Run B:** the first window starts at that block: 35:35–41:35 h; the second: 47:59–53:59 h.

For the 72-hour storm, every time is 24 h later.

5C.4 Gravity discharge is zero inside each window. Outside the windows the outlet discharges through the orifices of Table 4C.10. The routing is the same level-pool routing as in Annex 4C.

Results

Table 5C.2 — Outfall-closed check results (Illustrative — not design values)

Storm	Run	Lock windows (h:min)	Maximum stage (m)	Maximum storage (m³)	Time of maximum (h:min)	Largest release after a window (L/s)
1% AEP, 48 h	A	33:05–39:05; 45:29–51:29	2.01	5,019	39:05	566
1% AEP, 48 h	B	35:35–41:35; 47:59–53:59	**2.10**	**5,238**	41:35	584
1% AEP, 72 h	A	57:05–63:05; 69:29–75:29	2.00	5,012	63:05	565
1% AEP, 72 h	B	59:35–65:35; 71:59–77:59	2.09	5,233	65:35	584

Run B of the 48-hour storm governs. The first window closes the outlet just as the storm peak arrives, so the whole peak is stored. The second window arrives when the facility has drained to about 0.7 m, below the Stage 2 orifice, and adds little.

5C.5 **Volume balance (Clause 5.10.4).** Table 5C.3 gives the balance for Run B. The outflow in each period is found by continuity: outflow = storage at start + inflow − storage at end.

Table 5C.3 — Volume balance, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Period (h:min)	Inflow (m³)	Gravity outflow (m³)	Pumped (m³)	Storage at start (m³)	Storage at end (m³)
0:00–35:35, before window 1	3,817	2,213	0	0	1,604
35:35–41:35, window 1	3,634	0	0	1,604	5,238
41:35–47:59, between windows	941	4,423	0	5,238	1,756
47:59–53:59, window 2	28	0	0	1,756	1,784
After 53:59	0	1,784	0	1,784	0
Total	8,420	8,420	0	—	—

Check for window 1: V_inflow = 3,634 m³ ≤ V_storage available + V_pumped + V_gravity = (5,238 − 1,604) + 0 + 0 = 3,634 m³. The facility therefore needs **5,238 m³** of storage, which the routing confirms.

Table 5C.4 — Stage hydrograph, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
24	20	Open	18	0.18	445
28	39	Open	24	0.25	621
32	59	Open	32	0.36	906
34	85	Open	37	0.47	1,166

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
36	286	Closed	0	0.78	1,944
38	106	Closed	0	1.73	4,321
40	66	Closed	0	1.96	4,904
42	51	Open	529	1.79	4,472
44	42	Open	204	0.87	2,181
46	37	Open	49	0.74	1,854
48	33	Open	47	0.70	1,756
50	0	Closed	0	0.71	1,784
54	0	Closed	0	0.71	1,784
56	0	Open	43	0.58	1,459
60	0	Open	32	0.37	921
66	0	Open	16	0.16	397
72	0	Open	7	0.06	162

Assessment

5C.6 **Clause 5.10.4(a).** The facility of Annex 4C reaches 1.17 m in J2, and its spillway crest is at 1.35 m (Annex 4C). In the outfall-closed check the stage reaches 2.10 m, so the spillway would operate. **The facility of Annex 4C fails the check.**

5C.7 **Remedy.** Pumping (Clause 5.12) does not help here: during the lock windows the receiving drain is itself closed, and pumping into it would raise its level, which Clause 5.12.3 does not permit. The remedy is more storage. Keeping the plan area of 2,500 m² and the outlets of Annex 4C:

- the facility must hold 5,238 m³, to a stage of **2.10 m**;
- the spillway crest is set above that stage, with the 0.15 m clearance recommended in Clause 4.9.3: **2.25 m**;
- with the 4.0 m spillway of Annex 4C (head 0.30 m), the maximum level with the spillway flowing is 2.55 m, and with 0.3 m freeboard the top of the walls is at least **2.85 m** above the floor.

The outfall-closed check therefore governs the storage: 5,238 m³ against 2,913 m³ from the release-rate checks, about 80% more. A larger plan area would make the facility shallower; the outlet, caps and drawdown would then have to be re-checked, because the stage–discharge relationship changes.

5C.8 **Release after the lock.** When the first window ends, the stored water is released under a head of about 2 m, at up to 584 L/s. This is above the 100-yr cap of 356 L/s. Clause 5.10.4 allows this, because the release reaches a drain that has itself just reopened, and requires it to be included in the J4 run of the downstream analysis (Clauses 5.4 and 5.9) and reported on Form 5-1, Section H.

5C.9 **Drawdown after the storm (Clause 5.10.5).** The J1 tidal curve stays below the site outlet (Table 5C.1), so the drawdown of Annex 4C applies: 45.3 h for 90% of the 10-yr storage with the low-flow orifice 50% blocked, within the 48-hour limit of Clause 4.7. In Run B, 90% of the maximum J4 storage is released 22.6 h after the maximum.

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 31 March each year and after every event in which it closed against a storm flow (Clause 5.11.5).

- The deeper facility is checked for flotation with groundwater at the design groundwater level; in the flood plains of the Brahmaputra and Barak valleys, the char and chapori lands, the beel and pukhuri margins and the land behind embankments 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

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Form 5-1 — Downstream and Tailwater Report

Supports Clauses 5.3 to 5.14 of Chapter 5.

Draft form — Assam 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 pukhuri, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or pukhuri: 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, Guwahati, dyke-protected and bowl towns, tributaries and release reaches, beels and pukhuris, hill streams, and drains of other bodies: for a river-locked outfall, the operator of each sluice, gate and pumping station identified (WRD or the local body), gate sills, embankment, dyke or wall crest, installed capacity, operating levels and sluice-closing level obtained, with every level tied to the datum of the nearest CWC or WRD gauge and the operator named; 1% AEP river level at the outfall from a model, and not below the highest recorded level at the nearest CWC gauge transferred to the outfall (Dibrugarh 106.48 m, Neamatighat 87.37 m, Tezpur 66.59 m, Guwahati (DC Court) 51.46 m, Goalpara 37.43 m, Dhubri 30.37 m, Annapurnaghat 21.84 m, Badarpurghat 18.48 m, Karimganj 16.57 m, or the tributary levels of Clause 5.8.5(d)), with the profile or interpolation used; 10% AEP river level, not below the danger level transferred; the datum of each CWC level confirmed or flagged; drain, jan or beel behind the gate routed with its whole catchment (including any part in Meghalaya) and present storage, starting full to its outlet, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the design river level; the lock (the whole 72-hour storm and while the river stays above the sill, from the stage record used, or not less than 7 days on the Brahmaputra, the Barak and the Kushiyara and 72 hours on a tributary) and the pump-down to the starting level within 48 hours with the gate shut; gate-failure and breach checks; for Guwahati, the basin (Bharalu, Dipar, Silsako, Foreshore, North Guwahati or Kalmoni), the Bharalumukh pumps confirmed by WRD, the Noonmati and Bondajan pumped inflows, the Deepor Beel level and the Brahmaputra level at the Khanajan's outfall, and any ADB or other works counted only once commissioned and confirmed; for Dibrugarh, the Sessa sluice tailwater not below 97.50 m with Larua Jamira beel full and the drain flowing full, and its datum; for Silchar, the Annapurnaghat level and the breach check with the enclosed area filled to the Barak level; for a release reach, the operator's consent, levels in writing (feet converted at 1 ft = 0.3048 m, datum stated), the largest recorded release (Ranganadi 1,412.57 m³/s; Umtru 3,820 m³/s) or the spillway capacity, placed before, during and after the storm, and a lock of not less than 72 hours, with no warning, drawdown or attenuation credited; for a Kopili outfall, the river's pH; for a beel, pukhuri, jan or pond, its outlet level, surveyed monsoon water line, surveyed stage–storage relation, starting level and design level, and the interception and screens before it; for a hill stream, the 1% AEP study with the rainfall of its sub-area (the Guwahati catchment rule of Clause 2.3.6(c)(i) where it applies), the bulking and blockage of Clause 6.3.6, the surveyed flood marks and their sources, the bed survey and range of bed movement, the invert at least 0.5 m above the highest surveyed bed level, the scour depth of the foundation, the silt trap at the hill–plain break, and a lock of not less than 24 hours; WRD's permission under the Assam Embankment and Drainage Act, 1953 (ss.15 and 16); owner's consent (GMC under s.242 of the 1969 Act; a Municipal Corporation under ss.171 and 177 of the 2022 Act; PWD, NHAI, GMDA or another body; the District Council in an Autonomous District), permitted rate, design water level or computed channel level, and flap gate; and the byelaw 26(ix)/44(ix) setbacks, the water-bodies law, the Hill Land Act, the Master Plan riverfront strip and the byelaw 45(c) flood level checked (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				

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
R2				

H. Outfall-closed check (Clause 5.10; Clause 5.14, item 7)

Table 5F.9 — Form 5-1: outfall-closed check

Field	Entry
H1. Reason the check applies (Clause 5.10.1)	
H2. Storm: AEP, 48 h and 72 h, AMC III (Clause 5.10.2)	
H3. Lock duration and basis: default of two 6-hour windows, or site study (Clause 5.10.6); extension for sand-bar closure (Clause 5.13.5)	
H4. Lock windows of the two runs (start and end times) (Clause 5.10.3(d))	
H5. Maximum stage in each facility, against its 1% AEP maximum water level (Clause 5.10.4(a))	
H6. Maximum stage in the minor and major systems, against the Chapter 6 limits (Clause 5.10.4(b))	
H7. Property connections: surcharge level, or non-return valves fitted (Clause 5.10.4(c))	
H8. Stage hydrographs (attach)	
H9. Drawdown after the storm under the J1 tidal curve, and pumping where needed (Clause 5.10.5)	

Table 5F.10 — Form 5-1: volume balance for each lock window (Clause 5.10.4)

Period	Inflow (m^3)	Gravity outflow (m^3)	Pumped (m^3)	Storage at start (m^3)	Storage at end (m^3)
Before window 1					
Window 1					
Between windows					
Window 2					
After window 2					

I. Gates and valves (Clause 5.11; Clause 5.14, item 8)

Table 5F.11 — Form 5-1: schedule of flap gates, tide gates and non-return valves

Location	Type	Size (mm)	Invert (m, project datum)	Certified head–discharge data (reference)	Stop-log or penstock (outfalls > 600 mm)

J. Pumped outfalls (Clause 5.12; Clause 5.14, item 9)

Table 5F.12 — Form 5-1: pumped outfalls

Field	Entry
J1. Reason pumping is needed (Clause 5.12.1)	
J2. Duty capacity (m³/s) at the static head for the J2 tailwater; standby capacity (Clause 5.12.2)	
J3. Effect on the receiving water level (Clause 5.12.3)	
J4. Power supply: two independent supplies, or standby generation with 72 h of fuel; automatic changeover (Clause 5.12.4)	
J5. Level of electrical panels, controls, generators and fuel, against the higher of the 1% AEP flood level + 0.5 m and HAT + surge + SLA + 0.5 m (Clause 5.12.5)	
J6. Discharge arrangement (Clause 5.12.6); controls, alarms and logging (Clause 5.12.7); screens (Clause 5.12.8)	

K. Sand bar (Clause 5.13; Clause 5.14, item 10)

Table 5F.13 — Form 5-1: sand-bar assumption

Field	Entry
K1. River mouth or creek inlet concerned	
K2. Mouth assumed closed, or open with WRD certification attached (Clause 5.13.2)	
K3. Bar crest level from the most recent pre-monsoon survey (m) and the closed-mouth tailwater (Clause 5.13.3)	
K4. Extension of the lock duration, where required (Clause 5.13.5)	

L. Inspection and maintenance (Clause 5.14, item 11)

Table 5F.14 — Form 5-1: inspection and maintenance

Field	Entry
L1. Gate and valve inspection before 31 March and after closure events (Clause 5.11.5)	
L2. Pump test runs before 31 March (Clause 5.12.9)	
L3. Other requirements for the maintenance plan (Chapter 10)	

M. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 5 of the Assam 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	

Field	Entry
Date	

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

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — Assam Stormwater Design Manual, Draft v1.0. For sites of less than 0.5 ha. The Authority may accept this statement in place of the full analysis only where every answer in Section B is "Yes". Otherwise submit Form 5-1.

A. Site

Table 5F.16 — Form 5-2: site

Field	Entry
A1. Project name, applicant and location	
A2. Site area (ha), less than 0.5 ha	
A3. Receiving public drain: name or reference, type and size	
A4. Site Runoff Control Report reference (Form 4-1)	

B. Conditions (Clause 5.3.4)

Table 5F.17 — Form 5-2: conditions

Condition	Yes / No	Evidence
B1. The receiving public drain has documented capacity for its minor-system design flow (Chapter 6)		
B2. No flood-prone location is recorded within 500 m downstream of the site outfall. Records checked: local body, GMC, ASDMA, WRD (Clause 5.3.3(d))		
B3. The site does not drain to a tidal or backwater-affected outfall		

C. Route plan

Table 5F.18 — Form 5-2: attachments

Attachment	Attached?
C1. Plan of the drainage route from the site outfall for 500 m downstream, with the receiving drain and any recorded flood-prone locations	
C2. Copy or reference of the drain capacity record	

D. Statement

I state that the site meets the conditions of Clause 5.3.4 as shown above, and that the records listed have been checked.

Table 5F.19 — Form 5-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Assam 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 Assam 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 Assam 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 Guwahati Municipal Corporation standard details, IIT Guwahati and NIT Silchar, whose hydraulic testing capability was not confirmed during research [TBC], or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

Table 6A.1 — Interim requirements for inlets until Annex 6A is published (from Chapters 6 and 9)

Item	Requirement	Clause
Inlet type on public streets	Kerb-opening or combination inlets, unless the Approving Authority accepts grate-only inlets for a location	6.6.1(a)
Inlet level	Openings at road level; gutter depression where practicable	6.6.1(b)
Clean capacity	FHWA HEC-22 (4th ed., 2024) or the manufacturer's tested rating for the exact geometry; CPHEEO §5.6.2 equations as a cross-check only	6.6.2
Clogging, on grade	Grate 50%; kerb opening 10%	6.6.3, Table 6.5
Clogging, in a sag	Grate 50%; kerb opening 20%	6.6.3, Table 6.5
Spacing	By sequential calculation from the top of each gutter run; not more than 30 m on kerbed roads	6.6.4
Kerb opening size	Clear height at least 100 mm; length at least 1.0 m	9.11.4
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 Assam, by land use and drain type, for sizing the silt traps of Clause 6.13.3, and a calibration of the sediment allowance of Clause 6.7.8 against measured silt depths. It needs desilting records (volume or mass removed per drain length and per catchment area, with dates), silt-depth surveys before and after the monsoon season, and catchment land-use and soil data (data and likely sources: desilting records of Guwahati Municipal Corporation and other urban local bodies, WRD records for channels, land cover from NRSC, soils from the Assam 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.

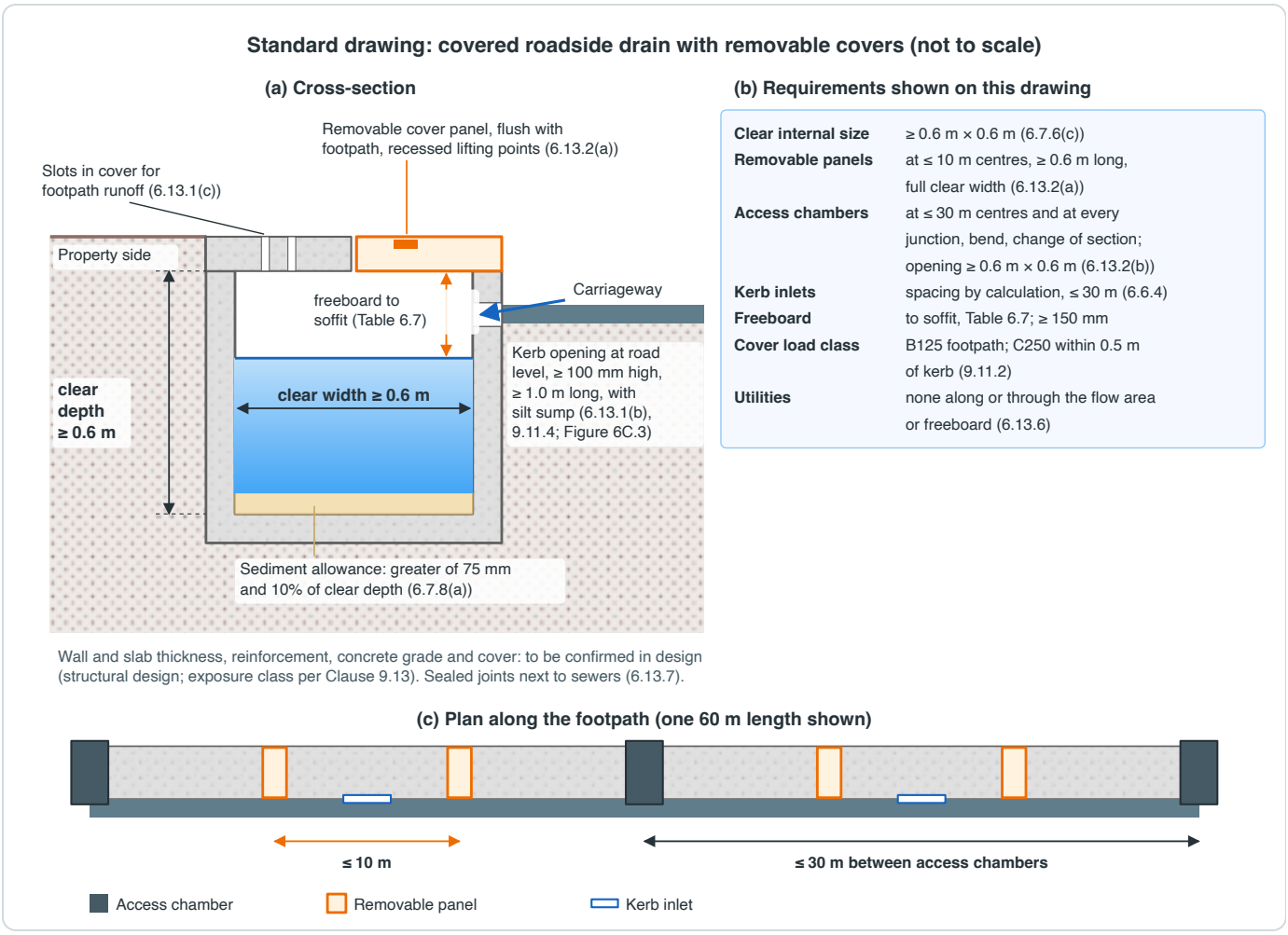


Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

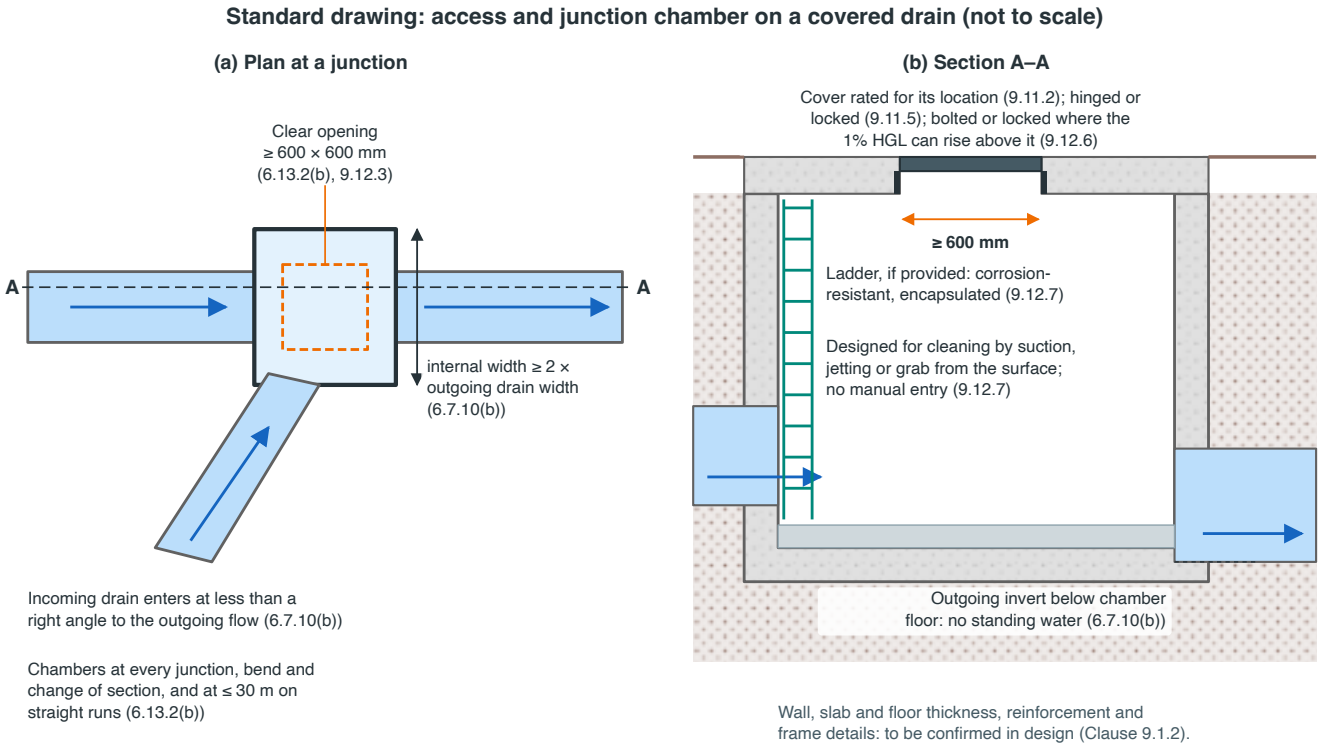


Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

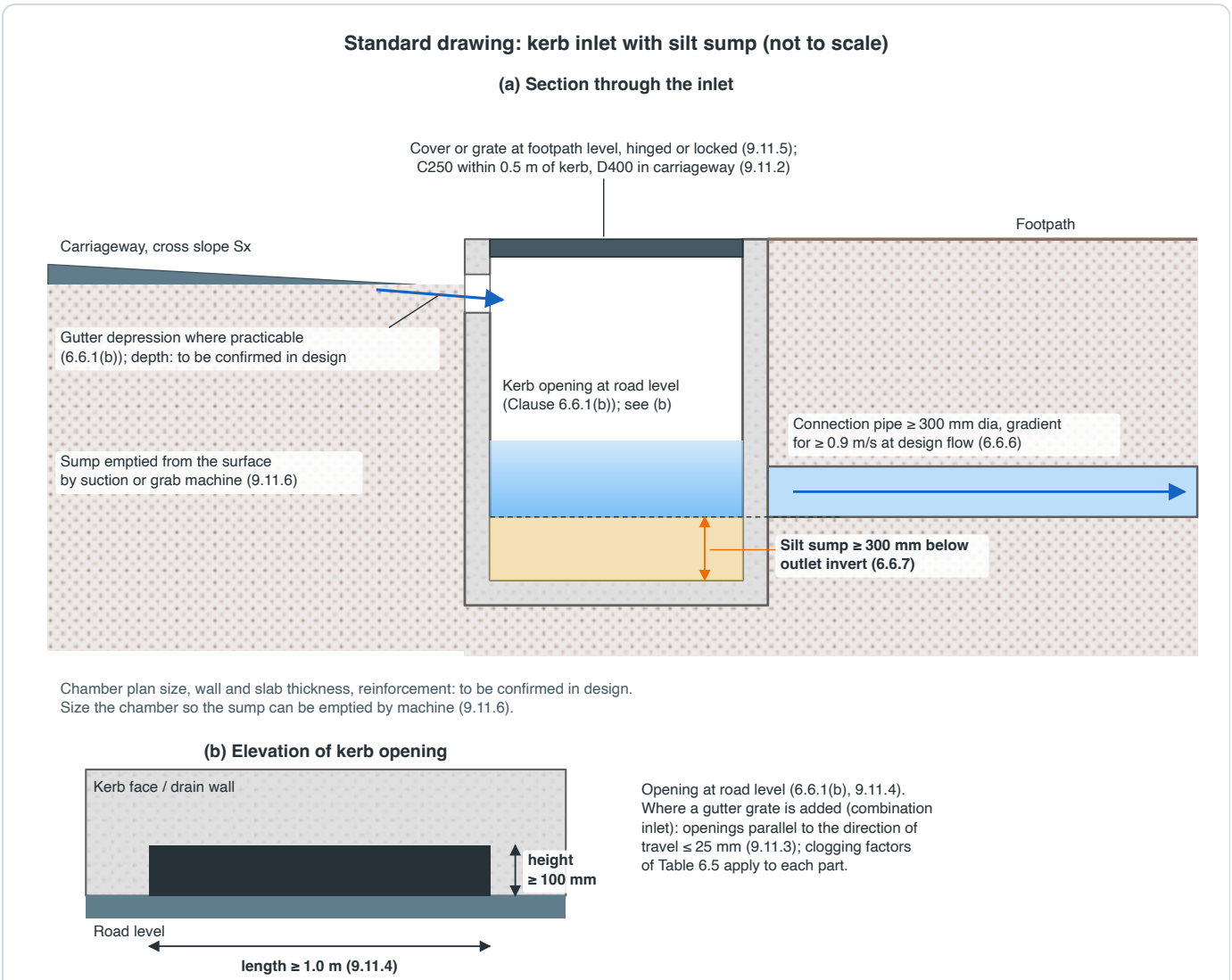


Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th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

ANNEXES TO CHAPTER 7

Waterbodies, Pukhuris (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 Assamese 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 Water Resources Department and the Revenue and Disaster Management Department. It needs the land records of the Revenue and Disaster Management Department, kept by district, mouza, revenue village, dag number and patta, including government land recorded as beel or water; the schedules of water bodies by district, mouza, revenue village and dag number, those of the Guwahati Waterbodies (Preservation and Conservation) Act, 2008 (Sorusola, Borsola, Silsako and land near Deepor Beel) and those that the District Level Committees prepare under section 5 of the Assam Urban Water Bodies (Preservation and Conservation) Bill, 2024 from Bhuvan and the Water Body Census of the Ministry of Jal Shakti; the land-use maps of the Master Plan for Guwahati 2025 and the other Master Plans (the byelaw setbacks apply to rivers and ponds "as marked in the plan"), with their Eco-Sensitive Zone; the Fisheries Department's register of beels (2,072 beels in 2021-22, then 447 registered and 1,625 unregistered, as quoted from the Statistical Handbook); WRD's records of its embankments, sluices and drainage channels; T&CP's AURA application for urban water bodies (as reported); the National Wetland Atlas (2011); in the Autonomous Districts, the land records of the District Councils (not researched [TBC]); and each town's drain register (Chapter 6); the WRD and Gaon Panchayat tank registers with FTL and MWL; surveyed levels on a common datum; the ISRO National Wetland Inventory and Assessment (NRSC); Survey of India topographic maps; and any list of waterbodies published under court directions. Until it is published, each Applicant identifies waterbodies from all the sources of Clause 7.3.3, with the larger extent governing, and records them on the Waterbody Sheet (Form 7-1).

The field specification below is complete. It is written so that every field the chapter asks for (Clause 7.3.1(a) to (g)) has a defined name, type and source, and so that the same fields can be filled from a project's Form 7-1.

7A.1 Layers

- **WB_POLY** — one polygon per waterbody: the Revenue record boundary (Clause 7.3.1(c)).
- **WB_FTL** — the surveyed FTL contour (tanks, lakes, ponds) or top of bank (channels), as a polygon or line.
- **WB_MWL** — the MWL contour of each tank, as a polygon.
- **WB_FLOOD** — the 1% AEP flood extent, where mapped (Clause 7.3.1(f)), with the floodway where delineated (Clause 7.6.1).

- **WB_STRUCT** — points for surplus weirs, sluices, regulators, inlets and drain outfalls.
- **WB_LINK** — lines for supply channels, surplus courses and the links between tanks in a cascade (Clause 7.3.1(e)).
- **WB_ENCR** — polygons of known encroachments, each with the date recorded (Clause 7.3.1(g)).
- **WB_SETBACK** — Zone 1 and Zone 2 polygons (Clause 7.4), derived from the layers above.

All layers shall carry the waterbody identifier (WB_ID) so that they can be joined. All levels shall be stated to one datum (Clause 7.3.5), named in the layer metadata.

Table 7A.1 — Attribute fields of the waterbody inventory (WB_POLY)

Field	Type	Unit / domain	Required	Content	Clause
WB_ID	Text	District code + serial	Yes	Unique identifier, never reused	7.3.1
WB_NAME	Text	—	Yes	Name as in Revenue and WRD records, with local name	7.3.1(a)
WB_NAME_AS	Text	Assamese script	Yes	Name in Assamese	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, mouza and district	7.3.1(a)
CUSTODIAN	Code	Table 7A.2	Yes	Custodian body	7.3.1(b)
AREA_REC	Number	ha	Yes	Area within the Revenue record boundary	7.3.1(c)
AREA_FTL	Number	ha	Tanks	Waterspread at FTL, surveyed	7.2, 7.3.1(d)
FTL	Number	m (datum)	Tanks	Full tank level	7.3.1(d)
MWL	Number	m (datum)	Tanks	Maximum water level (Clause 7.2 definition)	7.3.1(d)
MWL_BASIS	Code	WRD record / 1% AEP computed	Tanks	Which value governs MWL	7.2
TBL	Number	m (datum)	Tanks	Top bund level, lowest point	7.3.1(d)
WEIR_CREST	Number	m (datum)	Tanks	Surplus weir crest level	7.3.1(d)
WEIR_LEN	Number	m	Tanks	Surplus weir crest length	7.3.1(d)
WEIR_TYPE	Text	—	Tanks	Surplus weir type (for example fixed crest, with shutters or falling boards)	7.3.1(d)
SLUICE_N	Integer	—	Tanks	Number of sluices; details in WB_STRUCT	7.3.1(d)
SUPPLY_CH	Text	WB_ID(s)	Tanks	Supply channel(s) feeding the tank	7.3.1(d)
SURPLUS_CS	Text	WB_ID(s)	Tanks	Surplus course(s) leaving the tank	7.3.1(d)
UPSTR_WB	Text	WB_ID(s)	Cascades	Upstream tank(s) in the cascade	7.3.1(e)
DNSTR_WB	Text	WB_ID	Cascades	Downstream tank, river, drain or sea outfall	7.3.1(e)
CATCH_AREA	Number	ha	Channels	Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1)	7.4.1
DATUM	Text	—	Yes	Datum of all levels; conversion from any older WRD datum	7.3.5

Field	Type	Unit / domain	Required	Content	Clause
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; jan (stream or natural drainage channel); juri (small hill stream); nala or khal (built drain, ditch or channel); beel (natural floodplain lake or wetland; scheduled or not); akhat (natural pond); pukhuri (dug tank or pond); hola (seasonal hollow); marsh or swamp; ponded area behind an embankment (with its sluice); retention pond or basin; supply channel; surplus course	7.2
CUSTODIAN	GMC (GMC Act 1969, ss.231–252); other Municipal Corporation (AMC Act 2022, s.173); Municipal Board; GMDA or other Development Authority; WRD (embankment, sluice, drainage channel or pump; 1953 Act); PWD or NHAI (road drains and culverts); Fisheries Department (registered beel; fish farm); Environment and Forest Department (sanctuary, reserved forest); Revenue and Disaster Management Department (government land); Gaon Panchayat; religious institution; private owner (patta land); Railways, OIL, Army or other owner of its own drains; District Council [TBC]; Assam State Wetlands Authority (notified wetland); 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 WRD control, the operating rule is WRD's rule (Clause 7.8.4); this template sets out the content that Clause 7.8 asks for, so that the custodian's rule can be checked against it. Text in square brackets is to be completed for each tank.

7C.1 Identification

1. Tank: [name, WB_ID of Annex 7A, village, mouza, district].
2. Custodian: [WRD division / ULB / Gaon 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

Period	Target level (m)	Upper limit (m)	Lower limit (m)	Purpose
[date – start of cushion period]	[ ]	FTL	[ ]	Holding
[Flood-cushion period, if any]	Cushion level [ ]	Cushion level [ ]	[ ]	Flood cushion (Clause 7.8.2)
[End of cushion period – 31 Dec]	[ ]	FTL	[ ]	Refilling

9. Where no flood cushion is adopted, the starting level for design is FTL (Clause 7.7.3) and the row for the cushion period is deleted.

7C.4 Flood cushion (Clause 7.8.2)

10. Cushion level: [ ] m, which is [ ] m below FTL, giving a cushion volume of [ ] m³ from Schedule 1.
11. Dates: the cushion applies from [ ] to [ ].
12. Drawdown: the tank can be drawn down from FTL to the cushion level through [outlet] in [ ] hours, with a release not exceeding the maximum release rate of paragraph 18.
13. Reliability: continuous simulation (Clause 3.13) over the record [years] shows that the cushion is available at the start of a design storm in [ ]% of monsoon seasons, which shall be at least 90%. The simulation report is Schedule 2.
14. Yield: the custodian accepts the loss of irrigation or supply yield stated in Schedule 3 [and the compensation recorded there].
15. Where the tank has no controllable outlet, this section does not apply and no flood cushion is assumed (Clause 7.8.3).

7C.5 Releases (Clause 7.8.1(b) to (d))

16. Sluice and regulator settings at each level: Table 7C.2.
17. Operator: the sluices and regulators are operated by [post]. A release above [ ] m³/s may be ordered only by [post], or, in an emergency, by [post].
18. Maximum release rate: [ ] m³/s. This rate, added to the flow from the downstream catchment, does not flood buildings downstream (Schedule 4 gives the downstream check).
19. No person shall cut, lower or breach the bund or surplus weir except under the custodian's emergency procedure (Clause 7.14.5).

Table 7C.2 — Outlet settings by level (to be completed for each tank)

Tank level (m)	Sluice 1	Sluice 2	Regulator	Expected outflow (m³/s)	Notes
Below cushion level	[ ]	[ ]	[ ]	[ ]	
Cushion level to FTL	[ ]	[ ]	[ ]	[ ]	
FTL (weir begins to spill)	[ ]	[ ]	[ ]	[ ]	
Above FTL to MWL	[ ]	[ ]	[ ]	[ ]	Check freeboard to TBL (Clause 7.7.4(b))

7C.6 Forecasts, warnings and communication (Clause 7.8.1(e) and (f))

20. The triggers and actions are in Table 7C.3.
21. Before any release under this rule, the operator shall inform the ULBs and the district administration downstream, and residents by the means stated in Schedule 5, at least [ ] hours before the release where the forecast allows.

Table 7C.3 — Triggers and actions (to be completed for each tank)

Trigger	Source	Action	By whom
IMD district heavy-rainfall warning for the catchment	IMD	Read gauges [ ] hourly; check outlets are free; confirm the tank is at or below its rule level	[ ]
IMD or ASDMA red alert	IMD, ASDMA	Begin releases needed to reach the rule level, within the maximum release rate; notify downstream bodies (paragraph 21)	[ ]
City forecast system warning, where available	[ ]	[ ]	[ ]
Tank level reaches FTL	Gauge	Record outflow hourly; inspect bund and weir	[ ]
Tank level reaches [MWL − [ ] m]	Gauge	Emergency procedure; warning to the breach area of any emergency action plan (Clause 7.14.3(c))	[ ]

7C.7 Records and review (Clause 7.8.1(g))

22. During the monsoon (1 April to 31 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the monsoon, records shall be kept [weekly].
23. Records shall be kept with the O&M plan (Chapter 10) and given to the Authority on request.
24. The tank shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Clause 7.14.4).
25. This rule shall be reviewed after any event in which the tank surplused at a level above [ ] m, after any change to the weir, sluices or bund (Clause 7.7.6), and in any case with the review of the Manual.

Schedules: 1 stage–storage curve; 2 continuous simulation report; 3 yield and compensation; 4 downstream check of the maximum release; 5 communication list.

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 Pollution Control Board, Assam (PCBA) 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 Pollution Control Board, Assam (PCBA) directs.
- (c) Haul routes and temporary stockpiles shall meet the construction erosion and sediment control rules of Clause 8.12, including stockpiles outside Zone 1.

7D.6 Inlets (Clause 7.9.7)

Every inlet that brings urban runoff shall have a sediment forebay, a constructed wetland inlet zone or a gross pollutant trap, designed under Chapter 8 (Annex 8D).

7D.7 Timing (Clause 7.9.8)

Desilting shall be complete, and the waterbody made safe, by **31 March**. No excavation shall be left open, and no sluice or weir left dismantled, during the monsoon.

7D.8 Completion records

- (a) As-built survey and revised stage–storage curve. The curve is the one that Clause 7.7.1(b) requires "after the last desilting".
- (b) Volume removed, its disposal site, and the silt test results.
- (c) Photographs of the bund, weir, sluices and inlet works.
- (d) Update of the inventory record (Annex 7A: SSC_DATE, LEVEL_DATE, CONDITION).

Table 7D.1 — Hold points for desilting and restoration works

Hold point	Check	Clause
1. Before excavation	Pre-works survey, pit logs, silt tests, and hydrogeological report if deepening	7.9.1, 7.9.3
2. Original bed reached	Levels checked against pit logs; no excavation below the original bed unless approved	7.9.2
3. Edges formed	Side slopes or safety bench as 7D.3	7.9.4
4. Inlet works	Forebay, wetland inlet zone or GPT built	7.9.7
5. Completion (by 31 March)	As-built survey, stage–storage curve, silt disposal record	7.9.8, 7.7.1(b)

Annex 7E — Glossary of Assamese waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Assamese words for waterbodies, channels, embankments and river land. Many of them appear in the names of channels, beels and tanks (the Bondajan, the Lakhimijan, the Khanajan; Dighalipukhuri), and the name used in the land records, the schedules of the water-bodies law, the Fisheries Department's register, WRD's records or a municipal 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 found in one of two historical dictionaries: the *Chandrakanta Abhidhan* (2nd edition, Gauhati University, 1962, as served by the Digital South Asia Library; "CK") and M. Bronson, *A Dictionary in Assamese and English* (1867, read from page images of the Internet Archive copy, whose printed page is the scan leaf less 11, checked on two pages; "Br"). The crowd-sourced xobdo.org was used only as a modern check, and the *Hemkosh* was not checked, because its site could not be reached. **Two cautions apply.** The Digital South Asia Library renders র as ৰ, so its entries were read with র restored; and modern usage may be narrower or wider than the dictionaries' English glosses. Terms whose meaning or use was not confirmed, and terms this Manual avoids, are in Table 7E.4. The list is to be extended by the State Stormwater Technical Committee, with modern land-record, WRD and municipal usage and the terms of the other languages in use in the State.

The Manual's term for a dug tank or pond is **pukhuri**, written on first use as "**pukhuri (Assamese পুখুৰী: a dug tank or pond; plural pukhuris)**", and its term for a natural floodplain lake or wetland is **beel**, written on first use as "**beel (Assamese বিল: a natural floodplain lake or wetland)**". *Pukhuri* comes, by CK's account, from Sanskrit পুষ্কৰ, a large dug place to hold water: it names a **dug** water body, which matches the "tank" of this chapter, and leaves *beel*, the word of the 2008 Act's schedules and of the byelaws, for the natural lakes and wetlands of the floodplain. Assamese marks the plural with *-bor* or *-hot*, not with an ending of this kind, so the English plural **pukhuris** is a convention of this Manual. This Manual uses the modern spelling with long ī (পুখুৰী, as in CK), not Bronson's পুখুৰি. Engineered storage built under this Manual is a **detention pond**, never a pukhuri or a beel, and a natural wetland is never called a pukhuri. The word *doba*, which in Assamese means the deepest part of a river or lake and not a pond, is not used (Table 7E.4).

Table 7E.1 — Waterbodies

Assamese term	Meaning (source)	Manual term (Clause 7.2)
পুখুৰী (pukhurī)	"a pond; a tank", from Skt. পুষ্কৰ, a large dug deep place to hold water (CK, p. 604); "a tank, a reservoir of water" (Br, p. 351, as পুখুৰি); xobdo.org agrees	Pukhuri (dug tank or pond), see the definitions after Clause 7.2
টোকনী-পুখুৰী (tokonī-pukhurī)	"a small pond" (CK, p. 429)	A pukhuri
বিল (bil; beel)	"a lake"; a broad, long body of water without current (CK, p. 685); "a lake, a pond" (Br, p. 410)	Beel (natural floodplain lake or wetland), see the definitions after Clause 7.2
অখাত (akhāt)	"a natural pond or lake", not dug (CK, p. 4)	A beel, or a wetland under Clause 7.12 where it has no outlet

Assamese term	Meaning (source)	Manual term (Clause 7.2)
ডুবি (ḍubi)	"the deepest part of a river or lake" (CK, p. 442)	Not a waterbody type; the deepest part of a beel or river
হোলা (holā)	"a shallow ravine; a hollow land where water lodges during the rainy season" (CK, p. 920)	Seasonal hollow; a marsh under Clause 7.12 where it is one
বান, বানপানী (bān, bānpānī)	"a high flood"; বানপানী, "a flood" (CK, p. 666); "a flood, an inundation" (Br, p. 396)	Flood; not a defined term

Table 7E.2 — Streams, channels and drains

Assamese term	Meaning (source)	Manual term (Clause 7.2)
জান (jān; jan)	"a ravine; a stream"; a small river from a channel or beel (CK, p. 397); "a drain, a trench, a channel, a creek" (Br, p. 225)	Jan (stream or natural drainage channel); in names, as the Bondajan, the Lakhimijan and the Khanajan
জুৰি (jurī; juri)	"a small hill stream" (CK, p. 407)	Juri (small hill stream)
নলা (nalā; nala)	"a tube; a pipe … a spout … a drain" (CK, p. 535)	Nala (built drain)
খাল (khāl)	"a pit … a ditch; a trench … a deep place" (CK, p. 262); "khaals" for channels in the ADB's Dibrugarh drain study (2017)	Khal (ditch or channel); always glossed
ডোং (ḍoṅ; dong)	"a small hole or depression"; also a dish of plantain sheath (CK, p. 444)	Used only as the Assam Embankment and Drainage Act, 1953 uses "dongs", among drains (s.2); never glossed as an irrigation channel

Table 7E.3 — Embankments, sluices and river land

Assamese term	Meaning (source)	Use in this Manual
মথাউৰি (mothāuri)	"an embankment along the edge of a river", to hold back floodwater (CK, p. 737)	Mothauri: the term for a river embankment; an "embankment" under section 2 of the 1953 Act
ভেঁটা (bhẽṭā)	"a dam or embankment to confine water" (Br, p. 436)	Local only
চাপ (ḍhāp)	"an embankment or wall of earth" (CK, p. 446); "a mud wall, an embankment" (Br, p. 260)	Local only
বান্ধ (bāndh)	The noun is given as "friend" and "shield"; the verb's entry carries "an embankment" (CK, p. 667)	Not used; মথাউৰি is preferred
আলি (āli)	"a ridge; embankment across a rice-field … a road; a highway" (CK, p. 105)	Field ridge; not an "embankment" under section 2 of the 1953 Act, which excludes it
পানী-দুৱাৰ (pānī-duwār)	"a water-gate; a sluice" (CK, p. 594; no entry for the English loan স্লুইচ)	Pani-duwar: sluice, written with the English word
চৰ (sor; char)	"high land formed by river by deposit of silt; alluvial land" (CK, p. 336)	Char land: a hazard-first site (definitions after Clause 7.2)
চাপৰি (sāpori; chapori)	"high land formed by deposit of river sand and silt; high, open grass land" (CK, p. 346); "an island, high table land" (Br, p. 196)	Chapori land: a hazard-first site (definitions after Clause 7.2)

Table 7E.4 — Terms avoided or not yet verified

These terms or senses are in use or have been proposed but were not confirmed in a dictionary during research for this Manual, or are avoided because they mislead. They shall not be used in a record or a drawing as defined terms.

Term	Reported meaning or use	Status
ডোবা (ḍobā; doba)	Not in CK; xobdo.org gives "deepest part of a river or lake"	**Avoided.** In Bengali the word is a small pool, so it is a false friend; it is never used in this Manual for a pond
ডোং (dong) as "irrigation channel"	A Karbi entry in xobdo.org gives "man-made waterway for transportation and irrigation"	**Not used** in that sense: no dictionary support; the word is used only as the 1953 Act uses it
গড় (gaṛ) in the sense of an embankment road	CK gives "a fort; a stockade; a fortification" (p. 277)	The road sense is not sourced; not used
Hemkosh entries	—	Not checked (site unreachable) [TBC]
Terms in Bengali, Bodo, Karbi, Dimasa and the other languages of the State	—	Not researched for this Manual [TBC]

The Manual uses the terms in the last column of Tables 7E.1 to 7E.3 and the Assam 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 — Assam 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 Assamese) 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): Dag and patta records (district, mouza, revenue village), water-body schedules (2008 Act; District Level Committee), Master Plan maps, Fisheries Department beel register, WRD embankment and sluice records, AURA, District Council records [TBC], drain register □; WRD / Gaon Panchayat registers □; Authority inventory or court list □; historical maps and imagery, including NWIA □; site survey □	_____	7.3.3
A8	Where sources conflict: which extent governs (the larger)	_____	7.3.3
A9	Datum of all levels, and conversion from any WRD datum	_____	7.3.5

Table 7F.2 — Form 7-1, Section B: Levels and features

No.	Field	Entry	Clause
B1	FTL (tanks, lakes, ponds) or top of bank (channels), m	_____	7.2
B2	MWL (tanks), m, and basis (WRD record or 1% AEP computed)	_____	7.2
B3	TBL, lowest point (tanks), m	_____	7.3.1(d)
B4	1% AEP flood level, m, and source (adopted map / hydraulic study / not available)	_____	7.3.4
B5	Drainage area at the site (channels), ha	_____	7.4.1(b)
B6	Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no)	_____	7.3.2
B7	Known encroachments, with date recorded	_____	7.3.1(g)

Table 7F.3 — Form 7-1, Section C: Setback

No.	Field	Entry	Clause
C1	Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B)	_____	7.15(1)
C2	Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)?	_____	7.3.4
C3	Floodway outer edge, m from FTL or top of bank, and how delineated	_____	7.6.1
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3

No.	Field	Entry	Clause
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider statutory, plan or approval line: the byelaw 26(ix) / 44(ix) distance from the edge of a river, channel or water body (15 m from a river and from Deepor Beel and Silsako, wider than Zone 1 only where measured from a wider edge; 10 m or 6 m elsewhere, narrower than Zone 1, stated, never governing alone); the 15 m no-construction strip from the Brahmaputra bank of the Master Plan for Guwahati 2025; the Eco-Sensitive Zone or Zone E of a Master Plan; a schedule or condition under the water-bodies law; a condition under section 16 of the Assam Embankment and Drainage Act, 1953; the boundary of Deepor Beel Wildlife Sanctuary, the Ramsar site or a notified eco-sensitive zone (only drafts exist); a court or Tribunal 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 — Assam Stormwater Design Manual, Draft v1.0. One sheet per tank whose storage is counted. Storage that fails any item in Section B shall not be counted (Clause 7.7.1).

Table 7F.5 — Form 7-2, Section A: Tank and scheme

No.	Field	Entry	Clause
A1	Tank name and inventory ID (Annex 7A); custodian	_____	7.3.1
A2	Scheme in which storage is counted: basin plan / regional facility / fee-in-lieu (S-5)	_____	7.7.1, 7.11
A3	Cascade modelled: uppermost tank _____ to outfall _____	_____	7.7.2
A4	Datum	_____	7.3.5

Table 7F.6 — Form 7-2, Section B: Conditions for counting storage

No.	Condition	Date / reference	Met (yes / no)	Clause
B1	FTL, MWL, TBL, weir crest and length, sluice sills surveyed within the previous 5 years	_____	_____	7.7.1(a)
B2	Stage–storage curve from a bathymetric and topographic survey within 5 years or after the last desilting, whichever is later	_____	_____	7.7.1(b)
B3	Documented operating rule agreed with the custodian (Annex 7C)	_____	_____	7.7.1(c), 7.8
B4	Weir, sluices and bund under an O&M plan; latest pre-monsoon inspection found them serviceable	_____	_____	7.7.1(d), 7.14.4
B5	Custodian's written concurrence	_____	_____	7.7.1(e)

Table 7F.7 — Form 7-2, Section C: Levels and creditable volume

No.	Item	Value	Clause
C1	Starting level: FTL, or cushion level under a rule meeting Clause 7.8.2, m	_____	7.7.3
C2	If a cushion is used: controllable outlet (type) and drawdown time, h	_____	7.8.2(a)
C3	If a cushion is used: reliability from continuous simulation, % of monsoon seasons (≥ 90%)	_____	7.8.2(c)
C4	Computed maximum level, 1% AEP inflow with climate factor routed through the cascade, m	_____	7.7.4
C5	MWL, m; is C4 ≤ MWL?	_____	7.7.4(a)
C6	Freeboard C4 to TBL, m; WRD freeboard standard, m; met?	_____	7.7.4(b)
C7	Storage between C1 and C4, from the stage–storage curve, m^3	_____	7.7.5
C8	Volume already committed to another facility or scheme, m^3	_____	7.7.5
C9	Creditable volume = C7 − C8, m^3	_____	7.7.5
C10	Register entry under Clause 10.17 (fee-in-lieu storage)	_____	7.11.2(d)

Table 7F.8 — Form 7-2, Section D: Bund safety

No.	Item	Entry	Clause
D1	Specified dam under the Dam Safety Act, 2021? Height, crest length, capacity, maximum flood discharge	_____	7.14.1
D2	Hazard class: high / low	_____	7.14.2
D3	High hazard: weir passes 1% AEP at MWL with freeboard; 0.2% AEP check without overtopping	_____	7.14.3(a)
D4	High hazard: breach analysis and emergency action plan (references)	_____	7.14.3(b), (c)
D5	High hazard: independent check under Clause 10.6 (name)	_____	7.14.3(d)

Table 7F.9 — Form 7-2, Section E: Signatures

Role	Name and designation	Signature and date
Designer (Clause 10.6)	_____	_____
Independent checker, where Clause 7.14.3(d) applies	_____	_____
Custodian's concurrence (Clause 7.7.1(e))	_____	_____

Form 7-3 — Compensatory Storage Calculation (by elevation band)

Supports Clauses 7.6.3 to 7.6.5, 7.9.5 and 7.15(3) of Chapter 7.

Draft form — Assam 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 Assam 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 Assam 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 — Assam 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 Assam, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several monsoon seasons, with laboratory analysis to the CPCB methods, and the outfall monitoring of Clause 8.13.1 published under Clause 10.17. Until it is published, the Value Ratings of Table 8.3 (MARC/APWA 2012) apply, and a proprietary device earns a VR only from verified test data (Table 8.3).

The layouts below set the minimum records the programme shall keep, so that results from different authorities can be pooled.

Table 8C.1 — Monitoring site register (layout)

Site ID	BMP type (Table 8.3)	Location and authority	Catchment area (ha)	Impervious (%)	Soil and groundwater setting	Date commissioned	Pretreatment
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.2 — Event record (layout; parameters of Clause 8.13.2)

Site ID	Event date	Rainfall (mm)	Inflow volume (m^3)	Outflow volume (m^3)	TSS in / out (mg/L)	BOD in / out (mg/L)	COD in / out (mg/L)	Faecal coliform in / out (MPN/100 mL)	TN in / out (mg/L)	TP in / out (mg/L)	Oil and grease in / out (mg/L)	Heavy metals (industrial catchments)
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.3 — Performance summary and proposed VR (layout)

BMP type	Sites	Events	Volume reduction (%)	Median effluent TSS (mg/L)	Other findings	VR in Table 8.3	Proposed VR
_____	_____	_____	_____	_____	_____	_____	_____

Annex 8D — BMP design sheets, media specification, plant lists

Supports Clauses 8.5, 8.7, 8.8 and 8.11 of Chapter 8.

Each design sheet collects the requirements of Chapter 8 for one BMP. Values marked "recommended starting value" in Clause 8.7.1 may be departed from with justification. Values that the Manual does not set are marked "to be confirmed in design"; the designer shall state and justify them. Every BMP also needs: sizing for the WQv or Q_wq (Clause 8.6.4(a)), pretreatment (Clause 8.5.3), a safe bypass for flows above Q_wq (Clause 8.4.6) and maintenance access (Chapter 10).

8D.1 Design sheets

Table 8D.1 — Pretreatment (all BMPs)

Item	Requirement	Clause
Where needed	Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland, at each concentrated inflow	8.5.3
Types	Sediment forebay, grass filter strip, silt trap or proprietary device	8.5.3
Size	Holds at least 10% of the WQv of its contributing area; or sized for Q_wq (flow-through devices)	8.5.3
Access	Cleanable without entering or disturbing the main BMP	8.5.4
Silt traps and catch pits	At every inlet receiving runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody; sump at least 300 mm below the outlet invert; earn no VR	8.7.12

Table 8D.2 — Bioretention and rain gardens (Figure 8.2)

Item	Requirement	Clause
Ponding depth	≤ 300 mm above the mulch, with an overflow at maximum ponding level	8.7.2(a)
Ponding drawdown	Within 48 h	8.7.2(b)
Filter media	600–900 mm engineered sandy loam, low fines, low phosphorus (Table 8D.12)	8.7.2(c)
Mulch	50–75 mm	8.7.2(c)
Transition (choker) and gravel drainage layers	Required; thickness and grading to be confirmed in design	8.7.2(d)
Underdrain	Perforated; required where the design infiltration rate cannot meet the 48 h drawdown, or where lined; diameter to be confirmed in design	8.7.2(e)
Lining	Required where Clause 8.8 cannot be met, and at hotspots	8.7.2(f)
Plants	Native or naturalised, tolerant of waterlogging and long dry spells (Tables 8D.13 and 8D.14)	8.7.2(g)
VR	8.5 (rain garden / infiltration 9.0)	Table 8.3

Table 8D.3 — Vegetated swales

Item	Requirement	Clause
Section	Trapezoidal or parabolic; side slopes no steeper than 1V:3H	8.7.3(a)
Longitudinal slope	0.5% to 4%; check dams where steeper	8.7.3(b)
Flow at Q_wq	Depth not more than grass height; velocity ≤ 0.3 m/s	8.7.3(c)
1% AEP or bypass flow	No erosion (Chapter 9 permissible velocities)	8.7.3(d)
Underdrained ("dry") swale	Where slope < 1% or subsoil is poorly drained; filter media as Table 8D.12	8.7.3(e)
VR	4.0 (native vegetation swale)	Table 8.3

Table 8D.4 — Vegetated filter strips

Item	Requirement	Clause
Inflow	Sheet flow only; level spreader where flow arrives concentrated	8.7.4(a)
Length in flow direction	≥ 5 m	8.7.4(b)
Slope	1% to 8%	8.7.4(b)
Use	Mainly pretreatment for bioretention, infiltration and swales	8.7.4(c)
VR	5.0	Table 8.3

Table 8D.5 — Permeable pavement

Item	Requirement	Clause
Run-on	Impervious run-on area ≤ 2 × permeable area; none from unpaved or eroding areas	8.7.5(a)
Base reservoir	Clean open-graded aggregate holding its share of the WQv in its voids; void ratio confirmed by test	8.7.5(b)
Open (infiltrating) base	Only where Clause 8.8 is met; otherwise lined with underdrain and counted as filtration only	8.7.5(c)

Item	Requirement	Clause
Structure	Designed for traffic loading to the road authority's standards	8.7.5(d)
Exclusions	Not at hotspots; not where it will be resurfaced with impermeable material	8.7.5(e)
VR	7.5	Table 8.3

Table 8D.6 — Infiltration trenches and basins (Figure 8.3)

Item	Requirement	Clause
Pretreatment	Always (Table 8D.1)	8.7.6(a)
Fill	Clean washed aggregate, void ratio confirmed by test; geotextile on sides and top; sand base	8.7.6(b)
Observation well	To the base of each trench	8.7.6(c)
Storage	WQv (or Chapter 4 retention volume, if greater) held in the voids	8.7.6(d)
Drawdown	Empty within 72 h at the design infiltration rate	8.7.6(d), 8.8.7
Overflow	At grade, to the minor or major system	8.7.6(e)
Commissioning	Not in service until the contributing area is stabilised	8.7.6(f)
Criteria	All of Clause 8.8 (Table 8D.11)	8.8

Table 8D.7 — Wet ponds (extended wet detention)

Item	Requirement	Clause
Permanent pool	≥ WQv	8.7.7(a)
Extended detention	WQv above the pool, released over 24–48 h	8.7.7(a), 8.4.7
Forebay	At each inlet	8.7.7(b)
Flow path	Length-to-width ≥ 3:1; no short-circuiting	8.7.7(c)
Pool depth	1.0–2.5 m, with safety bench (Clause 7.9.4)	8.7.7(d)
Water balance	Monthly balance with IMD rainfall and pan evaporation: ≥ 50% of pool volume kept through the driest year in 10; no top-up with groundwater, potable water or sewage	8.7.8
Flood detention	Chapter 4 detention may sit above the extended detention level	8.7.7(f)
VR	5.0	Table 8.3

Table 8D.8 — Constructed wetlands

Item	Requirement	Clause
Layout	Inlet sedimentation pond (forebay), then shallow macrophyte zone	8.7.9(a)
Extended detention	WQv above normal water level, released over 24–48 h; depth ≤ 0.5 m	8.7.9(b)
Flow path	Length-to-width ≥ 3:1; deep zones across the flow path	8.7.9(c)
Bypass	High-flow bypass so that floods do not scour the macrophyte zone	8.7.9(d)
At a tank inlet	Within the tank's setback, outside its waterspread; not counted as tank storage	8.7.9(e)
Water balance	As wet ponds (minimum wetland depth kept)	8.7.8

Item	Requirement	Clause
VR	7.0 (extended detention wetland)	Table 8.3

Table 8D.9 — Gross pollutant traps and outfall screens

Item	Requirement	Clause
Treatment flow	Q_wq; all flows up to 1% AEP pass without washing out captured material	8.7.10(a)
Capture size	Down to about 5 mm	8.7.10(b)
Head loss	In the drain HGL (Chapter 9), screen 50% blocked	8.7.10(c), 8.10.3(a)
Storage	For the O&M cleaning interval; not less than 3-monthly cleaning	8.7.10(d)
Access	Vehicle access for suction or grab cleaning; safe cleaning platform	8.7.10(e), 8.10.3(d)
Blocked screen	Overflow or bypass path so that a fully blocked screen does not flood property	8.10.3(b)
Bar spacing	Chosen for the hazard: closer for litter capture, wider where blockage would cause flooding; to be confirmed in design	8.10.3(c)

Table 8D.10 — Oil-grit separators

Item	Requirement	Clause
Where	Fuel stations; vehicle workshops and washing bays; bus and truck depots; parking areas of more than 50 spaces	8.7.11(a)
Sizing	Q_wq, with high-flow bypass	8.7.11(b)
Not alone	Followed by a filtering BMP where the site needs a VR above 5; lined filtering BMP before any infiltration at hotspots	8.7.11(c), 8.8.8

Table 8D.11 — Infiltration and recharge criteria (all infiltrating BMPs)

Item	Requirement	Clause
Groundwater separation	Seasonal high groundwater ≥ 1.0 m below base (roof-only runoff in notified coastal sand: ≥ 0.5 m with mounding check, mound ≥ 0.3 m below base)	8.8.1, 8.8.9(d)
Bedrock or impermeable layer	Base ≥ 1.0 m above, unless designed for rock-aquifer recharge under Clause 8.8.10	8.8.2
Tests	Double-ring (ASTM D3385) for basins, bioretention, permeable pavement; falling-head borehole or trial-pit soakage (e.g. BRE Digest 365) for trenches, soakaways, pits, wells; ≥ 2 per facility and ≥ 1 per 100 m² of base or per 50 m of trench; Form 8-2	8.8.3
Design rate	Measured rate ÷ 2.0 (tests meet 8.8.3(c) and vary by no more than a factor of 2), otherwise ÷ 3.0	8.8.4
Minimum rates	≥ 13 mm/h full infiltration; 3–13 mm/h partial, with underdrain, credit only for volume infiltrated within 72 h; < 3 mm/h no credit	8.8.5
Setbacks (runoff from paved surfaces)	Foundations 3 m, basements 5 m; property boundary 1.5 m; drinking-water well or borewell 30 m; septic tank or soak pit 15 m; crest of slope steeper than 1V:3H 6 m	8.8.6
Expansive soils	Foundation setback doubled	8.8.11(b)

Item	Requirement	Clause
Drawdown	Empty within 72 h at design rate; tested after construction	8.8.7
Hotspots	No infiltration without treatment; none at all for waste sites and contaminated land	8.8.8
Road runoff	Never led directly into a well, borewell or recharge shaft	8.11.3(b)

8D.2 Bioretention drawdown check

The 48-hour ponding drawdown (Clause 8.7.2(b)) and the minimum rates of Clause 8.8.5 together decide whether a cell needs an underdrain.

- Rate needed to drain the maximum ponding depth in 48 h = 300 mm / 48 h = 6.25 mm/h.
- Design rate ≥ 13 mm/h: full infiltration, no underdrain, provided Clause 8.8 is met.
- Design rate from 6.25 mm/h to 13 mm/h: the ponding drains in time, but Clause 8.8.5(b) applies, so an underdrain is required.
- Design rate below 6.25 mm/h: the ponding cannot drain in 48 h by infiltration; an underdrain is required (Clause 8.7.2(e)), and below 3 mm/h no infiltration credit is given.

Illustrative — not design values. Two tests at the base of a proposed cell give 30 mm/h and 22 mm/h. The two results differ by a factor of 30 / 22 = 1.36, which is not more than 2, and the number of tests meets Clause 8.8.3(c), so the safety factor is 2.0. Taking the lower result, the design rate = 22 / 2.0 = 11 mm/h. This is above 6.25 mm/h, so the ponding drains in 300 / 11 = 27 h, within 48 h. It is below 13 mm/h, so the cell is a partial-infiltration design with an underdrain (Clause 8.8.5(b)).

8D.3 Filter media specification

Table 8D.12 — Bioretention filter media and layers

Layer	Requirement from Chapter 8	Values to be confirmed in design
Mulch	50–75 mm (Clause 8.7.2(c)); shredded hardwood or similar organic mulch that does not float away at the ponding depth	Material and source
Filter media	600–900 mm engineered sandy loam with low fines and low phosphorus content (Clause 8.7.2(c))	Particle size grading; fines (silt + clay) limit; organic matter content; phosphorus limit; saturated hydraulic conductivity of the compacted media; source and test certificate for each batch
Transition (choker) layer	Between media and gravel, to stop media washing into the gravel (Clause 8.7.2(d))	Thickness and grading, matched to the media and gravel
Gravel drainage layer	Below the transition layer, surrounding the underdrain (Clause 8.7.2(d))	Thickness, grading, washed
Underdrain	Perforated pipe where Clause 8.7.2(e) applies, with cleanouts	Diameter, slope, perforation, outlet level
Liner	Where Clause 8.7.2(f) applies (cannot meet Clause 8.8; hotspots)	Liner type and protection

Media shall be tested before placing, and placed in lifts without heavy compaction. The State Stormwater Technical Committee should set numeric limits for grading, fines, organic matter and phosphorus, with local sources of sand and compost, when it reviews this annex.

8D.4 Plant lists

No Assam source on planting for stormwater BMPs was found during research for this Manual, and none of the sources read names the native species to be used in bioretention, swales, filter strips or constructed wetlands in the State. The byelaws ask for trees and greenery on 20% of every plot (byelaw 111) and for ten evergreen trees with "unpaved soil surface of minimum 2(two) feet" (byelaw 104(iii)), without naming any species for drainage. This annex therefore lists **no species** for Assam, and gives no Assamese plant names, rather than carry over lists drawn up for other States or invent local names. Until the State Stormwater Technical Committee issues lists, the species for each BMP shall be chosen, and recorded on the BMP design sheet, by a horticulturist or the Environment and Forest Department for the site's sub-area of Annex 2A, its soil and its water table, under the following rules (set by this Manual):

- (a) **Native or long naturalised species only**, as the Environment and Forest Department confirms for the site; no species named in Table 8D.15 or otherwise known to be invasive in the State.
- (b) **Wet and dry ground.** On the floodplain, species that stand saturated ground and flooding through the season of 1 April to 31 October, when the water table is at or near the surface, and that survive the dry months of December to February without irrigation once established.
- (c) **Slopes.** In the Guwahati hills and the Karbi and Dima Hasao hills, species chosen first to bind soil on banks, cut slopes and the margins of juris; bioretention on a slope is lined (Clause 8.8.1).
- (d) **Not in the waterway or on the embankment.** No planting in the bed or on the banks of a river, jan or juri, or on an embankment, without the consent of its custodian (WRD, the Municipal Corporation or Board, or another body), and on an embankment or drain in a notified area only with the permission required by section 16 of the Assam Embankment and Drainage Act, 1953; and none that would obstruct the flow of a channel or the outlet of a beel or pukhuri.
- (e) **Not in the beels.** No planting under this annex in a beel, pukhuri, scheduled water body, Deepor Beel or a sanctuary, whose vegetation is managed by its custodian under Chapter 7.

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

Use	Botanical name	Local name	Notes
All BMPs of Clause 8.7	None listed for Assam in this draft	—	Chosen under rules (a) to (e) above and recorded on the BMP design sheet (Annex 8D)

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

Zone	Botanical name	Local name	Notes
All zones	None listed for Assam in this draft	—	Chosen under rules (a) to (e) above; constructed wetlands are built outside the waterspread of any natural waterbody (Clause 8.7.9(e))

Table 8D.15 — Species not to be planted

Botanical name	Local name	Reason
Any species the Environment and Forest Department lists as invasive in Assam	—	No list of invasive species for Assam was read for this Manual [TBC]

Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

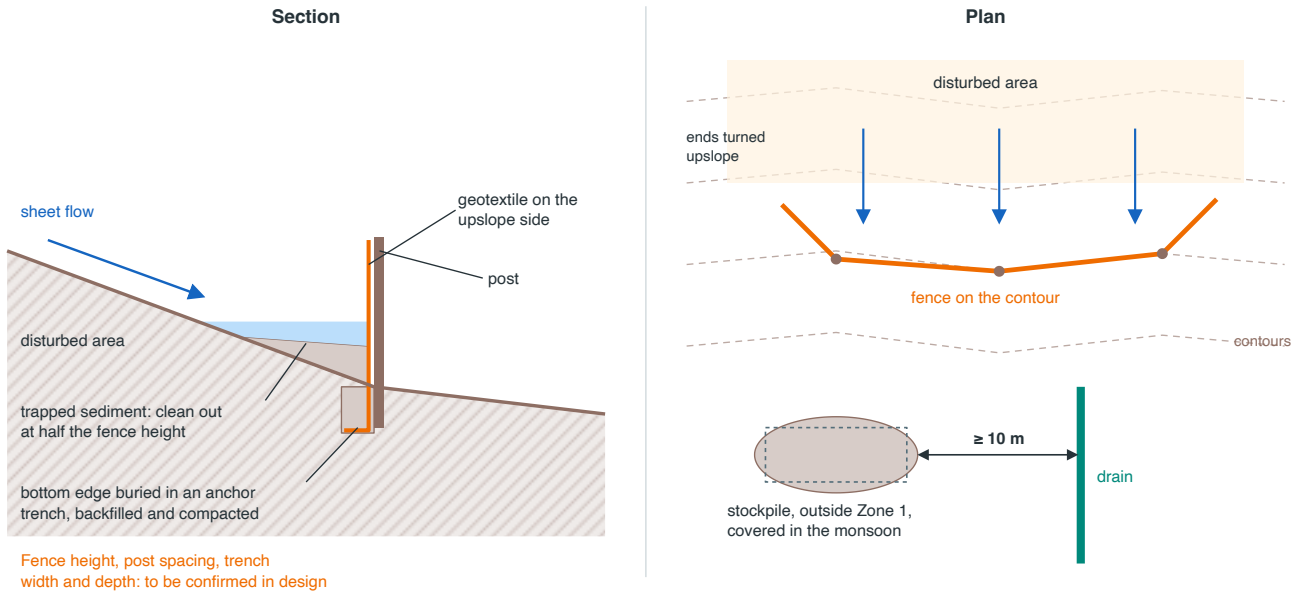
The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

Table 8E.1 — Selection of measures (Clause 8.12.3)

Situation	Measure	Detail
Sheet flow leaving a disturbed area, along its downslope edge	Silt fence	Figure 8E.1
Concentrated flow from a disturbed area of up to 2 ha	Sediment trap	Figure 8E.2
Disturbed area of more than 2 ha	Sediment basin with surface dewatering outlet	Figure 8E.2
Existing drain inlet receiving site runoff	Inlet protection	Figure 8E.4
Vehicle exit to a public road	Stabilised construction exit, with wheel washing	Figure 8E.3
Stockpiles	Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the monsoon	Notes to Figure 8E.1
Dewatering	Through a sediment basin, settling tank or filter bag; never pumped directly to a drain or waterbody	Notes to Figure 8E.2
Concrete washout	Lined pit; never into a drain	Notes to Figure 8E.3

8E.1 Silt fence

Silt fence (section and plan, not to scale)



Fence height, post spacing, trench width and depth: to be confirmed in design

Inspect weekly and within 24 h after heavy rain; repair within 48 h (Clause 8.12.5). Drainage area per fence: Annex 8E (to be prepared).

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 Assam rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

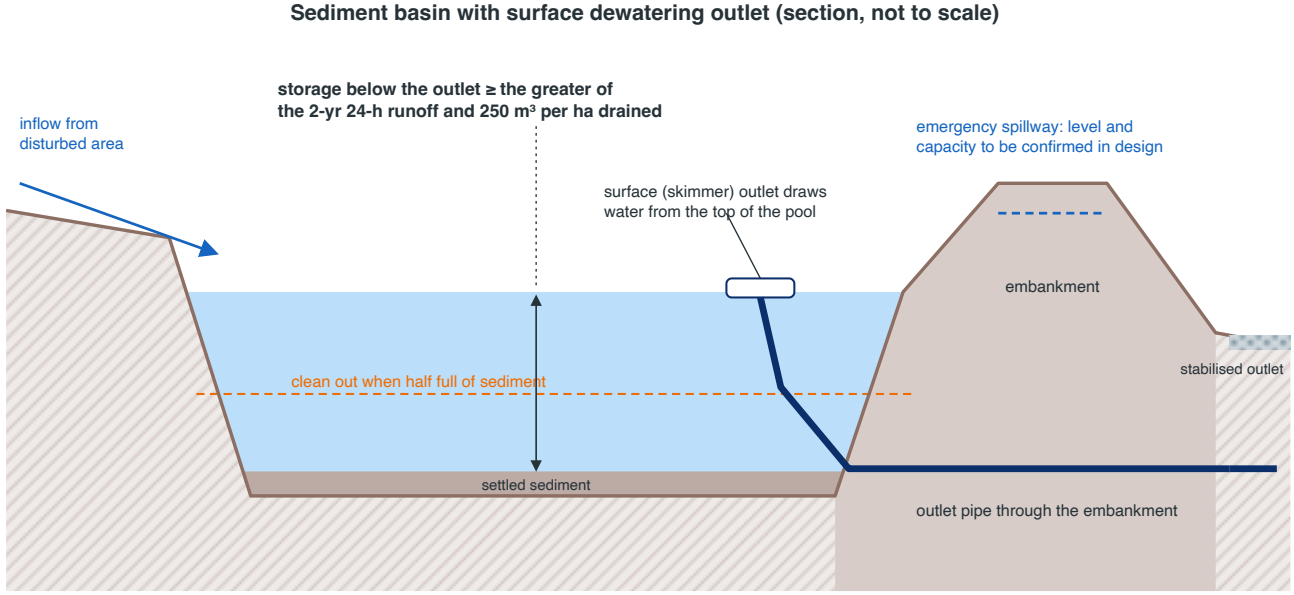
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used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

The designer shall show the drainage area and slope length served by each fence on the ESC plan.

Notes:

1. Place along the contour at the downslope edge of the disturbed area, never across a concentrated flow path.
2. Turn the ends upslope so that water cannot run round them.
3. Inspect weekly and within 24 hours after every heavy-rainfall event; repair within 48 hours; remove sediment when the deposit reaches half the fence height (Clause 8.12.5).
4. Remove only after the area draining to it is stabilised (Clause 8.12.6).
5. Stockpiles: outside Zone 1, at least 10 m from any drain, and covered during the monsoon (Clause 8.12.3(f)).

8E.2 Sediment trap and sediment basin



Sediment trap: disturbed area up to 2 ha. Sediment basin: more than 2 ha (Clause 8.12.3(b), (c)).
Design rainfall from Chapter 2 with climate factor 1.0 (Clause 8.12.4). Dewatering of excavations passes through the basin, a settling tank or a filter bag.

Figure 8E.2 — Sediment trap or basin in section: inflow, storage volume below the outlet, surface dewatering outlet (skimmer) drawing water from the top of the pool, emergency spillway, and sediment cleanout level at half the storage. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).

Notes:

1. **Sediment trap:** for concentrated flow from disturbed areas of up to 2 ha (Clause 8.12.3(b)). Storage volume, depth and outlet: to be confirmed in design.
2. **Sediment basin:** for disturbed areas of more than 2 ha. Storage below the outlet ≥ the greater of (a) the runoff from the 50% AEP (2-yr) 24-hour storm and (b) 250 m³ per hectare of drainage area (Clause 8.12.3(c)).
3. The dewatering outlet draws water from the surface (Clause 8.12.3(c)).
4. An emergency spillway and its capacity: to be confirmed in design. Where the basin is also a permanent detention facility, the Chapter 4 spillway rules apply.
5. Clean out when half full of sediment (Clause 8.12.5). Remove sediment from any permanent facility before its as-built survey (Clause 8.12.6).
6. Dewatering of excavations shall pass through a sediment basin, settling tank or filter bag (Clause 8.12.3(g)).

Illustrative — not design values. A sediment basin serves 3.0 ha of disturbed land. Assume a 2-yr 24-hour rainfall of 100 mm (climate factor 1.0, Clause 8.12.4) and a curve number of 86 for bare compacted ground under the antecedent moisture condition of Chapter 2.

- S = 25,400 / 86 − 254 = 41.35 mm; Ia = 0.2S = 8.27 mm
- Q = (P − Ia)² / (P − Ia + S) = (100 − 8.27)² / (100 − 8.27 + 41.35) = 8,414 / 133.08 = 63.2 mm
- (a) Runoff volume = 10 × Q × A = 10 × 63.2 × 3.0 = 1,896 m³
- (b) 250 m³/ha × 3.0 ha = 750 m³
- Required storage below the outlet = max (1,896, 750) = 1,896 m³. Here the 2-yr runoff governs.

8E.3 Stabilised construction exit and concrete washout

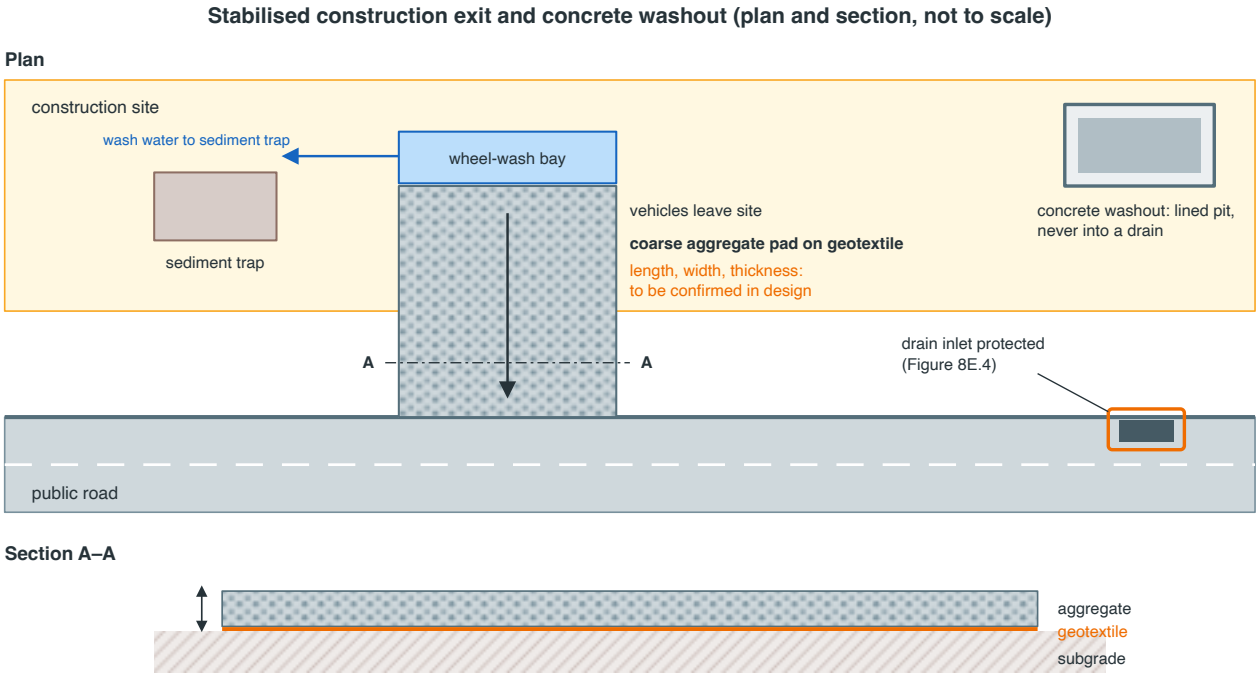


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).

Notes:

1. Provide at every point where vehicles leave the site onto a public road, with wheel washing (Clause 8.12.3(e)).
2. Pad length, width, thickness and aggregate size: to be confirmed in design.
3. Wash water drains to a sediment trap or basin, never to a drain.
4. Concrete washout in a lined pit, never into a drain (Clause 8.12.3(h)).
5. Sweep any sediment tracked onto the public road at the end of each working day.

8E.4 Inlet protection

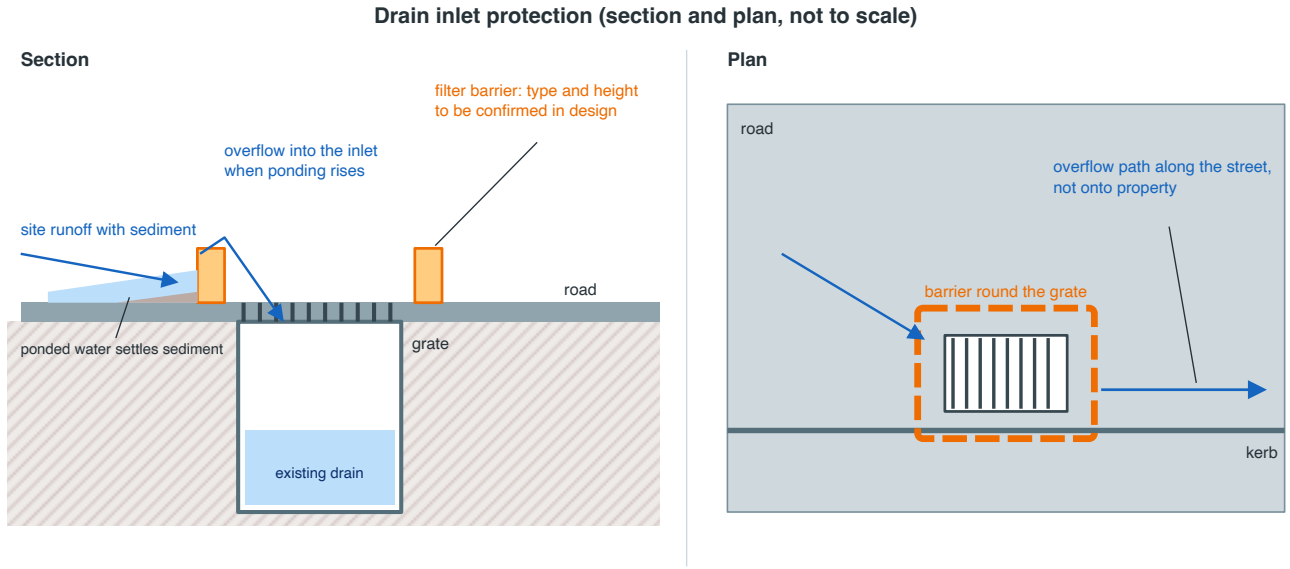


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

Notes:

1. At every existing drain inlet that receives runoff from the site (Clause 8.12.3(d)).
2. The protection must not block the inlet: water ponding behind it must be able to overflow into the inlet or along the street.
3. Barrier type and height: to be confirmed in design.
4. Remove sediment after each heavy-rainfall event (Clause 8.12.5).

8E.5 Timing and inspection

Table 8E.2 — ESC timing and inspection (Clauses 8.12.2 and 8.12.5)

Item	Requirement
Completed earthworks	Stabilised by vegetation, mulch, matting or paving by 31 March
Area cleared between 1 April and 31 October	Sediment controls in place before clearing
Area exposed in the monsoon	As small as practicable
Inspection	Weekly, and within 24 h after every heavy-rainfall event (Chapter 10)
Repair	Within 48 h

Item	Requirement
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 — Assam 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 — Assam 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.

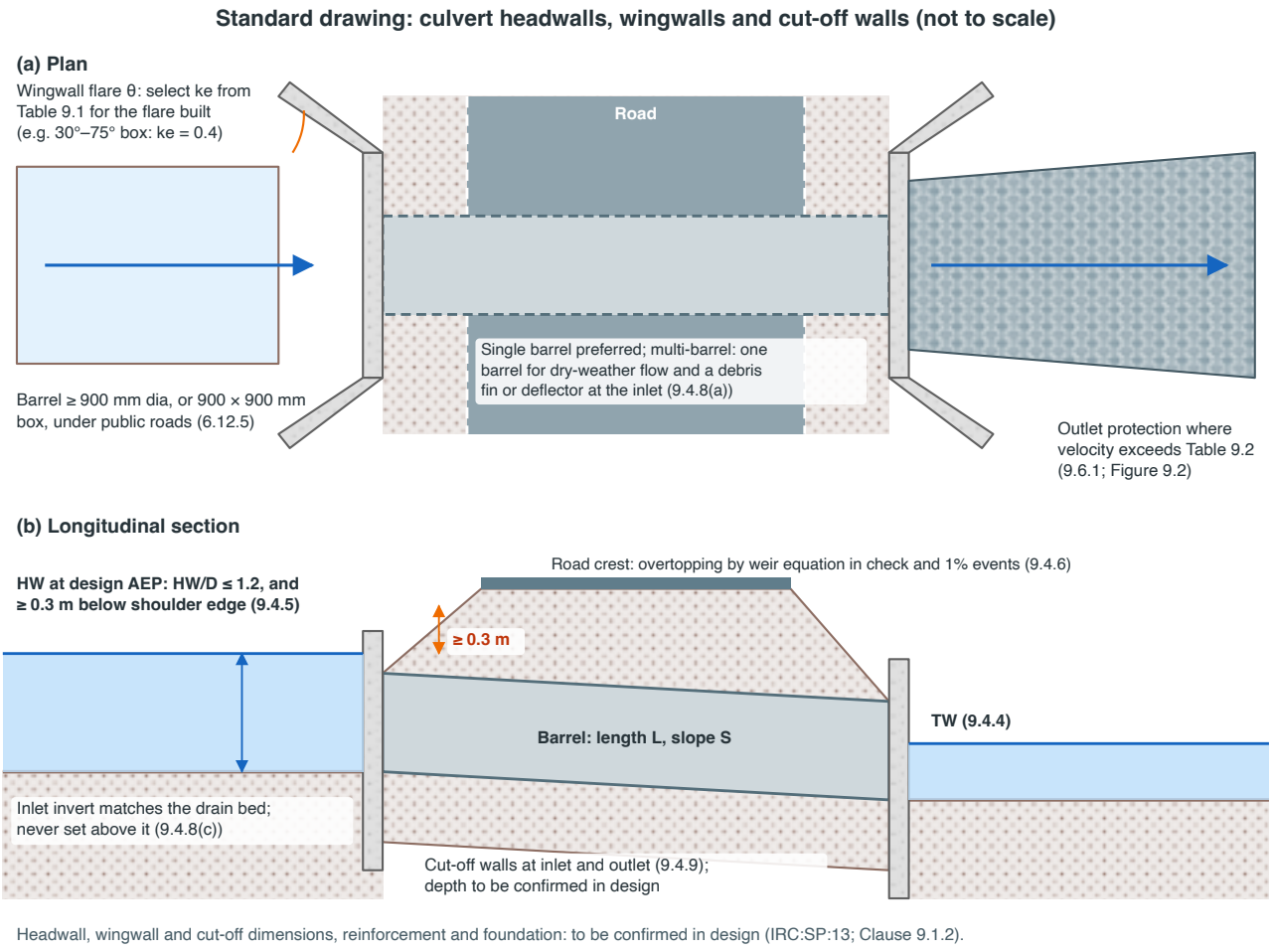


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

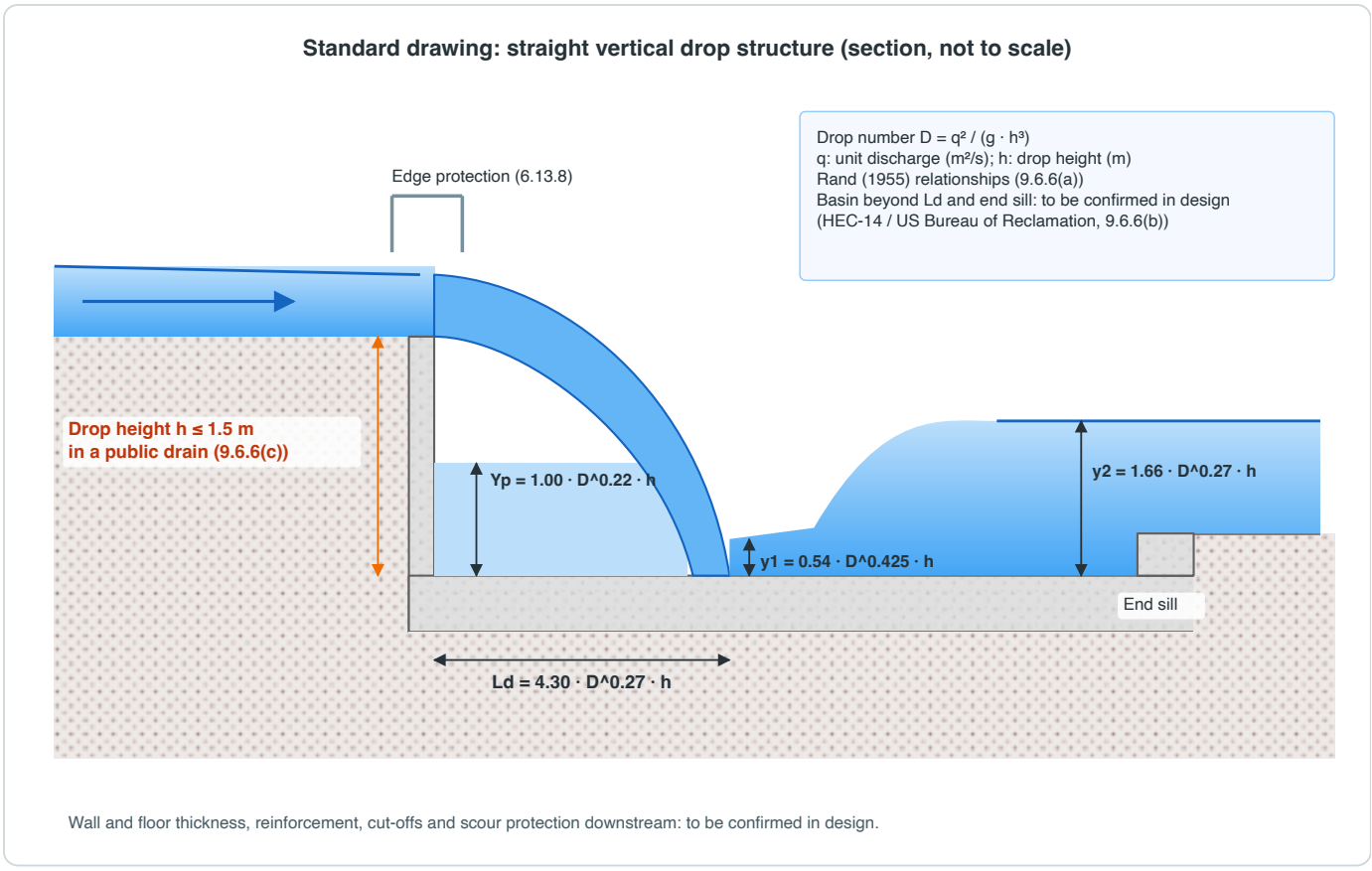


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

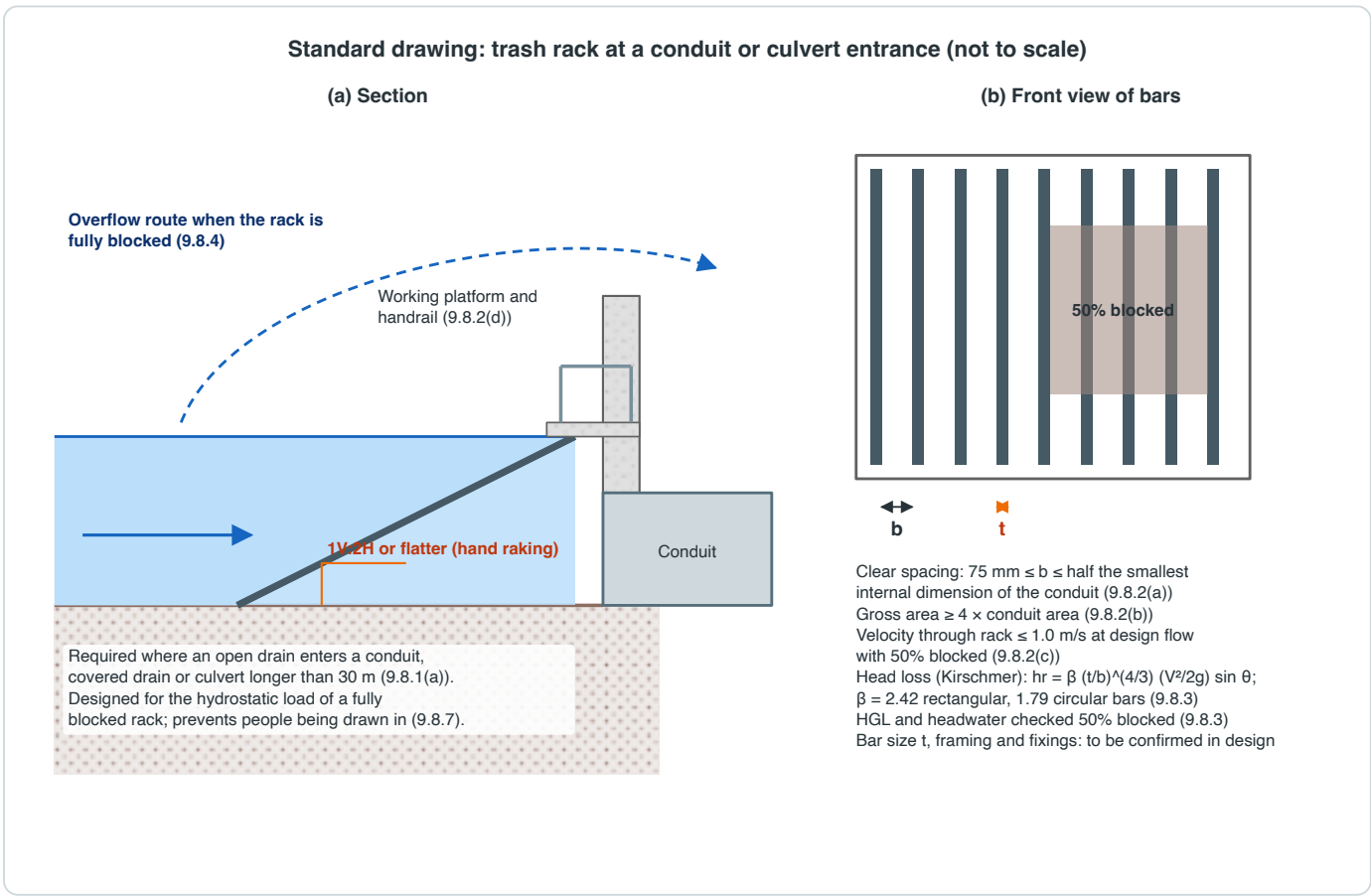


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

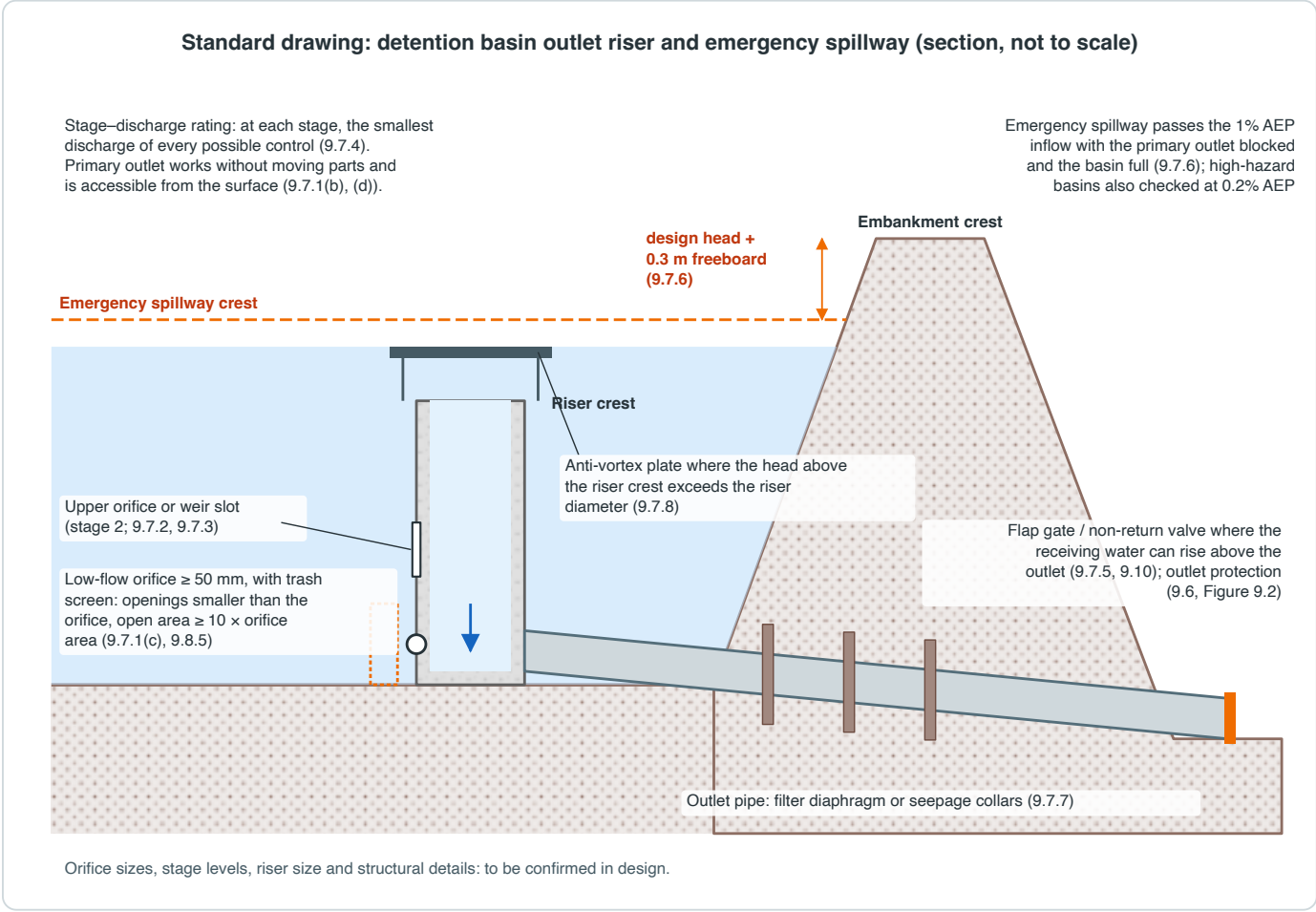


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — Assam 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 — Assam 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 to every building under byelaw 114 of the Unified Byelaws 2022 (structures of at least 5 m³ for every 100 m² of roof), with the percolation pits of Appendix VI and, on plots of 134 m² and more, storage and reuse, in hilly areas under byelaw 110(g), and, in an area notified under the Assam Ground Water Control and Regulation Act, 2012, to premises of 100 m² or more (s.19; no area has been notified); the volume is provided as storage and credited only as Clause 4.11 allows: never as a soakaway on the floodplain, on char and chapori land, on beel and pukhuri margins, behind an embankment that ponds when its sluices close or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, floodplain rule), or on natural ground sloping more than 10° without a geotechnical certificate (Clause 4.11, hill rule); recharge is credited only on tested ground under Clause 4.11 (recharge rule), and never through a recharge or injection well in the districts with arsenic or fluoride above the limits.	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

Step	Calculation	Clause
C17	**Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide.	10.5.2(c)
C18	**As-built re-run.** At Stage 4, repeat C4 to C17 with the as-built values and report each change from Stage 2.	10.9.1(b), 10.9.2

10A.4 Outputs

The calculator produces:

- (a) **Form 10-2**, filled in, with the calculator version and release date on every page;
- (b) a machine-readable export of every input and result of Tables 10A.1 and 10A.2; and
- (c) a list of the flags raised (C1 to C3, C6, C14, C17), each with the clause on which it is based (Clause 10.7.7).

10A.5 Testing before release

Before each release the State Stormwater Technical Committee shall check that the calculator reproduces, within rounding, the worked examples of the Manual that use the same method, including the illustrative examples of Clauses 4.6.7 and 4.14, and the benchmark problems of Annex 3C where they apply. The test results shall be published with the version log.

10A.6 Outline of the user guide

The user guide shall contain at least:

1. Purpose, status and limits of the calculator: a summary and screening check outside the design-aid route (Clause 10.5.2(c)).
2. How to obtain the current version, and the version rule of Clause 10.5.3.
3. Each input of Table 10A.1, with where to find it in the Manual and its annexes.
4. Each calculation of Table 10A.2, with its equation and clause.
5. The tolerance used in step C17, and what the drainage report must explain where it is exceeded (Clause 10.5.2(c)).
6. How to read and sign Form 10-2, and what to attach.
7. At least one worked example for each route, labelled "Illustrative — not design values".
8. The sources of every table in the calculator (Clause 10.5.4), and the version log.

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 46N (EPSG:32646), or 45N (EPSG:32645) for a project wholly west of 90° E (a strip of Dhubri, South Salmara-Mankachar and western Kokrajhar and Goalpara districts; a project 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 flood-forecasting and level-monitoring sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries (not stated in any source found [TBC]), of the gauges of WRD and of its embankment crests, sluice sills and gate-closing levels, and of the flood marks surveyed on ungauged channels, beels and pukhuris 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 `GMC–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
CTRL_AREA	R	ha	Yes	Area draining to the facility	Clause 4.5.1.3

Field	Type	Unit	Req.	Content	Source
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
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 flood-forecasting and level-monitoring sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries (not stated in any source found [TBC]), of the gauges of WRD and of its embankment crests, sluice sills and gate-closing levels, and of the flood marks surveyed on ungauged channels, beels and pukhuris (for example, MSL = x.xx m on the site datum)
SURVEYOR	Name and licence number of the surveyor
SURV_DATE	Date of the survey
PREP_BY	Name and registration number of the certifying professional

Field	Content
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)
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
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

Element	Requirement	Clause
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 Assam 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 March; after each heavy-rainfall day	No blockage; overflow clear	Table 10.3
Check drawdown at the observation well or surface	At each inspection after rain	Empties within 72 h of the end of rain; if not, investigate clogging	4.4.5, 8.7.6(c)
Clean pretreatment (forebay, filter strip, silt trap)	When the sediment trigger (item 3) is reached	Pretreatment cleaned without disturbing the main BMP	8.5.3, 8.5.4
Bioretention: mulch, plants, ponding	Every 6 months	Ponding drains within 48 h; dead plants replaced; mulch 50–75 mm	8.7.2
Permeable paving: surface	Every 6 months	Sweep or vacuum; no resurfacing with impermeable material	8.7.5(e)
Keep the contributing area stable	Each inspection	Bare soil stabilised; no sediment washing in	10.8.3(b)
Keep the facility in place and in use	Each inspection	Not filled, covered, paved or built over without approval	10.10.1(d)

Table 10D.3 — Surface detention basin or multi-use open space area

Task	Frequency	Standard or trigger	Clause
Inspect inlets, outlet, orifice, trash rack and spillway	Every 6 months; before 31 March; after each heavy-rainfall day	Orifice and rack clear; spillway unobstructed	Table 10.3, 4.8, 4.9
Remove debris and sediment	When the sediment trigger is reached, and after events	Design volume restored	10.11.1(c)
Check that the basin drains	After rain	No low point ponds for more than 72 h	4.15.7
Vegetation	As set in the plan	Grass cut; no woody growth on embankments or in the outlet zone	10.11.1(b)
Safety features	Every 6 months	Signs in Assamese and English and a depth marker in place; fences and gates sound where required	4.15.3, 4.15.5
Embankment (if any)	Every 6 months and after events	No cracks, slips, seepage or animal burrows	4.9.6

Table 10D.4 — Underground or podium detention tank, gravity outlet

Task	Frequency	Standard or trigger	Clause
Inspect from the access openings: inlets, outlet, orifice, screen, sump, vents	Every 6 months; before 31 March; after each heavy-rainfall day	Clear; vents open	Table 10.3, 4.10.2
Clean the sump and floor	When the sediment trigger is reached	Floor falls freely to the sump	4.10.2(c)
Inlet silt trap or GPT	Every 3 months (Table 10.3 row for GPTs)	Cleaned	4.10.2(e)
Overflow route	Each inspection	Operates when the outlet is blocked; route to the overland path unobstructed	4.9.5
Confined-space entry	Each entry	Entry procedure stated in the maintenance declaration followed; covers locked after	4.15.6
Use of the space	Each inspection	Not used for parking or storage; volume not reduced	10.10.1(d)

Table 10D.5 — Pumped detention, pumps and controls

Task	Frequency	Standard or trigger	Clause
Test run of each pump, duty and standby	Monthly	Each pump starts on level control; roles alternate	Table 10.3, 9.9.4(c)
Full duty test	Before 31 March	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 31 March	Automatic changeover works; fuel for at least 72 h of all duty pumps on site	9.9.9
Level sensors, float back-up, alarms, telemetry	Monthly	High-level and fault alarms reach the control room	9.9.8
Screens and silt trap	Every 3 months and after events	Clean	9.9.7
Records	Continuous	Sump levels, run hours and power status logged; kept at least 5 years	9.9.8(c)

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 March	Seals against the receiving water	Table 10.3, 10.9.3
Beach, estuary and creek outfalls	After every high-tide or surge event in the monsoon season	Sand and debris cleared	9.10.5(b)
Isolation	Before 31 March	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 31 March	No corrosion that would stop the gate working	9.10.6
Property non-return valves	Every 3 months	Cleaning eye accessible; valve seals	5.11.4

Table 10D.7 — Gross pollutant trap or first-flush device

Task	Frequency	Standard or trigger	Clause
Inspect and empty	Every 3 months; before 31 March; after each heavy-rainfall day	Emptied before the capture chamber is full; bypass clear	Table 10.3, 8.4.6
Screens	Each inspection	Clean; overflow path clear	8.10.3(b)
Disposal	Each cleaning	Material taken to an authorised solid-waste facility	—

Table 10D.8 — Private drains and inlets

Task	Frequency	Standard or trigger	Clause
Inspect and clean drains, inlets and silt sumps	Every 6 months; before 31 March	Free of silt and debris	Table 10.3
Check for sewage connections	Each inspection	None; any cross-connection removed	1.5.4, 8.9
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 Assam Unified Building Construction (Regulation) Byelaws 2022 (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 — Assam 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 flood-forecasting and level-monitoring sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries (not stated in any source found [TBC]), of the gauges of WRD and of its embankment crests, sluice sills and gate-closing levels, and of the flood marks surveyed on ungauged channels, beels and pukhuris	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 — Assam 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 — Assam 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, Unified Byelaws 2022 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 Assam 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 — Assam 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 — Assam 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 — Assam 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, mouza, district; extent	_____
A4	Approval reference (file number, Stage 2 approval date)	_____
A5	For multi-owner developments: the association or body that takes over after the developer (Clause 10.10.2)	_____

Table 10F.22 — Form 10-6, Section B: Schedule of facilities

Facility (FAC_ID)	Type	Location on the attached plan	Design volume (m³)	Outlet	O&M plan reference
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Model declaration. I/We, the owner named in Section A, declare and undertake, for myself/ourselves and for every successor in title to the land:

1. to operate, inspect and maintain each facility in Section B under the approved O&M plan, and to make the inspections of Clause 10.12 (Clause 10.10.1(b));
2. to give the Authority, its officers and its contractors a right of entry to inspect each facility and the access route shown on the plan, and to carry out works in default under Clause 10.15, with the cost recoverable from the owner (Clause 10.10.1(c));
3. not to remove, fill, cover, reduce or change the use of any facility, or obstruct its access route, without the Authority's written approval (Clauses 10.10.1(d), 10.13.5);
4. where Clause 10.10.3 applies, to lodge an Annual Maintenance Declaration and Inspection Report (Form 10-7) by 31 March each year;
5. for underground tanks, to follow the confined-space entry procedure stated here: _____ (Clause 4.15.6);
6. on sale or transfer of the land or any part of it, to disclose this declaration and the latest Form 10-7 to the purchaser, who takes on these obligations from the date of transfer (Clause 10.10.4); and
7. for a multi-owner development, that the developer remains responsible until the body named at A5 is legally constituted and has accepted this declaration in writing (Clause 10.10.2).

Table 10F.23 — Form 10-6, Section C: Execution and registration

Field	Entry
Owner: signature, name, date	_____
Witness 1: signature, name, address	_____
Witness 2: signature, name, address	_____
Acceptance by the association or body at A5 (when constituted): signature, date	_____
Registration: office, document number, date	_____
For the Authority: received and recorded in the facility register; officer, date	_____

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 — Assam Stormwater Design Manual, Draft v1.0. Due by **31 March** each year from every owner of a facility in a Tier A area, and from every owner of a pumped facility, tide gate or regional facility anywhere (Clause 10.10.3). See Figure 10.3.

Table 10F.24 — Form 10-7, Section A: Owner and facilities

No.	Field	Entry
A1	Reporting year (1 April to 31 March)	_____
A2	Owner or association; Maintenance Declaration registration reference	_____
A3	Facilities covered (FAC_ID and type)	_____
A4	Any facility under Clause 10.6.1(c) or (d) (yes / no). If yes, Section E is required	_____

Table 10F.25 — Form 10-7, Section B: Inspections made during the year (Table 10.3)

Facility	Routine inspections (dates)	Pre-monsoon inspection (date)	After heavy-rainfall events (dates)	Monthly pump test runs (number)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Table 10F.26 — Form 10-7, Section C: Pre-monsoon checklist (one per facility)

No.	Item	Condition (OK / defect)	Defect and date corrected
C1	Inlets, pretreatment and silt traps clear	_____	_____
C2	Orifice, trash screen and outlet clear; orifice size unchanged	_____	_____
C3	Sediment below the trigger in the O&M plan	_____	_____
C4	Storage volume not reduced; no filling, covering or change of use	_____	_____
C5	Overflow and spillway route clear	_____	_____
C6	Retention drains within 72 h (observation well or surface)	_____	_____
C7	Pumps: full duty test; standby pump and standby power tested; fuel for 72 h on site	_____	_____
C8	Alarms and telemetry tested	_____	_____
C9	Flap or tide gates and non-return valves: operated and seal tested	_____	_____
C10	Safety: covers locked, fences, signs and depth markers in place	_____	_____
C11	Access routes clear and not used for parking	_____	_____

Table 10F.27 — Form 10-7, Section D: Declaration of the owner

Field	Entry
I/We declare that the pre-monsoon inspection of Clause 10.12 has been made, that the defects found have been corrected as listed in Section C, and that the facilities are maintained under the approved O&M plan. Owner: name, signature, date	_____

Table 10F.28 — Form 10-7, Section E: Empanelled professional (facilities under Clause 10.6.1(c) and (d))

Field	Entry
I have inspected the facilities listed and confirm Section C. Name, empanelment number, signature, date	_____

Table 10F.29 — Form 10-7, Section F: For the Authority

Field	Entry
Date received; on time (by 31 March) yes / no	_____
Entered in the facility register (Clause 10.17), date	_____
Follow-up action, if any (Clause 10.15)	_____

Form 10-8 — Asset Handover Certificate

Supports Clause 10.14 of Chapter 10.

Draft form — Assam Stormwater Design Manual, Draft v1.0. Signed by the developer and the ULB when drains, open space facilities, regional facilities or other stormwater assets built by a developer are handed over.

Table 10F.30 — Form 10-8, Section A: Asset and parties

No.	Field	Entry
A1	Developer: name and address	_____
A2	ULB	_____
A3	Layout or project, approval reference	_____
A4	Assets handed over (FAC_ID, type, length or volume), with a plan	_____

Table 10F.31 — Form 10-8, Section B: Conditions of handover (Clause 10.14.1)

No.	Condition	Met (yes / no)	Reference or date
B1	As-built certificate (Form 10-5) accepted	_____	_____
B2	Facility cleaned; pipes and culverts inspected internally (CCTV or manual entry), record handed over	_____	_____
B3	Land, or an easement over it, transferred to the ULB	_____	_____
B4	O&M plan, drawings, GIS data (Annex 10B) and warranties handed over	_____	_____

Table 10F.32 — Form 10-8, Section C: Defects liability and register

No.	Field	Entry	Clause
C1	Defects liability period: from _____ to _____ (includes at least one full monsoon season, from 1 April to 31 October, after handover)	_____	10.14.2
C2	Developer responsible during the period for defects and routine maintenance	_____	10.14.2
C3	Security deposit held by the ULB, ₹, and release date	_____	10.14.2
C4	Entered in the ULB GIS drainage asset register and the facility register: date	_____	10.14.3

Table 10F.33 — Form 10-8, Section D: Signatures

Party	Name and designation	Signature	Date
Developer	_____	_____	_____
Certifying professional	_____	_____	_____
ULB	_____	_____	_____

ANNEXES TO CHAPTER 11

Basin and City Stormwater Master Plans

These annexes support Chapter 11. They give a terms of reference template for a Basin Stormwater Master Plan (BSMP), the layout of the basin list and boundary layer, the layout and method for depth–damage curves, the standard for publishing BSMP data and models, and the annual implementation report form. Annexes 11B and 11C need data that are not yet available; they say so and give the rule to use in the meantime. The template and the form are a model and a draft form for consideration by a competent authority, and are not in force.

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 Assam 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, pukhuri and tank restoration and major flow paths;
    - (e) set the basin inputs for site design: regional facilities, the fee-in-lieu unit rate, and any basin release rate stricter than Chapter 4; and
    - (f) recommend catchments for notification as flood-sensitive.
3. The BSMP may make the site criteria of Chapters 4 to 8 stricter for the basin. It shall not relax them, except through the regional detention and fee-in-lieu routes of Clauses 4.13 and 4.5.6 (Clause 11.1.3).

11A.2 Client, partners and study area

1. **Client:** [Lead Authority] (Clause 11.4.1).
2. **Partners:** WRD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, GMDA or T&CP, ASDMA] (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, jan or beel 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, pukhuri, 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 and embankments: outfall invert levels, on a named datum, against the warning, danger and high flood levels of the receiving river at the nearest CWC site and its recorded peaks, with any WRD or local gauge kept as a separate series and any conflict between published values stated; embankment crest levels; the sluices in the embankments, with their sills, gate types, closing levels and operating rules; the pumping stations on the outfalls, with their installed and working capacities, sump volumes and standby power; the stage–storage of the receiving beels and retention ponds; past breaches and cuts of the embankments; the release records of any dam that sets the receiving level; and the char and chapori land, eroding banks and bhabar fans in and below the basin;
- (f) rainfall and water levels: all available records (IMD, including the Regional Meteorological Centre Guwahati and its stations in *Extremes*, among them Guwahati (Borjhar) (42410), Dibrugarh (Mohanbari) (42314), Tezpur (42415), North Lakhimpur (Lilabari) (42309), Dhubri (42404) and Dhubri (Rupsi) (42406), Silchar (42619) and Silchar (Kumbhigram) (42620), Haflong (42522), Lumding (42523), Chaparmukh, Golaghat, Goalpara, Gohpur, Rangia, Tangla and Majbat; the self-recording gauges at Guwahati, Nowgong (Nagaon), Dibrugarh, Chabua and Jorhat used for the CWC Flood Estimation Report for subzone 2(b); the river gauges of CWC; the rain gauges of WRD, among them Chandmari and Beltola in Guwahati; the Guwahati city gauges reported in 2026, the City ARG, AAU-HRS, Gauhati University and SIRD Khanapara (owners, logging intervals and archives [TBC]); and any gauges or sensors kept by GMC, GMDA, ASDMA or Guwahati Smart City Ltd [TBC]), including the 31 May 2025 (111 mm in 24 hours at Guwahati (Borjhar), the highest May day on record there, with 120 mm and 99.6 mm given in other outlets, and three deaths in a landslide at Bonda, as reported), 14 June 2022 (84.6 mm at Chandmari and 88 mm at Beltola, gauges of WRD, against about 10 mm at Borjhar and 46 mm for the city, so that the gauges of one city differed about nine-fold in one storm, and four deaths in the landslide at Nizarapar and Boragaon, as reported), 20 April 2026 (117.4 mm at the airport, the April record, 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG overnight, as reported, with no hourly values found), June 2022 at Silchar (the Barak entering the town through the cut in its embankment at Bethukandi, with the Barak at

Annapurnaghat peaking at 21.59 m on 21 June and 251.20 mm in Cachar on 19 June, both as quoted from the Cachar district report, and no hourly rainfall in the town found) and June 2014 (the Guwahati floods, with seven flash-flood deaths and four electrocutions, CAG Report No. 4 of 2019, and no rainfall value found) 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 31 May 2025 (111 mm in 24 hours at Guwahati (Borjhar), the highest May day on record there, with 120 mm and 99.6 mm given in other outlets, and three deaths in a landslide at Bonda, as reported), 14 June 2022 (84.6 mm at Chandmari and 88 mm at Beltola, gauges of WRD, against about 10 mm at Borjhar and 46 mm for the city, so that the gauges of one city differed about nine-fold in one storm, and four deaths in the landslide at Nizarapar and Boragaon, as reported), 20 April 2026 (117.4 mm at the airport, the April record, 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG overnight, as reported, with no hourly values found), June 2022 at Silchar (the Barak entering the town through the cut in its embankment at Bethukandi, with the Barak at Annapurnaghat peaking at 21.59 m on 21 June and 251.20 mm in Cachar on 19 June, both as quoted from the Cachar district report, and no hourly rainfall in the town found) and June 2014 (the Guwahati floods, with seven flash-flood deaths and four electrocutions, CAG Report No. 4 of 2019, and no rainfall value found) 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, which is credited only on tested ground outside the floodplain and hill rules, the bhabar fans, the river terraces above the 1% AEP level and the hill-foot colluvium of Guwahati (Clause 4.11, recharge rule), waterlogging where the water table lies within 2 m of the surface, as CGWB found after the monsoon in almost every district, the stability of the Guwahati hills and the hill districts, where water put into colluvium or fill raises the pore pressure, and the quality of the shallow aquifer in the districts with arsenic or fluoride above the limits; effect on downstream basins and the receiving river, jan or beel; 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 floodplains, the beel basins and the Guwahati hills after any large flood or landslide, the drain network of every drain-owning body (GMC, GMDA, the other Municipal Corporations and Boards, PWD, NHAI, WRD, the Railways, OIL and the Army), the drain register of each town giving every reach its owner, its land status (patta, khas or government, or Council land) and whether it is a scheduled water body, an inflow or outflow channel of one or an embankment drain under the Assam Embankment and Drainage Act, 1953, the embankments of WRD with every sluice, its sill, closing level and operating rule, the pumping stations on the outfalls with their working capacities, the beels and pukhuris with their stage–storage and outlet levels, the scheduled water bodies by dag number, the char and chapori land, eroding banks and embankment breach paths, the release reaches below the dams, and the landslide and flood hazards mapped by ASDMA and in the Master Plans (other likely sources: Survey of India, CWC, CGWB, T&CP's Master Plan and drainage master plan maps, the comprehensive drainage master plan for Guwahati once final, the Revenue and Disaster Management Department's land records by district, mouza, revenue village and dag, and the District Councils' land records [TBC]). No basin map of any Assam town was found. Until the annex is published, the basins of Guwahati (the Bharalu–Bahini to Bharalumukh; the Mora Bharalu–Deepor Beel–Khanajan with the Basistha and the Kalmani, and Silsako; the Dipar, Foreshore, North Guwahati and Kalmoni basins; the hill fringe at Khanapara and Jorabat), Dibrugarh, Silchar, Karimganj, Hailakandi and Badarpur, Palasbari–Mirza, the north-bank towns on release and flash-flood reaches, Dhubri and Goalpara, Majuli and the char lands, and Haflong and Diphu 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); on char and chapori land, in breach paths and release reaches and on landslide ground 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
Guwahati Metropolitan Area (GMDA, GMC)	Bahini from its head in Meghalaya to Jonali, and the Bharalu to the sluice at Bharalumukh, with the Noonmati–Bondajan diversion	Whole catchment under Clause 2.3.6(c)(i); outfall-closed case at Bharalumukh a design case (Clause 5.8.5(b)); ADB pumps and pond; Brahmaputra at Guwahati (DC Court) as boundary
Guwahati Metropolitan Area (as above)	Basistha, Kalmani and Mora Bharalu to Deepor Beel and the Khanajan; Silsako basin	Beel stage–storage once surveyed [TBC]; draft eco-sensitive zone shown; Silsako retention basin
Guwahati Metropolitan Area (as above)	Dipar, Foreshore, North Guwahati and Kalmoni basins	Each to its outfall on the Brahmaputra; North Guwahati under the 2(b) rainfall of Clause 2.3.6(b)
Guwahati Metropolitan Area (as above)	Hill-fringe streams at Khanapara and Jorabat	Silt traps at the hill–plain break (Clause 6.3.6(m)); hazard screening first
Dibrugarh (Municipal Corporation, Development Authority)	Town behind the DTP dyke; drain to the Sessa past the Larua Jamira beel	Beel full and drain flowing full at the start; 97.50 m at the outfall sluice as boundary
Silchar (Municipal Corporation, Development Authority)	Town behind the Barak embankment	Outfalls once surveyed [TBC]; Barak at Annapurnaghat as boundary; Bethukandi breach path and 2022 flood marks
Karimganj, Hailakandi, Badarpur	Towns on the Kushiyara and the Barak	Kushiyara at Karimganj and Barak at Badarpurghat as boundaries; Clause 2.3.6(c)(ii)
Palasbari–Mirza	Channels and wetland of the town	Blocked channels and filled wetland (PIL/53/2023)

Tier A body or area	Basin	Note from Chapter 11
North Lakhimpur, Dhemaji, Subansiri reach, Tezpur	Towns on the Ranganadi, the Subansiri and the Jia Bharali	Largest recorded release, or spillway capacity, as boundary (Clause 5.8.5(d)); bhabar fans mapped
Dhubri, Goalpara	Towns on the lower Brahmaputra	High flood levels in conflict, both stated; record check of Clause 2.3.6(h) at Dhubri
Majuli and the char lands	River islands and chars	Hazard screening first; no permanent drainage works on active char land
Haflong, Diphu	Hill towns	Landslide ground mapped; hazard screening first
Other Tier A bodies and Municipal Corporations and Boards	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_AS	Text	Basin name in English and Assamese
TIER_A	Text	Tier A body or bodies in the basin
OUTFALL	Text	Outfall to the sea, river or major waterbody (Clause 11.2)
AREA_KM2	Real	Basin area, km²
LEAD_AUTH	Text	Lead Authority (Clause 11.4.1)
PARTNERS	Text	Partners, including WRD where it applies
LINKS	Text	Diversions to and from other basins (Clause 11.3.2)
BSMP_STAT	Text	None / in preparation / draft published / approved
BSMP_DATE	Date	Date of approval of the current BSMP
REVIEW_DUE	Date	Date of the next review (Clause 11.11.2)

Annex 11C — Depth–damage curves for Assam 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 Assam 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 31 May 2025 (111 mm in 24 hours at Guwahati (Borjhar), the highest May day on record there, with 120 mm and 99.6 mm given in other outlets, and three deaths in a landslide at Bonda, as reported), 14 June 2022 (84.6 mm at Chandmari and 88 mm at Beltola, gauges of WRD, against about 10 mm at Borjhar and 46 mm for the city, so that the gauges of one city differed about nine-fold in one storm, and four deaths in the landslide at Nizarapar and Boragaon, as reported), 20 April 2026 (117.4 mm at the airport, the April record, 215.9 mm at SIRD Khanapara, 134 mm at Gauhati University and 126.5 mm at the City ARG overnight, as reported, with no hourly values found), June 2022 at Silchar (the Barak entering the town through the cut in its embankment at Bethukandi, with the Barak at Annapurnaghat peaking at 21.59 m on 21 June and 251.20 mm in Cachar on 19 June, both as quoted from the Cachar district report, and no hourly rainfall in the town found) and June 2014 (the Guwahati floods, with seven flash-flood deaths and four electrocutions, CAG Report No. 4 of 2019, and no rainfall value found) floods (Revenue and Disaster Management Department and ASDMA 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, beel and embankment levels, sluices and pumping stations, 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 flood-forecasting and level-monitoring sites on the Brahmaputra, the Barak, the Kushiyara and their tributaries (not stated in any source found [TBC]), of the gauges of WRD and of its embankment crests, sluice sills and gate-closing levels, and of the flood marks surveyed on ungauged channels, beels and pukhuris 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 `bharalu_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 — Assam Stormwater Design Manual, Draft v1.0. Published by the Lead Authority for each basin with an approved BSMP before each monsoon season, by **31 March** (Clause 11.11.3).

Table 11F.1 — Form 11-1, Section A: Basin and plan

No.	Field	Entry
A1	Basin; Lead Authority; partners	_____
A2	BSMP version and date of approval	_____
A3	Reporting year (1 April to 31 March)	_____
A4	Date of publication (by 31 March) and web address	_____

Table 11F.2 — Form 11-1, Section B: CIP progress

CIP rank	Work	Agency	Cost in CIP (₹)	Spent this year (₹)	Spent to date (₹)	Status	Expected completion
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 11F.3 — Form 11-1, Section C: Fee-in-lieu ledger (Clauses 4.5.6.3(c) and 4.13.4)

Regional facility or tank	Volume credited to sites (m³)	Volume delivered (m³)	Fees received (₹)	Fees spent (₹)	Fees held, with year received
_____	_____	_____	_____	_____	_____
Basin total: volume owed and delivered	_____	_____	_____	_____	_____

Table 11F.4 — Form 11-1, Section D: Maintenance completed (Clause 11.8.4(f))

No.	Item	Planned	Done	Date completed
D1	Desilting of drains and canals (length, km; volume, m³)	_____	_____	_____
D2	Tank and pukhuri 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	_____