TRIPURA

Stormwater Design Manual

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

Preserve | Retain | Detain | Convey | Maintain

Draft v1.0

November 2026

Prepared by

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About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Tripura, by its Governor, its Council of Ministers or its Legislative Assembly, or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Urban Development Department (UDD) or its Town and Country Planning Organisation (TCPO), the Tripura Urban Planning and Development Board or the Tripura Urban Planning and Development Authority (TUDA), the Agartala Municipal Corporation (AMC), any Municipal Council or Nagar Panchayat, or Agartala Smart City Ltd (ASCL). Nor has it been adopted, notified or endorsed by the Tripura Tribal Areas Autonomous District Council (TTAADC), any Village Committee or Panchayat, the water-body committees of the Department of Science, Technology and Environment (DST&E), or the State Level Advisory Committee (SLAC) of the Revenue Department. Where it names a body, such as PWD (Water Resources), PWD (Roads and Buildings) or PWD (Drinking Water and Sanitation), the Revenue Department or a District Magistrate and Collector, DST&E, the Forest Department, the Wetland Authority of Tripura, the Tripura State Pollution Control Board (TSPCB), the Tripura Disaster Management Authority (TDMA) or a District Disaster Management Authority, the Tripura State Electricity Corporation Ltd (TSECL), the High Court of Tripura, the Tripura Human Rights Commission (THRC), the National Green Tribunal (NGT) or the Supreme Court, or a body of the Union or another public body, such as the Central Water Commission (CWC), the India Meteorological Department (IMD), the Central Ground Water Board (CGWB), the Central Pollution Control Board (CPCB), the National 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 the National Highways and Infrastructure Development Corporation Ltd (NHIDCL), or a lender, such as the Asian Development Bank (ADB), 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 Tripura Municipal Act, 1994 and the Tripura Building Rules, 2017 as amended (the TBR 2017); the Tripura Urban Planning and Development Act, 2018, the Master Plan for the Agartala Planning Area 2045 and its zoning and development control regulations, and the notifications of the Local Planning Areas; the Tripura Land Revenue and Land Reforms Act, 1960 and the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 as amended in 2026; the Wetlands (Conservation and Management) Rules, 2017; orders of courts and tribunals; and approval conditions in force continue to apply.

Tripura and the Sixth Schedule. The Tripura Municipal Act, 1994 "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (section 1(2)), and the TBR 2017 are made under that Act, so neither applies in the area of the TTAADC. That area is about 68% of the State, as reported. The State-made laws on the Council found for this Manual, among them the Tripura Tribal Areas Autonomous District Council Act, 1979 and the Village Committee Act, 1994, were seen only by their titles, and none of those titles concerns building or drainage; no building or land-development regulation of the Council was found [TBC]. Where a town and the Council's area meet, the line can be disputed: a proposal of 2026 to form a Nagar Panchayat at Bisramganj on land that the Council's leaders say lies within the autonomous district was unresolved in the reports read. This Manual therefore names its "competent authority for the area" by area and by subject, as Chapter 1 sets out. The UDD could make it part of the TBR 2017 by an amendment under section 274 read with section 118 of the Municipal Act; TUDA could write its drainage reserves, lunga and pukur protection and river buffers into the zoning regulations of the Master Plan 2045 and the layouts of the Local Planning Areas; the Agartala Municipal Corporation and the other urban local bodies could apply it at building permission and occupancy and to the drains vested in them; PWD (Water Resources) could set outfall, sluice and

embankment-crossing conditions; the Revenue Department could refer to it in decisions on water bodies; and the Council could adopt it for its own area by its own regulation or resolution. None has done so, and the Manual can reach the Council's area only through the Council. Land is recorded by district, sub-division and revenue circle, as the land-revenue forms of 2026 list them, and by mouza and plot [TBC]; in the Council's area land is held under the Council's 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 section 1(2) of the Municipal Act.

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

- the **Haora** is Agartala's river and CWC's name for its site at the city. Sources also write it in an English form used for a city elsewhere, and its Kokborok name is *Saidra*, as reported; this Manual writes Haora throughout. The **Katakhal**, Agartala's northern drainage channel, is also written Kathakhal and Kathakal; it is not the channel of the same name in another State;
- the **Gomati** is the river and the district; CWC prints the river as **Gumti**, and this Manual uses that form only in a CWC site name and in the name of the Gumti hydel project. **Dumbur**, also written Dumboor, is the reservoir of that project at Tirthamukh. The **Muhuri** at Belonia is also written Muhari, and the **Burima** at Gajaria and Boxanagar is also called the Burinala and the Bijoy;
- the South Tripura gauge **Bagafa** is also written Bokafa and Bogafa; IMD and the State name the same place. This Manual writes "Bagafa (IMD)" for the IMD gauge, which differs from "Bagafa AWS". Other places are also spelt in two ways: **Sepahijala** (Sipahijala), **Bisramganj** (Bishramganj) and **Sabroom** (Sabrum);
- IMD names its two Tripura stations in its tables of extremes **Agartala (A)** (index 42724), which its press releases call **Agartala Aero**, and **Kailashahar (A)** (index 42618), also **Kailashahar Aero**. **Kailashahar CWC** is a different gauge: CWC's river-level site on the Manu at Kailashahar. This Manual names the gauge each figure comes from;
- the State has eight districts, formed in 2012: West Tripura, Sepahijala, Khowai, Gomati, South Tripura, Dhalai, Unakoti and North Tripura. CWC's tables still print the older districts, so that Kailashahar appears under "North Tripura" and Sonamura under "West Tripura". A clause that names a district must be checked against the current list;
- no CWC Flood Estimation Report covers any part of Tripura. The report for subzone 2(b), South Brahmaputra, mentioned Tripura once, and its corrigendum deletes the mention; its plates stop at about 25° N, north of the State. By elimination the State lies in **subzone 2(c), "Barak and others"**, for which CWC never published a report; this is NEER's reading, to be confirmed against CWC's map of subzones [TBC]. That subzone is not the five rainfall zones (TR-Z1 to TR-Z5) and seven hydrologic sub-areas (TR-A, TR-B, TR-B1, TR-C, TR-D, TR-D1 and TR-E) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7;
- the land between the tillas is a **lunga** in the land records and in Agartala's place names, and "loonga" in CGWB's reports; this Manual writes lunga, and keeps "loonga" only in a quotation;
- the State's second official language is spelt "Kok-Borak" in the Official Language Act and "Kok Borok" in the notification of 1999; this Manual writes **Kokborok**;
- the **Master Plan for the Agartala Planning Area 2045** was declared final by the UDD on 24 February 2026 under section 53(1) of the 2018 Act, covering 238.57 km², the Agartala Municipal Corporation and 49 gram panchayats, as reported. Its notification number and its text, including its zoning regulations, were not read for this Manual [TBC], and no buffer, zone or drainage rule is taken from it;
- CWC's levels in the State were read only in a transcription by the South Asia Network on Dams, Rivers and People (SANDRP) and in the press, in metres, and no source read states their datum [TBC]. The values disagree: the Haora's danger level at Agartala is given as 10.48 m, 10.50 m or 10.70 m and its highest flood level as 11.08 m, 12.14 m, 12.4 m or 12.42 m (22 August 2024), probably from different gauges or

datums. This Manual uses the higher value until CWC confirms the gauge and datum, and names the gauge, the unit and the datum with every level. CWC, not PWD (Water Resources), runs the river-level sites cited;

- Agartala's position is given as 23°45' N, 91°30' E in *Tripura at a Glance* and at 91°17' E by CGWB and the ADB; the two longitudes conflict, and both lie in UTM zone 46N, which this Manual uses for the whole State; 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, the months of the nor'westers, and the south-west monsoon reaches Agartala in about the first week of June (about 5 June, inferred from press reports of IMD's onset dates in 2025 and 2026; another report gives 10 June, and IMD's revised normals were not read [TBC]); the date of its withdrawal from Tripura 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 **Tripura Building Rules, 2017** were made by the UDD under section 274 read with section 118 of the **Tripura Municipal Act, 1994**, by notification No. F.2(316)-UDD/GL/TCPO/2009 (Part-I)/371 of 10 November 2017, as cited in the UDD's BRAP-2019 document; the gazette of 2017 was not read [TBC]. They were amended by the Tripura Building (Amendment) Rules, 2019 (No. F.2(466)-UDD/GL/TCPO/2018/599-627, 19 February 2019; Gazette Extraordinary No. 482, 25 February 2019), the (Second Amendment) Rules, 2020 (dated 15 February 2020, Gazette 24 February 2020; its number is illegible in the copy read [TBC]), the (3rd Amendment) Rules, 2022 (No. F.01(24)-TUDA/Estt/2022/4902-30, 29 November 2022; Gazette 2 December 2022), the (Fourth Amendment) Rules, 2024 (No. F.1(23)-TUDA/ESTT/2024/66, 15 January 2025; Gazette No. 95, 17 January 2025) and the (Fifth Amendment) Rules, 2025 (F.No.2(466)-UDD/GL/TCPO/2018(P-V)/4009-20, 4 July 2025; Gazette No. 1294, 5 July 2025). No sixth amendment was found up to November 2026. The rules replace the Tripura Building Rules, 2004 (rule 1(4)) and apply to "buildings in the Urban Local Bodies (ULBs) in Tripura" (rule 1(2)), to which the amendment of 2019 added "and Planning Areas". This Manual cites a rule as "TBR 2017, r.9(4)". There is no "Tripura Building (Construction) Rules";
- the **Agartala Municipal Corporation** is constituted under the Tripura Municipal Act, 1994; there is no separate Act for it. It became a Municipal Corporation in January 2014, as reported, and its wards are given as 49 or 51 and its area as 76.5 km² or 92 km², as reported; the figures conflict. The Agartala Planning Area of the Master Plan 2045 is wider than the Corporation's area, and ASCL, the UDD, PWD (Roads and Buildings), PWD (Water Resources) and PWD (Drinking Water and Sanitation) build and hold drains in it. The State's other 19 urban local bodies are Municipal Councils and Nagar Panchayats. Under the Municipal Act, "all public tanks, streams, reservoirs, and wells" and "all public sewers, drains, channels, tunnels, culverts and water courses in, alongside, or under any street" vest in the Municipality "unless the State Government otherwise directs by a notification" (section 91), and the Municipality "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall" (section 156(1)); no order allocating Agartala's drains among the bodies that build them was found;
- **TUDA** is the Tripura Urban Planning and Development Authority under the **Tripura Urban Planning and Development Act, 2018** (Tripura Act No. 12 of 2018). It gives building permission and the occupancy certificate in the notified Local Planning Areas, and for buildings or townships of 50 or more flats or of one acre or more inside an urban local body (TBR 2017, r.13(3), inserted in 2020). In this Manual TUDA means the Authority; the Board of the same Act, which the Chief Minister chairs, is written in full. Section 163 of the 2018 Act repealed the Tripura Town and Country Planning Act, 1975, and orders made under it are deemed made under the new Act. TUDA's notification under section 52(1), of November 2019, declared Local Planning Areas adjacent to 20 cities and towns, the first of them the Agartala-Ranibazar-Jirania Local Planning Area. The **UDD**, whose file series is "UDD/GL/TCPO", makes the Building Rules, oversees the urban local bodies and contains the TCPO;

- the **Tripura Land Revenue and Land Reforms Act, 1960** (43 of 1960) and the **Diversion of Land Rules, 2025** made under it (Revenue Department No. F.4(05)-RCC/2025, 2 June 2025; Gazette Extraordinary No. 1072, 3 June 2025) treat the "Diversion of water body to any other purpose" as a diversion of land. As made, the rules required the recommendation of a district or sub-divisional committee of DST&E, a no-objection certificate of the Fire and Emergency Service and the approval of the SLAC, with the District Magistrate and Collector deciding. The (First Amendment) Rules, 2026, of 6 March 2026 (Gazette Extraordinary No. 2026350), substituted a self-declaration online for rule 3 and a revocation within 30 working days for rule 4, and omitted rules 6 to 10. Whether section 20 of the Act, as amended, still bars the diversion of a water body was not established, so this Manual does not state the procedure that now applies [TBC]. Appendix-I of the rules gives the land classes in Bengali with official English glosses, from which this Manual takes its local terms;
- **PWD (Water Resources)** builds and keeps the flood-protection embankments and anti-erosion works and the double-barrel sluice on the Katakhal, and has mapped flood-plain zones on the Haora for the NGT; no Tripura statute on embankments or drainage was found, and its consent to cut, cross or discharge through an embankment is taken in this Manual to be an owner's consent [TBC]. **PWD (Roads and Buildings)** builds the major roads and their drains, and **PWD (Drinking Water and Sanitation)** the drainage pump houses and, with the UDD, the sewage treatment plants. The **Wetland Authority of Tripura** was constituted on 5 September 2018, as cited, under the Wetlands (Conservation and Management) Rules, 2017; and
- **TDMA**, the Tripura Disaster Management Authority, is chaired by the Chief Minister, as reported, and the Revenue Department is the State's nodal department for disaster management; District Disaster Management Authorities are written in full. The **Gumti hydel project** at Dumbur is operated by TSECL, as reported.

Where a shared clause calls for the local language on a sign, a form field or a basin name, this Manual writes "Bengali". **Bengali and Kokborok are both official languages of the State, and English the language of this Manual.** Under the Tripura Official Language Act, 1964 (Act No. 5 of 1964), as amended by the Tripura Official Language (Amendment) Act, 1979 (Act No. 8 of 1979, as cited), "the Bengali language and the Kok-Borak language" are the languages for "all or any of the official purposes of the State of Tripura" from 1 May 1999, the date appointed by the Law Department's notification No. F.12(1)-LAW/88(Shadow) of 29 April 1999, and "The English language may continue to be used" (section 2(2)(a)). Shared clauses write "Bengali" because their fields hold one name in one script and the land records carry the Bengali name; Kokborok is not thereby the lesser language. So, as set by this Manual, **signs and flood-depth markers are in Bengali, Kokborok and English**, with Kokborok written in the script that the local body or the Council uses. The choice of script for Kokborok, Roman or Bengali, is disputed, as reported, and this Manual takes no side. In Annex 7A the field WB_NAME_BN holds a water body's name in Bengali; a Kokborok name, such as *Saidra* for the Haora, 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. The glosses in quotation marks are the official English of the land classes in Appendix-I of the Diversion of Land Rules, 2025:

- a **pukur** (Bengali পুকুর: a tank or pond — the land records' 'Tank/Pond'; plural pukurs) is this Manual's word for a dug pond or tank. Biswas's *Samsad Bengali-English Dictionary* (p. 653; edition not confirmed) gives "a pond, a tank, a pool", with পুকুর কাটা, "to excavate a pond", and পুকুর ঝালানো, "to dredge a tank". Bengali marks the plural with *-gulo* or *-guli*, so the English plural "pukurs" is a convention of this Manual. Its bank, the **pukurpar** (পুকুরপাড়), is a land class of its own, "Bank of tank";
- a **dighi** (Bengali দীঘি: a large tank) is "Large tank" in the land records and "a large and deep tank or pond" in Biswas; its bank, the **dighirpar**, is "Bank of large tank". Where a shared clause writes "tank (pukur)", it means a pukur or dighi, a palace or temple tank, a beel that has an outlet, or the Dumbur reservoir; Tripura has no cascades of irrigation tanks. This Manual calls engineered storage a **detention pond**, never a pukur, and never calls a natural wetland a pukur;
- a **doba** (ডোবা) is "Ditch" in the land records: a small pit of water, not a pukur;
- a **beel** (বিল) is "Watery land", a natural low wetland, and a **haor** (হাওর) "Big watery land", a large seasonal wetland;

- a **tilla** (টিলা) is "Hillock", the low rounded hills of the dissected uplands, and a **lunga** (লুঙ্গা) "Flat lands between tillas", the flat valley floor that is the natural flow path between them;
- a **chhara** (ছড়া) is "Streams" in the land records, a stream that runs down from the tillas or the hills; the Building Rules call such a stream a **jhora**, and this Manual keeps "jhora" only when it quotes them;
- a **khal** (খাল) is "Khal" in the land records and "a canal; a strait; a channel" in Biswas, a canal or drainage channel, and a **nala** (নালা) "Water channel", a smaller natural or built channel; and
- a **bandh** (বাঁধ) is "Embankment", this Manual's word for a river or pond embankment, though the text keeps the English "embankment" in clauses.

Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2, 3 and 4 and in Annexes 3, 4 and 10; where the text names a body, it is the Agartala Municipal Corporation;
- "TBR 2017" is the Tripura Building Rules, 2017 as amended, and "MBBL 2016", in Chapters 1 and 10, the national Model Building Bye-Laws of 2016, not the State's rules;
- TUDA is the Tripura Urban Planning and Development Authority. In other editions of this series and in some sources similar letters stand for other bodies; in this Manual it means only this one;
- 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. TBR 2017, r.55 sets the plinth by the crest of the road, at not less than 60 cm; no flood level fixed by a local authority was found for any town, and Chapter 7 says how this Manual finds one.

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

Tripura's towns flood, and fail, for three reasons. Agartala showed the first on 22 August 2024, when the Haora reached 12.42 m at the CWC site in the city, above its earlier highest level of 12.4 m in 2017, as reported, and the city's centre, a saucer between the Haora embankment and the Katakhal, could be drained only by pumping; Bagafa showed the second on the same day, when IMD's gauge there recorded 49 cm of rain in 24 hours, more than the 100-year value of any NIH-DHAARA cell in the State; and Agartala's drains show the third every day, because the city's sewers serve only its North Zone and its new sewage treatment plants are fed by tapping the storm drains, which the NGT has said "is not legal".

1. **Towns in saucers and on lungas that drain into rivers higher than themselves, and on across a border that no level data crosses.** Agartala's centre is "at a lower level than other areas giving it the appearance of a saucer", the ADB's environmental examination of 2020 records; "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded", and when the Haora and the Katakhal run high "Several pumps have been provided to lift the water out of the city during these seasons". In August 2024 the city had 18 flood pumps of up to 900,000 litres an hour each and 6 diesel pumps, discharging to the Katakhal and the Haora, as reported; the Katakhal drains through a double-barrel sluice of PWD (Water Resources); and a proposal of July 2026 for two more embankments and three more pumping stations, at ₹1,000 crore, is to be "implemented in phases, depending on the availability of funds", as reported. The other towns are built on the lungas and flood plains of rivers that leave the State: Kailashahar on the Manu, Dharmanagar on the Juri, Belonia on the Muhuri, Khowai on the Khowai, and Udaipur and Sonamura on the Gomati below the Dumbur reservoir, whose gates were opened on 21 August 2024, as a district alert reported and the State's power minister denied. In August 2024 the Muhuri at Belonia rose to 18.81 m, 1.83 m above its highest level of 1983, and the Juri at Nutan Bazar to 20.66 m, as reported. Every one of these rivers flows on into Bangladesh, as this Manual reads them; there is no control downstream in India and no level data from across the border. PWD (Water Resources)'s pages give the State's flood embankments as 154.41 km in one place and 134.55 km in another, as cited; no operating rule or closing time for any sluice was found.
2. **Rainfall that no CWC report covers, with a measured day above every estimate.** The whole State lies outside every published CWC Flood Estimation Report, so there is no plate, no ratio and no synthetic unit hydrograph for any part of it. IMD's national rainfall intensity curves (Das et al., 2022) have no panel for Tripura. NIH-DHAARA's reanalysis grids are of the right order here: Agartala's 50-year 24-hour depth, 320.5 mm, is 1.25 times the largest day in the 60 years of IMD's record at Agartala (A), 257.2 mm on 22 July 1993, and Kailashahar (A)'s record of 377.2 mm on 6 June 1993 equals DHAARA's 100-year value there, 379.4 mm, within 2.2 mm. But they are low against the extremes. Bagafa's 49 cm on 22 August 2024 exceeds every 100-year DHAARA value in the State, the largest of which is 435.1 mm, at Sabroom; two days earlier Belonia recorded 32 cm and Amarpur 31 cm, above the 50-year values of their own cells, 311.9 mm and 291.1 mm; and two cells 30 km apart in one valley, at Teliamura and south of Khowai, differ by 22%. No recording-gauge record of the State's short storms was found in any source. About 200 mm of rain in three hours was reported at Agartala in June 2022 and again on 31 May 2025, when a man died in a manhole, but no IMD value confirms either.
3. **Storm drains that are the sewers.** Agartala's sewers, 103.6 km "with 4011 nos. household connection", run "only in the North Zone", and its sewage treatment plants "are designed to be connected through Interception & Diversion of Drains", the State told the NGT in July 2026. The Corporation's area generates 61.0 MLD of sewage against 17.4 MLD of treatment capacity, and the other 19 urban local bodies 21.4 MLD, none of it treated; the State put its total at 82.4 MLD in that affidavit, but at a meeting of the Central Monitoring Committee in August 2025 asked CPCB to consider 227.43 MLD, and the figures conflict. The NGT's point, as the affidavit quotes it, is that "storm water drains are being tapped and taken to STPs which is not legal", and that sewage and storm water mixing in the monsoon "will not only upset functioning of STP but, will also lead overflow of untreated sewage". The Haora at Dashamighat is in CPCB's list of polluted river stretches (Priority V).

Over all three lie four more. **Lungas and pukurs filled**: ponds have been filled for housing at Barjala and Lanka Basti, as reported; the High Court of Tripura heard the filling of ponds and walling of their banks at Kalyan Sagar, Matabari, in PIL 2 of 2014, and the encroachment of Agartala's water bodies in 2017, as cited; the State reported 180 urban water bodies on government land in 2020, of which 30 were prioritised, as reported; and no inventory of Agartala's ponds was found. **Tilla cutting that silts the drains and slides in the rain**: the tilla uplands are "10 – 30 m high mounds with gullies in between them", as CGWB describes them, and in August 2024 landslides were reported at 2,032 locations; on the national highways the High Court's suo motu PIL 06 of 2026 found "culvert block by silt, vegetation, debris", and the CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste". **A water table near the surface**: in West Tripura CGWB found the water 0.22–6.64 m below ground in November 2017, with iron up to 4.99 ppm, and "The ground water table being very high" in Agartala, as the ADB records; the stage of groundwater extraction is 9.48%, and every assessment unit is Safe, as quoted. And **building rules that bar filling and regulate riverbanks but set no design storm, detention or volume**: the TBR 2017 forbid the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" without the State's approval (r.9(3)), limit buildings within 15 m of a river bank (r.9(4)), ask for a "site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" (r.14) and require rainwater harvesting on buildings of 200 m² of plinth or more (r.110); but no rule says for what storm a drain is sized, how much water a site must store, or how fast it may release its runoff, and since 2025 every use may cover 70% of its plot.

Behind all of this lie the State's rivers, pukurs, dighis and beels, which set the level at the outfall and hold the water when the gates are shut. Rudrasagar, in Sepahijala, is a Ramsar site of 240 ha, designated in 2005 by the Ramsar record and in 2007 by the Forest Department's account; the dates conflict. The palace and temple tanks of the towns are storage that already exists, with heritage and fisheries uses that this Manual does not draw down. The land records count pukurs, dighis, their banks, beels and haors as land classes of their own, so they can be counted as storage and protected as land.

Design for Tripura therefore has to cover a wet season that begins with the storms of April and May, before the south-west monsoon reaches the State in about the first week of June: Kailashahar's wettest month on IMD's record is May (1,175.0 mm, in 1991) and its next is April (1,012.8 mm, in 1977), and Agartala recorded 198.0 mm in a day on 11 April 2007. It is this Manual's monsoon season, 1 April to 31 October. Large falls come outside it too, as on 19 February 1993 at Agartala (142.2 mm), 11 October 1989 at Agartala (183.6 mm) and 10 November 1986 at Kailashahar (104.2 mm), so design statistics use the annual maxima of every month. CGWB's five-year averages give Agartala 1,851 mm a year, and the ADB's examination 1,922–2,855 mm across the State, increasing from south-west to north-east; IMD's normals were not obtained [TBC]. There is no snow. Underground, groundwater is plentiful, shallow and little used; rainwater is worth storing for use, but on the lungas and 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 chhara, khal, pukur or river is high, when the sluice in the embankment is shut and the town drains only by its pumps, when the Dumbur reservoir is releasing, or when a drain is choked with silt from the tillas.

The Manual also sets how public drains, roads and their drains, chharas, khals, pukurs and dighis, embankment sluices, pumped outfalls and basin-wide master plans are designed, and how drains below cut tillas 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 Tripura's wet season of April to October, with its pre-monsoon storms; to a State that no CWC report covers; to towns on lungas and flood plains that lie behind embankments and below the river's high stage, and drain through sluices and pumps into rivers that cross into Bangladesh; to the release reach of the Gomati below the Dumbur reservoir; to the silty clays of the flood

plains and lungas, the lateritic sandy clays and sandy loams of the tillas, the weathered Tipam sandstone and the sandstone–shale ranges; to a water table near the surface; to the pukurs and dighis; 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, 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.** NIH-DHAARA, the core's primary source, applies in Tripura as modified by this Manual, because no CWC report covers the State: the 24-hour depth at every return period is the greater of DHAARA's value at the site and its value at the governing cell of the site's sub-area; durations of 1 to 24 hours are not less than the ratios of CWC's report for subzone 2(a) applied to that day, used as a lower bound; floors at 1, 3 and 6 hours keep every short design storm above the largest falls recorded at the recording gauges of the nearest CWC report, in the Brahmaputra valley; and a check against the largest reliable days recorded within 25 km, and in the same zone, raises the 1% AEP day where a record exceeds it, so that no 1% AEP day in the Muhuri–Feni south falls below Bagafa's 49 cm. A station analysis of IMD's Agartala (A) and Kailashahar (A) records governs once one is made. All these rules are set by this Manual (Chapter 2). IMD's national rainfall intensity curves (Das et al., 2022) are not used, because none of their panels is for a station in Tripura.
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 TBR 2017 and their five amendments; the Tripura Municipal Act, 1994; the Tripura Urban Planning and Development Act, 2018 and TUDA's notification of the Local Planning Areas; the Tripura Land Revenue and Land Reforms Act, 1960 and the Diversion of Land Rules, 2025 with their amendment of 2026; the Tripura Official Language Act, 1964; the Wetlands (Conservation and Management) Rules, 2017; and the orders of the High Court of Tripura in PIL 06 of 2026 and PIL 2 of 2014, and of the NGT in OA 673 of 2018 and OA 606 of 2018. This Manual follows them or, where disclosed, makes them stricter. The Master Plan for the Agartala Planning Area 2045 and its zoning regulations, DST&E's guidelines for the protection of lakes, ponds and water bodies, section 20 of the Land Revenue and Land Reforms Act as amended, the Tripura Panchayats Act, 1993, any instrument of the TTAADC 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 Tripura 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 of 2017 and its second edition were not read for this Manual [TBC], and no factor for design was found in any source on them.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. No CWC report covers any part of Tripura, and IMD's 2022 national set of rainfall intensity curves has no panel for it; the North-East panels of Das et al. (2022) are all for stations outside the State. NIH-DHAARA's grids are of the right order at Agartala and Kailashahar, but every one of them is below the 49 cm that IMD measured at Bagafa in 2024.

Tripura has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of the UDD, TUDA, the Agartala Municipal Corporation, any Municipal Council or Nagar Panchayat, ASCL or any branch of the PWD 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. The ADB's environmental examination of 2020 for its Agartala project, which includes 48.2 km of new or rehabilitated storm drains, states no return period, runoff coefficient or design rainfall; the project's aim to cut the time the city takes to drain "from one to two hours to about 15–30 minutes" is known only from a report, and its design report was not read [TBC]. The TBR 2017 defer what they do not cover to "the latest edition of National Building Code and other relevant Indian Standards" (r.3A), and roads follow the IRC codes. This Manual is offered as a technical companion to the TBR 2017, the Municipal Act, the master plans and their zoning regulations, and the State's land-revenue rules on water bodies: it supplies the design storm, detention, water-level, tailwater and buffer values that they leave open. It has not been adopted by the UDD, TUDA, the Agartala Municipal Corporation, PWD (Water Resources), the TTAADC or any other body. In particular:

- **The rules ask for a site drainage plan, but name no storm.** The site plan shows "the means of drainage of the proposed building leading to existing public drains or drainage channels" and the "natural drainage channel/jhora" (r.5(1)(k) and (p)); the plans show "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" (r.14); and a site must be "capable of being well-drained" (r.4(1)(c)). None of them says for what storm. Since 2025, low-risk buildings are approved on an empanelled professional's self-certification, "on a trust-based approach" (r.13(3)), and "Inspection for self-certified buildings is hereby waived", with 10% to 15% of applications selected at random (r.34(9)); and every use may cover 70% of its plot, and some industrial and commercial plots 100% (r.46(1) and r.51(2)). Control at the stage of the plan now rests with the professional who certifies it;
- **The rules ask for rainwater harvesting with no volume, and for recharge in ground that is already full.** Rule 110 requires "the complete proposal of rainwater harvesting" for every building of 200 m² of plinth or more, and for group housing, public and industrial buildings of any size; group housing must use permeable materials "for all open parking spaces", and public open spaces over 500 m² must capture their storm water. It sets no storage volume, roof-area rate or infiltration test. It makes groundwater recharge mandatory on plots over 500 m² (r.110(5)), but on the lungas and flood plains, where the water can stand less than a metre below ground after the monsoon (0.22 m at the shallowest well in West Tripura in November 2017), a recharge pit is a soakaway in saturated ground. This Manual states the conflict and asks for storage in its place; it does not override the rule;
- **The rules regulate the riverbank but keep no corridor.** Within 15 m of a river bank, or of the front of a water body of more than 1,000 acres, a building may be no higher than 5.00 m (6.50 m on stilts), no longer than 20.00 m and no larger than 200.00 m², with 50.00 m between buildings (r.9(4)); that is a regulated zone, not a line within which nothing may be built. In the plains a building within 5.00 m of a tank must only keep its drainage out of the tank (r.4(1)(e)). The only distance within which no site may lie is 5 m from the "outside edge" of a water course, and it applies only in the urban local bodies of the hill areas (r.90(1)(i)), which the rules do not list [TBC]. There is no distance from a chhara, a lunga or a pukur in the plains, and "river bank" is not defined;

- **The water-body rules protect storage, but their procedure is in doubt.** Filling a pond, wetland, stream or drain needs the Local Body's decision with the State's prior approval (r.9(3)), and diverting a water body as land needed, under the rules of 2025, the SLAC's approval; the amendment of March 2026 replaced that procedure with a self-declaration online, and what now applies to a water body was not established [TBC]. DST&E's guidelines for the protection of lakes, ponds and water bodies, framed after the High Court's order in PIL 2 of 2014, as cited, were not read, and no buffer is taken from them;
- **There is no floodplain law and no line for the floodplain.** No Tripura Act on flood-plain zoning was found. The TBR 2017 count as hazard-prone the "flood prone areas in river plains" of CWC's Flood Atlas of India and areas flooded by "heavy intensity rains, inadequate drainage, etc. as identified through local surveys in the Development Plan" (r.2(44)), and PWD (Water Resources) has mapped flood-plain zones on the Haora for the NGT, at Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat); their return period and status are not known [TBC]; 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, and the Haora's disagree with one another. The Katakhal has no gauge; no level from Bangladesh, downstream of every river, was obtained; and PWD (Water Resources)'s operating rules for its sluices, the time they stay shut and the capacity of Agartala's pumping stations 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. In law Agartala's drains are the Corporation's (Municipal Act, sections 91 and 156), but its capital works are built by others: the CAG found that AMRUT's "major works (98 per cent)" were being carried out by the UDD and PWD (Drinking Water and Sanitation) "and only a few minor works … by AMC", and PWD (Roads and Buildings) builds the major roads and their drains; ASCL builds storm drains, flood pumps and works on the Akhaura canal and the Katakhal; PWD (Water Resources) holds the embankments and the sluice. No order allocating these drains among the bodies was found. A town's drain may be a municipal drain for part of its length, a roadside drain of PWD (Roads and Buildings) for another, a natural chhara or lunga for a third and an embankment drain where it reaches a sluice. In the TTAADC area the TBR 2017 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 seven hydrologic sub-areas: NIH-DHAARA at the site or at the governing cell of its sub-area, whichever is higher; the 2(a) ratios as a lower bound at durations of 1 to 24 hours; short-storm floors at 1, 3 and 6 hours; a check of the design day against the largest reliable days recorded within 25 km in the same zone, which sets the 1% AEP day in the Muhuri–Feni south at not less than 490 mm; and a checked station analysis to govern where one exists (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites, the detention that the TBR 2017 do not ask for (Chapter 4);
- a required tailwater check for every outfall against a design river level, the Haora's 12.42 m at Agartala until CWC confirms its gauge and datum, 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, where no stage record exists, as on every reach that runs to the border, the Katakhal and the Akhaura canal, for a further 72 hours, or for as long after the storm as the river stays above the sill, whichever is longer; the receiving pukur, dighi or lunga full at the start; the stored water pumped down within 48 hours; and the Dumbur reservoir releasing on the Gomati below it (Chapter 5);
- a design flood line, and corridors and setbacks along rivers, chharas, khals and lunga flow paths and around pukurs, dighis and beels, 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, in which nothing is built, and the 1% AEP extent plus 10 m wherever that is wider; it is stricter than the regulated zone of r.9(4) and the 5 m of r.90(1)(i) (Chapter 7);
- no deliberate infiltration on the lungas and flood plains, below the 1% AEP flood level, inside an embankment that ponds when its sluices close, at the margins of pukurs, dighis and beels, on filled ponds or where the water table rises within 2 m of the surface; infiltration on tilla tops only where tested; none on tilla slopes, cut faces or hill slopes steeper than 20% without a geotechnical certificate; roof runoff to storage for use, with its overflow to

lined drains; and the interception and screening of dry-weather flow before every outfall to a pukur, a dighi, the Haora, the Katakhal or the Akhaura canal, sized so that storm flows stay out of the treatment plants, where drains carry sewage (Chapters 4 and 8);
- silt traps at the foot of the tillas, allowances for sediment and debris, and sluices, flap gates and pumps designed for the river's high stage (Chapters 6 and 9), with drains, chharas, khals, 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). The Agartala Municipal Corporation, a Municipal Council or Nagar Panchayat, TUDA in its master plans, the UDD in the TBR 2017, or the TTAADC by its own regulation 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); Tripura Building Rules, 2017, as amended up to the Fifth Amendment of 2025 (High Court of Tripura consolidated texts), rules 1, 2, 3A, 4, 5, 9, 13, 14, 34, 46, 51, 55, 90 and 110; UDD, BRAP-2019 supporting documents (Uniform Building Code); Tripura Municipal Act, 1994, as amended up to 7 May 2025, ss. 1, 91 and 156–166; Tripura Urban Planning and Development Act, 2018 (Tripura Act No. 12 of 2018), ss. 52, 53 and 163; TUDA, notification of Local Planning Areas under s.52(1) (November 2019); Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 (Gazette Extraordinary No. 1072, 3 June 2025), Appendix-I, and the (First Amendment) Rules, 2026 (Gazette Extraordinary No. 2026350, 6 March 2026); Tripura Official Language Act, 1964 (Act No. 5 of 1964), as amended, and Law Department notification No. F.12(1)-LAW/88(Shadow) (29 April 1999); High Court of Tripura, WP(C)(PIL) No. 06 of 2026 (judgment of 8 September 2026) and WP(C)(PIL) No. 2 of 2014 (as cited); NGT, OA 606/2018 (State affidavit of 6 July 2026) and OA 673/2018 (State affidavit and CPCB report); CPCB, Polluted River Stretches for Restoration of Water Quality (2025); CAG, Audit Reports (Government of Tripura) for 2019-20, Chapter II, and 2022-23, Chapter II; ADB, draft Initial Environmental Examination, Agartala City Urban Development Project (53262-001, November 2020); 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) and its corrigendum; IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012), and press release of 22 August 2024, Annexure I; Das et al. (2022), MAUSAM 73(4); NIH-DHAARA (queried 14 November 2026); CGWB, Aquifer Mapping (NAQUIM) report for West Tripura district, and the Dynamic Ground Water Resources assessment of 2024, as quoted; S. Biswas, Samsad Bengali-English Dictionary (DSAL edition); CWC levels as transcribed by SANDRP (2018 and 2024); reports of the floods of 2022, 2024, 2025 and 2026, of Agartala's flood pumps and flood-protection proposal, of the ponds of Agartala, of the Master Plan 2045, of the TTAADC and of the Kokborok script (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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2	Design Rainfall and Design Storms	Annexes 2
3	Hydrologic Methods	Annexes 3
4	Site Runoff Control: Retention and Detention	Annexes 4
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Abbreviations

Abbreviation	Meaning
AAP	Annual action plan (CGWB; in a report title)

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 (Chapters 2–4 and Annexes 3, 4 and 10); Agartala Municipal Corporation (where a body is named)
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
ASCL	Agartala Smart City Ltd
ASTM	ASTM International (standards)
AWS	Automatic weather station
BOD	Biochemical oxygen demand
BRE	Building Research Establishment (UK)
BRO	Border Roads Organisation
BSMP	Basin Stormwater Master Plan
CAG	Comptroller and Auditor General of India
CDO	A design organisation named with CWC and RDSO in the sources (expansion [TBC])
CGP	Construction General Permit (US EPA)
CGWB	Central Ground Water Board
CN	Curve number (SCS/NRCS method)
COD	Chemical oxygen demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CWC	Central Water Commission
DL / WL	Danger level / warning level (CWC)
DM	District Magistrate and Collector
DPR	Detailed project report
DST&E	Department of Science, Technology and Environment, Tripura
DWF	Dry-weather flow
EN	European Standard (Norme Européenne)
EPD	Environmental Protection Division (Georgia, United States)

Abbreviation	Meaning
ESC	Erosion and sediment control
EV1	Extreme value type I (Gumbel) distribution
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FRL / MWL	Full reservoir level / maximum water level
FRP	Fibre-reinforced plastic
GWRA	Ground water resource assessment (CGWB)
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Tripura)
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
ICP	Integrated check post (the Akhaura border crossing)
IDF	Intensity–duration–frequency
IEE	Initial environmental examination (ADB)
IIT	Indian Institute of Technology
IMD	India Meteorological Department
IMDAA	Indian Monsoon Data Assimilation and Analysis (a regional reanalysis)
IRC	Indian Roads Congress
ISO	International Organization for Standardization
IST	Indian Standard Time
KC	Kansas City (Kansas City Metro APWA Section 5600)
KVK	Krishi Vigyan Kendra (a gauge site)
LiDAR	Light detection and ranging (laser survey)
LPA	Local Planning Area (under the Tripura Urban Planning and Development Act, 2018)
MBBL 2016	Model Building Bye-Laws 2016 (MoHUA; not the State's rules)
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
NAQUIM	National Aquifer Mapping and Management programme (CGWB)
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NDMA	National Disaster Management Authority
NEEPCO	North Eastern Electric Power Corporation
NGT	National Green Tribunal

Abbreviation	Meaning
NH	National Highway
NHIDCL	National Highways and Infrastructure Development Corporation Ltd
NIH	National Institute of Hydrology, Roorkee
NIT	National Institute of Technology
NOC	No-objection certificate
NPDES	National Pollutant Discharge Elimination System (United States)
NRLD	National Register of Large Dams (CWC)
NRSC	National Remote Sensing Centre
NWIA	National Wetland Inventory and Assessment (ISRO)
OA	Original Application (NGT)
OGC	Open Geospatial Consortium
PIB	Press Information Bureau
PIL	Public interest litigation
PSD	Permissible site discharge
PWD	Public Works Department, Tripura
PWD (DWS)	Public Works Department (Drinking Water and Sanitation)
PWD (R&B)	Public Works Department (Roads and Buildings)
PWD (WR)	Public Works Department (Water Resources)
RDSO	Research Designs and Standards Organisation (Railways)
RL	Reduced level
RMSE	Root-mean-square error
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 Tripura)
SLAC	State Level Advisory Committee (Revenue Department)
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
TBC	To be confirmed: a fact or value not yet found in a source
TBR 2017	The Tripura Building Rules, 2017, as amended
TCPO	Town and Country Planning Organisation (in the UDD)

Abbreviation	Meaning
TDMA	Tripura Disaster Management Authority
THRC	Tripura Human Rights Commission
TMA	The Tripura Municipal Act, 1994
TR-55	Technical Release 55 (USDA SCS/NRCS)
TSECL	Tripura State Electricity Corporation Ltd
TSPCB	Tripura State Pollution Control Board
TTAADC	Tripura Tribal Areas Autonomous District Council
TUDA	Tripura Urban Planning and Development Authority
UDD	Urban Development Department, Tripura
UH	Unit hydrograph
ULB	Urban local body (in Tripura, the Agartala Municipal Corporation, a Municipal Council or a Nagar Panchayat)
USACE	US Army Corps of Engineers
UT	Union Territory
UTM	Universal Transverse Mercator
VR	Value rating (of a BMP treating the WQv)
WP(C)	Writ petition (civil)
WQv	Water quality volume
WSUD	Water-sensitive urban design

CHAPTER 1

Policy, Applicability and Adoption

1.1 Purpose and objectives

1.1.1 This Manual sets the minimum standards for the planning, design, construction, operation and maintenance of stormwater systems in Tripura. 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 (377.2 mm at Kailashahar on 6 June 1993 and 49 cm at Bagafa on 22 August 2024, IMD) and fall for days on valley floors already saturated, while the rivers stand high behind their embankments and the sluices and pumps 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 into which the towns drain, every one of which flows on into Bangladesh with no Indian control downstream and no level data from across the border, and which in the monsoon stand above the towns behind their embankments, so that many outfalls pass through sluices and pumps that work only when the river is low: the Haora and the Katakhal round the saucer of central Agartala, where flood pumps lift the water over the embankments when the rivers are high; the Manu at Kailashahar, the Juri at Dharmanagar, the Khowai at Khowai and Teliamura, the Dhalai at Kamalpur and the Muhuri at Belonia; the Gomati below the Dumbur reservoir, into whose reach through Amarpur, Udaipur and Sonamura the reservoir releases floods; the pukurs, dighis and lungas that store a town's water while its outfall is shut; and the chharas (hill streams) that come down from the tillas and the hill ranges and rise within the hour, including the case where the outfall is closed;
- (e) to protect tanks (pukurs), 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 rules made by the Urban Development Department under section 274 read with section 118 of the Tripura Municipal Act, 1994 (the Tripura Building Rules 2017), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> **Commentary.** Tripura's floods come from four sources, often together. The first is the river. Every river of the State leaves it for Bangladesh, and the towns lie on the valley floors beside them, many behind embankments (bandh, Bengali বাঁধ, "Embankment" in the land records), whose length PWD (WR) gives as 154.41 km, with 98.00 km of anti-erosion works protecting 28,000 ha, and as 41 embankments of 134.55 km on another page (dates unknown, as quoted; conflict). The benchmark is the flood of 3–5 August 1983, when heavy rain caused "serious devastation", about thirty people died, around five lakh were affected and the road link to the north (NH-8) was cut by "over 60 breaches", with losses of ₹10 crore (Lok Sabha debates, as quoted); the Muhuri at Belonia reached

16.98 m on 4 August 1983, a level that stood until 2024 (CWC data as transcribed by SANDRP). The highest levels of the other CWC sites date the floods since: 15 May 1984 on the Dhalai at Kamalpur and the Juri at Nutan Bazar, before the monsoon; 7 June 1993 on the Manu at Kailashahar and Kumarghat and 22–23 July 1993 on the Gumti at Amarpur and Sonamura, the storms that set the IMD records at Kailashahar (377.2 mm on 6 June) and Agartala (257.2 mm on 22 July) (IMD, *Extremes*), for which no casualty figures were found; and 24 June 2004 on the Haora, the Burima at Gajaria and the Khowai, in floods that displaced about 90,000 people and killed 3 (as reported). Flash floods in May 2018 killed 6, and on 13 June 2018 the Manu at Kailashahar rose to 25.95 m, 16 cm above its level of 1993, leaving about 21,000 people homeless in Kailashahar and about 40,000 in relief camps, reported as 173, 189 or 224 camps (as reported; conflict), with about 3 deaths.

The second is drainage congestion. Central Agartala "is located at a lower level than other areas giving it the appearance of a saucer", between the Haora embankment to the south and the Katakhal to the north; "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded", and when the rivers are high "Several pumps have been provided to lift the water out of the city" (ADB, IEE, 2020). The Corporation runs 18 flood pumps of up to 900,000 litres an hour each and 6 diesel pumps, which lift water by pipeline to the Katakhal and the Haora (2024, as reported). The towns are built on the lungas (lunga, Bengali লুঙ্গা, "Flat lands between tillas" in the land records), the valley floors that are the natural flow paths, and ponds there have been filled for housing (as reported). On 11 August 2017 the Haora reached 12.4 m and "incessant rain & waterlogging paralyses normal life" (as reported). On 17–19 June 2022 the Haora stood above its danger level (10.82–10.85 m at the Jahar Bridge gauge against 10.50 m; 10.72 m at the CWC site against 10.70 m), West Tripura recorded 155 mm in 24 hours (145 mm in another report; conflict), the Mayor spoke of about 200 mm in 3 hours, 2,057 families, more than 10,000 people, were in 39 camps (1,623 families and 7,109 people in another report; conflict), and one person drowned at Jirania (all as reported). On the night of 31 May 2025 "around 200 mm in just three hours" was reported at Agartala, a man died in a manhole, and about 1,300 families were in camps after 48 hours of rain (as reported; no IMD hourly value found). On 22–24 August 2026 Chandrapur, Baldakhal and Aralia flooded while the Haora stood at 10.72 m against its danger level of 10.70 m (as reported; no rainfall value found).

The third is the great storm. On 19–24 August 2024 a low over Bangladesh brought the State's flood of record in most basins, "worst since 1983" in official words (as reported). Bagafa recorded 49 cm in the 24 hours to 0830 IST on 22 August, and Belonia 32 cm and Amarpur 31 cm in the 24 hours to 20 August (IMD, press releases); South Tripura district received 644.5 mm over 20–22 August (IMD district data as transcribed by SANDRP). The Muhuri at Belonia rose to 18.81 m, the Juri at Nutan Bazar to 20.66 m and the Haora at Agartala to 12.42 m, new highest levels, and the Gomati at Udaipur passed its extreme danger level (CWC data as transcribed by SANDRP; as reported). The gates of the Dumbur reservoir were opened on 21 August, the first release since 1993 by one account, while the power minister denied that a gate had opened (as reported; conflict). About 17 lakh people were affected and 1.25 lakh ha of crops damaged (as reported). The toll is given as 36 by the Inter-Ministerial Central Team (Lok Sabha Unstarred Question 1192, as quoted) and as about 38 by the Chief Minister in the Assembly (as reported), after 24 and 31 at earlier dates. The preliminary estimate of losses was ₹14,247 crore, with a package of ₹564 crore, and the State's memorandum of 13 September 2024 sought ₹7,080.55 crore from the National Disaster Response Fund: a loss estimate and a request for assistance, not two estimates of one thing; ₹288.93 crore of further assistance followed in February 2025 (as reported; as quoted). Cyclone Remal had brought 252.4 mm in 24 hours to Unakoti district on 27–28 May 2024 (district value, as reported).

The fourth is the slope. The tilla uplands (tilla, Bengali টিলা, "Hillock") are cut for roads and houses, and the national highways cross the hill ranges: landslides were reported at 17 locations in June 2018, 11 of them in Khowai district, and at 2,032 locations in August 2024, when 7 people died at Gardang near Santirbazar and 3 at Debipur (as reported). In a petition it took up of its own motion on 7 July 2026, the High Court of Tripura recorded on NH-108B and NH-208 "No proper drainage system … water logging everywhere; RCC drain hole blocked with mud, vegetation; Earthen drain damage & blocked", with culverts blocked "by silt, vegetation, debris", and called for reports, an audit and an inquiry (WP(C)(PIL) No. 06 of 2026, judgment of 08.09.2026).

> Missing design makes all four worse. No design storm, return period or drain standard was found in any document of the State's towns: the ADB's report on Agartala (2020), the State's filings before the NGT and the news reports give no storm-drain return period, design intensity, runoff coefficient or time of concentration, and the ADB's drainage upgrade for Agartala aims to cut drainage time "from one to two hours to about 15–30 minutes" (as reported; its DPR was not read [TBC]). The CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, 2022-23). The drains are also the sewers: Agartala's sewer network serves only its North Zone, and its treatment plants are fed by intercepting drains (State affidavit to the NGT, 2026). The TBR 2017 bar the filling of ponds, jhoras and streams, regulate building within 15 m of a river bank and set a plinth of at least 60 cm, but set no design storm, release rate or storage method, and in the TTAADC area, about 68% of the State (as reported), they do not apply at all. 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, flood plains 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 Tripura Building Rules 2017 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.

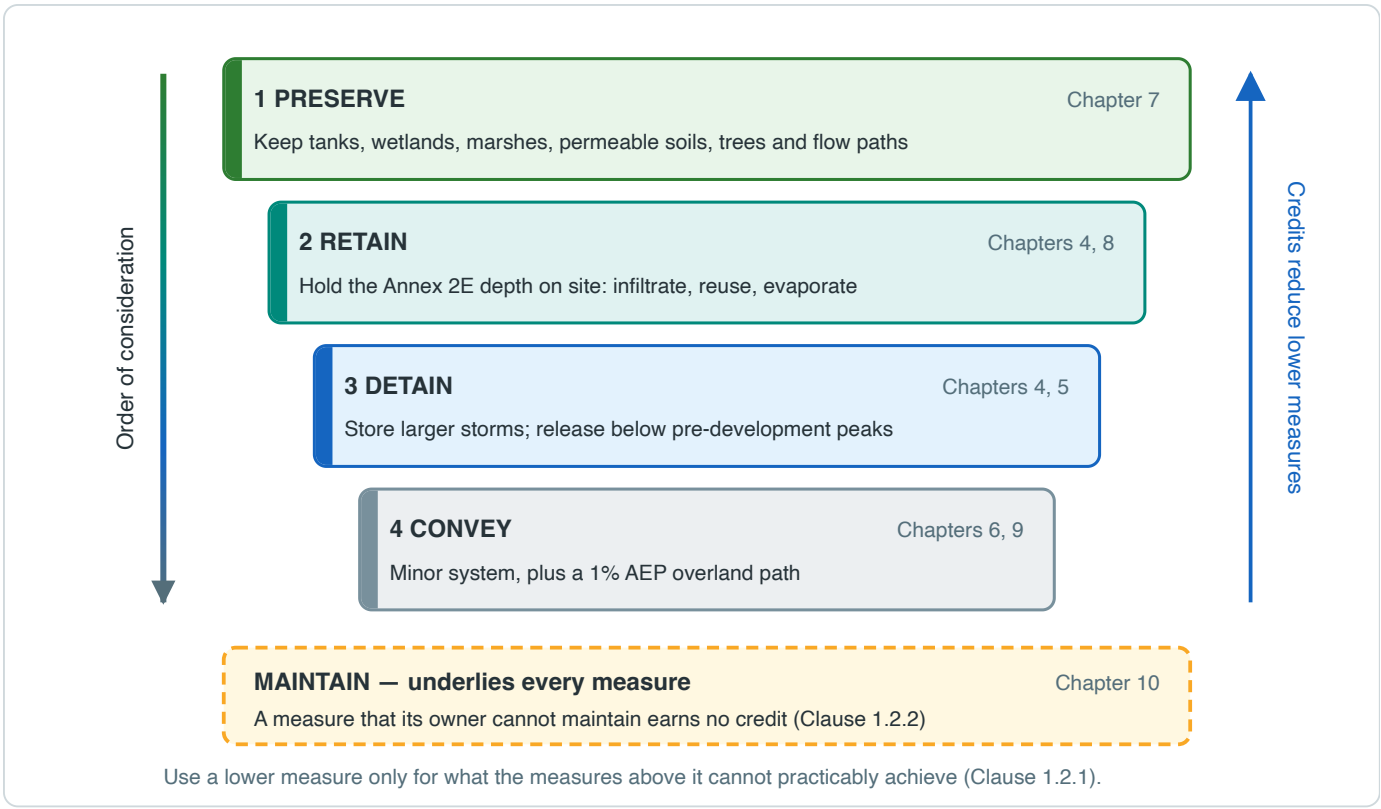

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

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 Tripura, the top two layers have a particular meaning. Much of the State's natural storage lies in its pukurs and dighis, among them the palace-era and temple tanks of Agartala and Udaipur; in its beels (natural low wetlands, "Watery land" in the land records) and haors ("Big watery land"); in the lungas, the flat valley floors between the tillas that carry the water of the valleys to the rivers; in Rudrasagar, a Ramsar site (No. 1572, 240 ha, designated 8 November 2005 by the Ramsar record and "officially designated" on 29 February 2007 by the Forest Department, as quoted; conflict); and in the Dumbur reservoir, which is not a Ramsar site. No pond inventory of Agartala was found; the State reported 180 urban water bodies on government land, of which 30 had been prioritised for restoration (2020, as reported), and about 65 water bodies have been cleaned and developed in Agartala (as reported). The law protects some of this. The TBR 2017 bar the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the State Government's prior approval for recorded reasons (r.9(3)), and the land records class the pukur ("Tank/Pond"), its bank (pukurpar, "Bank of tank"), the dighi ("Large tank") and its bank as land classes of their own (Diversion of Land Rules, 2025, Appendix-I). The ponds are being lost all the same: ponds have been filled for housing in Barjala and Lanka Basti (as reported), and the High Court found local bodies allowing ponds to be filled and walls built on their banks at Kalyan Sagar, Matabari (WP(C)(PIL) No. 2 of 2014, as cited). Since 6 March 2026 a change in the classification of land is made by online self-declaration, with post-facto revocation within 30 working days, and the procedure that applied to water bodies in 2025 was omitted; whether section 20 of the Tripura Land Revenue and Land Reforms Act, 1960 still bars their diversion was not established for this Manual [TBC]. On the valley floors the second layer changes. Groundwater is shallow: in West Tripura the dug wells read 1.63–10.30 m below ground in March 2017 and 0.22–6.64 m in November 2017, and the shallow water carries iron of up to 4.99 ppm from "the ferruginous nature of Tipam sandstones" (CGWB, West Tripura), which clogs infiltration media (NEER reading); under Agartala "The ground water table being very high" (ADB, IEE, 2020). A soakaway or recharge pit on a lunga floor therefore sits in

saturated ground when the storm comes. This Manual bars deliberate infiltration on lunga floors and recent flood plains, below the 1% AEP flood level, inside embankment-protected land that ponds when its sluices close or its pumps stop, on pukur, dighi, beel and haor margins, on filled ponds and lunga fills and wherever the seasonal high water table is less than 2.0 m below ground (Clause 4.11, lunga rule); allows it, after testing, on flat tilla tops and benches with a deep water table (Clause 4.11, tilla rule); and bars it on tilla slopes, cut faces and the hill ranges without a geotechnical certificate (Clause 4.11, hill rule) (all set by this Manual). Groundwater is not short: the stage of extraction is 9.48%, with every assessment unit Safe (Ground Water Resource Assessment 2024, as quoted by CGWB), so rainwater harvesting on most sites is storage for reuse, not recharge. Losing the pukurs and lungas cannot be offset by pipes, and a town that drains through a closed sluice has nothing but its pukurs, dighis and lungas to hold the water until the river falls or the pumps empty it.

1.3 Legal basis and status

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

- (a) an amendment to the Tripura Building Rules 2017 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 Tripura the building rules are the Tripura Building Rules, 2017 (UDD notification No. F.2(316)-UDD/GL/TCPO/2009 (Part-I)/371 of 10 November 2017, as cited in the UDD's BRAP-2019 document; the 2017 gazette was not read [TBC]), as amended by the Tripura Building (Amendment) Rules, 2019 (No. F.2(466)-UDD/GL/TCPO/2018/599-627, 19 February 2019; Gazette Extraordinary No. 482, 25 February 2019), the (Second Amendment) Rules, 2020 (dated 15 February 2020, Gazette 24 February 2020; number garbled in the copy read [TBC]), the (3rd Amendment) Rules, 2022 (No. F.01(24)-TUDA/Estt/2022/4902-30, 29 November 2022; Gazette 2 December 2022), the (Fourth Amendment) Rules, 2024 (No. F.1(23)-TUDA/ESTT/2024/66, 15 January 2025; Gazette No. 95, 17 January 2025) and the (Fifth Amendment) Rules, 2025 (F.No.2(466)-UDD/GL/TCPO/2018(P-V)/4009-20, 4 July 2025; Gazette No. 1294, 5 July 2025), made under section 274 read with section 118 of the Tripura Municipal Act, 1994. No sixth amendment was found up to November 2026. The rules replace the Tripura Building Rules, 2004 (r.1(4)), and apply "to buildings in the Urban Local Bodies (ULBs) in Tripura" (r.1(2)), to which the amendment of 2019 added "and Planning Areas" and the Tripura Urban Planning and Development Act, 2018 (Tripura Act No. 12 of 2018) as an "Act" of the rules. The building permit and the occupancy certificate are given by the Agartala Municipal Corporation, a Municipal Council or a Nagar Panchayat, and by TUDA "within the Notified Local Planning Area" and for buildings or townships of 50 or more flats or a project area of one acre or more inside a ULB area (r.13(3), as inserted in 2020). Since the Fifth Amendment of 2025, low- and very-low-risk

buildings are permitted through an empanelled professional's self-certification "on a trust-based approach" (r.13(3)), their occupancy certificate is issued by that professional (r.34), and inspection is waived but for a random 10% to 15% of applications (r.34(9)). The TBR 2017 carry drainage hooks: the site shall be "capable of being well-drained" and not lower than its approach road (r.4(1)(b), (c)); within 5.00 m of a tank the owner shall prevent drainage from the building passing into it (r.4(1)(e)); the site plan shows the means of drainage and the "natural drainage channel/jhora" (r.5(1)(k), (p)); "No canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts shall be filled up" except by the Local Body with the State Government's prior approval for recorded reasons (r.9(3)); in the "zone of river (within 15 metres from river bank)" a building is limited in height, length and covered area (r.9(4)), a regulated zone, not a no-build line; the plans include "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" (r.14); the plinth is at least 60 cm (r.55); basements keep surface drainage out and have pumping arranged (r.66); the hill ULBs of Part X (rr.88–101) keep sites five metres from water courses (r.90(1)(i)) and drain them by lined drains that "shall not be connected with any drain carrying sullage water or sewage" (r.99); and rainwater harvesting is required for buildings of 200 m² plinth and more (r.110). 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 (NEER reading). The route of Clause 1.3.1(a) therefore runs through an amendment to the Tripura Building Rules 2017 by the UDD under section 274 read with section 118 of the Tripura Municipal Act, 1994, which the UDD, the department that makes them, could prepare. It reaches only the ULB areas and the Local Planning Areas. Outside them, the Manual reaches development only through public works (Clause 1.5.1(b)) and through any body that adopts it. The Tripura Municipal Act, 1994 "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (s.1(2)), and its "District Council" is the Tripura Tribal Areas Autonomous District Council (s.2(10)); the TBR 2017 are made under that Act, so they do not apply in the council area, about 68% of the State (as reported), which is under the Sixth Schedule to the Constitution. No building or land-development regulation of the TTAADC was found [TBC]; the instruments made for the council area that were found (the TTAADC Act, 1979, the Village Committee Act, 1994 and its Rules of 2006, and two trade and money-lending regulations) do not concern building or drainage (index titles; NEER reading). A dispute over a proposed Bisramganj Nagar Panchayat on council land was unresolved in 2026 (as reported). In the council area the Manual could take effect only through the District Council, by a regulation of its own or a resolution that the Manual applies (Annex 1D). This Manual is a draft; neither the Government of Tripura, the UDD, TUDA, the Agartala Municipal Corporation, any other ULB, the TTAADC 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 ULB area, the Agartala Municipal Corporation, a Municipal Council or a Nagar Panchayat for the building permit and the occupancy certificate under the Tripura Building Rules, 2017, and for its own drains and works under the Tripura Municipal Act, 1994 (ss.91 and 156–166); in a notified Local Planning Area, and for a building or township of 50 or more flats or of one acre or more inside a ULB area, TUDA (TBR 2017, r.13(3), as inserted in 2020); for filling any canal, pond, water body, wetland, jhora, stream, drain or culvert, the Local Body with the prior approval of the State Government (r.9(3)); for diverting a water body as land, the District Magistrate and Collector under the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 (the procedure since their amendment of 6 March 2026 not established [TBC]); for any work that cuts, crosses or discharges through an embankment or sluice, PWD (WR) as its owner (no statute found [TBC]); for a notified wetland, the Wetland Authority of Tripura under the Wetlands (Conservation and Management) Rules, 2017; in a rural area outside the council area and outside every Local Planning Area, the Gram Panchayat (Tripura Panchayats Act, 1993, not read for this Manual; the TBR 2017 do not apply there); and, in the area of the Tripura Tribal Areas Autonomous District Council (TTAADC), the District Council or the authority it designates, only where the Council has made a regulation or resolved that this Manual applies (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 Tripura Building Rules 2017 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 Agartala's central saucer between the Haora embankment and the Katakhal, with the Akhaura canal; of the Katakhal basin and its sluice; of the Haora flood-plain-zone localities and Chandrapur; of Kailashahar on the Manu; of Belonia on the Muhuri; of Udaipur, Amarpur and Sonamura on the Gomati below the Dumbur reservoir; of Dharmanagar on the Juri; of Khowai and Teliamura on the Khowai; of Kamalpur on the Dhalai; of Santirbazar, Bagafa and Sabroom in the south; and of the hill-range corridors of NH-8, NH-108B and NH-208, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (pukur), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7).
Regional facility	A detention, retention or tank storage facility serving more than one development, built or restored under a basin plan (Chapter 4).
Tier A / Tier B authority	An Approving Authority classed under Clause 1.6.
Policy supplement	The set of adoptable alternative clauses in Clause 1.7 and Annex 1C.

Term	Meaning in this Manual
Drainage report	The preliminary or final report required by Chapter 10.
Registered professional	A person registered under the Tripura Building Rules 2017 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 Tripura 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 ULB area, the Agartala Municipal Corporation, a Municipal Council or a Nagar Panchayat for the building permit and the occupancy certificate under the Tripura Building Rules, 2017, and for its own drains and works under the Tripura Municipal Act, 1994 (ss.91 and 156–166); in a notified Local Planning Area, and for a building or township of 50 or more flats or of one acre or more inside a ULB area, TUDA (TBR 2017, r.13(3), as inserted in 2020); for filling any canal, pond, water body, wetland, jhora, stream, drain or culvert, the Local Body with the prior approval of the State Government (r.9(3)); for diverting a water body as land, the District Magistrate and Collector under the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 (the procedure since their amendment of 6 March 2026 not established [TBC]); for any work that cuts, crosses or discharges through an embankment or sluice, PWD (WR) as its owner (no statute found [TBC]); for a notified wetland, the Wetland Authority of Tripura under the Wetlands (Conservation and Management) Rules, 2017; in a rural area outside the council area and outside every Local Planning Area, the Gram Panchayat (Tripura Panchayats Act, 1993, not read for this Manual; the TBR 2017 do not apply there); and, in the area of the Tripura Tribal Areas Autonomous District Council (TTAADC), the District Council or the authority it designates, only where the Council has made a regulation or resolved that this Manual applies (none has). Where this Manual says "the Authority", the competent authority for the area is meant.
Building permit; occupancy certificate; self-certification	The building permission and the occupancy certificate given under the Tripura Building Rules, 2017 by the Agartala Municipal Corporation, a Municipal Council or a Nagar Panchayat, or by TUDA in a Local Planning Area and for the large projects of r.13(3). Since the Fifth Amendment of 2025 a low- or very-low-risk building is permitted through an empanelled professional's "Self-Certification Proforma … on a trust-based approach" (r.13(3)); its occupancy certificate is issued by that professional (Form H1, r.34); and "Inspection for self-certified buildings is hereby waived", with 10% to 15% of applications selected at random (r.34(9)). For such a building the drainage report and certificates of this Manual sit with the empanelled professional (Chapter 10).
Local Planning Area; Planning Area; Master Plan 2045	A planning area declared under section 52 of the Tripura Urban Planning and Development Act, 2018. TUDA notified Local Planning Areas adjacent to 20 cities and towns in November 2019 (No. F2(15)-TUDA/TECH/2019(P)), the first being the Agartala-Ranibazar-Jirania Local Planning Area, outside the ULB area. The Master Plan for the Agartala Planning Area 2045 was declared final by the UDD on 24 February 2026 under section 53(1), for 238.57 km², the Agartala Municipal Corporation and 49 gram panchayats (as reported); its notification number and text were not read [TBC]. The Planning Area is wider than the Corporation's area.
Tripura Tribal Areas Autonomous District; District Council	The area of the TTAADC under the Sixth Schedule to the Constitution, "nearly sixty-eight per cent of Tripura's territory" (as reported). The Tripura Municipal Act, 1994 "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (s.1(2)), and the TBR 2017 are made under that Act, so neither applies there. No building or land-development regulation of the Council was found [TBC]. This Manual reaches the council area only through the District Council.
Tilla; lunga; chhara	Tilla (Bengali টিলা, "Hillock"): the low, dissected terrace uplands of every valley, 10–30 m high (CGWB). Lunga (Bengali লুঙ্গা, "Flat lands between tillas"): the flat valley floor between them, CGWB's "low lands ('loonga') of Holocene terrace", which is the natural flow path and the land on which towns are built and ponds are filled. Chhara (Bengali ছড়া, "Streams"): a hill stream or small natural channel; the TBR 2017 call a hill stream a jhora. The glosses are the land classes of Appendix-I of the Diversion of Land Rules, 2025. A chhara or lunga flow path draining 8 ha or more is a natural channel under Chapter 7.

Term	Meaning in this Manual
Embankment (bandh); sluice	A river or pond embankment, bandh (Bengali বাঁধ, "Embankment" in the land records), with its sluices, flap gates and pumps. PWD (WR) builds and holds the flood embankments and the Katakhal double-barrel sluice (as quoted). No Tripura statute on embankments or drainage was found [TBC]; this Manual treats PWD (WR) as the owner whose consent a work through an embankment or sluice needs.
Khas land; land records	Land of the Government (khas land), and land recorded by district, sub-division, revenue circle and mouza (the online Form-1 of 2026 lists "District / Sub-Division / Revenue Circle"; mouza and plot numbers [TBC]). Where this Manual reserves a drainage corridor, an easement or a regional facility site on private land, it is reserved in the Master Plan or secured by agreement, not taken (set by this Manual); in the TTAADC area land is held under the Council's 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 Tripura Building Rules 2017;
- (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 Tripura, 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 rule 110 of the TBR 2017, in the ULB areas and Local Planning Areas to which the rules apply, to every building of plinth area 200 m² or more, to group housing, public, semi-public and industrial buildings of all sizes and to commercial and mixed-use buildings of 50 m² or more, with permeable materials for all open parking in group housing, the capture of storm water in public open spaces above 500 m², groundwater recharge on plots of more than 500 m² (r.110(5)), and inspection before the completion certificate, 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.

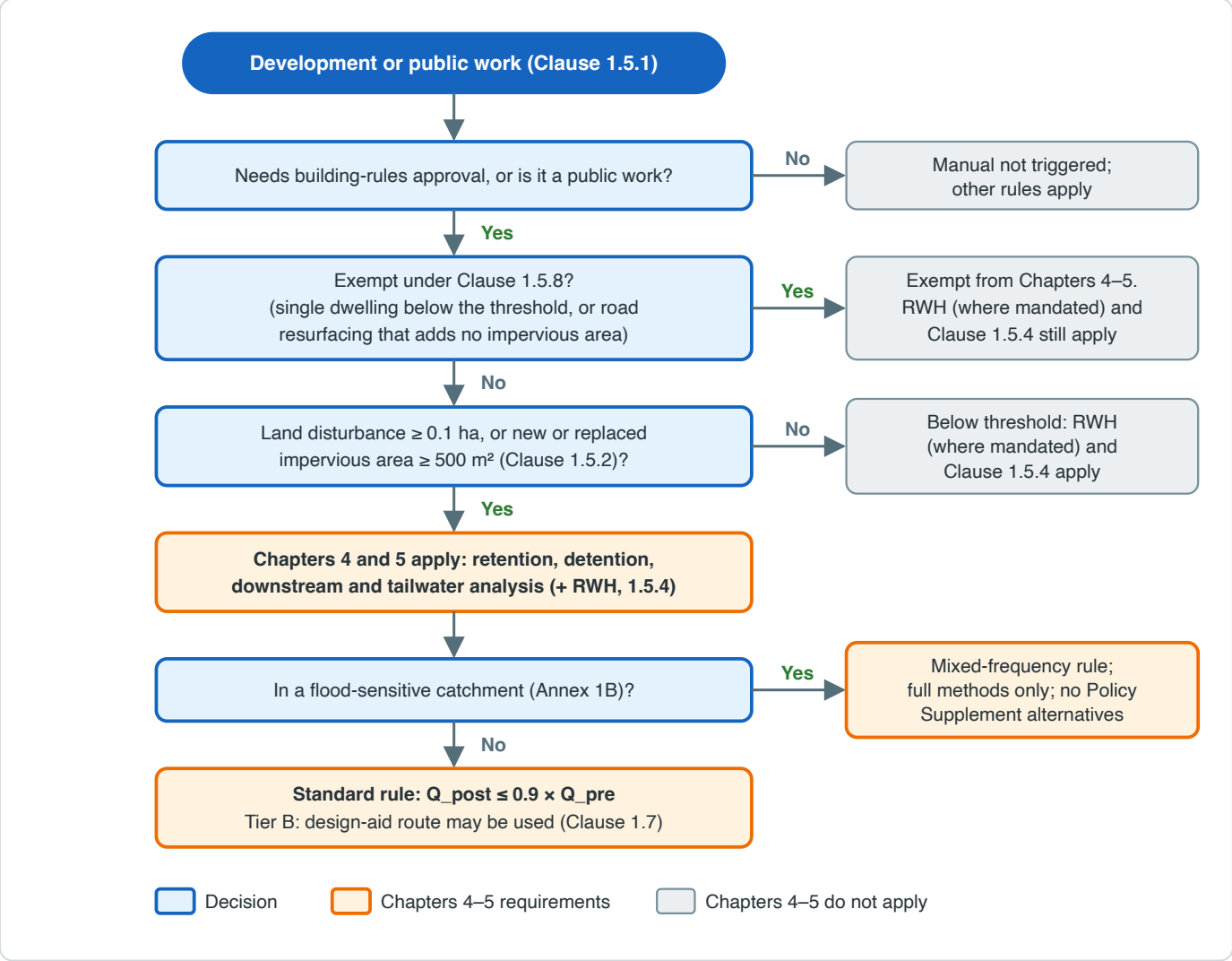

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Tripura plots are small and the cumulative effect of many small plots is what fills Agartala's drains. For small buildings in Tripura, the TBR 2017 reach every building of 200 m² plinth or more in the ULB areas and Local Planning Areas with rainwater harvesting, "with emphasis on both storage and reuse" for plotted housing, and require groundwater recharge on plots of more than 500 m² (r.110, r.110(5)); they place the plinth so that the drainage of the site is assured and "in no case … at a height less than 60 centimeters" (r.55), and require roof water to be carried by "sufficient rain-water pipes", which the ULB may require to be connected to a drain (r.57). None of these sets a design storm or a storage volume, so none of it yet limits what leaves the plot in a design storm; Chapter 4 supplies the calculation. The recharge structures of r.110, pits, trenches and wells, on a lunga floor or a recent flood plain with the water table near the surface, are recharge devices in saturated ground: this Manual states the conflict with its lunga rule (Clause 4.11, lunga rule) and requires storage in their place there, and the applicant seeks the ULB's relaxation of the recharge requirement; the Manual does not override the rule. Clause 1.5.4(b) applies to every building whatever its size, because the plinth of r.55 is set by the crest of the road and not by any flood level, and no "highest flood level" has been fixed for any town [TBC]; a small house on a lunga or behind an embankment is where a floor level does most good. Since 2025 a small, low-risk building is permitted and certified by an empanelled professional, with inspection only at random (r.13(3), r.34(9)), so the drainage checks of this Manual for such a building rest with that professional (Chapter 10). An Authority may make the lunga rule, the tilla 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). In the TTAADC area, and in rural areas outside the Local Planning Areas, 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 Agartala Municipal Corporation; and
- (b) TUDA, within the Agartala Planning Area of the Master Plan 2045 (238.57 km², the Corporation's area and 49 gram panchayats, as reported) and the Agartala-Ranibazar-Jirania Local Planning Area notified by TUDA in November 2019, as those areas are notified from time to time, the Corporation or TUDA being Tier A wherever it has jurisdiction over a site.

1.6.2 **Tier B authorities.** All other Municipal Councils and Nagar Panchayats, and TUDA in their Local Planning 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 UDD regional support or an empanelled reviewer (Clause 10.7)
Flood-sensitive catchment rule	Applies	Applies

1.6.4 **Moving between tiers.** A Tier B authority may opt into Tier A by council resolution. The Government may notify a Tier B authority as Tier A when it becomes a Corporation, joins the Agartala Planning Area of the Master Plan 2045 or a notified Local Planning Area, 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. Agartala Municipal Corporation, with a central city in a saucer between the embanked Haora and the Katakhal, which floods "During normal rainfall of about 3 to 4 hours" (ADB, IEE, 2020) and is drained by 18 flood pumps and 6 diesel pumps when the rivers are high (2024, as reported), drains and canals whose blockage by plastic waste causes "frequent water logging" (CAG, 2022-23), sewers in its North Zone only (State affidavit to the NGT, 2026) and capital works built mostly by others, 98 per cent of the major AMRUT works by the UDD and PWD (DWS) "and only a few minor works" by the Corporation (CAG, 2019-20), and a small Nagar Panchayat with one assistant engineer cannot be asked to review the same hydrograph models. The Kansas City solution was to keep one regional standard and publish adoptable alternatives for the most contested criteria, so that smaller agencies can "opt down" without leaving the standard (MARC Supplement, Nov 2025). The tiers here keep the performance criteria the same in both tiers and vary only the method, so that a building in a Tier B town is protected to the same level as one in Agartala.

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
Tripura Municipal Act, 1994, as amended up to the Ninth Amendment (7 May 2025) (High Court of Tripura, consolidated text)	Continue. It "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (s.1(2)); the Agartala Municipal Corporation, the Municipal Councils and the Nagar Panchayats are constituted under it, and there is no separate Act for the Corporation. It defines a "Municipal drain" as "a drain vested in the Municipality" and a "Watercourse" as including "any river, stream or channel" (s.2); vests "all public tanks, streams, reservoirs, and wells" and "all public sewers, drains, channels, tunnels, culverts and water courses in, alongside, or under any street" in the Municipality "unless the State Government otherwise directs by a notification" (s.91); requires it to "provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall in or outside the Municipal area" (s.156(1)), with power to hand trunk sewers, treatment plants and pumping stations to a Government agency with the State's approval (s.156(2)); to cleanse and flush drains (s.157); to drain "sudden waterlogging" across private land without prior notice (s.160, proviso); to permit private connections in writing (s.161) and demolish unauthorised ones (s.162); to "require separate provisions to be made for drainage of sewage and other offensive matters as distinct from rain-water" (s.164); and lets the State hand inefficient works to another agency (s.165). No tank may be made without the Municipality's permission (s.232, fine up to ₹2,000); owners must deal with water that "is or is likely to become a breeding place of mosquitoes" (s.233) and keep private tanks free of "pollution by surface drainage" (s.234(1)). Sections 156 and 164 are the hooks for the outfall and separation rules of Chapters 5 and 8, and s.233 for drain-down times (NEER reading).

Instrument	Relationship
The Tripura Building Rules, 2017 (UDD notification No. F.2(316)-UDD/GL/TCPO/2009 (Part-I)/371 of 10 November 2017, as cited in the UDD's BRAP-2019 document; the 2017 gazette was not read [TBC]), as amended by the Tripura Building (Amendment) Rules, 2019 (No. F.2(466)-UDD/GL/TCPO/2018/599-627, 19 February 2019; Gazette Extraordinary No. 482, 25 February 2019), the (Second Amendment) Rules, 2020 (dated 15 February 2020, Gazette 24 February 2020; number garbled in the copy read [TBC]), the (3rd Amendment) Rules, 2022 (No. F.01(24)-TUDA/Estt/2022/4902-30, 29 November 2022; Gazette 2 December 2022), the (Fourth Amendment) Rules, 2024 (No. F.1(23)-TUDA/ESTT/2024/66, 15 January 2025; Gazette No. 95, 17 January 2025) and the (Fifth Amendment) Rules, 2025 (F.No.2(466)-UDD/GL/TCPO/2018(P-V)/4009-20, 4 July 2025; Gazette No. 1294, 5 July 2025), made under section 274 read with section 118 of the Tripura Municipal Act, 1994; the original rules read in the UDD's copy and the consolidated texts to the Fourth and Fifth Amendments (High Court of Tripura); no sixth amendment found to November 2026	Continue. They apply to "buildings in the Urban Local Bodies (ULBs) in Tripura" and, since 2019, the Planning Areas (r.1(2)), and not in the TTAADC area, to which the parent Act does not extend; they replace the Tripura Building Rules, 2004 (r.1(4)) and defer to the latest National Building Code and Indian Standards for what they do not cover (r.3A). They define a "drain" to include a culvert, ditch or channel for carrying off "rain water or subsoil waters" (r.2(22)) and "Natural Hazard Prone Areas" to include flood-prone areas of the CWC Flood Atlas and areas flooded by "heavy intensity rains, inadequate drainage, etc. as identified through local surveys in the Development Plan" (r.2(44)); require a site "capable of being well-drained" and not lower than its approach road, and drainage kept out of any tank within 5.00 m (r.4(1)(b), (c), (e)); show drainage and the "natural drainage channel/jhora" on the site plan (r.5(1)(k), (p)); bar the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the State Government's prior approval for recorded reasons, which may also allow a "flood plain area to be filled up" (r.9(3)); limit buildings in the "zone of river (within 15 metres from river bank)" or on the front of a water body of more than 1,000 acres to 5.00 m in height (6.50 m on stilts), 20.00 m in length, 200.00 m² of cover and 50.00 m apart (r.9(4)), a regulated zone, not a no-build setback; keep abandoned brickfield pits as water bodies (r.9(5)); require pucca drains in sub-divisions (r.10(2)(f)); ask for "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" and a roof drainage plan (r.14), now through an online single window (r.14(1), 2025); allow a soil test, a height limit or refusal on "recently filled up … pond, lake, marshy" land (r.32); require notice before drains are covered (r.38, Form I); set ground coverage at up to 70% for every use and 100% for some industrial and commercial plots (r.46(1), r.51(2), 2025) and landscaping of 1.0% to 7.5% of plots above 150 m² (r.113, 2022); set the plinth at not less than 60 cm above the crest of the road (r.55) and roof drainage by rain-water pipes (r.57); keep surface drainage out of basements and require pumping where needed, with the basement ceiling 0.8–1.2 m above the front road (r.66(5), (6)(b), (6)(h)); and, in the hill ULBs of Part X (rr.88–101; which ULBs these are is not listed [TBC]), require a slope-stability certificate on slopes of 30° and more (r.90(1)(f)), bar sites within 200 m of a sinking or slip zone or on "high water table and fully saturated soil" (r.90(1)(h)), keep sites "five meters in any direction of the outside edge of such water courses" (r.90(1)(i)), the only no-build distance from a watercourse in the rules, require protective works within 5.0 m of a tank, jhora or natural drain and within 30 m of a jhora (r.90(1)(m)), and require slopes "not less than 1 : 60" round buildings and surface-water drains that "shall not be connected with any drain carrying sullage water or sewage" (r.99). Since 2025 low-risk buildings are self-certified by empanelled professionals, with inspection of 10% to 15% at random (r.13(3), r.34(9)). They set no design storm, release rate, detention volume or storm-water volume (NEER reading). The design criteria of Chapters 2–6, the lunga, tilla and hill rules of Clause 4.11 and the corridors of Chapter 7, whose Zone 1 is a no-build strip of at least 15 m and so stricter than r.9(4) and r.90(1)(i), are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the TBR 2017, a Master Plan or a statute are stricter, they govern (Clause 1.3.3).

Instrument	Relationship
Rainwater harvesting: TBR 2017, r.110	Continue unchanged. "All building having plinth area not less than 200 sq.m., while submitting the building plans for sanction, shall mandatorily include the complete proposal of rainwater harvesting"; group housing, public, semi-public and industrial buildings of all sizes and commercial and mixed-use buildings of 50 m² and above are listed; in group housing "Concrete paving to be avoided and permeable materials are to be used for all open parking spaces"; public open spaces above 500 m² "shall have arrangements for complete utilization and capture of storm water"; groundwater recharge "should be made mandatory" on plots of more than 500 m² (r.110(5)), by recharge pits, trenches, wells and shafts of stated sizes; each ULB constitutes a Rainwater Harvesting Cell and inspects the structures before the completion certificate, every year above 1,000 m² and at random (10%) below (r.110(6)). The 200 m² threshold replaced the 300 m² of the 2004 rules (as reported). No storage volume, roof-area rate or infiltration test is set (NEER reading). This Manual counts stored water against its retention requirement only as reuse (Clause 4.4.3), never as detention. Where the lunga rule or the hill rule of Clause 4.11 bars the recharge structures of r.110, the two conflict: this Manual requires storage in their place, and the applicant seeks the ULB's relaxation; the Manual does not override the rule.
Tripura Urban Planning and Development Act, 2018 (Tripura Act No. 12 of 2018); the notification of Local Planning Areas under section 52(1) (No. F2(15)-TUDA/TECH/2019(P), November 2019); the Master Plan for the Agartala Planning Area 2045	Continue. The Act constitutes the Tripura Urban Planning and Development Board, chaired by the Chief Minister, and TUDA, whose functions include the "development of water bodies or open spaces" and Master Plans; Planning Areas are declared under s.52 and Master Plans made under s.53(1); and s.163 repeals the Tripura Town and Country Planning Act, 1975 (Tripura Act No. 4 of 1976), deeming orders under it issued under the new Act. TUDA notified "Local Planning Areas adjacent to 20 Cities/Towns of Tripura" in November 2019 (the day is illegible in the copy read), the first being the Agartala-Ranibazar-Jirania Local Planning Area, bounded on the west by the "International border with Bangladesh". The Master Plan for the Agartala Planning Area 2045, a GIS-based plan for 238.57 km² taking in the Agartala Municipal Corporation and 49 gram panchayats, with "statutory zoning and development control regulations", was declared final by the UDD on 24 February 2026 under s.53(1) (as reported); its notification number, text, zoning regulations and any water-body, river or drainage buffers were not read [TBC]. Master Plans would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11).
Tripura Land Revenue and Land Reforms Act, 1960 (43 of 1960) (as cited); the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 (Revenue Department No. F.4(05)-RCC/2025, 2 June 2025; Gazette Extraordinary No. 1072, 3 June 2025), made under sections 20 and 98 of the Act, as amended by the (First Amendment) Rules, 2026 (6 March 2026; Gazette Extraordinary No. 2026350); the Revenue Department's "Guidelines on Diversion of Water Bodies" (April 2022, as quoted)	Apply as amended. The 2025 rules made the "Diversion of water body to any other purpose" a diversion of land (r.2(iii)) and required for it a recommendation of a district or sub-divisional committee of DST&E, a no-objection certificate of the Fire and Emergency Service and the recommendation of the State Level Advisory Committee, with the District Magistrate and Collector deciding (r.4(v), r.7). The amendment of 6 March 2026 substituted rule 3 with "Self certification for change of classification of land" online, subject to section 20(4) of the Act, and rule 4 with revocation within thirty working days of a diversion made in contravention of section 20(3) and (4), and omitted rules 6 to 10. Read literally, the water-body procedure of 2025 no longer stands; whether section 20 of the Act still bars the diversion of a water body was not established for this Manual, and the current procedure is not stated here [TBC]. In 2022 the Department found "no specific guidelines in the TLR & LR Act & Rules in respect of diversion of water bodies" (as quoted). Appendix-I of the 2025 rules classes the pukur ("Tank/Pond"), its bank ("Bank of tank"), the dighi ("Large tank"), the beel ("Watery land"), the haor ("Big watery land"), the chhara ("Streams"), the lunga ("Flat lands between tillas") and the bandh ("Embankment") as land, the hook for counting and protecting their storage under Chapter 7.
Tripura Official Language Act, 1964 (Act No. 5 of 1964), as amended by Act No. 8 of 1979 (as quoted); Law Department notification No. F.12(1)-LAW/88(Shadow), 29 April 1999	Continue. Bengali and Kokborok (written "Kok-Borak" in the Act and "Kok Borok" in the notification) are the languages for the official purposes of the State from 1 May 1999, and English "may continue to be used" (s.2). The Manual's rule for signs is in the front matter.

Instrument	Relationship
Wetlands (Conservation and Management) Rules, 2017; the Wetland Authority of Tripura (No. F.17(54)/For-Dev/WATIL/2017/24661-686, 05.09.2018, reconstituted on 04.04.2022 and 18.06.2022, as quoted); Rudrasagar (Ramsar site No. 1572)	Continue. Rudrasagar, 240 ha with a catchment of 6,052 ha, was designated on 8 November 2005 by the Ramsar record and "officially designated" on 29 February 2007 by the Forest Department (as quoted; conflict); the CAG found ring roads built in it without the Wetland Authority's permission, which "reduced the water level" (CAG, 2021-22). The Dumbur reservoir is not a Ramsar site. The pukurs, dighis, beels and other water bodies are governed by Chapter 7.
Department of Science, Technology and Environment: "Statutory Guidelines for protection and preservation of lakes, ponds and water bodies in Tripura" (reported as notified after WP(C)(PIL) No. 2 of 2014; not read [TBC]); a direction on construction near a lake (source and scope unverified)	Not used as rules. The guidelines were not read and no buffer is taken from them; the direction that "no construction is raised within 75 Mtrs. of the end of the lake" is of unverified source and scope and is not a rule (as quoted). The statutory lines are those of the TBR 2017, r.4(1)(e), r.9(3), r.9(4) and r.90(1)(i) and (m).
Floodplain zoning, groundwater and water bodies: no Act	No flood-plain zoning Act, groundwater Act or water-body Act of Tripura was found (the High Court's index of 166 State Acts; NEER reading). The "Natural Hazard Prone Areas" of r.2(44), to be identified "through local surveys in the Development Plan", r.9(3) and r.9(4) and the zoning of the Master Plan 2045 are the nearest hooks; PWD (WR)'s map of the flood-plain zone of the Haora, prepared for the NGT, has no known legal status [TBC]. The 1% AEP maps of Chapters 6 and 7 are offered as an input to the surveys of r.2(44), not as a notification. Groundwater is little used (stage of extraction 9.48%, every unit Safe; GWRA 2024, as quoted), so recharge is not a design objective of this Manual (Clause 4.11).
Embankments and drainage: no statute	No Tripura Act on embankments or drainage was found [TBC]. PWD (WR) holds the flood embankments, reported as 154.41 km and as 134.55 km (conflict), and the Katakhal double-barrel sluice, and this Manual treats it as the owner whose consent a work that cuts, crosses or discharges through an embankment or sluice needs (Chapter 5). No setback distance from an embankment was found [TBC].
High Court of Tripura: WP(C)(PIL) No. 2 of 2014, *Bibash Ch. Saha v. State of Tripura* (as cited, copy dated 16.08.2016); the order of 28.06.2017 on the encroachment of water bodies in Agartala (case number unconfirmed, as quoted); WP(C)(PIL) No. 05 of 2017 (Rudrasagar, as reported); WP(C)(PIL) No. 06 of 2026 (NH-108B and NH-208, judgment of 08.09.2026)	Apply where they bind; they are court directions, not design standards. In PIL 2/2014 the Court found ponds filled and walls built on their banks at Kalyan Sagar, Matabari, ordered 110 m of cement embankment to be demolished and the State to notify a guideline on protecting water bodies within six months; in 2017 it took a zone-wise affidavit of the Corporation on encroached water bodies; in PIL 05/2017 it took up the level of Rudrasagar (a minimum level of 11 m RL is reported); and in PIL 06/2026 it recorded "No proper drainage system … water logging everywhere" and culverts blocked "by silt, vegetation, debris" on the national highways, and called for bi-weekly reports by NHIDCL, an audit by the Border Roads Organisation by 30.01.2027 and an inquiry by the Union by 1.12.2026. None sets a setback or a design storm. The Tripura Human Rights Commission took up the filling of a water body at Gol Bazar in 2025 (as reported).
National Green Tribunal: OA 673/2018 (polluted river stretches; State affidavit and CPCB report); OA 606/2018 (solid and liquid waste; State affidavit of 06.07.2026 on the order of 13.04.2026); OA 325/2015 (water bodies; State report of 26 May 2020, as reported)	Apply where they bind. In OA 673/2018 six Priority V stretches of 2018 were reduced to one, the Haora at Dashamighat, which is to be a "Model River" with in-situ treatment of five drains, and the State said "Partial drainage system is present in Agartala Municipal Corporation"; the stretch is given as "Agartala to Champaknagar" by the State and "Agartala to Bishramganj" by CPCB (conflict). In OA 606/2018 the tribunal's point, as quoted in the State's affidavit, is that "storm water drains are being tapped and taken to STPs which is not legal", and its order of 13.04.2026 found two treatment plants near or on the flood plain that "may lead to flooding of the STP and flowing of untreated sewage in the river during the monsoon". 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 Tripura State Pollution Control Board	Continue. Chapter 8 governs sewage in storm drains.

Instrument	Relationship
Disaster Management Act, 2005; TDMA, the Revenue Department, the District Magistrates and Collectors and the District Disaster Management Authorities	Continue. TDMA's State Disaster Management Plan 2024-25 was not read [TBC]; its monsoon checklist of 2026 lists "urban drain de-silting" without a date (as quoted), 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. PWD (WR)'s calendar for embankment works remains its own.
IRC:SP:42-2014, IRC:SP:48 (Hill Road Manual) and the practice of PWD (R&B) and NHIDCL on road drainage on the tillas and the hill ranges	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 Tripura 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 and July 1993 and August 2024, 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.

Tripura is spending on Agartala's drains, but with no stated design basis. The ADB's Agartala City Urban Development Project (53262-001) includes 48.2 km of new or rehabilitated storm-water drains (ADB, IEE, 2020), on a loan of $61 million in 2021 (as reported); a later ADB loan of $100 million with 55 km of storm-water drains is reported, its year unconfirmed (as reported), and a Tripura Urban Livability Improvement Project (53276-003) of $181.28 million is listed as "Proposed" (ADB, as quoted). The Corporation sent the ADB a storm-water proposal, reported as about ₹5–6 billion of an Agartala programme of about ₹12 billion, whose aim is to cut drainage time "from one to two hours to about 15–30 minutes" (as reported). Agartala Smart City Ltd has built storm drains, flood pumps and works on the Akhaura canal and the Katakhal, with "6 new flood pumps" in 2025 among projects worth "over Rs 844 crores" (as reported); a 650 m embankment on the Haora was built and the Katakhal cleaned in March 2026, and a proposal of ₹1,000 crore for two protective embankments and three more pumping stations, to be "implemented in phases, depending on the availability of funds", was reported in July 2026 (as reported). About 50 km of new drains are planned by the Corporation and Agartala Smart City Ltd (as reported). None of the documents found states a design return period, design intensity or runoff coefficient for any of these works, and no development-control condition stops new plots in the same catchments from using up the capacity they create. Linking Chapters 4–5 to approvals closes that gap.

The State's law holds many of the tools. The TBR 2017 bar the filling of ponds, jhoras, streams and drains without the State's approval (r.9(3)), regulate building within 15 m of a river bank (r.9(4)), ask for a site drainage plan "up to nearest … natural outfall" (r.14), keep hill sites five metres from water courses and their surface-water drains apart from sewage (r.90(1)(i), r.99), and require rainwater harvesting (r.110). The Tripura Municipal Act, 1994 vests "all public tanks, streams, reservoirs, and wells" and "all public sewers, drains, channels, tunnels, culverts and water courses in, alongside, or under any street" in the Municipality (s.91), makes it "provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall in or outside the Municipal area" (s.156(1)), lets it drain "sudden waterlogging" across private land without notice (s.160), require "separate provisions … for drainage of sewage and other offensive matters as distinct from rain-water" (s.164) and act where water accumulation "is

or is likely to become a breeding place of mosquitoes" (s.233). The Diversion of Land Rules class the pukur, the dighi and their banks as land; the Wetlands Rules, 2017 and the Wetland Authority of Tripura cover notified wetlands. The courts and tribunals have acted too: the High Court on pond filling at Kalyan Sagar (WP(C)(PIL) No. 2 of 2014), on Rudrasagar (WP(C)(PIL) No. 05 of 2017) and on the drains and culverts of NH-108B and NH-208 (WP(C)(PIL) No. 06 of 2026), and the National Green Tribunal on the Haora (OA 673/2018) and on sewage in storm drains (OA 606/2018), where the tribunal's point, as quoted in the State's affidavit, is that "storm water drains are being tapped and taken to STPs which is not legal". The CAG has audited solid waste in the towns, sand mining that "caused weakening of river embankment", the Rudrasagar ring roads and the Corporation's role in AMRUT; no CAG audit of flood control, embankments, Smart City works or storm drainage was found. What the law lacks is a design standard. None of these instruments says which storm a drain must carry, how much storage a paved plot removes, how long a sluice may be assumed closed or where a flood line lies; no floodplain zoning law, water-body Act or groundwater Act exists in the State, and the zoning regulations of the Master Plan for the Agartala Planning Area 2045 were not read [TBC]. This Manual's checks are framed as part of the building permit and the occupancy certificate given by the competent authority for the area, not as a separate no-objection certificate. The 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, release rates, storage volumes, tailwater and outfall-closed cases, infiltration rules and corridors they do not set, as a proposal for the Government, the TTAADC and the other authorities to consider. Neither the UDD, TUDA, the Agartala Municipal Corporation, any Municipal Council or Nagar Panchayat, PWD (WR), the TTAADC 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
Urban Development Department (UDD) and its Town and Country Planning Organisation (TCPO)	The UDD makes the TBR 2017 under section 274 read with section 118 of the Tripura Municipal Act, 1994 (its file series is "UDD/GL/TCPO"), oversees the urban local bodies, carries out AMRUT works with PWD (DWS) and is the executing agency of the ADB's Agartala project (as reported); it declared the Master Plan for the Agartala Planning Area 2045 final on 24 February 2026 (as reported). If the Manual were adopted, the UDD would prepare the amendment of Clause 1.3.1(a) and the model bye-law of Clause 1.3.1(b), and give regional support to Tier B authorities (Table 1.1).
Tripura Urban Planning and Development Authority (TUDA) and the Tripura Urban Planning and Development Board	Constituted under the Tripura Urban Planning and Development Act, 2018 (the Board chaired by the Chief Minister, the Authority by the Minister-in-charge of Urban Development); prepares Master Plans and gives building permission and occupancy certificates in the notified Local Planning Areas and for buildings or townships of 50 or more flats or one acre or more inside a ULB area (r.13(3)); its functions include the "development of water bodies or open spaces". If the Manual were adopted, it would require the drainage report of Chapter 10 with each permission it grants, and could write drainage reserves, lunga and pukur protection and buffers along the Haora into the zoning regulations of the Master Plan 2045 and the layouts of the Local Planning Areas (Chapter 11).
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).
Agartala Municipal Corporation, the Municipal Councils and the Nagar Panchayats	Constituted under the Tripura Municipal Act, 1994 (the Corporation upgraded from a Municipal Council in January 2014, as reported; 19 other ULBs); give the building permit and the occupancy certificate under the TBR 2017 and hold the drains, tanks and water courses vested in them (s.91), with the duty to provide drainage and "a safe and sufficient out-fall" (s.156(1)) and the powers of ss.157–166. The Corporation desilts its drains every year, runs the flood pumps of the central city and an Integrated Command and Control Centre with rain and level sensors (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).

Agency	Role under this Manual
Agartala Smart City Ltd (ASCL)	Builds storm drains, flood pumps, works on the Akhaura canal and the Katakhal, the Ujjayanta and MBB College lakes, the 8 MLD treatment plant at the Akhaura ICP and the in-situ treatment of five drains to the Haora (as reported; as quoted). Would design its drainage works to this Manual from the dates of Clause 1.11 and hand them over with their records (Clause 10.14).
Public Works Department (Water Resources) (PWD (WR))	Builds and maintains the "flood protection embankments and anti-erosion work", the irrigation works and the Katakhal double-barrel sluice near Bhuturia, and has mapped the flood-plain zone of the Haora (as quoted). No Tripura statute on embankments or drainage was found [TBC]. Would set outfall, sluice and embankment-crossing conditions as the owner of those works, supply sluice sills, closing levels and operating rules for Chapter 5, and apply this Manual to its drainage works. 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.
PWD (Roads and Buildings) and NHIDCL	PWD (R&B) builds "Major roads and drains" (CAG, 2019-20); NHIDCL is the agency for NH-108B and NH-208 before the High Court (WP(C)(PIL) No. 06 of 2026). Would apply Chapter 6 and the hill-road rules to their roads and never discharge a road drain onto an unprotected slope.
PWD (Drinking Water and Sanitation)	Carries out water-supply and AMRUT works and, with the UDD, the drainage pump houses and sewage treatment plants (as quoted; CAG, 2019-20). Would keep sewage out of storm drains as the sewers are built (Chapter 8) and design pump houses to Chapters 5 and 9.
Revenue Department and the District Magistrates and Collectors; the State Level Advisory Committee	Keep the land records (district, sub-division, revenue circle and mouza) and the land classes of the Diversion of Land Rules, 2025; the Revenue Department is the nodal department for disaster management (as quoted). Since the amendment of 6 March 2026 a change of classification is made by online self-declaration, which the Competent Authority may revoke within 30 working days; how a water body is diverted under the amended rules was not established [TBC]. Would refer to this Manual in decisions on water bodies.
Department of Science, Technology and Environment (DST&E), its water-body committees and the Tripura State Pollution Control Board (TSPCB)	DST&E reports a notified "Statutory Guidelines for protection and preservation of lakes, ponds and water bodies in Tripura" (not read; no buffer is taken from it [TBC]), runs the State and sub-divisional monitoring committees and the River Rejuvenation Committee; TSPCB gives consents and monitors the Haora at Dashamighat (as quoted; CPCB). Would be consulted before a pukur or water body is used for storage or as an outfall (Chapter 7) and receive the records of sewage found in storm drains (Chapter 8).
Forest Department and the Wetland Authority of Tripura	The Wetland Authority (No. F.17(54)/For-Dev/WATIL/2017/24661-686, 05.09.2018, reconstituted in 2022, as quoted) administers the Wetlands (Conservation and Management) Rules, 2017; Rudrasagar is managed by the Fisheries Department by the Ramsar record and by the Forest Department by the State's page (as quoted; conflict). Would be the competent authority for the area for a notified wetland and be consulted before one is used for storage or as an outfall (Chapter 7).
TDMA and the District Disaster Management Authorities	TDMA, chaired by the Chief Minister, issued the State Disaster Management Plan 2024-25 and a monsoon checklist of 2026 with "urban drain de-silting", sluice gates and 42 vulnerable embankment points (as quoted; 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).
Tripura Tribal Areas Autonomous District Council (TTAADC)	Governs the Tripura Tribal Areas Autonomous District under the Sixth Schedule to the Constitution, "nearly sixty-eight per cent of Tripura's territory" (as reported), to which the Tripura Municipal Act, 1994, and so the TBR 2017, do not extend (s.1(2)); no building or land-development regulation of the Council was found [TBC]. The Manual has no force in the council area unless the Council adopts it. The Council could adopt it by a regulation of its own or by resolution; if it did, it, or the authority it designated, would be the competent authority for the area.
Operator of the Dumbur reservoir (the Gumti hydel project; TSECL, as reported) and NEEPCO	Operate the reservoir and its gates, whose release on 21 August 2024 is reported and denied (as reported; conflict); full reservoir level 93.55 m, "danger level" 94 m and spillway capacity 481.38 m^3/s (as reported). Would supply reservoir levels, release rules and release records for Chapter 5 and the screening of Clause 2.3.6(i), and give warnings of releases in writing and by siren or SMS.
Central Water Commission (CWC), a body of the Union	Publishes the Flood Estimation Reports (none for subzone 2(c), in which Tripura lies by elimination) and runs 12 river sites in Tripura, 2 of them for level forecasting (2018, as reported). Would supply river stage records with their datum for Chapter 5 and confirm the subzone of the State and whether any study for subzone 2(c) exists.

Agency	Role under this Manual
Central Ground Water Board (CGWB), North Eastern Region, State Unit Office Agartala, a body of the Union	Holds the observation wells and published the aquifer map of West Tripura (NAQUIM). Would supply groundwater levels and quality for Clause 4.11 and Chapter 8; no State observation-well network was found [TBC].
IMD (Meteorological Centre Agartala), and road, rail and other owners	IMD's stations supply the rainfall records of Chapter 2; Agartala (A) (42724) and Kailashahar (A) (42618) are the first data requests of Clause 2.3.6(a). Other owners of roads, railways and their drains would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. Stormwater in Tripura is split, first, by the river. The towns drain through sluices and pumps at embankments that PWD (WR) holds, into rivers that leave the State, so the body that holds a town's drains is not the body that decides when its outfall opens, and no one in India controls the river below it. It is split, second, by the Sixth Schedule: the Tripura Municipal Act, 1994 and the TBR 2017 reach the ULB areas and the Local Planning Areas, and not the TTAADC area, about 68% of the State (as reported), where no building regulation was found. And it is split, third, among the bodies that build Agartala's drains. The Act vests the public drains, tanks and water courses in the Corporation (s.91) and makes it provide "a safe and sufficient out-fall" (s.156(1)), but the capital works are built by others: 98 per cent of the major AMRUT works by the UDD and PWD (DWS), "and only a few minor works" by the Corporation, with no tripartite agreement (CAG, 2019-20); the major roads and drains by PWD (R&B) (CAG); storm drains, flood pumps and the Akhaura canal and Katakhal works by Agartala Smart City Ltd; the embankments, the Katakhal sluice and the flood-plain mapping by PWD (WR); and the pump houses and treatment plants by PWD (DWS) with the UDD (as quoted; as reported). The Agartala Planning Area of the Master Plan 2045, 238.57 km², is also wider than the Corporation's area (as reported). The Katakhal shows why the split matters. It is at once the northern trunk drain of the city, the receiver of three treatment plants that are to be fed by intercepting its drains (State affidavit to the NGT, 2026), and a channel whose outfall PWD (WR)'s sluice closes against the river. No order was found that allocates the Akhaura canal, the Katakhal, the Haora embankments or the sluices to one owner, or that hands any drainage work over under section 156(2) or section 165 of the Act (NEER reading) [TBC]. Until the State issues such an order, 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 (khas or government land, private land, or Council land), whether it is a vested municipal drain, an embankment drain or sluice, or a natural chhara (Bengali ছড়া, "Streams") or lunga, and its outfall (set by this Manual). The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers, and on private land it is put into effect by 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, public tanks, streams and water courses in a ULB area	The ULB, and in Agartala the Agartala Municipal Corporation (Tripura Municipal Act, 1994: vesting s.91, "unless the State Government otherwise directs by a notification"; drainage and "safe and sufficient out-fall" s.156(1); cleansing s.157; connections by written permission s.161; demolition of unauthorised drains s.162; separation of sewage from rain-water s.164; encroachment s.166)
Capital drainage works in Agartala, built by others: AMRUT works; storm drains, flood pumps and the Akhaura canal and Katakhal works; the Ujjayanta and MBB College lakes; the ADB's 48.2 km of drains	Built by the UDD and PWD (DWS) (AMRUT, 98%, CAG, 2019-20), Agartala Smart City Ltd and the ADB project; maintained by the Agartala Municipal Corporation unless handed over under s.156(2) or s.165 [TBC]
Major roads and their drains; the drains of NH-108B and NH-208	PWD (R&B) (CAG); NHIDCL (WP(C)(PIL) No. 06 of 2026)

Element	Assigned to
River embankments, sluices (among them the Katakhal double-barrel sluice), anti-erosion works and flood-plain mapping	PWD (WR) (no statute found [TBC])
Drainage pump houses and sewage treatment plants	PWD (DWS) with the UDD
Drains in the TTAADC area	The District Council or the body it designates [TBC]

No formal allocation order was found. 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. Tripura has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to a river through an embankment sluice, to a pukur, dighi or lunga behind a closed outfall, to a pumped outfall such as those of central Agartala, to a river that leaves the State with no downstream control, or to the Gomati below the Dumbur reservoir, 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 Tripura ponds have been filled for housing in Barjala and Lanka Basti in Agartala (as reported); local bodies allowed ponds to be filled and walls to be built on their banks at Kalyan Sagar, Matabari, until the High Court ordered the State to notify a water-body guideline and 110 m of cement embankment to be demolished (WP(C)(PIL) No. 2 of 2014, as cited); ring roads were built in Rudrasagar, a Ramsar site, without the Wetland Authority's permission, which "reduced the water level" (CAG, 2021-22); and the State Human Rights Commission took up the filling of a water body at Gol Bazar in 2025 (as reported).

1.11 Transition provisions

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

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

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

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

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

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

1.12 Review and amendment

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

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

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

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Agartala Municipal Corporation, of the Agartala Planning Area of the Master Plan 2045 and of the Agartala-Ranibazar-Jirania Local Planning Area
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model TBR 2017 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 Tripura. Where the Agartala Municipal Corporation, a Municipal Council, a Nagar Panchayat, TUDA or the TTAADC has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Tripura trace to the rainfall input, not the hydraulics. Tripura shows how. No design storm, return period, design intensity, runoff coefficient or time of concentration was found for the drains of any town in the State (ADB, IEE, 2020; State filings before the NGT; news reports); the ADB's drainage upgrade for Agartala states its aim as cutting drainage time "from one to two hours to about 15–30 minutes" (as reported), not as a storm. The published sources that seem to fill the gap do not reach the State: no CWC Flood Estimation Report covers any part of Tripura, and the corrigendum of the 2(b) report strikes out its one mention of the State; IMD Das et al. (2022) prints no Tripura panel. NIH-DHAARA reaches every site, but it is low against the largest measured day, Bagafa's 49 cm on 22 August 2024, which exceeds every one of its 100-year cells in the State, and two of its cells, at Khowai and Kamalpur, return no data (Clause 2.3.6). The figures that circulate after a flood conflict: the statewide fall of 20 August 2024 is reported as a "record 288.8 mm in a single day" and transcribed from IMD as a State average of 176.2 mm; Bagafa's day is 49 cm in IMD's table and 493.6 mm for "Bokafa" from the State, dated 21 or 22 August; and the "about 200 mm in 3 hours" reported at Agartala in June 2022 and May 2025 has no IMD value behind it (IMD; 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.

Term	Meaning in this Manual
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 months of April and May, with their nor'westers (the "Kalbaisakhi" of the District Disaster Management Plan, as cited by the ADB) and the remnants of cyclones, as well as the south-west monsoon. It is the Manual's season, not IMD's: the south-west monsoon does not begin in April. It reaches Tripura about 5 June: it entered the State on 7 June 2026, "two days later than its normal", and on 26 May 2025, "10 days before its normal date" (Meteorological Centre Agartala, as reported), both of which put the normal date at about 5 June (NEER reading); another report gives "June 10" (as reported; conflict), and IMD's revised normal dates were not read for this Manual [TBC]. No date of withdrawal from Tripura was found [TBC]; the monsoon withdrew from the North East on 15 October 2026, "close to its normal date" (as reported). The season begins on 1 April because the storms of April and May are among the State's largest. Kailashahar's wettest month on record is May (1,175.0 mm, May 1991) and its next April (1,012.8 mm, April 1977); its highest April day is 257.1 mm (19 April 2004) and its highest May day 231.2 mm (3 May 1993); Agartala's highest April day is 198.0 mm (11 April 2007) and its wettest May 723.8 mm (1984) (IMD, *Extremes*). The Dhalai at Kamalpur (33.85 m) and the Juri at Nutan Bazar (20.435 m) set their highest levels on 15 May 1984 (CWC data as transcribed by SANDRP); Cyclone Remal brought 252.4 mm to Unakoti district, 248.3 mm to Dhalai and 242 mm to North Tripura in the 24 hours to 0830 IST on 28 May 2024 (district values, as reported); and Agartala flooded on 31 May–1 June 2025 (as reported). The District Disaster Management Plan of 2016-17, as cited by the ADB, records that cyclones occur "during April & May and during October & November in terms of Kalbaisakhi" and that "Summer season starts from middle of March" (ADB, IEE, 2020; wording as printed). The pre-monsoon deadline of 31 March is therefore set before the season begins (Chapter 10): the drains are desilted, and their sluice gates, flap gates, pumps and standby power certified ready, by that date. A test date of 15 April, suggested in the research for this Manual, is not used, because the April storms come before it (198.0 mm at Agartala on 11 April 2007). No order of the State fixes a date: the Agartala Municipal Corporation desilts every year, PWD (WR) runs a pre-monsoon embankment programme and TDMA's monsoon checklist of 2026 includes "urban drain de-silting", none of them with a date (as reported; as quoted). The PWD (WR)'s calendar for embankment works is its own. The wettest months on record are 799.9 mm at Agartala (June 1976) and 1,175.0 mm at Kailashahar (May 1991) (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 fall inside it. In February Agartala recorded 142.2 mm (19 February 1993); in March Kailashahar 112.4 mm (25 March 1994) and Agartala 98.6 mm (1 March 1960); in October Agartala 183.6 mm (11 October 1989) and Kailashahar 182.0 mm (9 October 1986); and in November Agartala 104.6 mm (9 November 1955) and Kailashahar 104.2 mm (10 November 1986) (IMD, *Extremes*). 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, a mid-season clearance by 31 May and a post-season clearance by 15 November for this reason. December to February is this Manual's works window.
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 Tripura this clause

applies as modified by Clause 2.3.6, which raises its values to the governing cell of the site's sub-area and to the floors and records of that clause, because no CWC report covers the State.

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(c) (Barak and others), in which the whole of Tripura lies (NEER's reading, by elimination: the subzone 2(b) report stops north of the State and its corrigendum strikes out its one mention of Tripura; to be confirmed by CWC [TBC]) and for which CWC has published no Flood Estimation Report, so that no CWC point rainfall, plate or synthetic unit hydrograph exists for the State; in Tripura each such catchment is modelled by the site study of Annex 3E, calibrated to the CWC and State river gauges, with the subzone 2(b) unit hydrograph computed only as the cross-check of Clause 3.11.4(c) and not as the floor of Clause 3.11.4(d) where the site study is calibrated, because its catchments lie in Assam and Meghalaya and none drains to the Meghna, as applicable.

Where the design value is lower than the CWC subzone 2(c) (Barak and others) plate (none exists: CWC has published no report for subzone 2(c), so no CWC floor applies in Tripura, and Clause 2.3.6 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.

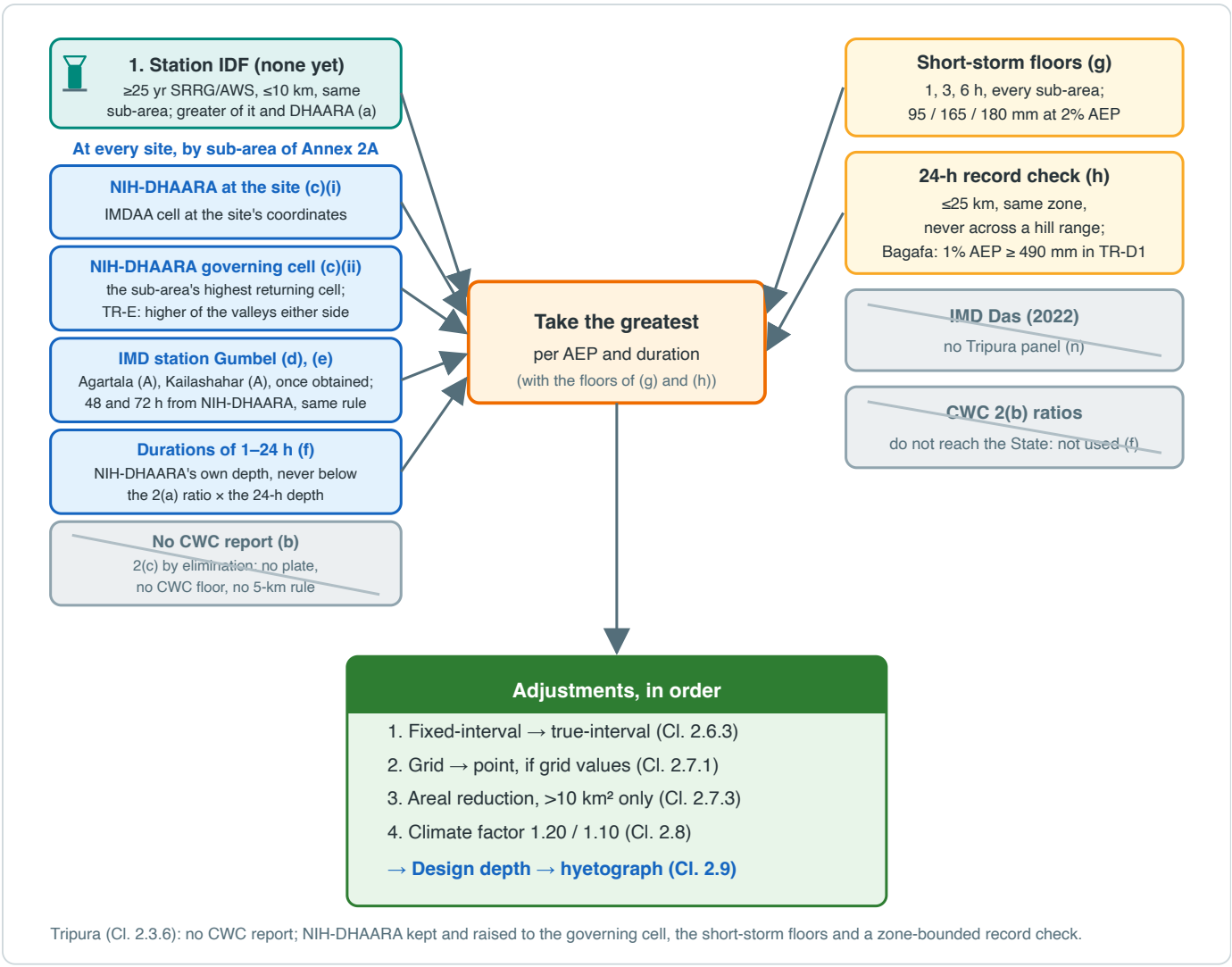

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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 Tripura.** Until Annex 2A is published and confirms NIH-DHAARA, or an approved station IDF, for a zone, Clause 2.3.1 applies in Tripura as modified by this clause, 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 is used within 10 km of the station, in the same sub-area of Annex 2A and never across a hill range of sub-area TR-E, for the durations and AEPs it covers, subject to the rule of Clause 2.3.2 that the design value is the **greater** of the station value and the NIH-DHAARA value (here the value of (c) and (f)), and to the floors of (g) and the check of (h). A record is checked when its annual totals and annual maxima have been compared with the IMD normals and station extremes for the station, and every year that disagrees has been explained or removed. An IDF derived from daily data by the one-third rule (Clause 2.6.4) or by any other fixed ratio is not a station IDF. In Tripura 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 constants was found for any station in the State: NIT Agartala's study of rainfall extremes and IDF curves in Tripura under CMIP6 projections (EGU General Assembly 2026, abstract EGU26-20865) gives no values in its abstract; a 2022 chapter on the rainfall of Agartala Sadar (*Lecture Notes in Civil Engineering*) was seen by its title only; and the IDF study of Basumatary and Sil for the Barak basin was seen as an abstract, and whether it used a gauge in Tripura is not known [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 72 hours, and the return-period tables of **Agartala (A) (42724)** and **Kailashahar (A) (42618)**,

with the hourly records of Agartala for **17–19 June 2022** and **31 May–1 June 2025**, the two nights of "about 200 mm in 3 hours" in the press (g), and for **22–24 August 2026**; (2) IMD's station extremes for 2013–2026, and for the **Bagafa** gauge its type, coordinates and record length, with the reason why Bagafa and Bagafa AWS differ (38 cm against 13 cm in the 24 hours to 0830 IST on 20 August 2024, IMD) (h); (3) the automatic rain gauge and weather station records of Belonia, Udaipur, Sonamura, Khowai, Teliamura, Kamalpur, Dharmanagar and Sabroom; (4) the list of gauges of IMD's Meteorological Centre Agartala with their types, start years and logging intervals, the rain sensors of the Agartala Municipal Corporation's Integrated Command and Control Centre, and the 10 automatic rain gauges IMD is to add in Agartala and the urban areas (TDMA, monsoon checklist of 2026, as quoted); and (5) the full text of the NIT Agartala study.

- (b) **Reports, zones and sub-areas. No CWC Flood Estimation Report covers any part of Tripura.** The report for subzone 2(b), South Brahmaputra (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), states its extent as "latitude 25° 15' to 28° North approximately" and its boundary as "on the south by Barak Subzone 2 (c)" (CWC, 2(b), p. 18); its §2.4.2.1 named "some parts of Tripura" among the areas of higher mean daily temperature, and its corrigendum orders "omit 'and some parts of Tripura' from this line" (CWC, 2(b), corrigendum, read by OCR); and its Plate 9, the 50-year map, stops at about 25° N (CWC, 2(b), page image), while Tripura lies between 22°56' and 24°32' N (as quoted). Its Annexure 1.1 lists subzone **2(c) as "Barak and others"**, and CWC has published 21 Flood Estimation Reports covering 24 of its 26 subzones, none of them for 2(c) (CWC, 2(b), lists of reports; CWC's page of its reports, captured on 20 March 2024). Tripura's rivers all reach the Meghna system in Bangladesh, so the State lies in subzone 2(c) by elimination: a NEER reading, to be confirmed against CWC's subzone map [TBC]. No small-catchment study of CWC, RDSO or the railways was found for Tripura. Hence no isopluvial plate, **no CWC floor under Clause 2.3.3** and no 5-km boundary rule apply in Tripura, and the isopluvials and the ratios of the 2(b) report are not used, because they do not extend to the State (set by this Manual); its areal reduction curves stand in under Clause 2.7.3, and its unit hydrograph is a cross-check only (Chapter 3). The rainfall zone and sub-area of the site are those of Annex 2A: zone **TR-Z1 Western valley**, with sub-area **TR-A Agartala–Sonamura valley (Agartala–Jirania–Mohanpur–Bishalgarh–Sonamura)**; zone **TR-Z2 Central valleys**, with sub-areas **TR-B Khowai valley (Khowai–Teliamura)** and **TR-B1 Dhalai valley (Ambassa–Kamalpur)**; zone **TR-Z3 Northern valleys**, with sub-area **TR-C Manu–Juri–Deo valleys (Kailashahar–Kumarghat–Dharmanagar–Panisagar–Kanchanpur)**; zone **TR-Z4 Southern valleys**, with sub-areas **TR-D Gomati valley (Udaipur–Amarpur–Karbook)** and **TR-D1 Muhuri–Feni south (Belonia–Santirbazar–Jolaibari–Bagafa–Sabroom)**; and zone **TR-Z5 Hill ranges**, with sub-area **TR-E Hill ranges (Baramura–Atharamura–Longtharai–Sakhan–Jampui)**. They fix the governing cell of (c), the bounds of the check of (h) and the screening of (i). A catchment that crosses the line between two zones or two sub-areas of Annex 2A takes, at every duration, the higher value of the two (set by this Manual). The town lists are a guide; the boundaries follow the crests of the hill ranges and are to be confirmed [TBC]. The districts are the eight of 2012 (West Tripura, Sepahijala, Khowai, Gomati, South Tripura, Dhalai, Unakoti and North Tripura); CWC's tables print the older districts. The tilla uplands and the lunga floors are not zones: they occur in every valley and are ground types for the infiltration rules of Clause 4.11 and the drainage rules of Clause 6.3.6.

- (c) **24-hour depth at every AEP: the governing-cell rule.** The 24-hour depth for each AEP is the **greater** of (i) the NIH-DHAARA value at the site's coordinates and (ii) the NIH-DHAARA value of the **governing cell** of the site's sub-area, and not less than (iii) the Gumbel estimate of (d), once the IMD station series is in hand, or (iv) the record check of (h) (set by this Manual). Where the site's cell returns no data, as the cells at Khowai town (24.12° N, 91.56° E) and Kamalpur (24.24° N, 91.80° and 91.92° E) did, (ii) alone applies. The governing cells, queried on 14 November 2026 (NIH-DHAARA, IMDAA dataset), give the following depths in millimetres:

Sub-area	Governing cell (grid point)	24 h at 2 / 5 / 10 / 25 / 50 / 100 years	1 h at 2 / 5 / 10 / 25 / 50 / 100 years
TR-A	Agartala (23.88° N, 91.32° E)	116.9 / 182.1 / 225.4 / 280.0 / 320.5 / 360.7	37.9 / 55.5 / 67.1 / 81.9 / 92.8 / 103.6
TR-B and TR-B1	The cell 6 km south of Khowai (24.00° N, 91.56° E)	110.3 / 169.1 / 208.0 / 257.1 / 293.6 / 329.8	39.0 / 57.9 / 70.4 / 86.2 / 97.9 / 109.5

Sub-area	Governing cell (grid point)	24 h at 2 / 5 / 10 / 25 / 50 / 100 years	1 h at 2 / 5 / 10 / 25 / 50 / 100 years
TR-C	Kailashahar (24.36° N, 92.04° E)	127.8 / 195.2 / 239.8 / 296.1 / 337.9 / 379.4	33.9 / 49.2 / 59.3 / 72.1 / 81.6 / 91.0
TR-D	Udaipur (23.52° N, 91.44° E)	112.4 / 174.7 / 216.0 / 268.1 / 306.8 / 345.2	32.4 / 49.4 / 60.6 / 74.8 / 85.3 / 95.7
TR-D1	Sabroom (23.04° N, 91.68° E)	133.3 / 214.1 / 267.6 / 335.2 / 385.3 / 435.1	33.7 / 51.4 / 63.1 / 77.9 / 88.9 / 99.8
TR-E	The higher of the governing cells of the valley sub-areas on either side of the range, at each duration and AEP	—	—

The governing cell is the sub-area's highest returning cell at 24 hours: in TR-A the Agartala cell, over Bishalgarh (314.6 mm at 50 years) and Sonamura (312.7 mm); in TR-B the cell south of Khowai, over Teliamura (240.3 mm), and TR-B1, whose one returning cell is Ambassa (258.3 mm), takes its zone's governing cell; in TR-C Kailashahar, over Dharmanagar (336.9 mm) and Kumarghat (274.9 mm); in TR-D Udaipur, over Amarpur (291.1 mm); and in TR-D1 Sabroom, over Belonia (311.9 mm) (NIH-DHAARA, queried 14 Nov 2026; choice a NEER reading). The site's own value still governs where it is higher, as at Bishalgarh at 2 years and at the Dharmanagar and Kumarghat cells at 1 hour. Values at other AEPs are read from NIH-DHAARA under the same rule. This is an interim rule for a State that no CWC report covers, set by this Manual because NIH-DHAARA is the only source that reaches every site and is of the right order here, while its cells differ more than the climate does (Teliamura's 50-year 24-hour depth is 240.3 mm and that of the cell south of Khowai, about 18 km away in the same valley, 293.6 mm; NEER reading) and it is low against the largest measured day (h). With (h), it keeps every 1% AEP 24-hour depth at or above every qualifying day recorded in the State. To the north, where the Manu, the Juri, the Deo and the Longai join the same Kushiyara plain as the Barak valley in Bangladesh, the 24-hour floors of the neighbouring North-East edition for that valley lie below the TR-C governing cell at 2% and 1% AEP, so no Tripura depth falls below them (NEER comparison).

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr): station series.** Once obtained, 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, enters (c) as a further lower bound for these AEPs and is extended to 2% and 1% AEP for comparison (set by this Manual). The stations are **Agartala (A) (42724, rainfall data 1953–2012)** for TR-A and **Kailashahar (A) (42618, rainfall data 1958–2012)** for TR-C (IMD, *Extremes*); no other Tripura station is in IMD's *Extremes*, and the other sub-areas have no IMD series in hand [TBC]. No Gumbel fit to either station's annual maxima was found for this Manual [TBC]. Until a fit is made, (c) applies alone at these AEPs.

- (e) **48- and 72-hour depths.** The NIH-DHAARA 48- and 72-hour depths under the governing-cell rule of (c), not less than the 24-hour depth for the same AEP as checked under (h), and checked against the IMD 2-day and 3-day series of the stations of (d) when they are obtained (set by this Manual). The long durations are probably low as well: the August 2024 falls of 644.5 mm over 20–22 August in South Tripura district and 363.7 mm over the State (IMD district data as transcribed by SANDRP, as reported) approach the 100-year 72-hour depths of the Sabroom and Belonia cells, 679.8 mm and 607.5 mm (NIH-DHAARA), although they are district averages, not point falls (NEER reading).

- (f) **Durations of 1 to 24 hours.** The t-hour depth for each AEP is the greatest of (all set by this Manual):

    - (i) the NIH-DHAARA t-hour depth under the governing-cell rule of (c), read directly where NIH-DHAARA gives the duration (it gives 1, 2, 4, 8, 9, 12, 18, 24, 36, 48 and 72 hours; Clause 2.6.1) and, at 3 and 6 hours, interpolated on logarithmic axes between its 2-, 4- and 12-hour depths;
    - (ii) **the ratio of the 2(a) report times the 24-hour depth of (c) or (d) before the check of (h)**: 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, Flood Estimation Report for North Brahmaputra Subzone 2(a), NB/18/1991, §3.1.2, p. 24, and Fig. 10, which gives the 2-hour value), interpolated on logarithmic axes between the tabulated durations; and
    - (iii) at 1, 3 and 6 hours, the floors of (g).

  The 2(a) set is used because it is the CWC set built on a 50-year basis from the most recording gauges, its 1-hour ratio of 0.26 lies inside the range of NIH-DHAARA's Tripura cells (0.23 to 0.36 at 50 years; 0.29 in the Agartala cell), and it is the set that the neighbouring North-East editions use on their ridges and north bank (NIH-DHAARA; NEER reading). It is a lower bound, not the shape: NIH-DHAARA's own depths govern where higher, and they are higher at 1 to 6 hours in most cells (in the Agartala cell at 50 years 185.4 mm in 4 hours, against about 166 mm from the interpolated 2(a) ratio applied to 320.5 mm), while the 2(a) product governs at 12 hours in the Agartala, Kailashahar, Udaipur and Sabroom cells and at 1 hour in the Kailashahar and Sabroom cells, whose 1-hour ratios are the lowest (NEER arithmetic). **The 2(b) ratios are not used**: their 1-hour ratio of 0.48 exceeds the ratio of every Tripura cell by 33% to 109%, and the report does not extend to the State (NEER arithmetic). The edition for the adjoining valley floor uses the 2(b) set there; the two differ because the evidence each holds differs, no recording-gauge record having been found for Tripura and NIH-DHAARA being plausible at the hour scale. 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

  Tripura has no recording-gauge record in any source found for this Manual. The 2% AEP values are the largest falls on the record of the valley recording gauges of the CWC 2(b) report in the Brahmaputra valley, rounded up to 5 mm: 95 mm in 1 hour, 163 mm in 3 hours and 179 mm in 6 hours (CWC, 2(b), Annex 4.2, read by OCR), the nearest recorded convective storms of a valley floor. The other AEPs are scaled by the shape, not the values, of NIH-DHAARA's 1-hour growth curve in the Agartala cell: 67.12/92.78 = 0.723 at 10 years, 81.85/92.78 = 0.882 at 25 years and 103.62/92.78 = 1.117 at 100 years (NIH-DHAARA, queried 14 Nov 2026; ratios a NEER reading), which gives the same table, rounded to 5 mm, as the neighbouring North-East edition. Treating the record maxima as 50-year values is a floor, not a frequency estimate. The floors govern at 1 hour in most cells, where NIH-DHAARA's 50-year depths are 78–98 mm. 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. Two press reports of "about 200 mm in 3 hours" at Agartala, on 17–19 June 2022 (the Mayor) and on the night of 31 May 2025 (the Mayor and officials, PTI), have no IMD value behind them (as reported) [U] and set no value; if an IMD record confirms either, the 3-hour floor at 1% AEP, 185 mm, is below it and Annex 2B revises the table, which is why Agartala's hourly record is the first data request of (a). The floors are interim: Annex 2B replaces them with station fits under (a); if a fit shows 1-, 3- or 6-hour depths above them for a sub-area, the fit governs there, and if the fits show depths well below them, a reduction may be proposed to the State Stormwater Technical Committee. No other absolute floor is used below 24 hours.

- (h) **24-hour record check, bounded by zone.** 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 zone of Annex 2A**, where that record is higher; the record is used as printed, without the fixed-interval factor, and is treated as a 1% AEP depth; a record never counts from one valley to another across a hill range of TR-E, and a site in TR-E may take a qualifying record from either adjoining valley within 25 km (all 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, a monthly or seasonal climate summary or a later IMD table that names the gauge and

the day); the number of years of data at its gauge is confirmed by an IMD table as at least 20; it was made in 1901 or later; it falls in a month in which a fall of that size is plausible for the station; the location of its gauge is known; and it is not contradicted by another IMD table for the same gauge. **One Tripura addition (set by this Manual):** a station value printed by IMD in the station table (Annexure I) of an IMD press release qualifies without a confirmed record length, as a 1% AEP floor, until IMD's station tables confirm or withdraw it, because IMD's *Extremes* stops in 2012, Tripura has only two stations in it, and the State's largest measured day (2024) is in no other IMD table: a single measured day that exceeds every estimate is evidence that the estimate is low, whatever the record length. Distances are measured from the coordinates of the gauges and towns (NEER reading; IMD's station coordinates to be confirmed [TBC]). The outcomes at present are:

- **Agartala (A), 257.2 mm on 22 July 1993** (IMD, *Extremes*, rainfall data 1953–2012), qualifies; it is below the TR-A governing cell (360.7 mm at 100 years) and raises nothing.
- **Kailashahar (A), 377.2 mm on 6 June 1993** (rainfall data 1958–2012), qualifies and sets the 1% AEP 24-hour depth at not less than 377.2 mm within 25 km of the gauge in TR-Z3, which takes in Kailashahar, Kumarghat (about 19 km) and Dharmanagar (about 17 km) (NEER reading); the Kailashahar cell, 379.4 mm, already exceeds it by 2 mm, so it raises nothing now, and it becomes the binding check if a station fit under (a) or (d) comes lower. Kailashahar's April record, 257.1 mm (19 April 2004), is below every cell.
- **Bagafa (IMD), 49 cm in the 24 hours to 0830 IST on 22 August 2024** (IMD, press release of 22 August 2024, Annexure I), qualifies under the Tripura addition and **sets the 1% AEP 24-hour depth at not less than 490 mm throughout sub-area TR-D1**, raising the Sabroom cell's 435.1 mm and the Belonia cell's 350.1 mm. It applies across the sub-area rather than by radius **because the gauge's coordinates are not confirmed** (about 23.1–23.2° N, 91.6° E, NEER reading [TBC]); when IMD gives them, the 25-km radius within TR-Z4 governs instead. IMD's 490 mm is used, not the State's 493.6 mm for "Bokafa", dated 21 or 22 August in different releases (as reported; conflict). This is the largest effect of the check in the State: 490 mm is 1.4 times the Belonia cell's 100-year depth (NEER arithmetic).
- **Recorded, raising nothing** (IMD, press releases, Annexure I): in the 24 hours to 0830 IST on 20 August 2024, Belonia 32 cm, Amarpur 31 cm and Bagafa 38 cm; to 0830 IST on 22 August 2024, KVK South 31 cm, Agartala Aero 23 cm, Teliamura 23 cm, Sonamura 20 cm and Belonia 14 cm. Each is below its sub-area's 1% AEP depth (Amarpur's 310 mm against TR-D's 345.2 mm; Belonia lies in TR-D1). Co-located gauges disagree: on 20 August 2024 Belonia read 32 cm, Belonia ARG 25 cm and Belonia CWC 15 cm, and Amarpur 31 cm against Amarpur CWC 27 cm (IMD), so the gauge is named with every value on Form 2-1.
- **Not station values and not used:** the statewide "record 288.8 mm in a single day on August 20" (as reported) against IMD's State average of 176.2 mm for that day (as transcribed by SANDRP) [U]; the district values of Cyclone Remal of 27–28 May 2024 (as reported); the "333 mm" reported for Agartala on 20 and 21 August 2024, a two-day figure (as reported); the 145 mm and 155 mm reported for a day of June 2022 (as reported; date unconfirmed; conflict); and the claim of 270 mm in one hour at Agartala, which is implausible.

No record from Bangladesh or from another State reaches a Tripura site, because none is in the sources found for this Manual. Until Annex 2A is published, the designer lists on Form 2-1 every record within 25 km of the site, with its zone 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.** Tripura 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 hazard pages of TDMA and the State Disaster Management Plan [TBC], PWD (WR)'s maps of the flood-plain zone of the Haora, the landslide maps of the Geological Survey of India [TBC] and the Natural Hazard Prone Areas of TBR 2017, r.2(44), once they are mapped in a Development Plan; 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: **landslide ground**, among it the tilla cuts and the cuttings of NH-8 through the Atharamura and Longtharai ranges (NEER reading), where landslips were reported at 2,032 locations in August 2024, with 7 deaths at Gardang near Santirbazar and 3 at Debipur, and at 17 locations in June 2018, 11 of them in Khowai district (as reported); **the**

release reach of the Dumbur reservoir on the Gomati, through Amarpur, Udaipur and Sonamura, whose gates were opened on 21 August 2024, the first release since 1993 by one account, while the power minister denied that a gate had opened (as reported; conflict); **embankment breach and leakage paths**, among them the 6 km of the Haora embankment at Agartala under leakage repair, the 16.8 km of the Manu embankment raised at Kailashahar and the 7.47 km of the Muhuri at Belonia (as reported); **the active flood plains**, the "recent flood plains constituting the present-day flood-prone belts fringing the rivers" (CGWB), and **filled ponds and lunga fills** (TBR 2017, r.32); and the **border reaches**, where no downstream control or level data exist.

- (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 Tripura, and no hourly value from any Tripura gauge is in a primary source: the "about 200 mm in 3 hours" at Agartala are press reports only (g), and a press claim of 270 mm in one hour is implausible and is not used. The floor of (g) at 1% AEP, 105 mm in 1 hour before the climate factor, reaches the threshold. What a burst does on a cut tilla slope or a hill range 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, silt traps 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).

- (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 is the primary source in Tripura, as modified by this clause. It was queried at 15 points in the State on 14 November 2026 (IMDAA dataset); 13 cells returned data and two returned empty series, those at Khowai town (24.12° N, 91.56° E) and Kamalpur (24.24° N, 91.80° and 91.92° E), for which the cell 6 km south of Khowai (24.00° N, 91.56° E) stands in under (c); a further query was refused. Its 50-year 24-hour depths range from 240.3 mm (Teliamura) to 385.3 mm (Sabroom), and its 50-year 1-hour depths from 77.6 mm (Belonia) to 97.9 mm (the cell south of Khowai) (NIH-DHAARA, queried 14 Nov 2026). The site value, the governing cell's value and the depths adopted are all recorded on Form 2-1. Its projected depths are not used under Clause 2.8.4.

- (n) **IMD Das et al. (2022).** The paper prints no panel for any station in Tripura among its 27 (IMD Das et al., 2022, pp. 895–896). Its North-East panels are for stations outside Tripura, one an escarpment curve and the others a generic curve that the paper repeats for several cities; none is used as a value, a check or a floor in Tripura, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as "no panel". The paper's national isopluvial maps were not read at a scale that resolves Tripura [TBC].

- (o) **Earlier design values.** None was found: no Tripura document states a storm-drain return period, design intensity, runoff coefficient or time of concentration (ADB, IEE, 2020; State filings before the NGT; news reports). The ADB's drainage upgrade for Agartala aims to cut drainage time "from one to two hours to about 15–30 minutes" (as reported; its DPR was not read [TBC]); and the ADB's report records that "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded" (ADB, IEE, 2020). Roads follow IRC:SP:42-2014 and IRC:SP:48, and the TBR 2017 defer to the latest National Building Code and Indian Standards for what they do not cover (r.3A). The CPHEEO (2019) minimums are the national comparison. A designer who uses any earlier design value 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 Tripura the platform is kept, as Clause 2.3.1 provides, and raised. It was queried at 15 points of the State for this Manual. It is of the right order: Agartala's 50-year 24-hour depth, 320.5 mm, is 1.25 times the IMD record of 257.2 mm (22 July 1993) in 60 years of data, and Kailashahar's record of 377.2 mm (6 June 1993) sits at its 100-year depth of 379.4 mm (IMD, *Extremes*; NIH-DHAARA; ratios a NEER reading). It is low against the extremes: Bagafa's 49 cm of 22 August 2024 exceeds every 100-year cell in the State, the largest being Sabroom's 435.1 mm, and Belonia's 32 cm and Amarpur's 31 cm of 20 August 2024 exceed the 50-year depths of their cells, 311.9 mm and 291.1 mm (IMD, press releases). And its cells disagree more than the climate does: Teliamura's 50-year 24-hour depth is 240.3 mm and that of the cell south of Khowai, about 18 km away in the same valley, 293.6 mm, 22% more, while the cells at Khowai town and Kamalpur return no data. Because no CWC report covers the State, no station series is in hand and NIH-DHAARA is the only source that reaches every site, Clause 2.3.6 keeps it and raises it: to the governing cell of the site's sub-area, to the short-storm floors and to a record check bounded by zone, with the 2(a) ratio as a lower bound from 1 to 24 hours. Tripura is the first State of this series whose whole area lies outside every published CWC Flood Estimation Report, and the third North-East edition to state that CWC has published no report for subzone 2(c), "Barak and others". Each of the three sets its own interim rule for that gap: the escarpment edition uses an IMD station curve, the edition for the adjoining valley floor its IMD stations with floors and the 2(b) ratios, and this edition NIH-DHAARA with governing cells, floors and a record check, because the evidence each holds differs. The receiving waters, not only the rain, set the design of the outfalls (Clause 2.12). The governing cells, the use of NIH-DHAARA's own durations with the 2(a) lower bound, the short-storm floors, the zone-bounded record check and its Tripura addition, the hazard-first screening and the rule for durations below 1 hour are set by this Manual. Several points are unresolved. Neither IMD station's recording-gauge or annual-maximum series was obtained, so no Gumbel fit or station IDF exists [TBC]; the type, coordinates and record length of the Bagafa gauge are not known [TBC]; the "about 200 mm in 3 hours" reported twice at Agartala has no IMD value behind it [U]; that the State lies in subzone 2(c) is a reading by elimination, not a statement of CWC [TBC]; the zone boundaries follow the crests of the hill ranges and are to be confirmed [TBC]; Annex 4.2 of the 2(b) report was read by OCR and the record length behind it is not printed [TBC]; and no storm-drain DPR with a design rainfall analysis was found for any town in the State [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: Agartala 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

Element	Design AEP (return period)	Check event	Chapter
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.** Tripura's worst floods have come when days of rain raise the rivers while the town outfalls are shut. On 19–24 August 2024 South Tripura district received 644.5 mm over 20–22 August, in daily totals of 261.6, 67.6 and 315.3 mm, and the State 363.7 mm (IMD district data as transcribed by SANDRP, as reported), and the event ran for six days, with the Haora at Agartala at its peak of 12.42 m on 22 August (as reported). The storms of 1993 that set the IMD records at Kailashahar (6 June) and Agartala (22 July) set the highest levels of the Manu (7 June) and of the Gumti at Amarpur and Sonamura (22–23 July) with them (IMD, *Extremes*; CWC data as transcribed by SANDRP). The wettest months reach 799.9 mm at Agartala (June 1976) and 1,175.0 mm at Kailashahar (May 1991) (IMD, *Extremes*). Agartala's central saucer floods "During normal rainfall of about 3 to 4 hours" (ADB, IEE, 2020), but the storage behind a closed sluice, the pukurs and lungas that receive 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 Tripura recording gauges. Until Annex 2B is published, they are the ratios of the CWC Flood Estimation Report for subzone 2(a) (North Brahmaputra), which Clause 2.3.6(f) applies in every sub-area because no CWC report covers Tripura; no depth shall be lower than NIH-

DHAARA's own depth for that duration at the site under Clause 2.3.6(f), and the 1-, 3- and 6-hour depths shall not be lower than the short-storm floors of Clause 2.3.6(g). The ratios of the CWC report for subzone 2(b) are not used, and IMD Das et al. (2022) prints no panel for any Tripura station.

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

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

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

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

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

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(c) (Barak and others), for which CWC has published no Flood Estimation Report, so that in Tripura the report for subzone 2(b) (South Brahmaputra) stands in only for its areal reduction curves and as a cross-check on the site study of Annex 3E: 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's district data for 20–22 August 2024, as transcribed by SANDRP, give South Tripura 644.5 mm over three days and the State 176.2 mm on 20 August (as reported), while single gauges in the same storm recorded 32 cm at Belonia and 31 cm at Amarpur in the 24 hours to 0830 IST on 20 August and 49 cm at Bagafa on 22 August (IMD, press releases); and on 20 August co-located gauges at Belonia read 32 cm, 25 cm and 15 cm (IMD). The NIH-DHAARA cells, which are reanalysis grid values, give the Sabroom cell 435.1 mm at 100 years, below Bagafa's measured day (NIH-DHAARA, queried 14 Nov 2026). Neither gap 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 Tripura. The State Action Plan on Climate Change (2017) and its second version for 2021–2030 were not read for this Manual [TBC]; a newspaper, as quoted by SANDRP, found "only a few sentences on floods and landslides" in the State's plan (as reported). The Block-Level Vulnerability Assessment of 2022 by the Climate Change Cell of the Department of Science, Technology and Environment was not read (as quoted) [TBC]. NIT Agartala's study of CMIP6 projections for 2025–2054 reports "more frequent" days of 100 mm or more, with no factor in its abstract (EGU26-20865), and a study by CSTEP (2022) projects more heavy-rainfall events in almost all districts of the North East by 2021–2050 (as reported). No trend statistic for Tripura's extremes was found. The case for an uplift rests on the size of recent extremes, among them Bagafa's 49 cm of 22 August 2024, 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. 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); the research for this Manual suggested not applying them to the record floors, and this edition keeps the series' practice so that every design depth carries the same allowance. NIH-DHAARA's projected depths are not used (Clause 2.3.6(m)). The factors of Table 2.2 are therefore interim values, not Tripura 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.

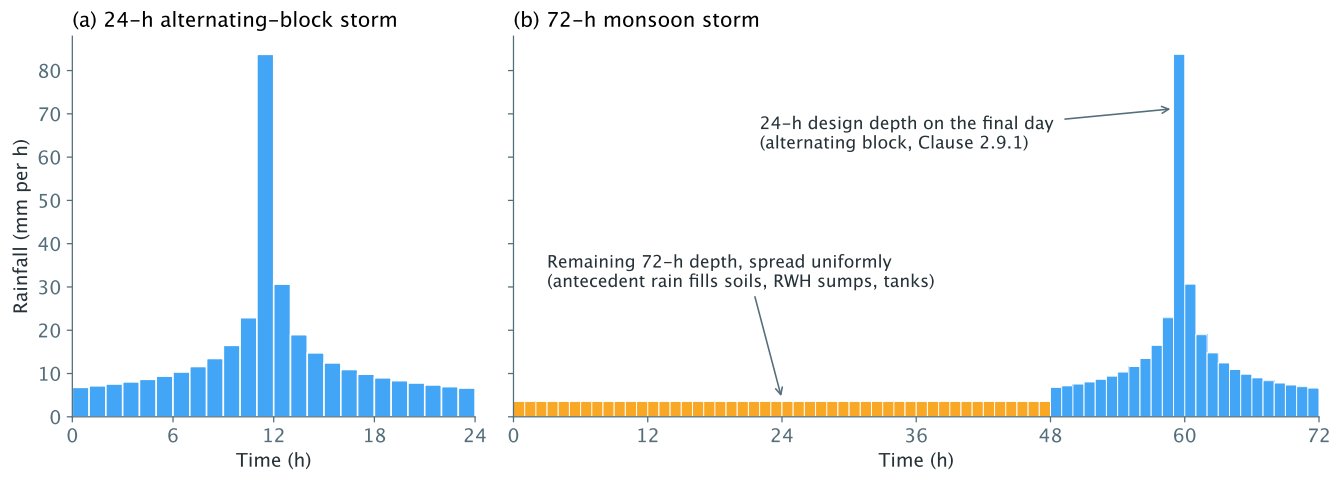

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Tripura 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 Tripura: by the time the largest falls arrive in June, July or August, after the storms of April and May, the lunga floors and flood plains are saturated, the water table is near the surface (0.22–6.64 m below ground in West Tripura in November 2017, CGWB), the pukurs are full, the rivers 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 Tripura 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 Agartala's central saucer and the Katakhal basin, of the Haora flood-plain-zone localities, of Kailashahar, Belonia, Dharmanagar, Khowai, Teliamura and Kamalpur behind their rivers, of Udaipur, Amarpur and Sonamura on the Dumbur release reach, of Santirbazar, Bagafa and Sabroom, and of the hill-range highway corridors, 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 TR-A (Agartala–Sonamura valley), TR-B (Khowai valley), TR-D (Gomati valley), TR-D1 (Muhuri–Feni south) or TR-E (Hill ranges) of Annex 2A, and from 1 May to 31 October at a site in sub-area TR-B1 (Dhalai valley) or TR-C (Manu–Juri–Deo valleys). Use AMC III for every design storm from 1 April to 31 October, in every sub-area, on lunga floors and recent flood plains below the 1% AEP flood level, on the margins of a pukur, dighi or beel, and in every catchment behind a closed sluice or a pumped outfall, such as those of central Agartala, Kailashahar, Belonia, Sonamura and Udaipur. Use AMC III for every design storm at any time of year in a catchment that drains to the Dumbur reservoir or to the Gomati below it, into which the reservoir releases water. At any other site or time, use AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm. Use AMC II (average conditions) for every other storm. AMC I is not used for design.

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

> Commentary. Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that monsoon extremes arrive after weeks of rain. In Tripura the season, the ground and the receiving waters together decide how wet a catchment is. The valley floors are recent flood plains and lungas of silty clay: under Agartala "a top soil underlain by a soft to medium/stiff, silty clay/clayey silt layer" (ADB, IEE, 2020). The water table is shallow, 0.22–6.64 m below ground

in West Tripura in November 2017 (CGWB), and "Within a few hours most of the rainwater goes as run off and finally enters Bangladesh" (CGWB). The wettest months on record reach 799.9 mm at Agartala (June 1976) and 1,175.0 mm at Kailashahar (May 1991) (IMD, *Extremes*). Lunga floors, flood plains below the 1% AEP level, the margins of pukurs, dighis and beels, and every catchment behind a closed sluice or a pumped outfall are wet whenever the river is high, which is much of the season. In the north the pre-monsoon storms are the largest: Kailashahar's wettest months are May and April, and the Dhalai at Kamalpur and the Juri at Nutan Bazar set their highest levels on 15 May 1984 (IMD, *Extremes*; CWC data as transcribed by SANDRP). The Dumbur reservoir releases water into the Gomati, whose reach is wet whenever it releases. This Manual therefore uses AMC III for every design storm from 1 June to 30 September in sub-areas TR-A, TR-B, TR-D, TR-D1 and TR-E, the main part of the south-west monsoon; from 1 May to 31 October in TR-B1 and TR-C; from 1 April to 31 October, in every sub-area, on lunga floors and flood plains below the 1% AEP level, on pukur, dighi and beel margins and in every catchment behind a closed sluice or a pumped outfall; at any time of year in catchments draining to the Dumbur reservoir or its release reach; and otherwise after a 5-day total of more than 53 mm, the NRCS growing-season threshold for AMC III; AMC II otherwise (Clause 2.11.4). 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 lunga between tillas on the edge of Agartala 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.

Tripura has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is a river behind an embankment, or a channel behind a sluice, into which a town drains, and every one of those rivers flows on into Bangladesh, where no level is known to this Manual: the Haora to the Titas, the Gomati towards Comilla, the Khowai to Habiganj, the Manu, the Dhalai, the Juri and the Deo to the Kushiyara, and the Muhuri and the Feni towards Feni (general geography, to be confirmed for each river; NEER reading). For an outfall under river 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 river-level sites cited here are CWC's, not PWD (WR)'s, apart from the State gauges named as such, and their levels are known to this Manual only

as transcribed by SANDRP from CWC's tables or as reported, with no datum stated (presumably metres above mean sea level [TBC]): on the Haora at Agartala, a danger level of 10.70 m (CWC, as reported), 10.50 m at the State's Jahar Bridge gauge and 10.48 m in a third source, and a highest level of 12.14 m (24 June 2004), 12.4 m (11 August 2017) or 11.08 m (2004), passed at **12.42 m on 22 August 2024** (conflict; probably different gauges or datums, NEER reading); on the Manu at Kailashahar, warning, danger and highest levels of 24.34, 25.34 and 25.79 m (7 June 1993), passed at 25.95 m on 13 June 2018, with a danger mark of "24.00 mtr" (2018) and a "critical level" of 23.05 m (2024) in State reports (conflict); on the Gumti at Sonamura, 11.5, 12.5 and 14.43 m (23 July 1993), with 14.27 m on 23 August 2024; on the Muhuri at Belonia, a highest level of 16.98 m (4 August 1983), revised to 17.32 m (2 August 2024) and passed at **18.81 m on 22 August 2024**; on the Juri at Nutan Bazar, 20.435 m (15 May 1984), passed at 20.66 m on 22 August 2024; and on the Gomati at Udaipur, a State gauge, 22.05 m against its "extreme danger" level of 22.00 m on 21 August 2024 (CWC data as transcribed by SANDRP; as reported). The other sites are listed in Chapter 5. In June 2022 and again on 24 August 2026 the Haora stood above its danger level while rain fell on Agartala (as reported), so the outfalls of the embanked towns are designed for gates closed and pumps running, with the local storm falling before, during or after the river's peak (Chapter 5). The Dumbur reservoir releases water into the Gomati through Amarpur, Udaipur and Sonamura: on 21 August 2024, with the reservoir at 93.85 m against a "danger level" of 94 m and a full reservoir level of 93.55 m (as reported; conflict), its gates were opened ("two flap gates fully open and one at 50%", as reported), so outfalls on that 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]; Chapter 5 sets the interim rule. Every level is stated on a named datum, as Chapter 5 requires.

> Commentary. Tripura 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 channel behind the sluice, into which the town drains, and which flows on into Bangladesh. The coincidence is the normal case, not the exception. The ADB's report on Agartala finds that the most severe problems arise when high rainfall puts the waters of the Haora and the Katakhal "higher than the city", and that "Several pumps have been provided to lift the water out of the city during these seasons" (ADB, IEE, 2020). The 18 flood pumps reported in 2024, each of up to 900,000 litres an hour, about 0.25 m³/s, would lift about 4.5 m³/s together (as reported; NEER arithmetic), and no design capacity of the pumping stations was found [TBC]. On 22 August 2024 the Haora at Agartala reached 12.42 m and the Muhuri at Belonia 18.81 m on the day Bagafa recorded 49 cm (CWC data as transcribed by SANDRP; IMD), and the Dumbur reservoir released water into the Gomati the day before (as reported; conflict), so that the river and the local storm peaked together. Below the border there is no Indian control and no level data, and the tailwater can be raised by backwater from the Meghna or by embankments in Bangladesh (NEER reading). 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 Haora's danger level is given as 10.48, 10.50 and 10.70 m and its highest level as 11.08, 12.14, 12.4 and 12.42 m (as reported; CWC data as transcribed by SANDRP), which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Tripura, which has no coast, the counterpart of surge is the stage of the rivers behind their embankments, raised by the same storm that falls on the towns: on 22 August 2024, the day Bagafa recorded 49 cm (IMD), the Haora at Agartala reached 12.42 m and the Muhuri at Belonia 18.81 m, both new highest levels, and in June 2022 the Haora stood above its danger level while Agartala flooded (as reported)), they cannot be treated as independent. Case (b) is a simple joint-probability surrogate until a statistical joint analysis is adopted.

2.13 Submittal requirements

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

1. the site coordinates and zone;
2. the source (Clause 2.3), version or access date, and a screenshot or export of the values extracted;

3. a depth table for each AEP and duration used, before and after the fixed-interval factor, grid-to-point factor, ARF and climate factor;
4. the cross-check values of Clause 2.3.3 and the floor check;
5. the hyetographs used, as a table and a plot, for each design storm; and
6. the AMC and pre-development definition adopted.

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

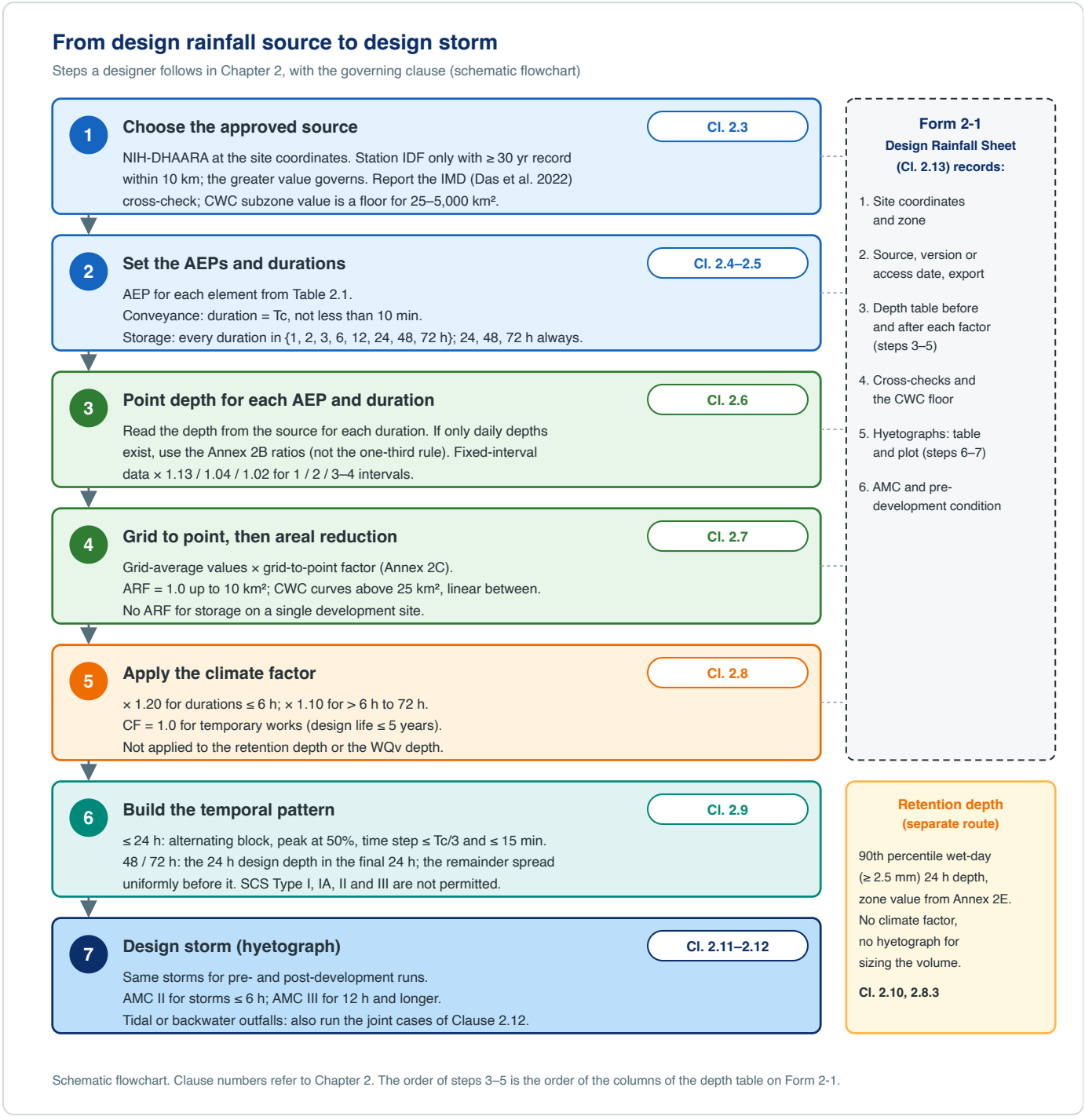

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the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

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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	Tripura 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 (pukur) 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 (pukurs) 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 silty clays of the Haora, Gomati, Khowai, Dhalai, Manu, Juri and Muhuri flood plains and of the lungas (the flat valley floors between the low hills), the lateritic sandy clays and sandy loams of the tilla uplands (the low hills), the weathered Tipam sandstone, and the sandstone and shale of the hill ranges, 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(c) (Barak and others), for which CWC has published no Flood Estimation Report, so that in Tripura the report for subzone 2(b) (South Brahmaputra) stands in only for its areal reduction curves and as a cross-check on the site study of Annex 3E	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 (pukur) 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

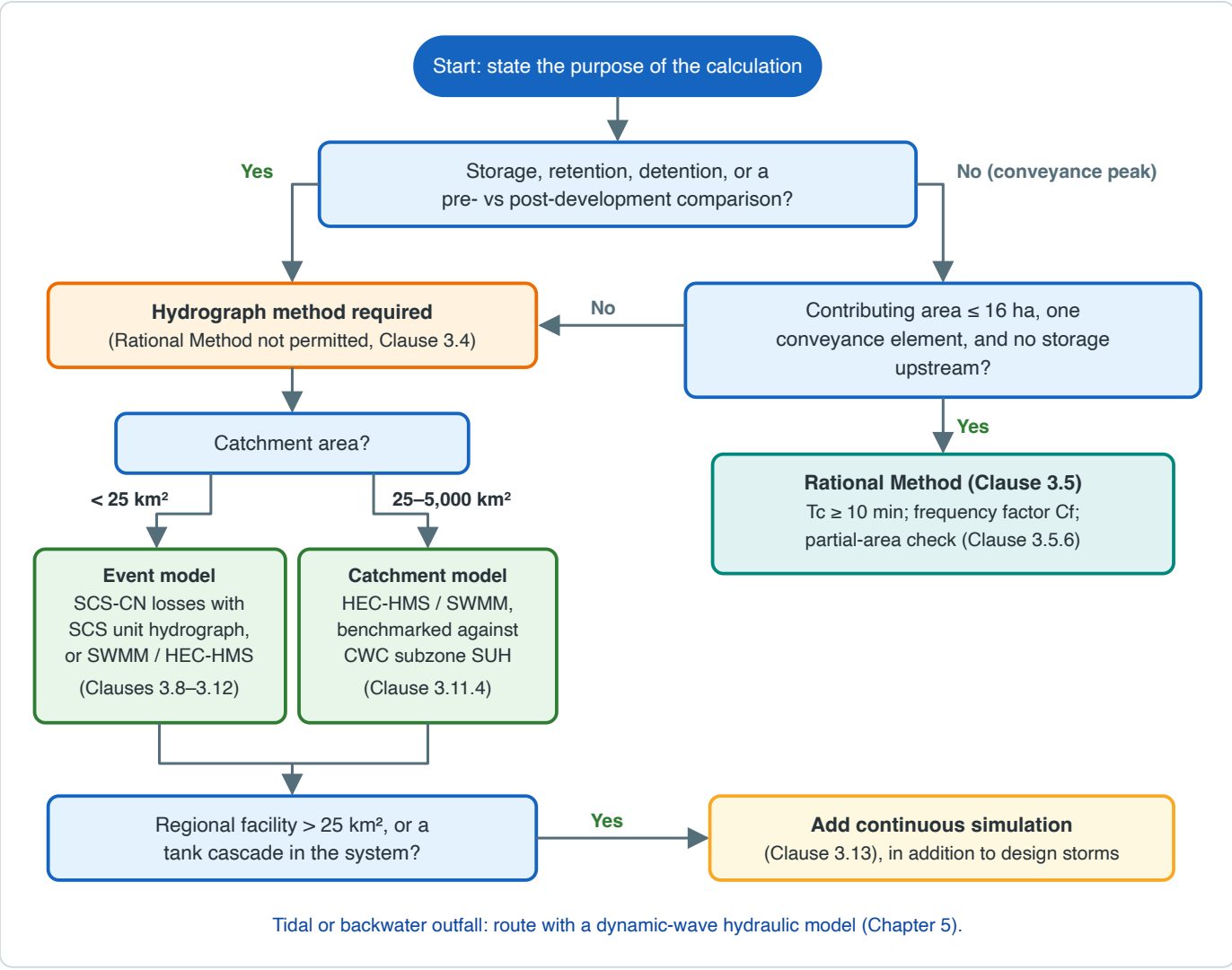

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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 Public Works Department (Water Resources).

> **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
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

Surface or land use	C	Source
Lawns, heavy soil, average (2–7%)	0.18–0.22	ASCE/WPCF 1969
Lawns, heavy soil, steep (> 7%)	0.25–0.35	ASCE/WPCF 1969
Undeveloped land (maximum for any condition)	0.30	KC APWA 5600 (2011), §5602.3E

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

Table 3.3 — Frequency factor Cf

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

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

3.5.5 **Time of concentration and networks.**

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

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

> **Commentary.** The developed-surface coefficients in Table 3.2 are CPHEEO Table 4.2, which CPHEEO adapted from ASCE/WPCF (1969). CPHEEO keeps C constant for all return periods. Table 3.3 instead adopts the APWA antecedent-precipitation factors (KC Metro APWA 5600, 2011, §5602.2A: K = 1.1, 1.2 and 1.25 for 4%, 2% and 1% storms, with C·K ≤ 1.0). These factors matter here because Tripura'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.

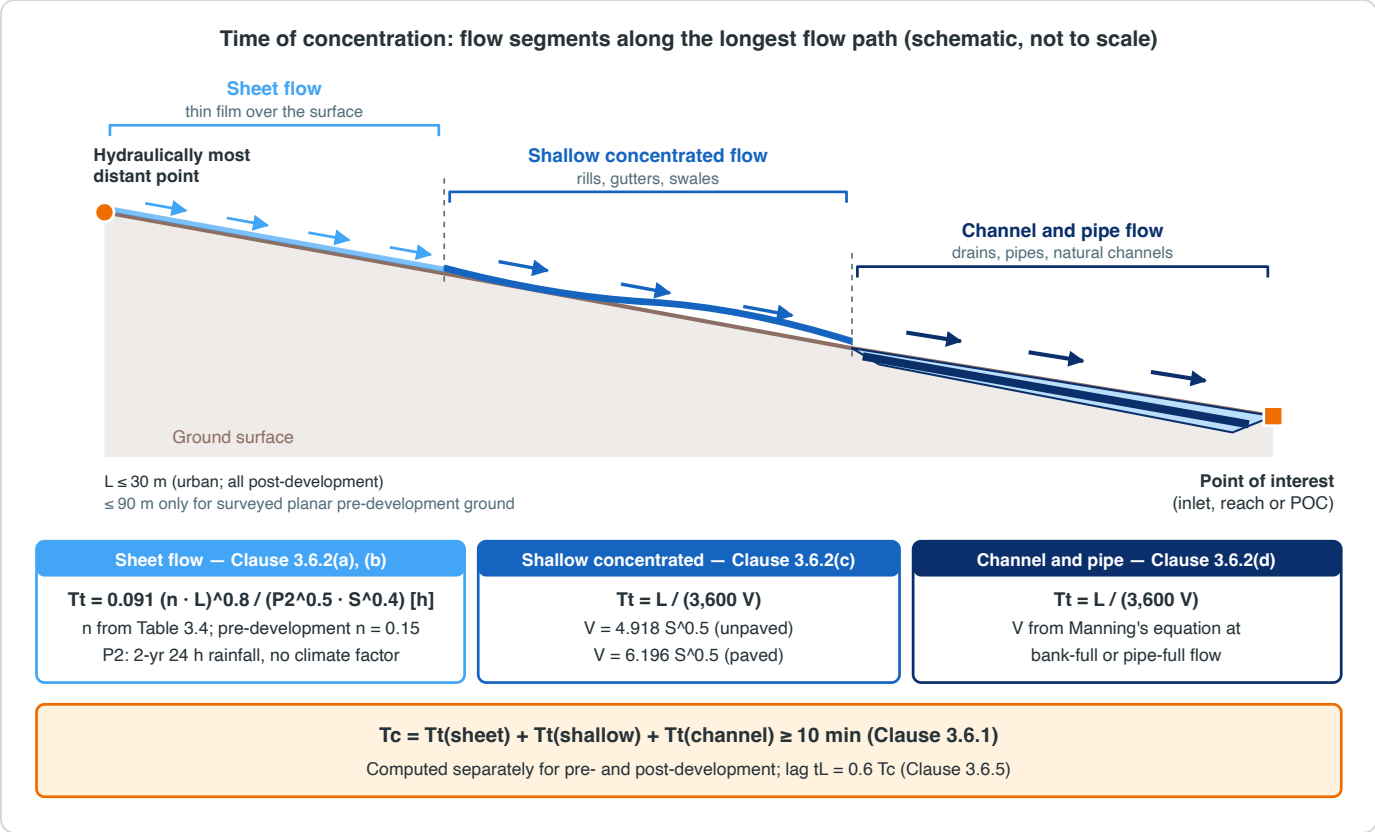

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986),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

Surface	n
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, Tripura (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 Tripura: the recent flood plains and the lunga floors (lunga, Bengali লুঙ্গা: the land records' "Flat lands between tillas"), with silty clay at the surface and the water table within 2 m of the surface in the monsoon season, HSG D; the Holocene terraces and higher flood plains, HSG C, and HSG D where they are clayey or the seasonal high water table is within 2 m of the surface; the tilla uplands (tilla, Bengali টিলা: the land records' "Hillock") of Dupitila sandy clay with laterite, HSG C, and HSG B on their sandy tops where a site test shows it; weathered Tipam sandstone where it crops out, HSG B or C by test; the sandstone and shale of the hill ranges and every natural slope of more than 20%, HSG D for design; and urban fill, HSG C, and HSG D where it is clayey or compacted or fills a pond or a lunga. 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 lunga rule, the tilla rule and the hill 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 Holocene terraces, where a silty clay that is C by texture behaves as D once the water table rises in the monsoon season (Clause 3.10); on the tilla tops, where a sandy top that tests as B can pass within one site into lateritic sandy clay or onto fill; on weathered Tipam sandstone, where "The sandstones are highly porous underlain by impermeable shales or clay" (ADB, IEE for the Agartala City Urban Development Project, 2020), so that a pit can stand in porous rock a metre above a bed that holds water; and on filled ponds and lunga fills, where a high rate in a test pit can be water entering fill that will settle, over a water table that the fill hides (Clause 4.11). No soil-series map of Tripura 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 CGWB and the ADB describe. The CGWB's aquifer-mapping report for West Tripura records "Quaternary & Upper Tertiary groups of rocks": recent alluvium; the Dupitila ("Brown to buff sandy clay … clayey sandstone with ferruginous materials & laterites"); the Tipam ("Massive medium to coarse sandstone with sandy shale"); and the Surma below. It describes three landforms, "(1) table lands (tilla lands) and rolling mounds formed by the Upper Pleistocene terraces characterized by maximum dissection, drainage density and weathering; (2) low lands ('loonga') of Holocene terrace comprising stabilized, undissected, higher flood plains; (3) recent flood plains constituting the present-day flood-prone belts fringing the rivers", and "10 – 30 m high mounds with gullies in between them, locally called 'loonga'"; the CGWB spells the word loonga, and this Manual writes lunga, as the land records do. The soils are "acidic in nature", and the lithologs show 3–10 m of reddish-brown lateritic, sandy-loam or reddish clayey surface soil (CGWB, NAQUIM report, West Tripura, AAP 2017-18). In central Agartala the plains of the Haora have "a top soil underlain by a soft to medium/stiff, silty clay/clayey silt layer, which follows a moderately dense to very dense silty sand layer" (ADB IEE, 2020), and "lateritic soil is found in tilla … areas" (CGWB, South Tripura district profile, as quoted). The CGWB's rainfall infiltration factor of 0.16 for the Tipam sandstone, "very porous and permeable", approved by its R&D committee, is a resource-assessment fraction of a year's rain, not a design infiltration rate, and the same report excludes slopes of more than 20% from its recharge computation (NAQUIM, West Tripura). No primary source was read for the soils of the northern and southern valleys or of the hill ranges [TBC]. The groups for the lunga floors and flood plains are set for the wet season, not for dry ground: the CGWB's dug wells in West Tripura stood 1.63–10.30 m below ground in March 2017 and 0.22–6.64 m below ground in November 2017 (Commentary to Clause 3.10), so a silty clay that might test as C in

March behaves as D in August. Cut tilla slopes and fills are D because their surface is bare or compacted and their water goes into a slope or a fill that cannot take it (Clause 4.11). The only regional measures of losses are the design loss rate of the CWC subzone 2(b) report, 0.35 cm/h (3.5 mm/h), and its base flow of 0.05 m³/s per km², fitted to floods of rural catchments outside Tripura (Annex 3E). They shall be used only in the cross-check of Annex 3E, and not to assign an HSG, not in the site study, 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 lunga floors, cut tilla slopes and fills as group D and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Tripura. The method rules matter as much as the soil, because the State's towns lie on three kinds of ground that no CWC relationship describes: flat lunga floors and flood plains that drain through sluices and pumps into a river that is often higher than they are; the dissected tilla uplands round them, whose short, gullied slopes of 10–30 m relief reach the lunga within minutes; and the settlements and road corridors of the hill ranges. 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, even on a tilla slope whose segment Tc comes out shorter; 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 laterite, a cut tilla face or a paved road shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (c) A catchment that runs from a tilla or a hill range onto a lunga floor, such as a chhara (Bengali ছড়া: the land records' "Streams"; a hill stream or small natural channel) from the tillas round Agartala or from the Baramura and Atharamura ranges, shall be split at the break of slope and the tilla or hill sub-area modelled on its own, so that a flatter lower reach does not average away its fast response. (d) Every catchment of 25–5,000 km² is designed by a site study (Annex 3E): an SCS-CN, Clark or Snyder hydrograph model in HEC-HMS or SWMM, with the design rainfall of Clause 2.3.6, the areal reduction of Clause 2.7.3 and the AMC of Clause 3.8.4, calibrated under Clause 3.15 to the CWC and State river gauges where they exist: the Manu at Kailashahar, Kumarghat and Manughat, the Dhalai at Kamalpur, the Khowai at Khowai and Teliamura, the Gumti at Amarpur and Sonamura, the Haora at Agartala, the Muhuri at Belonia, the Juri at Nutan Bazar and the Burima at Gajaria (CWC levels as transcribed by SANDRP, as reported; no rating curve or datum was obtained [TBC]); where no gauge exists, to surveyed flood marks of a recorded event. No CWC unit hydrograph exists for any Tripura river; the subzone 2(b) unit hydrograph is computed beside the site study only as a cross-check, within its range of 50–1,500 km² (Clause 3.11.4). (e) The towns on the lunga floors and flood plains behind embankments, central Agartala between the Haora embankment and the Katakhal, Kailashahar, Belonia, Sonamura and Udaipur, 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 pukurs, dighis, lunga wetlands, khals (Bengali খাল: a canal or channel, the land records' "Khal") 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 with the gates shut (Chapter 5) and dynamic-wave routing where the outfall is submerged (Clause 3.12.4). When the river is high their peak is set by pump and gate capacity and by storage, not by the rainfall peak alone (NEER's reading of the ADB's description of central Agartala, Commentary to Clause 4.6). (f) Pukurs, dighis, beels and lunga wetlands are routed as storage with a surveyed stage–storage relation, never left out of the model and never treated as zero storage, and their storage below the outlet level is never credited (Clause 3.12.5). (g) Catchments that drain to the Dumbur reservoir, or to the Gomati below it, 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; in tilla and hill catchments the design flow is bulked for sediment and debris, and silt traps at the tilla foot, 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:

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

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

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

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

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

3.8.3 **Use of Table 3.5.**

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

3.8.4 **Antecedent moisture.** AMC shall follow Clause 2.11.4: AMC III for every design storm, whatever its duration, from 1 June to 30 September at a site in sub-area TR-A (Agartala–Sonamura valley), TR-B (Khowai valley), TR-D (Gomati valley), TR-D1 (Muhuri–Feni south) or TR-E (Hill ranges) of Annex 2A, and from 1 May to 31 October at a site in sub-area TR-B1 (Dhalai valley) or TR-C (Manu–Juri–Deo valleys); AMC III for every design storm from 1 April to 31 October, in every sub-area, on lunga floors and recent flood plains below the 1% AEP flood level, on the margins of a pukur, dighi or beel, and in every catchment behind a closed sluice or a pumped outfall, such as those of central Agartala, Kailashahar,

Belonia, Sonamura and Udaipur; AMC III for every design storm at any time of year in a catchment that drains to the Dumbur reservoir or to the Gomati below it, into which the reservoir releases water; at any other site or time, AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm; and AMC II for every other storm. AMC I is not used. CN for AMC I and III shall be obtained from AMC II by:

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

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

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

3.8.5 **Initial abstraction.**

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

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

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

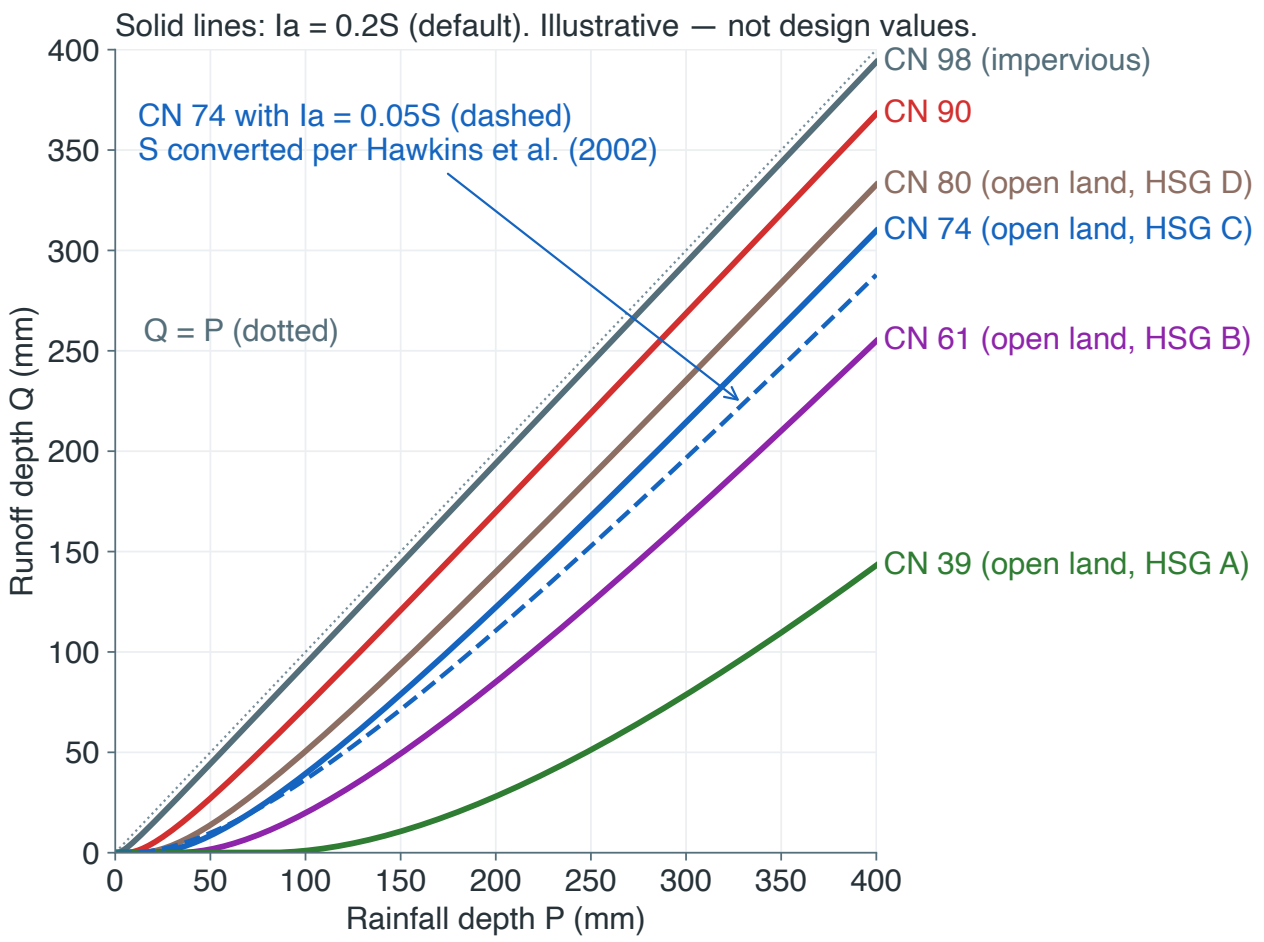

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion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

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

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

3.9 Impervious connectivity

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

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

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

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

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

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

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

> **Commentary.** The composite equations are from TR-55 (USDA SCS, 1986, Ch. 2, Figures 2-3 and 2-4). This Manual prefers separate representation in 3.9.2 because a composite CN spreads the impervious response over the whole area, which suppresses runoff from small storms. For a site that is 50% directly connected impervious on HSG B open space (CNp 61), 25 mm of rain gives about 9.9 mm of runoff when the two parts are modelled separately, but only about 1.8 mm with the composite CN 79.5. At 200 mm the two methods agree (139.5 mm vs 138.4 mm). *Illustrative — not design values.* The error is largest for the frequent storms that set retention and water-quality volumes. The disconnection criteria of 3.9.3 are set by this Manual, drawing on common practice in US runoff-reduction manuals. Criterion (d) follows the rule of Clause 3.3.3(c) that RWH sumps are full at the start of 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 PWD (WR) 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, pukur, 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 on the lunga floors and flood plains of Tripura the water table stands a few metres below 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 aquifer-mapping area of West Tripura, which takes in the Agartala–Sonamura and Khowai valleys, the dug wells stood 1.63–10.30 m below ground in March 2017 and 0.22–6.64 m below ground in November 2017 (CGWB, NAQUIM report, West Tripura, AAP 2017-18); older district summaries give 1.42–5.82 m before and 0.90–5.10 m after the monsoon in South Tripura, and 1.45–8.14 m before and 1.20–4.37 m after it in North Tripura (CGWB district profiles, 2008 data, as quoted) [TBC]. Under central Agartala lies "a soft to medium/stiff, silty clay/clayey silt layer", and "The ground water table being very high" is recorded for the city (ADB, IEE for the Agartala City Urban Development Project, 2020). The CGWB adds that "Within a few hours most of the rainwater goes as run off and finally enters Bangladesh" (NAQUIM, West Tripura). These are the CGWB's wells: no State observation-well network, groundwater Act or groundwater authority was found, and whether PWD (WR) keeps observation wells is not known [TBC], so the CGWB record is the one in use. 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, khals behind sluices and, below them, rivers that cross into Bangladesh with no downstream Indian control and no level record that crosses the border. Agartala's centre "is located at a lower level than other areas giving it the appearance of a saucer", and "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded"; when the Haora and the Katakhal run high, "Several pumps have been provided to lift the water out of the city during these seasons" (ADB IEE, 2020). CWC, not PWD (WR), runs the river-level sites cited here. On the Haora at Agartala the danger level is given as 10.48 m, 10.50 m (a State gauge at Jahar Bridge) or 10.70 m (CWC), and the highest level as 11.08 m (2004), 12.14 m (24 June 2004), 12.4 m (11 August 2017) and 12.42 m (22 August 2024), probably on different gauges or datums (all as reported); on the Manu at Kailashahar the CWC danger level is 25.34 m and the highest level 25.95 m (13 June 2018); on the Gumti at Sonamura 12.5 m and 14.43 m (23 July 1993); and on the Muhuri at Belonia the river reached 18.81 m on 22 August 2024 against a highest level of 16.98 m that had stood since 4 August 1983 (CWC tables as transcribed by SANDRP, as reported; no datum is stated for any level [TBC]). A site in such a town drains to a water surface that stands above it for days, and Clause 3.10.4(b) applies to all the land below that level. The town's own storage is its pukurs and dighis and the lunga wetlands round it: the ADB lists College Tilla lake among "the 7 important inland" water bodies of the city (ADB IEE, 2020), about 65 water bodies were cleaned and developed under city schemes (as reported), and ponds have been filled for housing in Barjala and Lanka Basti (as reported). No inventory of Agartala's pukurs with their beds, outlets and stage–storage relations 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:

> qp = PRF' · A · Q / tp, with PRF' = 0.208 (SI form of the standard peak rate factor 484) tp = Δt / 2 + tL, tL = 0.6 Tc

where qp 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; tp 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 Tc 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(c) (Barak and others), in which the whole of Tripura lies (NEER's reading, by elimination: the subzone 2(b) report stops north of the State and its corrigendum strikes out its one mention of Tripura; to be confirmed by CWC [TBC]) and for which CWC has published no Flood Estimation Report, so that no CWC point rainfall, plate or synthetic unit hydrograph exists for the State; in Tripura each such catchment is modelled by the site study of Annex 3E, calibrated to the CWC and State river gauges, with the subzone 2(b) unit hydrograph computed only as the cross-check of Clause 3.11.4(c) and not as the floor of Clause 3.11.4(d) where the site study is calibrated, because its catchments lie in Assam and Meghalaya and none drains to the Meghna:

- (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 2000, for the subzone 2(b) report used in this Manual only as a cross-check; no report exists for subzone 2(c), which covers Tripura; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the subzone 2(b) report of 2000 (its 14 gauged catchments are railway and national-highway bridge sites in Assam, two of them on rivers that rise in Meghalaya, gauged from 1961 to 1983 and from 1981; none lies in Tripura or drains to the Meghna, and no Tripura catchment of any size has a CWC unit hydrograph), 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 pukurs, dighis, beels and detention ponds at their outlet level in 3.12.5 because in Tripura the heavy storm comes when the river is high, the outfall sluice is shut and the storage behind it is filling, not drawn down. Central Agartala is a saucer between the Haora embankment and the Katakhal, and the worst flooding comes when heavy rain coincides with the Haora and the Katakhal standing "higher than the city", when "Several pumps have been provided to lift the water out of the city" (ADB, IEE for the Agartala City Urban Development Project, 2020); in August 2024 the Haora reached 12.42 m on 22 August against a CWC danger level of 10.70 m (as reported; datum not stated [TBC]), and the city's flood pumps, 18 of up to 900,000 litres per hour each and 6 diesel pumps (as reported), discharge by pipeline to the Katakhal and the Haora. No pukur, dighi or beel in the State was found to have a documented operating rule, a level record or a stage–storage relation, and no design capacity was found for the pumps or the Katakhal sluice [TBC]. The starting levels are therefore as follows (set by this Manual):

- **A pukur, dighi, beel, lunga wetland or detention 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; Clauses 5.8.5(a), (b) and (e)): for the whole of the 72-hour design storm, and, where no stage record exists, as at every border reach, on the Katakhal and on the Akhaura canal, for a further 72 hours. In central Agartala this is the normal monsoon case. A pond that is pumped is started full to the level at which its pumps start, unless its operating rule commits it to be pumped down before the storm.
- **A pukur, dighi or beel with a free outlet** is started at its surveyed outlet or spill level.
- **The palace and temple tanks**, among them the Ujjayanta palace lakes in Agartala and Kalyan Sagar at Matabari near Udaipur, are existing storage with heritage and fisheries constraints, not detention to be drawn down: they are started full to their outlet level in every case, and only their storage above that level is counted.
- **The Dumbur reservoir** of the Gumti hydel project at Tirthamukh is not started here: its full reservoir level is given as 93.55 m and its "danger level" as 94 m, with 93.85 m reached in August 2024 (both as reported, a conflict), and its release scenarios are the tailwater of the Gomati below it (Clause 5.8.5(d)).

A pukur, dighi or beel 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, which in this Manual takes in IMD's pre-monsoon months of April and May as well as the south-west monsoon. It starts on 1 April, not with the onset of the south-west monsoon, which is normally about 5 June (NEER's inference from two press reports of the Meteorological Centre Agartala's dates; another report gives 10 June, a conflict; IMD's revised normals were not read [TBC]), because the storms of April and May are among the State's largest: Kailashahar's wettest month on record is May (1,175.0 mm, May 1991) and its next is April (1,012.8 mm, April 1977), its April 24-hour record is 257.1 mm (19 April 2004) and its May record 231.2 mm (3 May 1993), and Agartala recorded 198.0 mm on 11 April 2007 (IMD *Extremes*); the Dhalai at Kamalpur and the Juri at Nutan Bazar set their highest levels on 15 May 1984 (SANDRP's transcription of CWC, as reported); and Cyclone Remal brought 252.4 mm in 24 hours to Unakoti district on 27–28 May 2024 (district value, as reported). The window ends on 31 October because large falls still come in October, such as 183.6 mm at Agartala on 11 October 1989 and 182.0 mm at Kailashahar on 9 October 1986 (IMD *Extremes*), while no withdrawal date of the monsoon from Tripura was found [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.

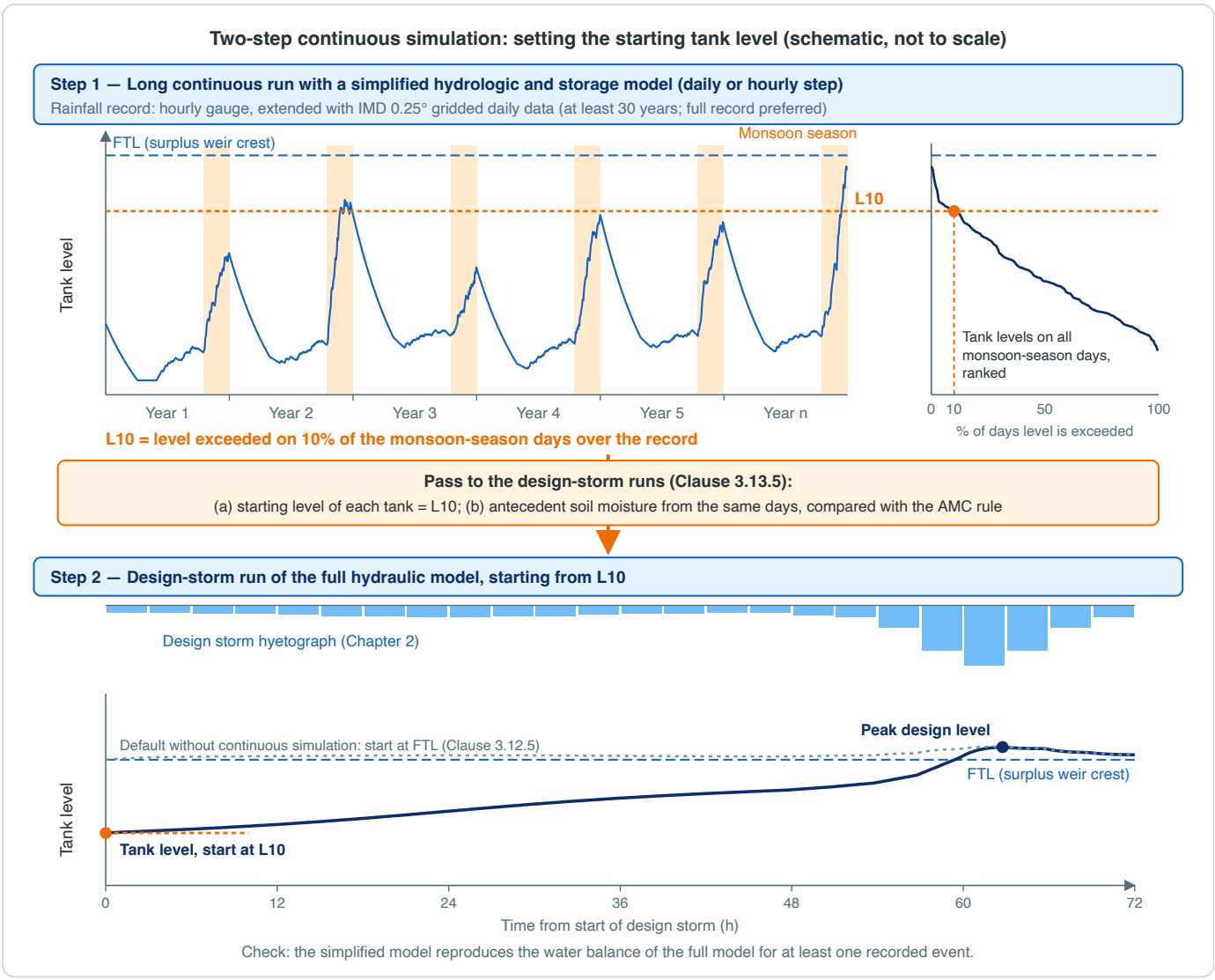

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 April to 31 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place 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 Tripura. 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 August 2024, when South Tripura district received 644.5 mm over 20–22 August (IMD district data as transcribed by SANDRP, as reported) and the Dumbur reservoir stood at 92.6 m, 86% of its live storage, on 22 August (CWC bulletin, as reported).

3.14 Pre- vs post-development comparison procedure

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

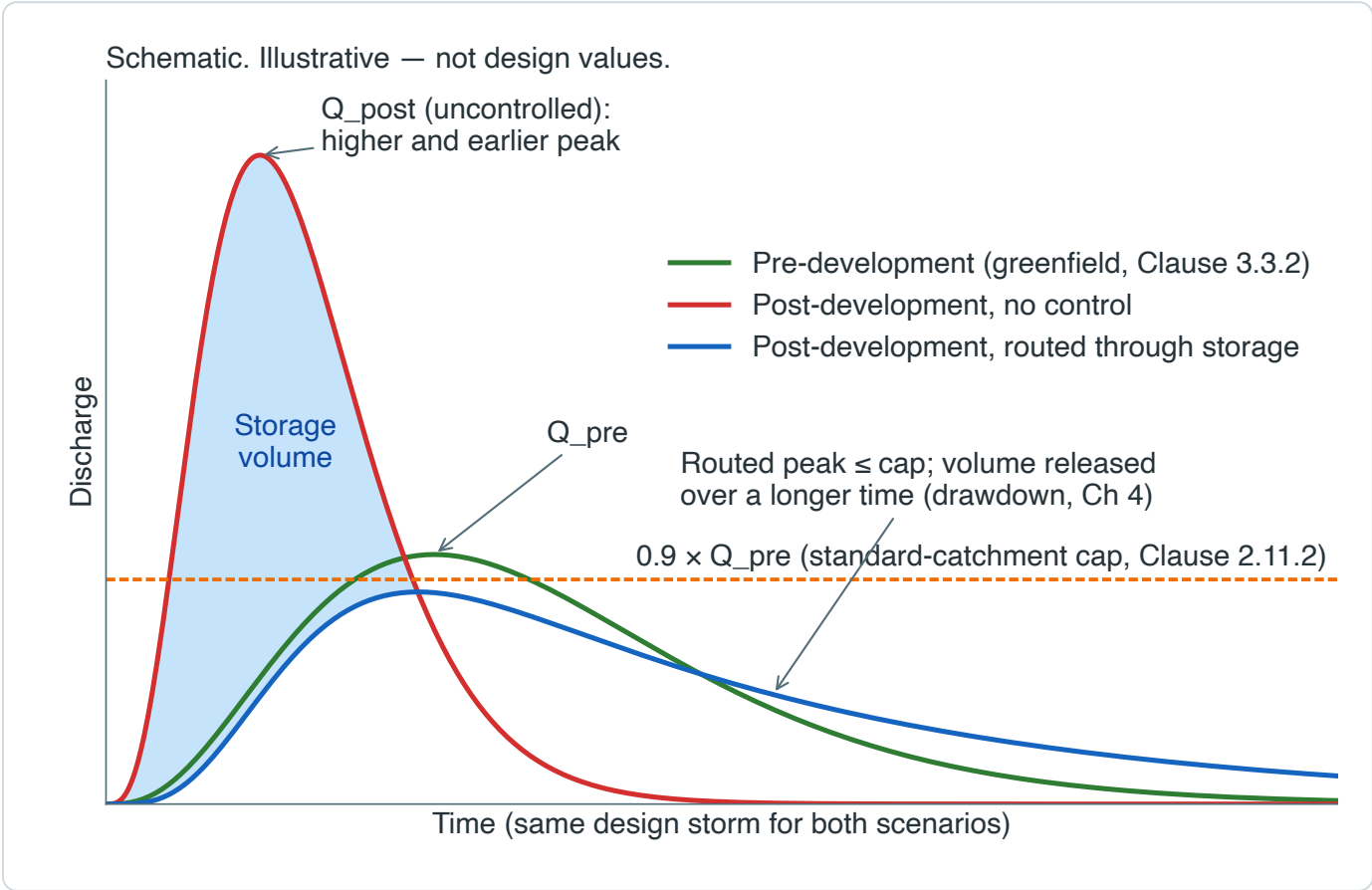

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro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

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

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

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

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

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

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

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

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

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

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

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

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

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

- (a) standard catchments: $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$ 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 Tripura 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 (PWD (WR) gauging sites, AMC or TDMA 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 Agartala flood of 22 August 2024, the Manu flood of 13 June 2018 at Kailashahar, the Agartala storms of 17–19 June 2022 and 31 May 2025, or the Agartala flood of 22–24 August 2026, where data exist).

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

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

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

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

3.16 Software acceptance

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

- (a) EPA Storm Water Management Model (SWMM 5.x);
- (b) USACE HEC-HMS and HEC-RAS;

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

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

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

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

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

3.17 Documentation

Every hydrologic submittal shall include:

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

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Annexes and forms

Annex / Form	Content
3A	Tripura soil series to HSG lookup; seasonal high water table map
3B	Tripura CN calibration and supplementary land covers (forest of the hill ranges and tillas, lunga land, beel and haor beds, cut tilla slopes and fills, filled ponds and lunga fills)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for Tripura (subzone 2(c): no CWC report; the subzone 2(b) relationships as a cross-check only), 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 (rule 110 of the Tripura Building Rules, 2017: a complete rainwater harvesting proposal with the plans of every building of 200 m² plinth area or more, of group housing, public, semi-public and industrial buildings of all sizes and of commercial and mixed-use buildings of 50 m² or more; permeable materials for all open parking in group housing; capture of storm water in public open spaces of more than 500 m²; and groundwater recharge on plots of more than 500 m²; all 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 Tripura 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 Tripura document found sets a design storm, a return period, a runoff coefficient or a time of concentration for any town drain: not the ADB's environmental assessment for Agartala, not the State's filings before the National Green Tribunal, and not any report of the city's works (NEER's reading of the sources). The ADB-supported upgrade of Agartala's drains aims to cut the time the city takes to drain "from one to two hours to about 15–30 minutes" (as reported); its design basis was not seen [TBC]. **Chapter 4's detention is therefore new in Tripura.** The building rules are the Tripura Building Rules, 2017 (UDD notification No. F.2(316)-UDD/GL/TCPO/2009 (Part-I)/371 of 10 November 2017, as cited in UDD's BRAP-2019 document; the 2017 gazette was not read [TBC]), as amended by the Tripura Building (Amendment) Rules, 2019 (No. F.2(466)-UDD/GL/TCPO/2018/599-627, 19 February 2019; Gazette Extraordinary No. 482, 25 February 2019), the (Second Amendment) Rules, 2020 (dated 15 February 2020, Gazette 24 February 2020; number garbled in the copy read [TBC]), the (3rd Amendment) Rules, 2022 (No. F.01(24)-TUDA/Estt/2022/4902-30, 29 November 2022; Gazette 2 December 2022), the (Fourth Amendment) Rules, 2024 (No. F.1(23)-TUDA/ESTT/2024/66, 15 January 2025; Gazette No. 95, 17 January 2025) and the (Fifth Amendment) Rules, 2025 (F.No.2(466)-UDD/GL/TCPO/2018(P-V)/4009-20, 4 July 2025; Gazette No. 1294, 5 July

2025), made under section 274 read with section 118 of the Tripura Municipal Act, 1994; no sixth amendment was found to November 2026. They replace the Tripura Building Rules, 2004 (r.1(4)) and apply "to buildings in the Urban Local Bodies (ULBs) in Tripura" (r.1(2)), to which the 2019 amendment added "and Planning Areas". The Municipal Act "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (s.1(2)), so the rules made under it do not apply in the council area, about 68% of the State (as reported), and no building or land-development regulation of the Council was found [TBC]. The rules carry many drainage hooks, but every one of them protects the building, the plot or the watercourse; none sizes anything to a storm. A "drain" includes "a culvert, a ditch, a channel and any other device for carrying off sullage, sewage, offensive matter, polluted water, rain water or subsoil waters" (r.2(22)). A site on the plains shall be no lower than its approach road and "capable of being well-drained by means of drainage facilities leading to existing public drains of drainage channels" (r.4(1)(b) and (c), as printed), and within 5.00 m of a tank the owner shall prevent "any risk of drainage from such building passing into the tank" (r.4(1)(e)); no building site may lie in a "sinking zone or central business area" without the State's approval (r.4(2)). The site plan shows the drainage to the public drains and the "natural drainage channel/jhora" (r.5(1)(k) and (p)); the plans show "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" and "the roof plan indicating the drainage and slope of the terrace" (r.14(f) and (h)), and the specification states how roof, house and surface drainage "will be disposed of" and how the open space is paved; sub-divisions need "pucca drain ensuing drainage of each individual plot" (r.10(2)(f)); group housing "Should indicate the system of Strom Water Drainage" (r.110, as printed); and a drain may not be covered without notice in Form I (r.38). No canal, pond, water body, wetland, jhora, spring, stream, drain or culvert may be filled except by the Local Body with the State's prior approval for reasons recorded in writing (r.9(3)); within 15 m of a river bank, buildings are limited in height, length and covered area (r.9(4)), a regulated zone, not a no-build line (Chapter 7); and on land "recently filled up … pond, lake, marshy" the Mayor or Chairperson may seek a soil test, restrict the height or reject the building (r.32). The plinth shall be placed so that "adequate drainage of the site" is assured and "in no case be at a height less than 60 centimeters" (r.55(1)); roofs drain by "sufficient rain-water pipes", which the ULB may require to be connected to a drain through a covered channel (r.57). Where the rules are silent the "latest edition of National Building Code and other relevant Indian Standards" apply (r.3A). In the ULBs of the hill areas, Part X (rr.88–101) adds a soil test and slope-stability certificate for slopes of 30° and above (r.90(1)(f)), no site within 200 m of a sinking or probable slip zone or in "high water table and fully saturated soil" (r.90(1)(h)), no site within 5 m of the outside edge of a watercourse (r.90(1)(i)), the diversion of uphill water from foundations (r.91(r)), and the drainage measures of r.99 (Commentary to Clause 4.11); which ULBs are "hill areas" is not listed [TBC]. No storm-water detention, peak-runoff, release-rate or design-storm rule was found in the rules as amended to 2025 (NEER's reading). Two amendments of 2025 widen the gap. Ground coverage may now be 70% "for a building of any type of uses", and 100% for industrial or commercial plots with roads of at least 5 m on three sides (r.46(1) and r.51(2), Fifth Amendment), against 50–70% before, by use and plot size; and the only rule for unpaved ground is landscaping of nil up to 150 m² of plot, 1.0% up to 500 m², 2.3% up to 20,000 m², 5.0% up to 50,000 m² and 7.5% above (r.113, 2022). With coverage set for floor area rather than runoff, **the Manual's detention rule, not the coverage rule, controls runoff.** And low and very-low-risk buildings now go through an empanelled professional with a "Self-Certification Proforma … on a trust-based approach" (r.13(3), 2025), the occupancy certificate for them is issued by that professional in Form H1 (r.34), "Inspection for self-certified buildings is hereby waived. However, 10% to 15% of total applications shall be randomly selected" (r.34(9)), and applications go through an "online single window system" (r.14(1), 2025). The plan-stage check of drainage therefore rests on the empanelled professional, and this Manual's submittal checklist and certificate sit with that professional's self-certification (Chapter 10). The Municipal Act gives the local bodies drains to keep, not a standard to meet: the Municipality "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall in or outside the Municipal area" (s.156(1)); drains are to be "cleansed, flushed and emptied from time to time" (s.157); in "sudden waterlogging" it may drain water across private land without notice (s.160, proviso); a private drain may join a municipal drain only "after obtaining the written permission of the Municipality" (s.161); it may require "separate provisions … for drainage of sewage and other offensive matters as distinct from rain-water" (s.164); and an owner must deal with water that "is or is likely to become a breeding place of mosquitoes" (s.233), the legal hook for the drawdown times of Clause 4.7 (NEER's reading). Where a town's drain leaves through a river embankment, no Tripura embankment or drainage statute was found; consent to cut, cross or discharge through an

embankment or sluice is PWD (WR)'s as its owner (NEER's reading [TBC]). None of these sets a design storm, a release rate or a detention volume. The only design figures found are those of projects, and none gives a return period: the ADB's Agartala City Urban Development Project provides 48.2 km of new or rehabilitated storm drains (ADB, IEE, 2020); a ₹1,000 crore proposal for "construction of two protective embankments and installation of three additional pumping stations" in Agartala is to be "implemented in phases, depending on the availability of funds" (July 2026, as reported). Basements are limited for drainage, but with no flood level. No kitchen, bath or water closet may be placed in a basement unless "there is no chance of back flow and flooding of sewerage", with plans of its drainage and pumping (r.66(5)); every basement shall keep surface drainage out, be able to pump water out and have "water-tight walls and floors" (r.66(6)(b) and (c)); and since 2025 its ceiling stands 0.8–1.2 m above the average road level at the front (r.66(6)(h)), so that for a usual storey height its floor lies some 2 m or more below the road (NEER's reading), which on a lunga floor (lunga, Bengali লুঙ্গা: the land records' "Flat lands between tillas"; tilla, Bengali টিলা: "Hillock") is within the monsoon water table (Commentary to Clause 3.10). 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); no basement in Zone 2 (Clause 7.5.2); and a flotation check of the empty basement against the design groundwater level of Clause 4.12.1. On land to which the lunga rule of Clause 4.11 applies (the lunga floors and the recent flood plains), 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 or its pumps stop, stands above the surrounding ground; and wherever a basement or lower floor is cut into a tilla or 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 sloping site this chapter also supplies what r.91(r) and r.99 leave open: runoff from the slope 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 and a silt trap, never onto an unprotected tilla slope or into fill. These are the Manual's proposals, not rules of the Tripura Building Rules, 2017. This chapter is written so that it can supply, as a technical companion to the Building Rules, the Master Plan for the Agartala Planning Area 2045 and its zoning regulations (notified, as reported; text not read [TBC]) and the Municipal Act, the design storm, release rates and storage volumes that they leave open; a competent authority could adopt it for that purpose, for example the Urban Development Department (UDD) by an amendment to the Tripura Building Rules, 2017 under section 274 read with section 118 of the Tripura Municipal Act, 1994, but none has. In practice the storm drains of every Tripura town are its sewers. In 2020 "Agartala city is not covered by an underground sewerage system at present" (ADB IEE, 2020); by July 2026 a sewer network of "103.6 Km … with 4011 nos. household connection" served "only … the North Zone", the Agartala Municipal Corporation's area generated 61.0 MLD of sewage against 17.4 MLD of treatment capacity, and the plants built and building "are designed to be connected through Interception & Diversion of Drains" (State affidavit of 06.07.2026 in NGT OA 606/2018); the Tribunal's point, as quoted there, is that "storm water drains are being tapped and taken to STPs which is not legal" (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 already carries 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.

Term	Meaning in this Manual
Retention depth	The 90th percentile wet-day 24-hour rainfall depth for the site's zone (Clause 2.10, Annex 2E).
Required retention volume (RRV)	The runoff volume from the retention depth over the post-development site (Clause 4.4.2).
Detention	Temporary storage of runoff, released through a controlled outlet at a rate set by Clause 4.5.
Retention credit	The reduction in required detention storage that results from retention practices, determined by routing under Clause 4.4.6. It is **not** the same as the retained volume.
Permissible site discharge (PSD)	The maximum rate at which a site may discharge for a stated AEP, in L/s or L/s/ha.
Site storage requirement (SSR)	The detention storage required per hectare of site under the simplified method of Clause 4.14.
Multi-stage outlet	An outlet structure with separate openings at different levels, each controlling a different AEP (Figure 4.2).
Drawdown time	Time from the peak stored volume until the stated fraction of that volume has been released.
Emergency spillway	A secondary overflow that passes flows above the primary outlet capacity, or all flow when the primary outlet is blocked, without overtopping the embankment.
Freeboard	Vertical distance between the maximum design water level and the embankment crest or other critical level.
Flood-sensitive catchment	A catchment listed in Clause 4.5.3 or notified under Clause 4.5.4.
Authority	The approving authority under Chapter 1 (in an Urban Local Body area, the Agartala Municipal Corporation, Municipal Council or Nagar Panchayat for the building permit and the occupancy certificate under the Tripura Building Rules, 2017, and for its own drains and works under the Tripura Municipal Act, 1994; in a notified Local Planning Area, and for a building or township of 50 or more flats or of one acre or more inside an Urban Local Body area, TUDA (TBR 2017, r.13(3), as inserted in 2020); for any work that cuts, crosses or discharges through an embankment or sluice, PWD (WR) as its owner; and, in the area of the Tripura Tribal Areas Autonomous District Council, the District Council or the authority it designates, only where the Council has made a regulation or resolved that this Manual applies (none has), as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Agartala Municipal Corporation and TUDA, whichever has jurisdiction over a site, within the Agartala Planning Area of the Master Plan 2045 (238.57 km², the Corporation's area and 49 gram panchayats, as reported) and the Agartala-Ranibazar-Jirania Local Planning Area notified by TUDA in November 2019. Tier B: Municipal Councils and Nagar Panchayats, and TUDA in their Local Planning 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, pukurs, 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

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

where:

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

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

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

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

4.4.3 Verification

Retention by infiltration shall be supported by:

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

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

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

4.4.4 Limits on retention

4.4.4.1 Infiltration practices shall not be used:

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

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

4.4.5 Drawdown of retention

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

4.4.6 Retention credit: definition and computation

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

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

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

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

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

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

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

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

> **Commentary.** "Credited against detention" (APWA 5600 2025.01) can be read in two ways. One reading subtracts the retained volume from the detention volume, cubic metre for cubic metre. The other routes the storms with retention in place and sees what detention is still needed. The two readings give very different answers in Tripura, 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) ≤ 0.9 × 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) **Agartala's central saucer**: the land between the Haora embankment and the Katakhal, the erstwhile area of the Agartala Municipal Corporation, that drains through the Akhaura canal and the city's other channels to the Haora and the Katakhal (a khal, Bengali খাল: a canal or channel, the land records' "Khal") and is pumped when the rivers are high;
- (b) **the Katakhal basin and its sluice**: the land that drains to the Katakhal and through its double-barrel sluice near Bhuturia, with the three sites on its banks, at Ranjit Nagar, Abhaynagar Bridge and Astabal Bridge, of the sewage treatment plants being built to be fed by interception of drains;
- (c) **the Haora flood-plain-zone localities and Chandrapur**: Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat), as mapped by PWD (WR), and Chandrapur, which flooded in August 2026 (as reported);
- (d) **Kailashahar on the Manu**: the land of the town that drains to the Manu behind its embankment;
- (e) **Belonia on the Muhuri**: the land of the town that drains to the Muhuri behind its embankment;
- (f) **Udaipur, Amarpur and Sonamura on the Gomati below the Dumbur reservoir**: the land of the three towns that drains to the Gomati, into which the reservoir releases water;
- (g) **Dharmanagar on the Juri**: the land of the town that drains to the Juri;
- (h) **Khowai and Teliamura on the Khowai**: the land of the two towns that drains to the Khowai;
- (i) **Kamalpur on the Dhalai**: the land of the town that drains to the Dhalai;
- (j) **Santirbazar, Bagafa and Sabroom in the south**: the land of the three settlements, with the landslide ground round them;
- (k) **the hill-range corridors**: the catchments that cross or drain to NH-8 where it runs through the Atharamura and Longtharai ranges, and to NH-108B and NH-208; 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 Haora, the Gomati, the Manu, the Muhuri, the Khowai, the Juri or another river is high, or that depends on pumping, such as the Katakhal sluice and the flood pumps of central Agartala, or that discharges to a pukur, dighi or beel held full behind such a gate, or to the Gomati below the Dumbur reservoir when the reservoir releases water, for part of the monsoon season (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and pukur 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 Agartala entries follow the city's drains to its two rivers. The central part of the city "is located at a lower level than other areas giving it the appearance of a saucer", the ground falling from 25–30 m to a low of 8 m; "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded"; the main drains are masonry-lined but "the feeder drains are earth-lined and in a poor condition with silt and vegetation choking them"; and "The Akhaura canal system running along the Akhaura road serves mainly the central area" (ADB, IEE for the Agartala City Urban Development Project, 2020), and flows on into Bangladesh (as reported). When the Haora and the Katakhal are high the city is pumped: 18 flood pumps of up to 900,000 litres per hour each, about 0.25 m³/s each and about 4.5 m³/s for the 18 (NEER's arithmetic), and 6 diesel pumps discharge by pipeline to the Katakhal on the north and the Haora on the south (August 2024, as reported); 6 more flood pumps were reported in August 2025, and a ₹1,000 crore proposal for two embankments and three pumping stations in July 2026 (as reported). No design capacity for the pumps, the Katakhal sluice or the Akhaura canal was found [TBC]. The CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste", with photographs of the Haora near Battala and the Katakhal near Abhoynagar bridge (CAG, Audit Report for 2022-23, performance audit of solid waste management in urban areas of Tripura). The Katakhal entry follows the sluice and the sewage: PWD (WR) holds the double-barrel sluice near Bhuturia (as quoted from its pages); the Katakhal was cleaned in March 2026 (as reported); it has no level gauge [TBC]; and three of the sewage treatment plants being built for the city, of 10 MLD at Ranjit Nagar, 15 MLD at Abhaynagar Bridge and 1.5 MLD at Astabal Bridge, all to be fed by interception and diversion of drains, stand on its banks, with a target of March 2027 (State affidavit of 06.07.2026 in NGT OA 606/2018). The

Haora entry follows the river's flood plain: PWD (WR) has mapped flood-plain zones on the Haora at Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat) for the National Green Tribunal, with the map, its return period and its status not known [TBC] (State affidavit in NGT OA 673/2018); the Tribunal found on 13.04.2026 that the 5 MLD plant at Kalapania Khal and the 8 MLD plant on the Haora bank sit near or on the flood plain and "may lead to flooding of the STP and flowing of untreated sewage in the river during the monsoon" (as quoted in the affidavit of 06.07.2026); Chandrapur, Baldakhal and Aralia flooded on 22–24 August 2026, when the Haora stood at 10.72 m against a CWC danger level of 10.70 m (as reported); in June 2022 the Haora stood at 10.82–10.85 m at the Jahar Bridge gauge, whose danger level is given as 10.50 m (as reported); and 6 km of the Haora embankment needed leakage repairs (as reported). The Haora's highest level is given as 11.08 m, 12.14 m, 12.4 m and 12.42 m, probably on different gauges or datums (all as reported); this Manual uses 12.42 m (22 August 2024) at the CWC site until CWC confirms the gauge and datum (Clause 5.8.5(b)). The Kailashahar entry follows the Manu: its CWC danger level is 25.34 m and its highest level 25.79 m (7 June 1993), exceeded at 25.95 m on 13 June 2018, when 21,000 people were reported homeless in Kailashahar (as reported); State press gave the danger mark as "24.00 mtr" in 2018 and a "critical level" of 23.05 m in 2024, a conflict (as reported); 16.8 km of the Manu embankment at Kailashahar was raised in 2025 (as reported); and Kailashahar holds the State's largest IMD station record, 377.2 mm on 6 June 1993 (IMD *Extremes*). The Belonia entry follows the Muhuri: its highest level of 16.98 m (4 August 1983) stood until 2024, when the river reached 17.32 m on 2 August, 18.12 m on 20 August and 18.81 m on 22 August (SANDRP's transcription of CWC, as reported); Belonia's IMD gauge recorded 32 cm in the 24 hours to 0830 IST on 20 August 2024 (IMD press release, Annexure I); and 7.47 km of the Muhuri embankment at Belonia was in the 2025 programme (as reported). The Gomati entry follows the Dumbur reservoir: on 21 August 2024 the Gomati at Udaipur stood at 22.05 m at 14:45 against an "extreme danger" level of 22.00 m on the State gauge, the Amarpur State gauge at 31.94 m against 32.00 m on 22 August, and the Gumti at Sonamura at 14.27 m on 23 August, against a highest level of 14.43 m (23 July 1993) (as reported); Amarpur's IMD gauge recorded 31 cm in the 24 hours to 0830 IST on 20 August 2024 (IMD); the district reported the reservoir's gates opened on 21 August, the first release "since 1993", while the power minister denied that a gate had opened, a conflict (as reported); and the reservoir's spillway capacity is given as 481.38 m³/s (as reported). The Dharmanagar entry follows the Juri at Nutan Bazar, whose highest level of 20.435 m (15 May 1984), a pre-monsoon flood, was exceeded at 20.66 m on 22 August 2024 (as reported). The Khowai entry follows the Khowai at Khowai, highest level 28.005 m (24 June 2004) (as reported), and the landslides of June 2018, 11 of whose 17 reported locations were in Khowai district (as reported); NIH-DHAARA returns no data for the cell of Khowai town, and Teliamura's cell is the lowest in the valley (Clause 2.3.6(c)). The Kamalpur entry follows the Dhalai at Kamalpur, highest level 33.85 m on 15 May 1984 (as reported); both NIH-DHAARA cells at Kamalpur return no data. The southern entry follows the rain and the slopes: the IMD gauge at Bagafa recorded 49 cm in the 24 hours to 0830 IST on 22 August 2024 (IMD press release of 22 August 2024, Annexure I), more than every NIH-DHAARA 100-year cell in the State, and Clause 2.3.6(h) raises the 1% AEP 24-hour depth to 490 mm throughout sub-area TR-D1; 2,032 landslip locations were reported across the State in August 2024, with 7 deaths at Gardang near Santirbazar and 3 at Debipur (as reported); and the CWC sites at Sabroom and on the Feni were reported not working in 2024 (as reported). The corridor entry follows the High Court of Tripura, which in its suo motu WP(C) (PIL) No. 06 of 2026 (judgment of 08.09.2026) recorded the District Legal Services Authority's finding on NH-108B and NH-208 of "No proper drainage system … water logging everywhere; RCC drain hole blocked with mud, vegetation; Earthen drain damage & blocked", with "culvert block by silt, vegetation, debris" chainage by chainage; and the Assam–Agartala road, NH-8, which crosses the Atharamura and Longtharai ranges, was cut by "over 60 breaches" in the floods of 3–5 August 1983 (Lok Sabha debates, as quoted). Kumarghat on the Manu, highest level 32.97 m (7 June 1993) (as reported), Jirania, where one person drowned in June 2022 (as reported), 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 pukur 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 PWD (WR) 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 central zone of Agartala between the Haora embankment and the Katakhal, or Chandrapur, Baldakhal and Aralia, which flooded in August 2026 (as reported), 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 TR-A, TR-B, TR-D, TR-D1 and TR-E and from 1 May to 31 October in TR-B1 and TR-C, from 1 April to 31 October on lunga floors and recent flood plains below the 1% AEP level, pukur, dighi and beel margins and every catchment behind a closed sluice or a pumped outfall, at all times in catchments draining to the Dumbur reservoir or the Gomati below it, and at other sites and times after a 5-day total of more than 53 mm, AMC II otherwise).
5. Compute the release caps for each AEP and duration under Clause 4.5.2 or 4.5.3.
6. Compute post-development hydrographs with the same storms and AMC, including retention practices (Clause 4.4.6).
7. Choose a trial facility geometry (stage–storage) and a multi-stage outlet (Clause 4.6.5).
8. Route every storm and duration. Use a time step of no more than **5 minutes**, and no more than Tc/3 of the post-development catchment.

9. Check every release against its cap, and check drawdown (Clause 4.7). Adjust the outlet and storage and repeat.
10. Check the tailwater condition of Clause 4.6.6 and the downstream analysis of Chapter 5.
11. Size the emergency spillway and set freeboard (Clause 4.9).
12. Report the governing storm for storage, for each outlet stage, and for the spillway (Clause 4.17).

4.6.3 Storms to be routed

Every facility shall be routed for the full matrix:

Table 4.1 — Design storms to be routed for detention sizing

AEP	Durations (h)	AMC
50% (2-yr)	1, 2, 3, 6, 12, 24, 48, 72	II for ≤ 6 h; III for ≥ 12 h
10% (10-yr)	1, 2, 3, 6, 12, 24, 48, 72	II for ≤ 6 h; III for ≥ 12 h
1% (100-yr)	1, 2, 3, 6, 12, 24, 48, 72	II for ≤ 6 h; III for ≥ 12 h

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

4.6.4 Initial conditions

Each run shall start with:

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

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

4.6.5 Multi-stage outlet design

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

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

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

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

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

4.6.6 Tailwater on the outlet

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

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

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

4.6.7 Illustrative example

Illustrative — not design values. This example shows the procedure and the sizes it produces. The inputs are invented to be plausible for a lunga between tillas on the edge of Agartala. 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**

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)
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.

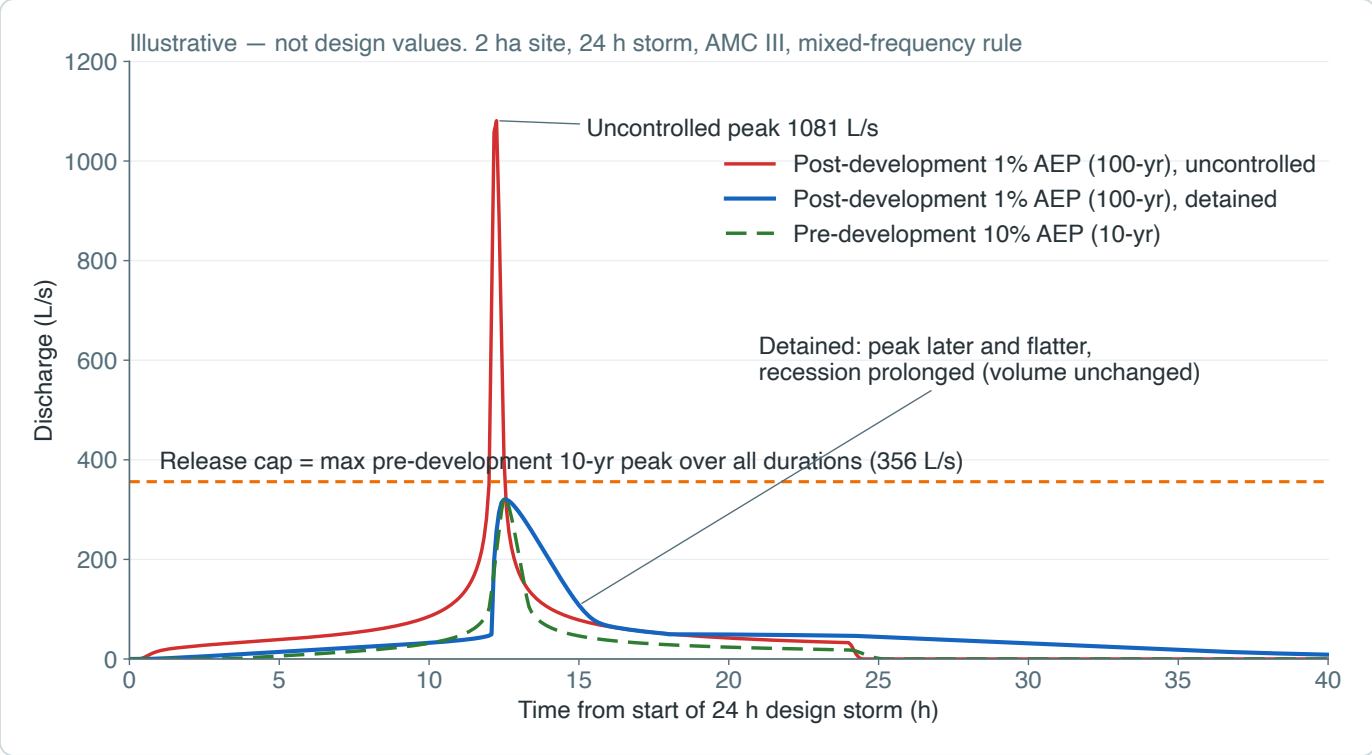


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA 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 Tripura 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 August 2024, when the IMD gauge at Bagafa recorded 38 cm in the 24 hours to 0830 IST on 20 August and 49 cm in the 24 hours to 0830 IST on 22 August (IMD press releases of 20 and 22 August 2024, Annexure I) followed within days.

4.8 Outlet structures

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

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

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

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

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

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

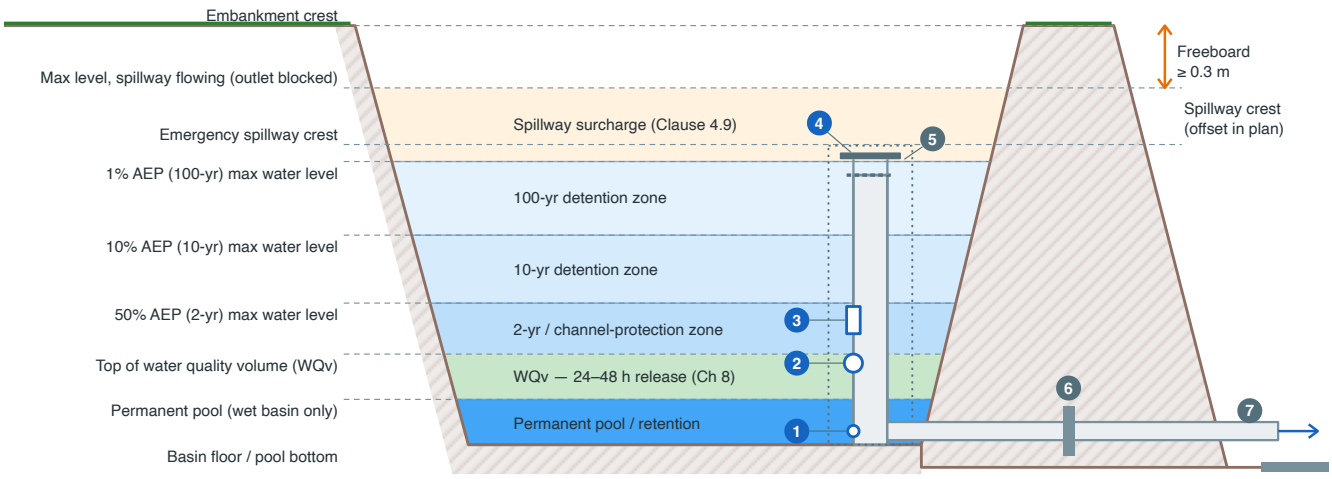
4.8.5 **Outlet barrels.** Outlet barrels through embankments shall:

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

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

> **Commentary.** The 50 mm minimum is smaller than the 75 mm (3 in) of KC APWA 5600 (2006), so the trash-rack requirements are correspondingly stricter. The ratios in 4.8.3 (bar spacing at half the opening, open area 10 times the opening, 50% blockage for the drawdown check) have no direct precedent and are set by this Manual. The blockage factor matches the 50% grate clogging factor for sag inlets in Chapter 6. Indian urban drains carry heavy loads of solid waste, so a low-flow orifice without an effective rack will block within one season.

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



Key

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

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

4.9 Emergency spillway, freeboard and embankment safety

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

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

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

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

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

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

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

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

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

4.9.6 **Embankments.**

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

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

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

4.10 Facility types

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

4.10.2 **Underground tanks and vaults.**

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

4.10.3 **Rooftop detention.**

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

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

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

4.10.5 **Parking-lot detention.**

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

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

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

4.10.7 **Ponds and wet basins.**

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

- (b) Only storage above the permanent pool counts as detention.

Commentary.

- The rooftop depth (150 mm) and parking depths (200 and 300 mm) have no direct precedent. This Manual sets them so that a blocked outlet is noticed before it becomes dangerous.
- The 1.2 m pool depth equals the 4 ft minimum permanent pool of KC APWA 5600 (2006). This Manual adopts it mainly for weed and mosquito control.
- Pumped detention tanks need maintenance declarations in Singapore (PUB Addendum No. 3, April 2025). This Manual adopts the same approach through Chapter 10.
- Using open space for multi-use detention fits rule 110(4) of the Tripura Building Rules, 2017, under which "All such public open spaces above the size of 500 sq.m shall have arrangements for complete utilization and capture of storm water with scientific rain water harvesting arrangements", including "Artificial or natural storage of storm water runoff from larger sites"; rule 110(5) extends recharge to "open spaces like parks, parking, plazas and playgrounds". Unpaved ground on private plots is scarce: the landscaping rule asks for nil up to 150 m² of plot and 1.0–7.5% above (r.113, 2022), and coverage may reach 70% for every use (r.46(1), 2025), so a shared open space is often the only place where surface storage fits. On land to which the lunga rule of Clause 4.11 applies, most of the valley towns, surface storage in the open space 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 materials" that rule 110 requires "for all open parking spaces" in group housing are laid there on a lined, non-exfiltrating base with an underdrain to the site's detention. On a tilla top or bench that meets the tilla rule of Clause 4.11, an open-space basin may infiltrate after the field test that rule requires. On ground under the hill rule, slopes of more than 20%, tilla slopes and cut faces, 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 pukur or dighi 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; its bank, which the land records class separately as pukurpar (পুকুরপাড়, "Bank of tank") or dighirpar ("Bank of large tank"), is kept as bank, not graded for storage. A beel or haor and its margins are never turned into a detention pond, and engineered storage is called a detention pond, never a pukur. The 15 m "zone of river" of rule 9(4), the protective strips of rule 90(1)(i) and (m) in the hill ULBs, and the Manual's corridor of Chapter 7 along rivers, chharas (Bengali ছড়া: the land records' "Streams"; hill streams and small natural channels), khals and lunga flow paths and round pukurs, dighis and beels are flood land already: water reaches them first, so they are not counted as detention for the development beside them. And the area of a water body is excluded from the area of a park (r.9(2)), so a pukur in a park is not open space either.
- Signs and depth markers under Clause 4.15.5, and the flood-warning signs of 4.10.5(b), are in Bengali, Kokborok and English (set by this Manual), Kokborok being written in the script that the local body, or the Tripura Tribal Areas Autonomous District Council in its area, uses where the sign stands; the Manual takes no side in the dispute over whether Kokborok is written in the Roman or the Bengali script (as reported). The rule follows the Tripura Official Language Act, 1964 (Act No. 5 of 1964), as amended, under which "the Bengali language and the Kok-Borak language shall … be the language to be used for all or any of the official purposes of the State of Tripura" (s.2(1); the Kokborok words added by the Tripura Official Language (Amendment) Act, 1979, Act No. 8 of 1979, as quoted), from 1 May 1999 (Law Department notification No. F.12(1)-LAW/88(Shadow), 29 April 1999), and "The English language may continue to be used" (s.2(2)(a)). The core's "signs in Bengali and English" is the floor of this rule, not its whole.

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 rule 110 of the Tripura Building Rules, 2017, any condition of a building permit or occupancy certificate, or any rainwater harvesting rule of the Tripura Tribal Areas Autonomous District Council (none found [TBC]).

> Commentary. Rainwater harvesting in Tripura is required by rule 110 of the Tripura Building Rules, 2017, which sizes nothing. "All building having plinth area not less than 200 sq.m., while submitting the building plans for sanction, shall mandatorily include the complete proposal of rainwater harvesting", with components that include "Rain water/ Storm water drains", "Storage Tanks/ Pits/ sumps" and "Ground Water recharge structures". The rule describes recharge pits 1–2 m wide and up to 3 m deep, trenches 0.5–1 m wide, 1–1.5 m deep and 10–20 m long, recharge wells of 100–300 mm diameter and shafts of 0.5–3 m diameter and 10–15 m depth. Its table requires an RWH structure, with "emphasis on both storage and reuse", for plotted residential buildings of 200 m² plinth area and above; RWH, "Rain Water Harvesting Structure and Recharging Well" and "Concrete paving to be avoided and permeable materials are to be used for all open parking spaces" for group housing of all sizes; RWH, storage and recharge pits for public and semi-public buildings of all sizes; RWH and "Soft landscape provisions and open spaces with Percolation pits" for commercial and mixed-use buildings of 50 m² and above; and, for industry of all sizes, percolation pits, with "Provision should be made not to inject contaminated water into recharge structures". Public open spaces of more than 500 m² shall capture storm water (r.110(4)), and "Recharging of ground water should be made mandatory … for all types of buildings, including Group Housing Societies having a plot area more than 500 sq. m. and above" (r.110(5)). Each ULB shall constitute "a rainwater Harvesting Cell", inspect the structures before issuing the completion certificate, verify 100% of the provisions in buildings above 1,000 m² every year and 10% of the rest by random survey, and set incentives and penalties (r.110(6)). The 200 m² threshold replaced the 300 m² of the 2004 rules (PIB, as reported; date not checked). No storage volume, rate per square metre of roof or infiltration test is set, and nothing warns against recharge where the water table is high or the ground is a filled pond (NEER's reading), although rule 32 (filled ponds) and rule 90(1)(h) ("high water table and fully saturated soil", in the hill ULBs) point at both. The structures that rule 110 describes put water into the ground, and on most of the State's town land the ground is full of water when it rains: the CGWB's dug wells in West Tripura stood 0.22–6.64 m below ground in November 2017, "The ground water table being very high" in Agartala (ADB, IEE for the Agartala City Urban Development Project, 2020), and the shallow groundwater carries iron of 0–4.99 ppm "due to the ferruginous nature of Tipam sandstones" (CGWB, NAQUIM report, West Tripura), which clogs the gravel and filter media of a recharge structure (NEER's reading).

Nor does the State need recharge: the stage of groundwater extraction was 9.48% in the 2024 assessment, with every assessment unit Safe (GWRA 2024, State compilation of February 2025, as quoted by the CGWB), and 9.92% in 2023 (as quoted). **Recharge is therefore not a design objective in Tripura, and rainwater harvesting is storage and reuse.** This Manual sets three infiltration rules and one sizing rule for credit (all set by this Manual), cited as "Clause 4.11 (lunga rule)", "Clause 4.11 (tilla rule)" and "Clause 4.11 (hill rule)", and credits the rule 110 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.
- **RWH credit rule.** Rule 110 sets no volume. Where the lunga rule or the hill rule below bars infiltration, the RWH structure is a storage tank of at least 25 L per m² of roof (about 25 mm over the roof), and the recharge structures of rule 110 are replaced by storage of the same kind. The tank counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or washing, demonstrated under Clause 4.4.3, 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 25 L/m² is the neighbouring hill edition's figure, set where the building rules also give none; a larger tank is always allowed. The store serves the dry months as well, because "70 to 80 percent of rainfall occur between May to September" (CGWB, NAQUIM report, West Tripura).
- Recharge pits, trenches, shafts and wells count as retention only where they meet Clause 4.11.4 and the tilla 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.
- **Lunga rule** (the valley floors; most towns, including central Agartala). 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 a lunga floor (the CGWB's "low lands ('loonga') of Holocene terrace") or a recent flood plain ("the present-day flood-prone belts fringing the rivers", the same report); on land below the 1% AEP flood level of a river, chhara or khal; inside embankment-protected land that ponds when its sluices close or its pumps stop; on the margins of a pukur, dighi, beel or haor (its Zone 1 and Zone 2 under Chapter 7); on a filled pond, a lunga fill or clayey urban fill (r.32); 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, a closed sluice or a stopped pump 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 evidence: in November 2017 the CGWB's dug wells in West Tripura stood 0.22–6.64 m below ground, and older summaries give 0.90–5.10 m after the monsoon in South Tripura and 1.20–4.37 m in North Tripura (CGWB district profiles, 2008 data, as quoted); central Agartala stands on "a soft to medium/stiff, silty clay/clayey silt layer" with "The ground water table being very high" (ADB IEE, 2020); and "Within a few hours most of the rainwater goes as run off and finally enters Bangladesh" (NAQUIM, West Tripura).
- **Where rule 110 requires recharge on lunga land.** Rule 110(5) makes groundwater recharge mandatory on plots of more than 500 m², and the rule 110 table asks for recharge wells in group housing and percolation pits in commercial, mixed-use and industrial buildings. On land under the lunga rule such a structure is a recharge device in saturated ground, often fed with water from a drain that carries sewage, not storage. This Manual does not override the rule. It states the conflict plainly: on such a site the Manual requires storage in place of the recharge structure, under the RWH credit rule, with the overflow taken to the drain without passing through a pit, and the applicant seeks the ULB's relaxation of the recharge requirement, citing this rule. Until the ULB relaxes it, the rule 110 requirement stands, and a recharge structure that the rule forces on such a site earns no credit under this Manual.

- **Permeable parking on lunga land.** The "permeable materials … for all open parking spaces" of rule 110 in group housing are laid, on land under the lunga rule or the hill rule, on a lined, non-exfiltrating base with an underdrain to the site's detention; they earn no infiltration credit, and the water held in their base counts only as detention, routed under Clause 4.6 through an orifice.
- **Tilla rule** (the dissected terrace uplands of every valley, and weathered Tipam sandstone outside sub-area TR-E). Infiltration may be built and credited only on the top or a bench of a tilla (the CGWB's "table lands (tilla lands) and rolling mounds"), where the natural ground slopes 10% or less, the seasonal high water table is more than 3.0 m below ground, and the practice is set back from the edge of the tilla by at least twice the height of the slope below it; it needs a silt trap, a filter and a first-flush diverter ahead of the structure, a field infiltration test at the depth of the practice, and the separation of Clause 4.11.4. It shall never be built on a tilla slope, a cut face or fill, within twice the height of a cut or retaining wall upslope of it, or on the lunga below. Weathered Tipam sandstone supports it where tested: the CGWB uses a rainfall infiltration factor of 0.16 for it, "very porous and permeable", approved by its R&D committee (NAQUIM, West Tripura); the Dupitila sandy clays with laterite are slower (HSG C, B on sandy tops: Clause 3.7.2). Everywhere that neither this rule's conditions nor a piezometer record are met, rainwater harvesting is storage and reuse.
- **Hill rule** (sub-area TR-E, any natural slope of more than 20% elsewhere, and every tilla slope and cut face). No deliberate infiltration practice shall be built or credited: on natural ground sloping more than 20%; on a tilla slope or a cut face; on colluvium, fill or slide debris, whatever its slope; in a mapped landslide zone or at a landslip location; or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless, on the slopes of the hill ranges, a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope. No certificate makes an infiltration practice acceptable on a tilla slope, a cut face or fill (tilla rule). 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 20% threshold is the CGWB's own: "Area with more than 20% slope has been excluded for the recharge computation" (NAQUIM, West Tripura), a resource-assessment convention that this Manual uses as the line between ground types; the mountain editions of this series use 10°, about 17.6%, and the Tripura-sourced figure is used here. The hooks are in Part X of the Building Rules (rr.88–101), which applies "only to the ULB in the hill areas", although which ULBs those are is not listed [TBC]: a soil test and slope-stability certificate for sites with "inclinations of 30° and above", for buildings above 6.5 m or over 500 m² of cover (r.90(1)(f), IS 14243); no site within 200 m of "a sinking or probable slip zone", or where there is "high water table and fully saturated soil" (r.90(1)(h)); "diversion of the natural flow of water coming from uphill side of the building away from the foundation" (r.91(r)); and the drainage measures of r.99: "proper slops not less than 1 : 60 shall be maintained all around a building", surface-water drains that "shall not be connected with any drain carrying sullage water or sewage", no covering of an open drain without the ULB's written permission and "no building shall be placed over any drain", outfalls "protected and guided", gutters and pipes to a drain, an impervious apron "not less than 0.75 m. wide" round the building, "minimum clearance of 2.1 meters between the foundation and the soak pit" and private bridges with "sufficient waterway"; with breast and retaining walls with weep holes and filters (r.100). Where the certificate of r.90(1)(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: 2,032 landslip locations were reported in August 2024, with 7 deaths at Gardang near Santirbazar (as reported), and 17 landslide locations in June 2018 (as reported); the State lies in seismic zone V, and in the 1897 earthquake "Several landslide and liquefaction took place" (ADB IEE, 2020).
- **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, as rule 110 itself says for industry; road and parking runoff shall be recharged, where the tilla 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 lunga floors, water put into the ground has nowhere to go in the monsoon, and on the tilla slopes and hill ranges it goes into the slope. In the monsoon season an RWH tank is full after the first heavy rain, and on a lunga 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 lunga rule, the tilla rule, the hill rule, the treatment of the rule 110 recharge conflict, the permeable-parking rule and the polluted-runoff rule are set by this Manual. The 2.0 m water-table screen of the lunga rule is set by this Manual from the CGWB depths above: it is the least depth at which a practice 1.0 m deep keeps the 1.0 m separation of Clause 4.11.4, and the rule 110 pits, up to 3 m deep, need more. The tilla rule's 10% slope is set by this Manual as half the CGWB's 20% recharge exclusion, its 3.0 m water-table condition is set by this Manual, stricter than the lunga rule's 2.0 m, so that a pit 2.0 m deep, within the range that rule 110 describes, keeps the 1.0 m separation of Clause 4.11.4, and the distance of twice the height of a slope, cut or wall is set 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 recent flood plains and lunga floors of the Haora, Gomati, Khowai, Dhalai, Manu, Juri, Deo, Muhuri and Feni valleys, where the CGWB's dug wells in West Tripura stood 0.22–6.64 m below ground in November 2017, central Agartala between the Haora embankment and the Katakhal and the other land behind embankments, the pukur, dighi and beel margins, and filled ponds and lunga fills, 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 PWD (WR) record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, chhara, khal, pukur, dighi or beel, or of the water ponded behind any embankment or closed sluice that encloses the site.

For the flotation check of 4.12.3 at sites in the recent flood plains and lungas of the Haora, Gomati, Khowai, Dhalai, Manu, Juri and Muhuri valleys, the pukur, dighi and beel margins, filled ponds 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. Tripura 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 shallow groundwater is iron-rich instead: iron of 0.00–4.99 ppm "due to the ferruginous nature of Tipam sandstones", with pH 6.52–8.35 (CGWB, NAQUIM report, West Tripura), and iron above the permissible limit "in most of the places in the phreatic aquifer" in an older State assessment (as quoted). Iron stains and clogs outlets, screens and filters more than it attacks concrete (NEER's reading); 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 the lunga floors and flood plains of every valley. The CGWB's dug wells in West Tripura stood 1.63–10.30 m below ground in March 2017 and 0.22–6.64 m in November 2017 (NAQUIM, West Tripura), and "The ground water table being very high" is recorded for Agartala (ADB, IEE for the Agartala City Urban Development Project, 2020). On the lunga floors, the recent flood plains, the pukur, dighi and beel 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, a detention sump or a basement can float, especially when a river in flood, a pukur at its outlet level or water ponded behind a closed sluice 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, chhara, khal, pukur, dighi or beel, or of the water ponded behind an embankment or closed sluice that encloses the site, where that is higher than the well record; and on the recent flood plains and lungas, the pukur, dighi and beel margins, filled ponds 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 detention tank below ground is lined, anchored and checked for flotation when empty. On a tilla or 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 the CGWB's wells in West Tripura stood higher than in March (0.22–6.64 m below ground in November 2017, against 1.63–10.30 m in March); a reading taken in March understates the design level. The observation wells in use are the CGWB's (North Eastern Region; State Unit Office, Agartala). No State groundwater Act, groundwater authority or State observation-well network was found; PWD (WR), which runs irrigation, is named in this Manual as the State groundwater agency because groundwater irrigation would be part of its work (NEER's reading), and whether it keeps observation wells is not known [TBC]; 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 lunga floors, flood plains, waterbody margins, filled ponds 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 Tripura 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 pukur 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.
>
> Tripura has no tank Act and no water-body Act, and no instrument found treats a pond as storm-water storage. Its water bodies are protected as land and as public property. The Tripura Building Rules, 2017 bar the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the State Government's prior approval for reasons recorded in writing (r.9(3)); the Tripura Municipal Act, 1994 vests "all public tanks, streams, reservoirs, and wells" in the Municipality (s.91), forbids a new tank without its permission (s.232), and requires the owner of a private tank used for drinking, bathing or washing to "cleanse it of silt, refuse or vegetation and to protect it from pollution by surface drainage" (s.234(1)); and the Diversion of Land Rules, 2025, made under the Tripura Land Revenue and Land Reforms Act, 1960, class pukur (পুকুর, "Tank/Pond"), dighi (দীঘি, "Large tank"), pukurpar ("Bank of tank"), dighirpar ("Bank of large tank"), beel (বিল, "Watery land") and haor (হাওর, "Big watery land") as land in their own right (Appendix-I); the 2025 procedure for diverting a water body was replaced by online self-declaration on 6 March 2026, and whether section 20 of the Act still bars such a diversion was not established, so this Manual does not state the current procedure [TBC]. The State's regional storage is of five kinds: the pukurs and dighis of the towns, of which about 65 in Agartala were cleaned and developed under city schemes (as reported) and 180 urban water bodies on government land were identified statewide for the National Green Tribunal in 2020, 30 of them prioritised (as reported); the palace and temple tanks, among them the Ujjayanta palace lakes in Agartala and Kalyan Sagar at Matabari, which are heritage and fisheries storage, not detention to be drawn down; the beels, haors and lunga wetlands of the valley

floors; the Rudrasagar wetland in Sepahijala district, Ramsar site no. 1572, 240 ha, designated on 8 November 2005 by the Ramsar record or "officially designated" on 29 February 2007 by the Forest Department (both as quoted, a conflict), with a catchment of 6,052 ha (as quoted), whose ring roads, built without the Wetland Authority's permission, "reduced the water level" (CAG, Audit Report for 2021-22); and the river flood plain behind and between the embankments of PWD (WR). The Wetland Authority of Tripura was constituted on 05.09.2018 and reconstituted in 2022 (as quoted). The Dumbur reservoir is the operator's storage for power, not regional detention, and it is not a Ramsar site. Four points follow:

- A pukur or dighi on the record may not be a working one. No inventory of the pukurs and dighis within the towns, with their beds, outlets and stage–storage relations, was found [TBC], and pukurs are being lost: ponds have been filled for housing in Barjala and Lanka Basti in Agartala (as reported), and the High Court of Tripura has heard the filling of ponds and the walling of banks at Kalyan Sagar (WP(C)(PIL) No. 2 of 2014, as quoted). A pukur or dighi 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 beel or haor is never turned into a detention pond, and engineered storage is called a detention pond, never a pukur.
- The storage is the basin's, not a site's. A pukur's flood storage is held for the whole catchment, 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 pukur. Because the drains of every town carry sewage (Commentary to Clause 4.1), no new storm drain shall discharge to a pukur, a dighi or the Rudrasagar catchment without dry-weather interception and screening (Clause 8.9), which is what section 234(1) of the Municipal Act asks of private tanks.
- A pukur behind a sluice is full when it is needed. The receiving pukur, dighi or lunga wetland 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)); 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 PWD (WR) 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. No Tripura embankment or drainage statute was found, so a regional facility that relies on an embankment, a sluice or a pumping station needs PWD (WR)'s written agreement, as owner, for a stated flow and level [TBC]. No formal order allocates the Akhaura canal, the Katakhal, the Haora embankments or the sluices among the Agartala Municipal Corporation, Agartala Smart City Ltd, PWD (WR), PWD (R&B) and PWD (DWS) (NEER's reading); until one 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 vested municipal drain, an embankment drain or sluice, or a natural chhara or lunga, and its outfall.

The first point is the basis of condition 4.13.2(c) in Tripura. A pukur or dighi 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
TR-Z1 Western valley: TR-A Agartala–Sonamura valley (Agartala–Jirania–Mohanpur–Bishalgarh–Sonamura); from the Agartala governing cell and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
TR-Z2 Central valleys: TR-B Khowai valley (Khowai–Teliamura); from the governing cell 6 km south of Khowai and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
TR-Z2 Central valleys: TR-B1 Dhalai valley (Ambassa–Kamalpur); from the governing cell of TR-B and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
TR-Z3 Northern valleys: TR-C Manu–Juri–Deo valleys (Kailashahar–Kumarghat–Dharmanagar–Panisagar–Kanchanpur); from the Kailashahar governing cell, not below 377.2 mm in 24 hours at 1% AEP within 25 km of Kailashahar (Clause 2.3.6(h)), and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
TR-Z4 Southern valleys: TR-D Gomati valley (Udaipur–Amarpur–Karbook); from the Udaipur governing cell and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
TR-Z4 Southern valleys: TR-D1 Muhuri–Feni south (Belonia–Santirbazar–Jolaibari–Bagafa–Sabroom); from the Sabroom governing cell, with the 1% AEP 24-hour depth not below 490 mm (Bagafa, Clause 2.3.6(h)), and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
TR-Z5 Hill ranges: TR-E Hill ranges (Baramura–Atharamura–Longtharai–Sakhan–Jampui); the higher of the rows of the valley sub-areas on either side of the range (Clause 2.3.6(c))	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]

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:

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

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

Hydrologic soil group	C_10	C_2
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]

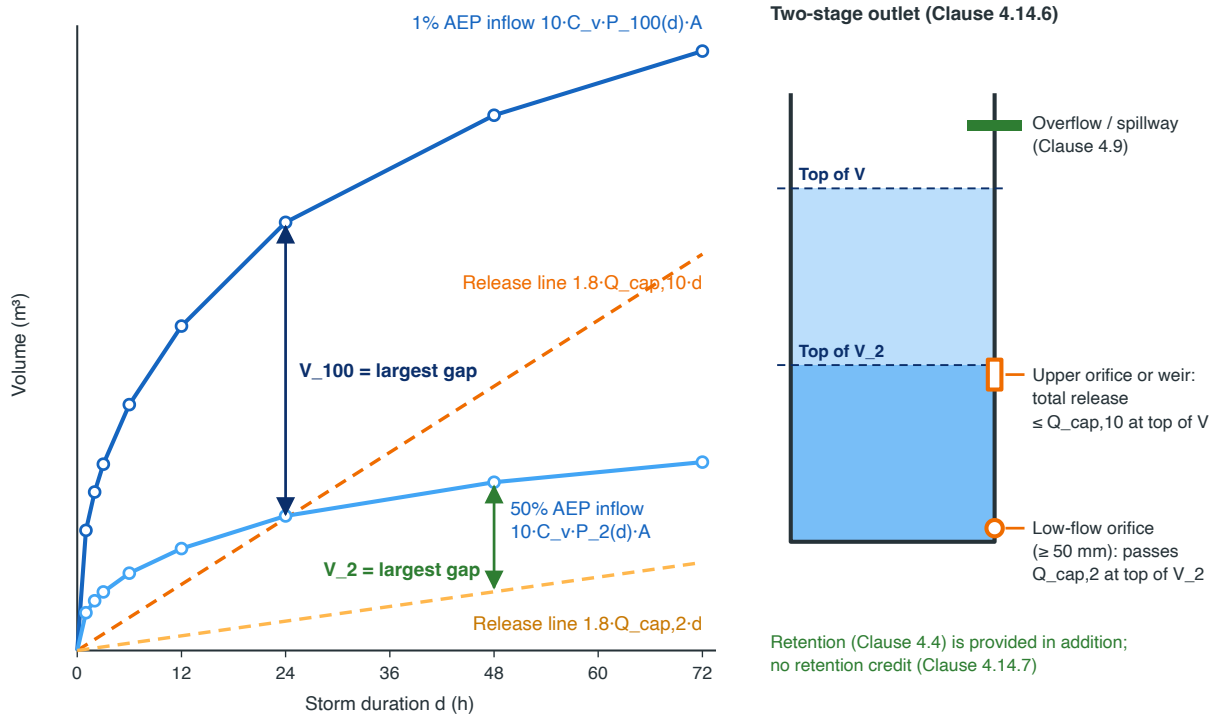
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

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 valley floors of Tripura, 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 Bengali 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 Tripura the closed outfall is not the exception but the normal monsoon case. Central Agartala lies between the Haora embankment and the Katakhal, lower than the land round it, and when the two rivers run high "Several pumps have been provided to lift the water out of the city during these seasons" (ADB, IEE for the Agartala City Urban Development Project, 2020); on 22 August 2024 the Haora stood at 12.42 m against a CWC danger level of 10.70 m (as reported; datum not stated [TBC]). Kailashahar on the Manu and Belonia on the Muhuri sit behind embankments, and they, Sonamura and Udaipur on the Gomati stand on rivers that all cross into Bangladesh, with no Indian control downstream and no level record that crosses the border, and the Gomati below the Dumbur reservoir also carries the reservoir's releases (Chapter 5). The flood of August 2024 ran from 19 to 24 August, six days (as reported), so a storm that falls on a closed outfall can be followed by days of high river. What fills behind the closed gate is storm water mixed with sewage, because Agartala's sewers serve only its North Zone and the State's 19 other urban local bodies treat none of their sewage (State affidavit of 06.07.2026 in NGT OA 606/2018; Commentary to Clause 4.1). No record of how long any sluice stays shut, no operating rule for the Katakhal sluice and no design capacity for the city's pumps were found [TBC]; Chapter 5 sets the river level and the closure to be assumed (Clause 5.8.5: the whole of the 72-hour design storm, and a further 72 hours where no stage record exists). The illustrative site of Clause 4.6.7 and Annex 4C, a lunga between tillas on the edge of Agartala, is the instructive Tripura case: the lunga rule of Clause 4.11 gives it no infiltration, and its outfall is locked when the river is high. Its 10- and 100-yr 24-hour depths of 200 and 350 mm are invented, but plausible against the NIH-DHAARA Agartala cell's 225.4 and 360.7 mm, which govern sub-area TR-A (Clause 2.3.6(c)); they are a little below those values, and the example must not be used for design. 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 pukur 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 Tripura.** Tripura is landlocked: it has no coast, no tide and no Coastal Regulation Zone, and every one of its rivers leaves the State for Bangladesh. The monsoon reaches it as rainfall and as the floods of its own rivers, 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 Tripura: 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. The towns of Tripura lie on the lungas (Bengali লুঙ্গা: the flat valley land between low hills — the land records' "Flat lands between tillas") and flood plains of valleys between tillas (Bengali টিলা: a low hill or hillock — the land records' "Hillock") and the hill ranges, and their receiving water is one of six kinds: a river reached through a sluice or flap gate in a PWD (WR) embankment or bandh (Bengali বাঁধ: an embankment — the land records' "Embankment"), or over it by a pumping station, which is closed when the river runs higher than the town behind it; the gated and pumped outfalls of Agartala's central saucer to the Haora and the Katakhal, and the Akhaura canal; a river, khal (Bengali খাল: a canal or channel — the land records' "Khal") or canal that crosses into Bangladesh a short way below the town, with no downstream control and no level data from across the border; a river with a CWC site, or the Gomati below the Dumbur reservoir; a pukur, a dighi (a large tank), a beel or an unfilled lunga that stores the town's water while its outlet is closed; or a chhara (Bengali ছড়া: a stream — the land records' "Streams") coming down from the tillas or the hill ranges, laden with silt; 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, by Agartala's gated and pumped outfalls, by a border reach, by the Dumbur release reach, by a full pukur, dighi, beel, lunga or pond, by a chhara or by a receiving drain, with the locks and closures of Clause 5.8.5(a) to (f) in place of the tidal lock windows.

Commentary. Tripura's towns drain into rivers that are often higher than themselves. Agartala's centre "is located at a lower level than other areas giving it the appearance of a saucer"; "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded"; and when the Haora and the Katakhal run high "Several pumps have been provided to lift the water out of the city during these seasons" (ADB IEE, 2020). So the closed outfall is the design case, not the exception. In August 2024 the Agartala Municipal Corporation was reported to run 18 flood pumps, about 4.5 m³/s in all on the press figures (as reported; NEER arithmetic), and the Haora rose to 12.42 m at the CWC Haora site on 22 August (as reported), the highest of four reported highest flood levels at that site, whose gauges and datums are not stated (Clause 5.8.5(b)). Below the towns every river crosses into Bangladesh, and no level from across the border was obtained, so the tailwater at the border cannot be checked against a downstream record (Clause 5.8.5(c)). The outfalls also belong to one body while the drains above them belong to others: the embankments and the Katakhal sluice are PWD (WR)'s; the drains, public tanks and water courses of a town vest in its Municipality (Tripura Municipal Act, 1994, s.91); the major road drains are built by PWD (R&B), and storm drains, flood pumps and the Akhaura canal and Katakhal works by Agartala Smart City Ltd; and no formal allocation among them was found (Chapter 6, Clause 6.9). No document found during research sets a design level for any outfall in the State, and PWD (WR)'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 days, if the pukur below it is already full, or if the chhara it drains to has buried its outlet in silt. This chapter makes these failure modes part of the design. Tripura 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, PWD (WR) canal, the Haora, the Katakhal, the Akhaura canal, the Bangeshwar Gang, the Debta Gang, the Nagichara, the Kalapani Charra and the Kalapania Khal in Agartala, every channel that discharges through a sluice in an embankment or to a drainage pumping station, any drain built or held by a Municipality, Agartala Smart City Ltd, TUDA, PWD (R&B) or NHIDCL with an internal width of 1.0 m or more, and every chhara, khal and lunga flow path 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, pukur** 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 pukur 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, AMC, TDMA or PWD (WR); 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.

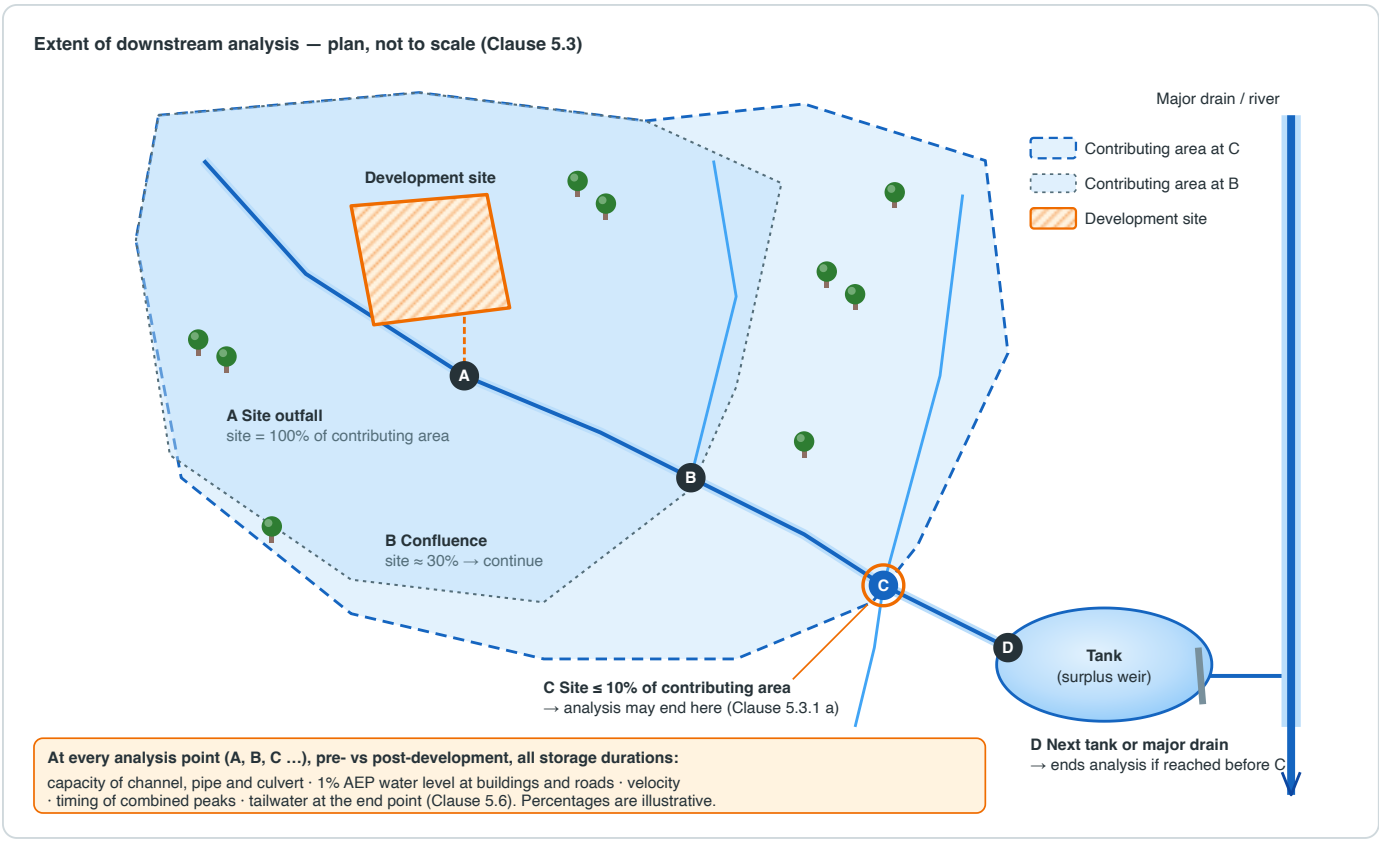

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next pukur or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Tripura. In the valleys of Tripura, where a drain may pass several pukurs and lunga wetlands before it reaches the Haora, the Gomati or the Khowai, which leave the State for Bangladesh near Agartala, near Sonamura and 1 km north of Khowai town (CGWB NAQUIM, West Tripura), 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 Agartala's central saucer, where "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded" and the outfalls to the Haora and the Katakhal must be pumped when the rivers run high (ADB IEE, 2020), and in Tripura's embanked valley towns, whose rivers stayed high through the flood of 19–24 August 2024 (as reported), when the Haora reached 12.42 m at the CWC Haora site on 22 August (as reported, datum not stated (TBC)). 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 Tripura, 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, TUDA 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.

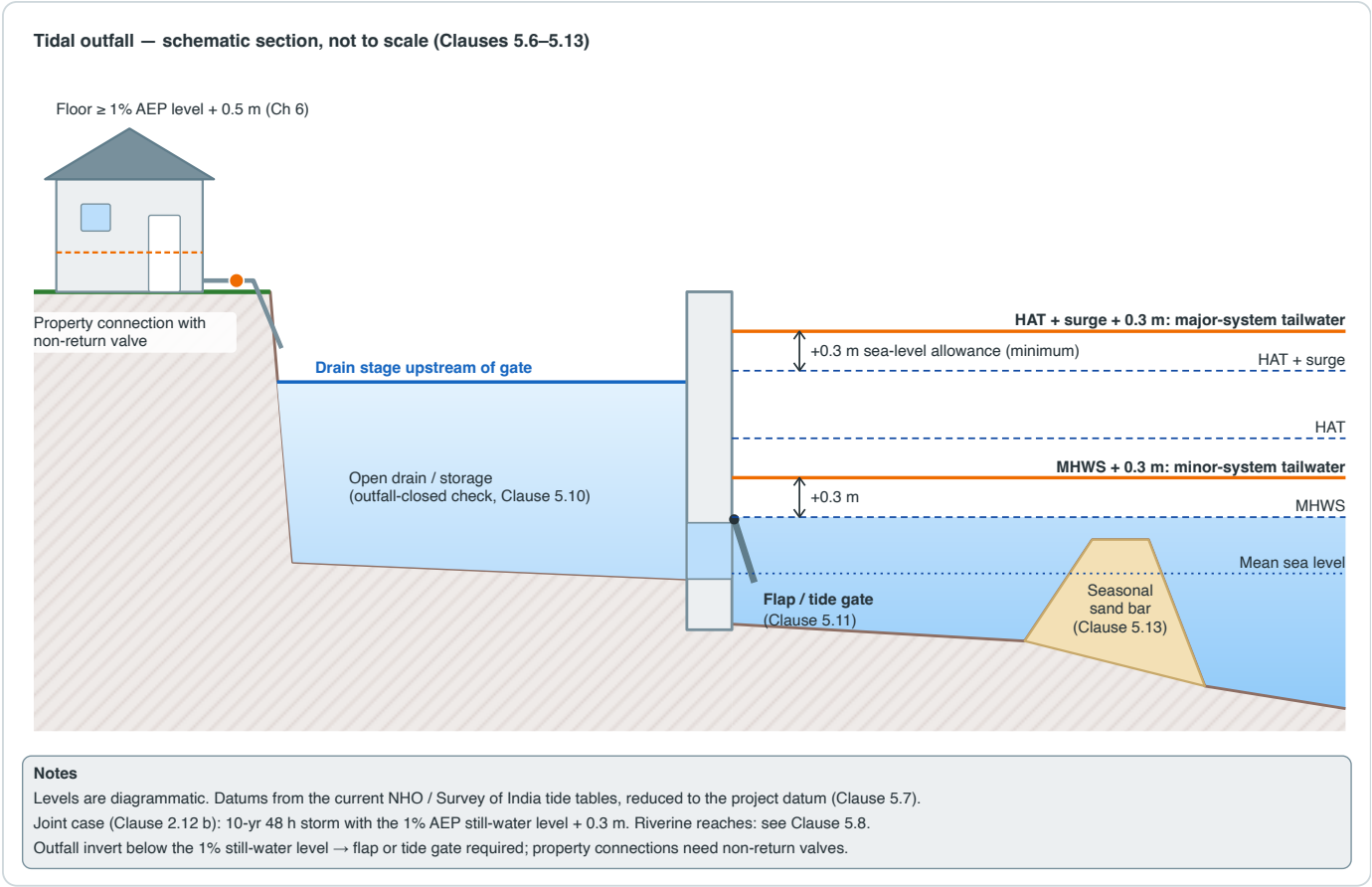

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater 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; Tripura has no coast, and the surge term does not arise in the State, whose rivers are held high by their own floods and possibly by backwater from the rivers they join in Bangladesh, for which no level data were obtained, 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 Tripura, 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:

- every river at every town on its banks, through the sluices and pumping stations in PWD (WR)'s embankments, among them the **Manu** at **Kailashahar** and **Kumarghat**, the **Gomati** (CWC: Gumti) at **Amarpur**, **Udaipur** and **Sonamura**, the **Muhuri** at **Belonia**, the **Juri** at **Nutan Bazar** and **Dharmanagar**, the **Khowai** at **Khowai** and **Teliamura**, the **Dhalai** at **Kamalpur** and the **Burima** (Bijoy) at **Gajaria** (Clause 5.8.5(a));
- in **Agartala**, the **Haora** at the CWC Haora site, the **Katakhal** and its double-barrel sluice, the **Akhaura canal**, and the **Bangeshwar Gang**, the **Debta Gang**, the **Nagichara**, the **Kalapani Charra** and the **Kalapania Khal**, with the outfalls of the central saucer and the flood pumps (Clause 5.8.5(b));
- every reach that ends at the border with Bangladesh, among them the Haora below Agartala, the Katakhal, the Akhaura canal, the Gomati below Sonamura, the Burima, the Khowai below Khowai, the Manu below Kailashahar, the Juri, the Deo, the Muhuri below Belonia and the **Feni** at **Sabroom** (Clause 5.8.5(c));
- the rivers with no gauge level, among them the **Deo**, the **Longai**, the **Feni**, the Manu at Manughat and the upper reaches above the first gauge of every river (Clause 5.8.5(d));
- the **Dumbur** reservoir of the Gumti hydel project at Tirthamukh and its release reach, the **Gomati** past Amarpur, Udaipur and Sonamura to the border (Clauses 5.8.3 and 5.8.5(d));
- every pukur, dighi, beel, haor, unfilled lunga and detention pond that receives a town's drains, among them the **Ujjayanta palace lakes**, the **MBB College lake**, the **College Tilla lake** and **Banamalipur Dighi** in Agartala, **Kalyan Sagar** at Matabari and **Rudrasagar** (Clause 5.8.5(e));
- the chharas of the tilla uplands of every valley and of the Baramura, Atharamura, Longtharai, Sakhan and Jampui ranges (Clause 5.8.5(f));
- any drain or channel of a Municipality, Agartala Smart City Ltd, TUDA, PWD (R&B) or NHIDCL, and any channel or sluice of PWD (WR), that receives storm water (Clause 5.8.5(g)); and
- elsewhere: any river or PWD (WR) channel listed in Annex 5B.

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

- (a) PWD (WR) 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 Dumbur reservoir of the Gumti hydel project at Tirthamukh, above the Gomati at Amarpur, Udaipur and Sonamura), 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, Agartala, transboundary outfalls, tributaries with CWC sites and the Dumbur release reach, pukurs, dighis and lunga wetlands, chharas, and consents and lines.**

- (a) **River-locked outfalls through embankment sluices.** For an outfall to a river directly, through a sluice or flap gate in an embankment (bandh), a town protection embankment or a wall, or through a drainage pumping station, or into a drain, khal, chhara, pukur or lunga wetland 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 or wall, the installed pumping capacity and the operating levels, including the river level at which each sluice is closed. Every level shall name its gauge and state its datum and its connection to the gauge datum of the nearest CWC gauge or State gauge, with its operator named; where the source does not state the datum, the level shall be entered as "datum not stated (TBC)" until it is confirmed. The river-level sites cited in this clause are CWC's, except the State gauges named as such (as reported); PWD (WR) runs none of them in the sources found. Most embankments and sluices in the State are PWD (WR)'s, which builds "flood protection embankments and anti-erosion work" (PWD (WR), as quoted): its pages give "154.41 Km of embankment and 98.00 Km of anti-erosion to protect 28000 ha" and, elsewhere, "41 nos. (134.55 Km) of flood protection embankment" (as quoted; dates not stated), its 2025 programme covered 44 embankments on 12 rivers (as reported), and TDMA's 2026 monsoon checklist lists 42 vulnerable embankment points (as reported). These counts conflict and are not used for design; the designer shall take the record of the embankment and sluice concerned. No Tripura embankment or drainage statute was found, and PWD (WR)'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). Tripura has no flood-plain 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 or State gauge on the same river, transferred to the outfall. The highest levels found during research (Table 5B.1), all as reported, from SANDRP's transcriptions of CWC tables (2018 and 2024) unless another source is named, and with the datum not stated for any of them (TBC), are: the Haora at the **CWC Haora site** (Agartala) **12.42 m** (22 August 2024); the Manu at **Kailashahar 25.95 m** (13 June 2018) and at **Kumarghat 32.97 m** (7 June 1993); the Gumti at **Sonamura 14.43 m** (23 July 1993) and at **Amarpur 32.74 m** (22 July 1993); the Gomati at the **State gauge at Udaipur 22.05 m** (14:45, 21 August 2024; Gomati district administration, as reported); the Dhalai at **Kamalpur 33.85 m** (15 May 1984); the Juri at **Nutan Bazar 20.66 m** (22 August 2024); the Muhuri at **Belonia 18.81 m** (22 August 2024); the Burima at **Gajaria 11.25 m**; and the Khowai at **Khowai 28.005 m** (24 June 2004). Where two values are reported for the same gauge, the higher applies until CWC confirms the gauge and its datum [TBC]: at the CWC Haora site the highest level is also given as 12.14 m (24 June 2004), 12.4 m (11 August 2017) and, by ENVIS, 11.08 m (2004), so **12.42 m** applies (item (b)); at Gajaria it is given as 11.15 m (24 June 2004) in the 2018 list and as 11.25 m in 2024, so **11.25 m** applies. Where a later flood has exceeded the listed level, the later level governs: at Belonia the 2024 peaks of 18.12 m (20 August) and 18.81 m (22 August) stand above the listed 16.98 m (4 August 1983) and 17.32 m (2 August 2024); at Nutan Bazar 20.66 m stands above 20.435 m (15 May 1984); at Kailashahar 25.95 m stands above 25.79 m (7 June 1993). The highest level on the Manu at **Manughat** is reported as 46.6 m (5 June 2001), 46.97 m (1993), 48.04 m (a 2024 table) and as "corrected" to 18.04 m (12 June 2018); the conflict is unresolved, none of these values shall be used, and an outfall there takes a modelled or surveyed level under item (d). The recorded level shall be transferred along the river with the water-surface slope of the flood that set it, from the CWC and State 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: **10.70 m** at the CWC Haora site (the highest of 10.48 m (ENVIS), 10.50 m at the State's Jahar Bridge gauge and 10.70 m at the CWC site, all as

reported); **25.34 m** on the Manu at Kailashahar (CWC, as reported; the State's press gave the danger mark as "24.00 mtr" in 2018 and a "critical level 23.05 m" in 2024, as reported, which conflict, so the higher applies); and **12.5 m** on the Gumti at Sonamura (CWC, as reported) (set by this Manual). The level-monitoring sites have a highest level only, and the State gauges at Udaipur and Amarpur only an "extreme danger" level (22.00 m and 32.00 m, as reported); there the 10% AEP case uses the design river level until a frequency analysis is accepted (set by this Manual).

  - **Tailwater.** The tailwater at the outfall shall be the higher of that river level beyond the sluice, gate or embankment, and the maximum level in the drain, khal, chhara, pukur or lunga 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, its storage as surveyed in its present condition, net of silt, encroachment, fill, 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 pukur, dighi, beel, lunga wetland or detention 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 or diesel 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 after it for the longer of (i) as long 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, and (ii) where no stage record has been analysed, which is the case at every border reach, on the Katakhal and the Akhaura canal and, until CWC's records are obtained, at every other outfall in the State, **a further 72 hours** (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 State gauge under Clause 5.10.6 shows it and the Authority approves it.
  - **Gate failure, leakage and breach.** Floor levels and pumped outfalls behind a sluice 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. Tripura's embankments leak and are weakened: the 2025 programme included 6 km of leakage repairs on the Haora embankment at Agartala (as reported), and the CAG found that sand extraction outside approved blocks "caused weakening of river embankment and erosion of riverbed" (CAG, Audit Report for the year 2022-23, Sand Mining).
- (b) **Agartala.** For an outfall in Agartala or elsewhere in the Agartala Planning Area (the Master Plan 2045 area of 238.57 km², which takes in the Agartala Municipal Corporation and 49 gram panchayats, as reported), whose Greater Agartala Planning Area has a North Zone (north of the Katakhal), a Central Zone (between the Haora embankment on the south and the Katakhal on the north, the erstwhile municipal area) and a South Zone (south of the Haora) (ADB IEE, 2020):
  - **The central saucer.** "The major part of the City (Central Agartala) has a flat terrain", the North and South Zones have "a rolling terrain with average altitude varying from a high of 25 to 30 m to a low of 8 m", and "the central part of the city is located at a lower level than other areas giving it the appearance of a saucer"; "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded"; the main drains are masonry-lined, but "the feeder drains are earth-lined and in a poor condition with silt and vegetation choking them" (ADB IEE, 2020); and the lowest ground of the Agartala–Sonamura valley is at Bamutia, 8.91 m above MSL (CGWB NAQUIM, West Tripura). Every outfall of the Central Zone to the Haora or the Katakhal, and every outfall of the North and South Zones whose invert is below the design river level, is river-locked under item (a), and every drain is taken in its present condition.

- **The Haora.** The Haora rises in the Baramura range and runs 46 km, with a catchment of 414 km², west through the Agartala–Sonamura valley into Bangladesh near Agartala (CGWB NAQUIM), and it is "the only source of surface water for Greater Agartala" (ADB IEE, 2020). The river level at every Haora outfall is that of item (a) at the **CWC Haora site**: design level **12.42 m** (22 August 2024, as reported), **datum not stated (TBC)**, the highest of the values reported, 11.08 m (2004; ENVIS, as reported), 12.14 m (24 June 2004; the CWC list of 2018, as reported), 12.4 m (11 August 2017, as reported) and 12.42 m; and danger level **10.70 m**, the highest of 10.48 m (with an "extreme" level of 10.78 m; ENVIS, as reported), 10.50 m at the State's Jahar Bridge gauge and 10.70 m at the CWC site (as reported; for the CWC site Google Flood Hub gives warning 10.0 m, danger 10.7 m and extreme 12.4 m, as reported). These are probably different gauges or datums (NEER reading), and the higher applies until CWC confirms the gauge and datum of each (set by this Manual). The river stood above its danger level in Agartala's urban flood of June 2022 (10.82–10.85 m at Jahar Bridge against 10.50 m, and 10.72 m at the CWC site against 10.70 m) and on 24 August 2026 (10.72 m at 08:00 against 10.70 m) (all as reported). The level at which the gates on the Haora are closed is the operator's, and is to be obtained in writing [TBC].
- **The Katakhal and its sluice.** The Katakhal drains the north of the city to Bangladesh through a double-barrel sluice of PWD (WR) near Bhuturia (as cited). No gauge, level or hydraulic description of the Katakhal or of its sluice was found during research [TBC]. Its level at an outfall shall be the higher of a modelled level under Clause 5.8.2(b), with the Katakhal routed as a closed storage behind its sluice, and the highest flood level surveyed at the outfall from flood marks of 19–24 August 2024 or of a later flood, with its source stated; until both have been made, the Haora design level of this item applies at the Katakhal's outfalls, as the higher river level of the two that bound the saucer (set by this Manual). It is a border reach under item (c). Its cleaning in 2026 and the three sewage treatment plants being built on its banks (10 MLD at Ranjit Nagar, 15 MLD at Abhaynagar Bridge and 1.5 MLD at Astabal Bridge, all fed by interception of drains; State affidavit to the NGT, July 2026) do not change its level for design until they are completed and surveyed.
- **The Akhaura canal and the city's other channels.** "The Akhaura canal system running along the Akhaura road serves mainly the central area" (ADB IEE, 2020) and flows to Bangladesh (as reported); no level or hydraulic description was found [TBC], so its level is found as the Katakhal's, with the Haora design level until then, and it is a border reach under item (c). The Bangeshwar Gang, the Debta Gang, the Nagichara and the Kalapani Charra (ADB IEE, 2020) and the Kalapania Khal are routed as storage behind the outfall they end in; where they come down from the tillas they are also chharas under item (f).
- **The flood pumps.** When the Haora and the Katakhal run high, "Several pumps have been provided to lift the water out of the city during these seasons" (ADB IEE, 2020). In August 2024 the Agartala Municipal Corporation was reported to run 18 flood pumps of "up to 900,000 liters … per hour" each, which is about 0.25 m³/s each and about 4.5 m³/s for the 18 (NEER arithmetic), and 6 diesel pumps, discharging by pipeline to the Katakhal in the north and the Haora in the south (as reported); 6 new flood pumps were reported in August 2025 (as reported); and a ₹1,000 crore proposal for "two protective embankments and installation of three additional pumping stations", to be "implemented in phases, depending on the availability of funds", was reported in July 2026 (as reported). No pump-station design capacity was found [TBC]. Every outfall of the central saucer shall be designed for **local rain with the outfalls shut**: the drain, khal, pukur or lunga behind each gate is routed as a closed storage under item (a), with its whole catchment and with an outflow of no more than the permanent pumps that serve that outfall, as their owner confirms them in writing, less the largest pump. The per-pump figure above is a press figure, not a rating: the certified pump curve at the design river level of this item shall be used (Clause 5.12), and the pumped discharge shall be included in the level of the Haora or the Katakhal (Clause 5.12.3). The proposed pumping stations and embankments shall not be counted until they are commissioned, and the 650 m Haora embankment reported in March 2026 (as reported) only once PWD (WR) confirms its crest and extent in writing.
- **Drainage projects.** The ADB Agartala City Urban Development Project (53262-001) provides 48.2 km of new or rehabilitated storm-water drains (ADB IEE, 2020); about 50 km of new drains were reported planned by the Agartala Municipal Corporation and Agartala Smart City Ltd (as reported); and the stated aim of a later ADB proposal, to cut drainage time "from one to two hours to about 15–30 minutes" (as reported;

DPR not read [TBC]), is not a design value under this Manual (Clause 2.3.6(o)). None of these works shall be counted until it is built, and none of the documents found gives a design return period, intensity or outfall level. The drainage chapter of the Master Plan for the Agartala Planning Area 2045, if it has one, was not read [TBC]; where it publishes 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.

- (c) **Transboundary outfalls.** Every river of the State leaves it for Bangladesh: the Haora towards the Titas, the Gomati towards Comilla, the Khowai towards Habiganj, the Manu, the Dhalai, the Juri and the Deo towards the Kushiyara, and the Muhuri and the Feni towards Feni, while the Longai runs north out of the State towards the Kushiyara (general geography, to be confirmed for each river (NEER reading)). The Haora enters Bangladesh near Agartala, the Gomati near Sonamura and the Khowai 1 km north of Khowai town (CGWB NAQUIM). No Bangladesh river level was obtained for any of them, there is no downstream control in India, and the level at the border can be raised by backwater from the rivers they join or by embankments across the border (NEER reading). For an outfall to a river, khal or canal on the reach that ends at the border, among them the Haora below Agartala, the Katakhal, the Akhaura canal, the Gomati at Sonamura, the Burima below Gajaria, the Khowai at Khowai, the Manu at Kailashahar, the Juri, the Muhuri at Belonia and the Feni at Sabroom:
    - **Level.** The tailwater is the highest of: (i) the highest recorded level at the nearest CWC or State gauge on the same river under item (a), transferred to the outfall; (ii) the level of August 2024 at that gauge where it is higher; and (iii) a modelled level under Clause 5.8.2(b) where one has been made. No lower level shall be assumed because the river leaves the State, and no channel, regulator or embankment across the border shall be credited (set by this Manual). Where the sites named in 2024 were not working (Sonamura-2, Feni, Sabroom and Kadamtala, as reported), or no site exists, the level is the higher of a modelled level and the highest flood level surveyed at the outfall from flood marks, with its source stated, and no outfall shall be designed without one of them (set by this Manual).
    - **Lock.** A gates-shut case shall be run for the duration of the river peak, with the lock of item (a); where no stage record has been analysed, the gate stays closed for a further 72 hours after the 72-hour storm (item (a)) (set by this Manual).
    - **Extent of analysis.** Where the downstream analysis of Clause 5.3 would continue across the border, it ends at the last analysis point in India, with the level of this item as its boundary (set by this Manual).
- (d) **Tributaries with CWC sites, and the Dumbur release reach.** For an outfall to a river with a CWC site, to a river with no gauge, or to the Dumbur reservoir or the Gomati below it:
    - **Rivers with and without gauges.** Item (a) applies, with the levels it lists. On the Deo, the Longai, the Feni, the upper reaches of every river above its first gauge, the Manu at Manughat and 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 PWD (WR), the local body or the District Magistrate and Collector, with its source stated, and no outfall shall be designed without one of them (set by this Manual). No catchment area or length was obtained for the Manu, the Juri, the Deo, the Dhalai, the Longai, the Muhuri or the Feni [TBC]; the Khowai runs 140 km with a catchment of 1,100 km² in the old West Tripura district, the Burima (Bijoy) 54 km, and the Gomati is the "biggest river in the state" (CGWB NAQUIM).
    - **Consent and levels of the operator.** Storm water shall not be discharged to the Dumbur reservoir or to the Gomati below it within the release reach without the written consent of the operator of the Gumti hydel project at Tirthamukh (TSECL, as reported; NEEPCO's role was not established [TBC]). 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.
    - **Reservoir level.** The reservoir's full reservoir level is reported as **93.55 m** and its minimum drawdown level as 83.6 m (NRLD and CWC, via SANDRP, as reported), and its "danger level" as **94 m**, with 93.85 m reached in August 2024 (the Gumti Hydel Project, as reported). These conflict, and the higher, **94 m**, is used as the reservoir level at release and as the tailwater of an outfall to the reservoir, datum not stated (TBC), until the operator confirms its levels in writing (set by this Manual).
    - **Release reach.** For an outfall to the Gomati below the dam, past Amarpur, Udaipur and Sonamura to the border, a river that travels about 120 km in Tripura (as reported), 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 dam, routed to the outfall, with the flow of the catchment below the dam 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 after the storm (set by this Manual). No release record was found: on 21 August 2024 the Gomati district administration reported "two flap gates fully open and one at 50%", the first release "since 1993", while the State's power minister said that no gate had opened (all as reported), and the Ministry of External Affairs said the releases were "automatic" (as quoted). Until the operator states a recorded release and its duration in writing, the release is the dam's spillway capacity of **481.38 m³/s** (as reported) (set by this Manual). No attenuation by the storage of the reservoir shall be credited to the river below, and no gate shall be assumed to open earlier or wider than the operator's records show. Catchments that drain to the reservoir or to the release reach take AMC III at any time (Chapter 3).
    - **Warnings are not notices.** No design shall rely on a notice, a siren, a telephone call or an SMS warning of a release, on the 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) **Pukurs, dighis and lunga wetlands as receiving storage.** For an outfall to a pukur, a dighi, a beel or haor, a lunga wetland, a khal or a detention pond, directly or through a drain that ends in it, among them the Ujjayanta palace lakes, the MBB College lake, the College Tilla lake and Banamalipur Dighi in Agartala, Kalyan Sagar at Matabari (Udaipur) and Rudrasagar:
    - **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 khal or drain 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 (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 khal 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 any pukur, dighi or beel in the State, and no inventory of Agartala's ponds was found [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.** Public tanks vest in the Municipality (Tripura Municipal Act, 1994, s.91), no pond, water body or wetland may be filled except by the Local Body with the State Government's prior approval (TBR 2017, r.9(3)), and the land records class the pukur ("Tank/Pond"), the dighi ("Large tank"), the beel ("Watery land") and the haor ("Big watery land") as land classes of their own, with the doba a "Ditch", not a pond (Diversion of Land Rules, 2025, Appendix-I). The storage of a pukur, dighi, beel or lunga wetland is part of the drainage system: it shall not be credited to one project, and no project shall reduce it (Chapter 7). A pukur 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 pukur. No drain that carries sewage shall discharge to a pukur, dighi or beel without the interception and screens of Clause 6.3.6(e) and Clause 8.9.
    - **Heritage and fisheries tanks.** The palace-era and temple tanks, among them the Ujjayanta palace lakes and Kalyan Sagar, are existing storage with heritage and fisheries constraints, not detention: they start full, they shall not be drawn down before or after a storm to make room for a project's water, and their banks, the pukurpar and dighirpar of the land records ("Bank of tank", "Bank of large tank"), shall not be cut for an outfall without the written consent of their custodian (set by this Manual).
    - **Rudrasagar.** Rudrasagar is a Ramsar site (No. 1572, 240 ha; designated on 8 November 2005 by the Ramsar record and "officially designated" on 29 February 2007 by the Forest Department, both as cited, which conflict) with a catchment of 6,052 ha (as cited), and its water level is the subject of the High Court's suo motu PIL 05/2017 (as reported). No storage in it shall be credited to a project, no drain shall be brought to it or to its catchment's channels without the interception and screens of Clause 6.3.6(e) and

Clause 8.9, and no work in it shall be designed without the permission of the Wetland Authority of Tripura (Chapter 7): the CAG found that ring roads built without that permission "reduced the water level" (CAG, Audit Report for the year 2021-22).

    - **Lunga floors.** An unfilled lunga is the natural flow path and storage of the land between tillas. It shall be routed as storage, never as zero storage, in its present condition, and the rule of this item applies to it as to a pukur (set by this Manual).

- (f) **Chharas from the tillas and the hill ranges.** For an outfall to a chhara or other hill stream, among them the Nagichara and the Kalapani Charra in Agartala, the chharas that come down from the Baramura, Atharamura, Longtharai, Sakhan and Jampui ranges, and the gullies of the tilla uplands of every valley, 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, with the rainfall of its sub-area in Annex 2A (in sub-area TR-E the higher of the adjoining valley sub-areas, Clause 2.3.6(c)), 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, fill, silt and solid waste; (ii) the level at the outfall of any flood study of the stream made by or for PWD (WR), PWD (R&B) or the local body [TBC]; and (iii) the highest flood level surveyed at the outfall from flood marks of 19–24 August 2024 or of a later flood, and from the records of the local body, PWD (WR) or the District Magistrate and Collector, with its source stated. No outfall to such a stream shall be designed without items (i) and (iii) (set by this Manual).
    - **Bed level 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 chhara drops its load on reaching the lunga floor, the silt trap of Clause 6.3.6(m) shall be placed above the outfall. An outfall on landslide ground, or in the path of a slide or of sediment from one, is a hazard-first site (Clause 2.3.6(i)): 2,032 landslip locations were reported in August 2024 (as reported).
    - **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 chhara itself ends at a river-locked sluice or in Agartala's central saucer, 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 or sluice without the written consent of PWD (WR), which builds and holds the State's flood embankments and the Katakhal sluice. No Tripura embankment or drainage statute was found, so the consent rests on PWD (WR)'s ownership of the work, and no written procedure or form for it was found during research [TBC] (set by this Manual). Storm water shall not be discharged to a drain of another body without the written consent of that body: in a ULB, private drains may be connected to municipal drains only "after obtaining the written permission of the Municipality" (Tripura Municipal Act, 1994, s.161), an unauthorised drain into a municipal drain or water course may be demolished at the owner's cost (s.162), and the Municipality "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall in or outside the Municipal area" (s.156(1)), with outfalls and pumping stations built "singly or jointly", within or outside its area (s.159); to a road drain or culvert, the consent of PWD (R&B), or of NHIDCL on a national highway it builds; to a work of Agartala Smart City Ltd that has not been handed over, that of Agartala Smart City Ltd; and in the area of the Tripura Tribal Areas Autonomous District Council, where the Municipal Act does not extend (s.1(2)), that of the District Council or the body it designates [TBC] (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 bar on filling any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the prior approval of the State Government (TBR 2017, r.9(3)), so that an outfall seated by filling part of a pukur, chhara or lunga is a filling; the "zone of river (within 15 metres from river bank)", which limits the height, length and covered area of buildings in it (r.9(4)) and on this Manual's reading reaches a pump house; the rule that within 5.00 m of a tank the owner shall prevent drainage from the building passing into it (r.4(1)(e)), which this Manual reads as allowing only storm water that has passed the interception of Clause 6.3.6(e) to reach a pukur by an outfall (NEER reading); in the ULBs in the hill areas, the 5 m no-build distance from the outside edge of a water course (r.90(1)(i)) and the protective works within 5.0 m of a tank, jhora or natural drain and within 30 m of a jhora (r.90(1)(m)); and the status of a water body as land under the Diversion of Land Rules, 2025, as amended on 6 March 2026, whose current procedure for a water body this Manual does not state [TBC]. Tripura has no flood-plain zoning law; the "Natural Hazard Prone Areas" of r.2(44) and the Haora flood-plain-zone localities that PWD (WR) has mapped (Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat); map, return period and status not known) mark land where an outfall is built with the river-locked and breach cases of item (a) in place, and the plinth rule of r.55 (not less than 60 cm) sets no flood level, so the 1% AEP level of this clause and the floor levels of Clause 6.11 govern.

No pump, sluice, gate or dam operation that helps drainage, such as pumping a drain, khal, pukur or lunga down before a storm, closing a sluice late, opening a sluice while the river is higher than the land behind it, or opening the Dumbur 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 khal, the pukur or the river (Clause 5.12.3). Pumping shall not be used to move water into a pukur, a dighi, a beel 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. Tripura's rivers and towns break that assumption, because the same storms fill the rivers and fall on the towns beside them. In 1993 the IMD 24-hour records of both of the State's stations in IMD *Extremes*, Kailashahar (A) 377.2 mm on 6 June and Agartala (A) 257.2 mm on 22 July, came with the highest levels on the Manu at Kailashahar and Kumarghat (7 June 1993) and on the Gumti at Amarpur (22 July) and Sonamura (23 July 1993) (IMD *Extremes*; CWC levels as reported). In the 24 hours to 08:30 IST on 22 August 2024, Bagafa recorded 49 cm and Agartala Aero 23 cm (IMD press release of 22 August 2024), and on the same day the Haora reached 12.42 m at the CWC Haora site, the Muhuri 18.81 m at Belonia and the Juri 20.66 m at Nutan Bazar (as reported). The Haora stood above its danger level in Agartala's urban flood of June 2022 and again on 24 August 2026 (as reported). The Dhalai at Kamalpur and the Juri at Nutan Bazar set their earlier highest levels on 15 May 1984, before the south-west monsoon (as reported), and Kailashahar's wettest months on record are May and April (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 one reservoir found above a Tripura town, the **Dumbur** reservoir of the Gumti hydel project at Tirthamukh, whose release reach is the Gomati past Amarpur, Udaipur and Sonamura to the border. Its operator is reported as TSECL (as reported); NEEPCO's role was not established [TBC]. The dam is reported as 30 m high and 103 m long, with a spillway capacity of 481.38 cumec, a full reservoir level of 93.55 m, a minimum drawdown level of 83.6 m and live storage of 0.312 BCM (NRLD and CWC, via SANDRP, as reported). Other reported figures conflict: the dam is said to have been built in 1974 or in 1977 and to be of 15 MW or of 8.6 MW (as reported); its reservoir area is given as 0.709 km² (NRLD, as quoted), which is implausibly small for 0.312

BCM (NEER reading), against a water spread of 4,500 ha originally and 3,049.3 ha by 2012 (ICAR, *Indian Journal of Fisheries*) and "41 sq km" or about 40–42 km² (as reported). In August 2024 the reservoir reached 93.85 m against a "danger level of 94 m" (the Gumti Hydel Project, as reported), above the reported full reservoir level, while a CWC bulletin gave 92.6 m and 86% of live storage on 22 August and SANDRP gave 92.7 m (as reported). On 21 August 2024 the Gomati district administration reported "two flap gates fully open and one at 50%", and the opening was reported as the first release "since 1993", while the State's power minister said that no gate had opened (all as reported); the Ministry of External Affairs said that Bangladesh's floods were due to rain in the catchment downstream of the dam and that the releases were "automatic" (as quoted). The same day the Gomati at the State gauge at Udaipur stood at 22.05 m against an "extreme danger" level of 22.00 m (as reported). No operating rule that bounds a release, and no release record with a discharge, was obtained [TBC]. Until they are, Clause 5.8.5(d) uses the reported spillway capacity, with the flow of the catchment below the dam as it occurred in the same event, and takes the higher of the conflicting reservoir levels. The minor-irrigation earth dams of PWD (WR) can also fail in heavy rain: the Kashari Cherra earth dam was eroded by the heavy rain of September 2017 (CAG, Audit Report for the year 2022-23); no register of such dams above towns was obtained [TBC]. The river levels used in this Manual come from SANDRP's transcriptions of CWC tables and from district and press reports; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Tripura the tailwater at a town outfall is set not by the tide but by a river held above the town behind an embankment, by the Haora and the Katakhal standing above Agartala's central saucer, by a river that leaves the State with no level data from across the border, by a pukur or lunga that is already full, by the release of the Dumbur reservoir, or by a chhara 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 ADB IEE for Agartala (2020), the State's filings before the NGT and the press give no return period, design intensity, runoff coefficient or time of concentration for any drain (Clause 2.3.6(o)). The State has no flood-plain 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 neighbouring North-East editions of this series: the operator, the sills, crests, pumps and closing levels, every level tied to a named gauge, and a design level never below the highest level recorded at the nearest CWC or State gauge. All the river levels used come from SANDRP's transcriptions of CWC tables or from district and press reports, with no datum stated, so each is "as reported" and is entered with "datum not stated (TBC)". Where the sources give two or more highest levels for one gauge (the Haora, the Burima at Gajaria) or two danger levels (the Haora, the Manu at Kailashahar), 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 Manu at Manughat, whose four reported levels range from 18.04 m to 48.04 m, is left out altogether. The lock is the heart of the clause. The gate is shut for the whole 72-hour storm and for as long after it as the river stays above the sill. Where no stage record has been analysed, which is the case everywhere in the State until CWC's records are obtained and always on the border reaches, the Katakhal and the Akhaura canal, the lock lasts a further 72 hours. The reason is the event of record: the flood of August 2024 ran from 19 to 24 August, six days, with the Haora at its peak of 12.42 m on 22 August (as reported), and the 72-hour storm with a 72-hour recession spans an event of that length (NEER reading). A longer minimum, such as the neighbouring edition's seven days on its main rivers, was not used, because Tripura's rivers are rain-fed ("All rivers are rain-fed and ephemeral", ADB IEE, 2020) and far smaller than the main rivers for which that minimum was set (NEER reading); a shorter one was not used, because no transboundary level is known and the 2024 rivers stayed high for days. The receiving pukur, dighi or lunga starts full because one that has filled in the first storm of a spell is full for the next, and because no stage–storage relation exists to show otherwise. The pump-down of 48 hours with the gate still shut is the drawdown time of Clause 4.7, and the Municipality's duty against water that "is or is likely to become a breeding place of mosquitoes" (Tripura Municipal Act, 1994, s.233) points the same way: 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 in writing, less the largest unit, because the only figures for Agartala's pumps are press figures and no pump-station design capacity was found. A designer with an analysed CWC stage record can justify a different lock under Clause 5.10.6.

The second case is Agartala. Item (b) names the city's outfalls because the State's capital drains through them: a saucer between the embanked Haora and the Katakhal, drained by pumps when they are high (ADB IEE, 2020). It takes the highest of the reported Haora levels, 12.42 m at the CWC Haora site, because the four reported highest flood levels and three danger levels probably belong to different gauges or datums (NEER reading), and requires a surveyed and modelled level for the Katakhal and the Akhaura canal, for which no level of any kind was found, with the Haora level in the meantime, because a tailwater set too low floods the saucer. It counts the proposed pumping stations and embankments only once they are built.

The third case is the border. Item (c) is new to this series: every river of the State leaves it for Bangladesh, with no downstream control in India and no level data from across the border, so the tailwater is the highest recorded level at the nearest gauge or the 2024 peak, never a lower level because the river leaves the State, and the downstream analysis ends at the border.

The fourth case is the tributary and the release reach. Item (d) applies the river rule of item (a) to the rivers with CWC sites, asks for a modelled or surveyed level where there is none, and applies to the Dumbur reservoir and the Gomati below it the reservoir and release-reach rule of the neighbouring editions: the operator's levels in writing, 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 reservoir level at release is the "danger level" of 94 m rather than the full reservoir level of 93.55 m, because the reservoir rose above the full reservoir level, to 93.85 m, in August 2024 (as reported); and no release discharge was recorded for that event, which the district reported as a gate opening and the power minister denied (as reported).

The fifth case is the pukur, the dighi and the lunga. Item (e) treats them as storage that belongs to the drainage system and starts every storm full to its outlet. The law already protects them as land and as water: public tanks vest in the Municipality (s.91 of the Municipal Act), the Building Rules bar the filling of any pond, water body or wetland without the State's prior approval (TBR 2017, r.9(3)), and the land records class pukurs, dighis and their banks separately (Diversion of Land Rules, 2025, Appendix-I). Agartala's palace-era and temple tanks are civic landmarks and fisheries as well as storage (NEER reading), so item (e) does not let a project draw them down. No stage–storage relation was found for any pukur or dighi, so the clause asks for a survey rather than a figure.

The sixth and seventh cases are the chharas and the consents. Item (f) follows the hill-stream rule of the hill editions of this series for the chharas that come down from the tillas and the hill ranges: 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 PWD (WR)'s consent and the owner's consent because a design that discharges through an embankment or into another body's drain cannot be checked without them; no Tripura embankment statute was found, so PWD (WR)'s consent rests on its ownership of the work, and 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 Building Rules' bar on filling, their 15 m zone of river and their hill-ULB distances bind where they apply, and the floor levels follow Clause 6.11 because no rule in the State fixes a flood level to build 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

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

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

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

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

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

5.10 Outfall-closed (tide-locked) storage check

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

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

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

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

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

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

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

- (a) the outfall is closed for **two consecutive lock windows of 6 hours each**, centred on two consecutive high tides of the local tidal curve. For a semi-diurnal tide, the window starts are therefore about 12.4 hours apart.
- (b) During each lock window, gravity discharge is **zero**.

- (c) Between lock windows, gravity discharge is computed against the J1 tidal curve, including the head loss of the flap gate and any non-return valve.
- (d) The first lock window shall be placed so that it is centred on the peak 1-hour block of the final 24 hours of the storm. A second run with the first window **starting** at that peak block shall also be made. The more severe governs.

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

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

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

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

This shall be demonstrated by routing, not by a single volume balance. The release from each facility after a lock window ends may exceed the release caps of Chapter 4, because the facility is emptying into a drain that has just reopened. That release shall be included in the downstream analysis (Clauses 5.4 and 5.9).

5.10.5 **Drawdown after the storm.** After the second lock window, the storage shall drain under the J1 tidal curve. The drawdown requirement of Clause 4.7 shall be met, with pumping where gravity cannot meet it (Clause 5.12).

5.10.6 **Site study.** A longer or shorter lock may be used where a site study gives a time series of still-water level for the design case. The study may use a calibrated hydrodynamic model, gauge records of past events, or a surge hindcast. Locks shorter than the default require the Authority's approval. A longer lock shall be used where:

- sand-bar closure (Clause 5.13) or river backwater (Clause 5.8) keeps the outfall closed for longer; or
- the gauge record shows tailwater above the outfall invert for more than 6 hours per tide in comparable past events.

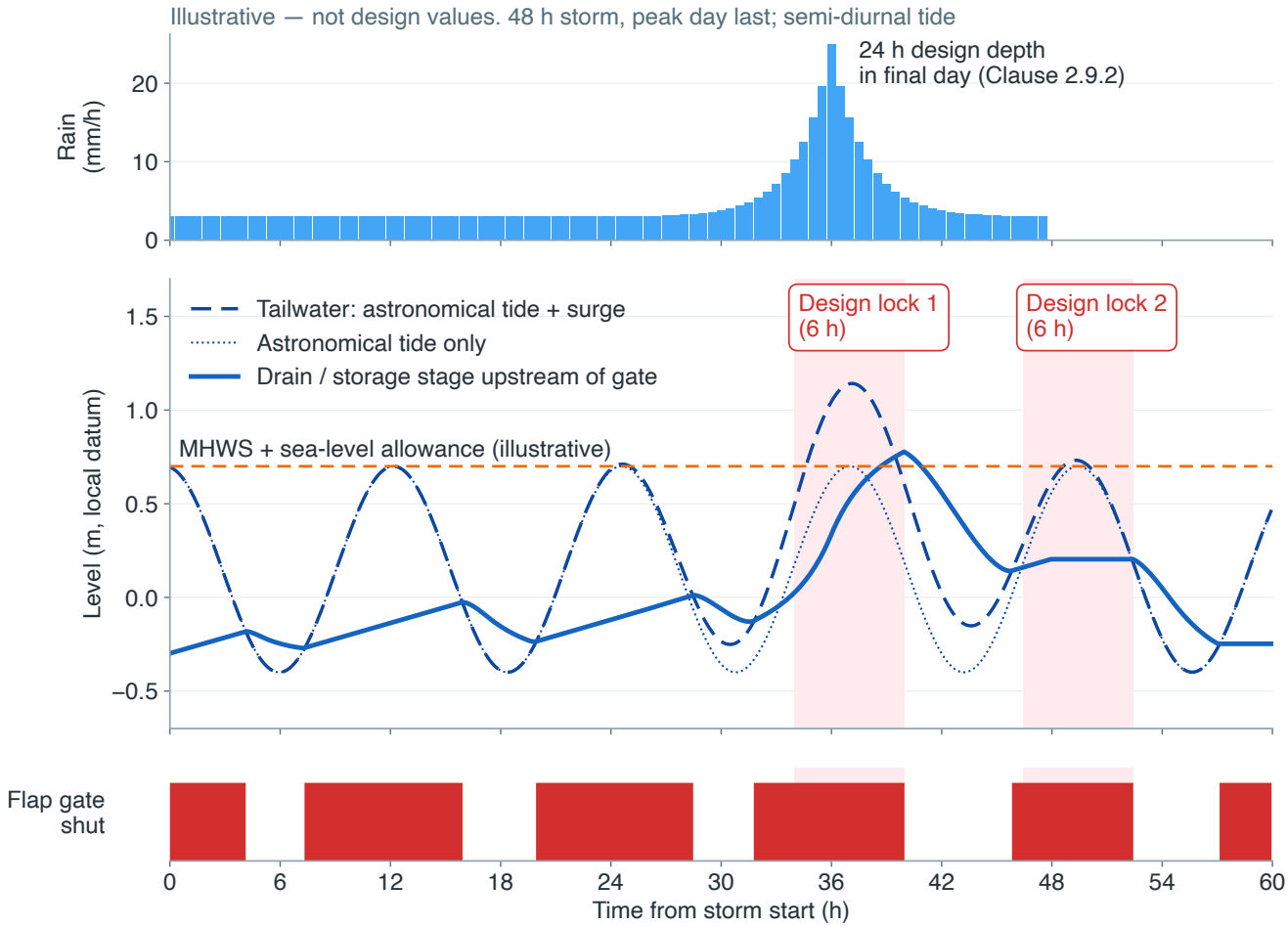

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal tailwater and joint-probability concepts of MoHUA/CPHEEO Manual on Storm Water Drainage Systems (2019), Part A, §6.3.6.

Commentary. The outfall-closed check is the distinctive Tripura requirement in this Manual. In Tripura it applies where an outfall is shut not by the tide but by a river held above the town behind an embankment sluice, by the Haora and the Katakhal standing above Agartala's central saucer, which then drains only by its pumps, by a river that leaves the State with no level data from across the border, by a pukur or lunga that is already full, by a release from the Dumbur reservoir, or by a chhara in spate. In August 2024 the State's flood ran from 19 to 24 August, six days, and the Haora reached 12.42 m at the CWC Haora site on 22 August (both as reported); the Muhuri at Belonia rose to 18.12 m on 20 August and 18.81 m on 22 August, above its earlier record of 16.98 m (CWC levels as reported); and Agartala's 18 flood pumps, about 4.5 m³/s in all on the press figures (as reported; NEER arithmetic), lifted the central saucer's water over the embankments to the Haora and the Katakhal. No gate-closure record or stage hydrograph was obtained for any outfall in the State [TBC]. 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, where no stage record has been analysed, for a further 72 hours, so that the lock spans a six-day event such as that of August 2024 (NEER reading), or for as long as the river stays above the sill where it is longer; a pukur, dighi, beel or lunga full to its outlet at the start; a pump-down within 48 hours with the gate still shut; a lock of not less than 72 hours after the storm on the Dumbur release reach; and a lock of at least 24 hours at a chhara 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 Tripura the outfalls do not cross a beach, but the outfalls of Agartala and of the embanked valley towns pass through sluices and flap gates in PWD (WR)'s embankments or are pumped over them, and the gates and pumps are the towns' defence against the rivers. When the Haora and the Katakhal run high, "Several pumps have been provided to lift the water out of the

> city during these seasons" (ADB IEE, 2020); in August 2024 the Agartala Municipal Corporation was reported to run 18 flood pumps of "up to 900,000 liters … per hour" each, about 0.25 m³/s each (NEER arithmetic), and 6 diesel pumps, discharging by pipeline to the Katakhal and the Haora (as reported), and no pump-station design capacity was found [TBC]. The Katakhal leaves the city through a double-barrel sluice of PWD (WR) near Bhuturia (as cited). The embankments leak and are weakened: PWD (WR)'s programme of 2025 included 6 km of leakage repairs on the Haora embankment at Agartala (as reported), and the CAG found that sand extraction "caused weakening of river embankment and erosion of riverbed" (CAG, Audit Report for the year 2022-23). The CAG also found "frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report for the year 2022-23), and plastic and silt hold flap gates open or shut. No Tripura embankment or drainage statute was found, and PWD (WR)'s sluice operating rules and closure durations were not found during research [TBC]. The embankments and sluices are PWD (WR)'s, while the drains and pumps behind them are a Municipality's, Agartala Smart City Ltd's or another body's, 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 Tripura: 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 PWD (WR) 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 PWD (WR) 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. Tripura 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 chharas bring down from the tillas and the hill ranges, the sand bars that the rivers build (balurchar, "Sandy land bed", is a land class of its own in the land records, Diversion of

> Land Rules, 2025, Appendix-I), and the plastic and solid waste that block drains and gates. The tilla uplands are "10 – 30 m high mounds with gullies in between them" (CGWB NAQUIM, West Tripura), and their cut slopes silt the drains on the lunga floor below; Agartala's feeder drains are "in a poor condition with silt and vegetation choking them" (ADB IEE, 2020); and the CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report for the year 2022-23, Solid Waste Management). 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 PWD (WR) 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 chhara outfalls above the range of bed movement, by putting a silt trap above an outfall where a chhara reaches the lunga floor, and by 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 PWD (WR) 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 a lunga between tillas on the edge of Agartala draining to a khal
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) Tripura 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.** Tripura'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 (Clause 2.3.6(o)). The ADB found that "Although GAPA has numerous storm water drains and two major rivers flowing through it, the city suffers from recurrent flood problems. During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded", that "Most of the main drains are masonry-lined, but the feeder drains are earth-lined and in a poor condition with silt and vegetation choking them" (ADB IEE, 2020), and its Agartala project provides 48.2 km of new or rehabilitated drains (ADB IEE, 2020); the State told the NGT that a "Partial drainage system is present in Agartala Municipal Corporation" (State affidavit in O.A. No. 673 of 2018), and about 50 km of new drains were reported planned by the Agartala Municipal Corporation and Agartala Smart City Ltd (as reported). Nothing was found for the drains of the other towns [TBC]. The drains also work in a setting that the plains editions of this Manual meet only in part. They run on lungas (Bengali লুঙ্গা: the flat valley land between low hills — the land records' "Flat lands between tillas"), the natural flow paths of the valleys, where towns are built and ponds filled; they take the runoff and silt of the tillas (Bengali টিলা: a low hill or hillock — the land records' "Hillock"), "10 – 30 m high mounds with gullies in between them" (CGWB NAQUIM, West Tripura), and of chharas (Bengali ছড়া: a stream — the land records' "Streams") from the hill ranges; they end at sluices in embankments, or bandhs (Bengali বাঁধ: an embankment — the land records' "Embankment"), behind rivers that stand above the town, in khals (Bengali খাল: a canal or channel — the land records' "Khal") such as the Katakhal and the Akhaura canal that cross into Bangladesh, and in pukurs and dighis; and they carry the towns' sewage, because Agartala's

sewers serve only its North Zone and no other town has any (State affidavit to the NGT, July 2026). And they are divided among owners: the drains vest in the Municipality (Tripura Municipal Act, 1994, s.91), but in Agartala the UDD and PWD (DWS) carry out 98% of the AMRUT works "and only a few minor works" are the Corporation's (CAG, Audit Report 2019-20), PWD (R&B) builds the major roads and drains, Agartala Smart City Ltd the new storm drains and flood pumps, PWD (WR) the embankments and the Katakhal sluice, and NHIDCL the national-highway drains on NH-108B and NH-208, with no formal allocation among them (see the Commentary to Clause 6.9). Fixing the rainfall (Chapter 2) is only half the answer. The other half is a second, surface-level system that carries the flows the pipes cannot, without flooding buildings. That is the dual drainage concept of this chapter, taken from Kansas City Metro APWA Section 5600 (5601.8, Levels of Service), which requires every element to have a 1% AEP overflow path.

6.2 Definitions

Term	Meaning in this Manual
Minor system	Inlets, pipes, covered drains and open drains that carry runoff up to the minor design AEP of Table 6.1 without surcharge above the limits of Clause 6.8.
Major system	The surface flow paths (streets, overland flow paths, open channels, floodways and storage) that carry flow above the capacity of the minor system, up to the 1% AEP (100-yr) event.
Overland flow path	A defined surface route, in public land or a recorded easement, that carries major-system flow to a receiving waterway.
Spread (T)	Width of flow in the gutter and carriageway, measured from the face of the kerb.
Sag	A low point on a road or flow path from which water can leave only through an inlet or by ponding to an overflow level. A trapped sag has no surface overflow route.
Clogging factor	The fraction of an inlet's clean hydraulic capacity assumed lost to debris (Clause 6.6.3).
Hydraulic grade line (HGL)	The line joining the free-surface levels in a conduit system, or the piezometric levels where the system is under pressure.
Covered drain	A rectangular drain, usually beside a road, closed by cast-in-situ or precast cover slabs that form a footpath.
Sediment allowance	The depth or area of a drain or pipe assumed filled with silt when its design capacity is computed (Clause 6.7.8).
Check event	An AEP rarer than the design AEP at which the combined minor and major system must still meet the limits of Table 6.2.
High-density area	An area notified as such by the approving authority under Clause 6.4.4.
Class I area	An urban local body with a population of 1 lakh or more (the CPHEEO definition).

6.3 The dual drainage concept

6.3.1 Every drainage system shall be designed as two systems that work together:

- (a) a **minor system** that carries the minor design flow of Table 6.1 below ground or in drains, keeping streets usable and spread within Table 6.2; and
- (b) a **major system** that carries all flow above the minor-system capacity, up to the 1% AEP (100-yr) flow, on the surface without entering buildings and within the depth and hazard limits of Clause 6.5.

6.3.2 **Every element has a 1% path.** Every inlet, sag, pipe, drain, culvert and storage element shall have an identified 1% AEP overland flow path to a receiving waterway, tank or outfall. The path shall be shown on the drainage plan (Clause 6.15).

6.3.3 **Major-system design flow.** The major system at any point shall carry the 1% AEP peak flow less the minor-system capacity at that point. The minor-system capacity used in this subtraction is the capacity of the inlets after the clogging factors of Clause 6.6.3, or the pipe capacity, whichever is less. At sags and at any location used to set building floor levels, the major system shall also be checked with the minor system **fully blocked** (Clause 6.10.3).

6.3.4 **Rainfall and method.** Design flows shall use the rainfall of Chapter 2 (including the climate factor of Clause 2.8) and the methods of Chapter 3:

- (a) the Rational Method only for catchments ≤ 16 ha and a single conveyance element. It shall not be used to accumulate flows down a network whose total catchment exceeds 16 ha;
- (b) a hydrograph method with hydraulic routing (for example SWMM, HEC-HMS with a hydraulic model, or an equivalent 1D/2D model) for networks above 16 ha and for any network with storage, pumping or a tidal outfall;
- (c) a minimum time of concentration of 10 minutes.

6.3.5 **No transfer between catchments.** Neither the minor nor the major system shall divert flow from one natural catchment to another unless the approving authority accepts a catchment-wide study showing no adverse effect.

6.3.6 **Drains that carry sewage, and tilla and hill drains.** No town in Tripura has a full sewerage system: Agartala's sewers serve only its North Zone, and the other 19 ULBs treat none of their sewage (State affidavit to the NGT in O.A. No. 606 of 2018, 6 July 2026). 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 on the tillas and in the hill ranges the drains also carry silt, sand 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 Municipality's existing power to "require separate provisions to be made for drainage of sewage and other offensive matters as distinct from rain-water and other unpolluted sub-soil water" (Tripura Municipal Act, 1994, s.164), its written permission for every connection (s.161), and, in the ULBs in the hill areas, the rule that drains for surface water "shall not be connected with any drain carrying sullage water or sewage" (TBR 2017, r.99(2)(d)) 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), and in Agartala's central saucer with the pumps of Clause 5.8.5(b). 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 pukur, a dighi, a beel, the Haora, the Katakhal, the Akhaura canal, the Kalapania Khal or a channel that drains to Rudrasagar, designed under Clause 8.9. The interception shall be **sized on the dry-weather flow, with a defined bypass for monsoon flows**, so that it does not reduce the drain's storm capacity and so that **storm flows are kept out of the sewage treatment plants that the interception feeds**; the screen shall be sized for the plastic and solid waste that the drain carries. No new storm drain shall be brought to a pukur, a dighi or the catchment of Rudrasagar 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 sewered North Zone of Agartala as its connections are made, 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, whether it is intercepted to a sewage treatment plant, 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 tilla or hill catchment, which in this Manual means land in sub-area TR-E of Annex 2A (the Baramura, Atharamura, Longtharai, Sakhan and Jampui ranges and the hill faces above the valley towns), the tilla slopes and cut faces of every valley (Clause 4.11 (tilla rule) and (hill rule)), any catchment whose natural ground slopes more than 10% on average, and every chhara that comes down from the tillas or the hill ranges:

- (f) **Debris racks and traps.** Every inlet, drain or pipe entrance and culvert that receives flow from **1 ha or more** of unbuilt tilla or hill land (forest, bamboo, scrub, cultivated or bare slope, a cut tilla, a quarry or a cut slope), or from a chhara 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 chhara, a lunga floor or a pukur 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 tilla or 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 landslides, or that drains a mapped slide, a cut tilla face that has failed or a 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 tilla or 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 tilla or 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 (R&B), NHIDCL, the Municipality 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 chhara 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 (R&B), NHIDCL 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, kept clear of silt, vegetation and debris after every heavy-rainfall day and on the dates of item (f); 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 tilla or hill cutting beside it, placed in or beside a chhara, a lunga floor or another line of natural drainage, or on a slope from which a storm can carry it into one.
- (l) **Sloping sites and tilla 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 tilla rule or the hill rule of Clause 4.11. These items give a design standard to what the Tripura Building Rules 2017 already ask of the ULBs in the hill areas: "diversion of the natural flow of water coming from uphill side of the building away from the foundation" (r.91(r)); a drainage system that carries the water of the site and of "the hillside above" to "main drains or natural streams/jhoras without stagnation, avoiding any possibility of erosion, slope failure" (r.99(1)(c)); slopes "not less than 1 : 60" all round a building and the uphill flow diverted "through suitable lined or unlined drains" (r.99(2)(a) and (b)); an impervious apron "not less than 0.75 m. wide" (r.99(2)(l)); breast and retaining walls with weep holes and filters (r.100); a soil test and slope-stability certificate on slopes of 30° and above (r.90(1)(f)); and no site within 200 m of "a sinking or probable slip zone" (r.90(1)(h)). The rules do not list which ULBs are in the hill areas [TBC], and they do not extend to tilla land outside Part X or to the TTAADC area, where this item applies on its own.
- (m) **The tilla foot, the hill–lunga break, silt and waste.** Where a chhara, a gully of the tilla uplands or a drain that receives one reaches the lunga floor or flatter ground, a silt trap designed under Chapter 9 (Clause 9.8) shall be provided above the point where the gradient falls, at every tilla foot that drains 1 ha or more of tilla land to a public drain, with machine access and a stockpile place that is not a chhara, a lunga floor, a pukur 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 tilla or hill cutting and no construction and demolition waste shall be placed where a storm can carry it into a drain, a chhara, a lunga or a pukur; placing it in a chhara, a stream or a drain is a filling

that r.9(3) of the TBR 2017 already bars without the State's prior approval. 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 Agartala 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 Tripura, and it has two parts because the State's drains fail in two ways that the criteria of this chapter, which assume clear storm water on gentle ground, do not see. The first is sewage. The State generates 82.4 MLD of sewage against 17.4 MLD of treatment capacity, and Agartala alone 61.0 MLD; its 103.6 km of sewers, "with 4011 nos. household connection", run "only in the North Zone"; and its sewage treatment plants, the one at Akhaura and the 39.5 MLD under construction, "are designed to be connected through Interception & Diversion of Drains" (State affidavit to the NGT in O.A. No. 606 of 2018, 6 July 2026; the State gave the Central Monitoring Committee a figure of 227.43 MLD in August 2025, which conflicts). The tribunal's concern, as the State's affidavit quotes it, is that "storm water drains are being tapped and taken to STPs which is not legal. If surface drains are used as open conduit, then storm water flows should have separate conveyance system. Sewage and storm water mixing particularly during monsoon will not only upset functioning of STP but, will also lead overflow of untreated sewage"; and two of the plants stand near or on flood plain, where flooding may lead to "flowing of untreated sewage in the river during the monsoon" (NGT order of 13 April 2026, as quoted in the same affidavit). The law already allows the separation that item (a) asks of each site: the Municipality may "require separate provisions to be made for drainage of sewage and other offensive matters as distinct from rain-water" (Tripura Municipal Act, 1994, s.164), and in the hill ULBs surface-water drains "shall not be connected with any drain carrying sullage water or sewage" (TBR 2017, r.99(2)(d)). Items (a) to (e) follow the combined-sewer rules of the plains editions of this series and of the neighbouring North-East edition: a site keeps its storm water separate up to the boundary, so that the town can separate its system street by street as sewers 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 pukur, the Haora, the Katakhal or the Akhaura canal is intercepted and screened. Item (e) sizes the interception on dry-weather flow with a monsoon bypass because that is the tribunal's own point: an interception that takes storm flow upsets the plant and overflows untreated, and one that is sized for storm flow takes the drain's capacity. The screens are there because the CAG found that, with no wire nets on the drains, "solid waste or plastic waste reached to the river" and that "there is frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report for the year 2022-23). Separation itself is for the Authority to plan, not for each site.

The second is the tillas and the hills. The tilla uplands are "10 – 30 m high mounds with gullies in between them" (CGWB NAQUIM, West Tripura), and they are cut for building and fill; the lungas between them are the valleys' flow paths, so the silt of every cut runs onto the lunga floor and into its drains. The slopes fail: 2,032 landslip locations were reported in August 2024, with deaths at Gardang near Santirbazar and at Debipur, and 17 in June 2018, 11 of them in Khowai district (all as reported). The roads through the hill ranges carry the same load: inspections for the High Court found on NH-108B and NH-208 "No proper drainage system … water logging everywhere; RCC drain hole blocked with mud, vegetation; Earthen drain damage & blocked", with culverts blocked "by silt, vegetation, debris" chainage by chainage (WP(C)(PIL) No. 06 of 2026, judgment of 8 September 2026, para 44). That is why item (m) puts a silt trap at every tilla foot and at the hill–lunga break, and item (k)(v) keeps culverts clear. No Tripura 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 tilla and 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 bamboo, timber, stones 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 tilla and hill drains carry coarser sand and 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). Part X of the Tripura Building Rules 2017 already reaches towards these rules in the hill ULBs without numbers; items (l) and (m) give them design standards of this Manual's own, and apply them also on the tillas of the plains ULBs and outside the rules' extent. The clause deals with sewage, silt and debris at the drain; it does not ask for the concrete channelisation of the chharas and lungas, whose capacity has been lost to filling and encroachment, 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: Agartala 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 Agartala, the Central Zone between the Haora embankment and the Katakhal, the erstwhile municipal area and the city's saucer (ADB IEE, 2020); the localities that the sources name for flooding, Chandrapur, Baldakhal and Aralia (August 2026, as reported); the Haora flood-plain-zone localities that PWD (WR) has mapped, Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat) (State affidavit to the NGT in O.A. No. 673 of 2018); and any central business district or transit-oriented development zone with the base FAR of 7 under TBR 2017, r.50(6)(a); with the boundary of each to be confirmed by the Agartala Municipal Corporation and TUDA under the Master Plan for the Agartala Planning Area 2045, whose text was not read [TBC];
- (b) in every Municipal Council and Nagar Panchayat area and every Local Planning Area, the area that the applicable Master Plan or development plan identifies as the core area, old town or central business district, and the main market of a town [TBC]; and
- (c) any area in a Tier A body where the master plan permits a floor space index above the base value for the zone.

6.4.5 **Retrofit.** Where an existing drain cannot practicably be enlarged to the Table 6.1 AEP, the shortfall shall be made good by upstream storage (Chapter 4), regional storage (Chapter 7) or an improved major-system path. The approving authority shall record the residual level of service.

> Commentary. The values in Table 6.1 match the Clause 2.4 summary and add rows for underpasses and critical infrastructure. They exceed the CPHEEO (2019) national advisory minimums of 5-yr for Class I cities and 2-yr elsewhere (CPHEEO Part A, Table 4.1). Note 2 of that table allows a State committee to adopt higher values. The 10-yr tier for high-density areas follows Gupta (IIT Bombay), who recommends "1 in 10 year for residential-high density", and Malaysia's MSMA 2, which uses 10-yr minor and 100-yr major systems for link houses, apartments, commercial and industrial land. The road values resolve a conflict in Indian codes. IRC:SP:50-2013 recommends 1–2 years for urban road drains. IRC:SP:42-2014 suggests 25 years for urban roadside drains and a check flood at the next higher return period. APWA 5600 (2006) uses 50-yr for arterial, 25-yr for collector and 10-yr for residential street crossings. Table 6.1 adopts the APWA tiers and the IRC:SP:42 check-flood concept. Splitting arterials into 50-yr evacuation routes and 25-yr others has no direct precedent and is set by this Manual. The 50-yr standard for underpasses is likewise set by this Manual, because an underpass is a trapped sag where the failure mode is deep water on a live carriageway. The default high-density areas in Clause 6.4.4 are set by this Manual and apply until the approving authority notifies a map.

6.5 Street hydraulics: spread, depth and flow hazard

6.5.1 **Gutter flow.** Flow in a triangular kerb-and-gutter section shall be computed with the modified Manning (Izzard) equation:

> Q = (Ku / n) · Sx^(5/3) · SL^(1/2) · T^(8/3)

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

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

Table 6.2 — Street flow limits

Road class	Minor design event (Table 6.1)	Check event and 1% AEP event
Arterial	Spread shall leave at least one through lane in each direction clear of water. No flow across the crown.	Depth ≤ 150 mm at the crown and ≤ 350 mm at the deepest point; hazard limits of Clause 6.5.3
Collector	Spread T ≤ 3 m. No flow across the crown except at a sag intersection.	As above
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.

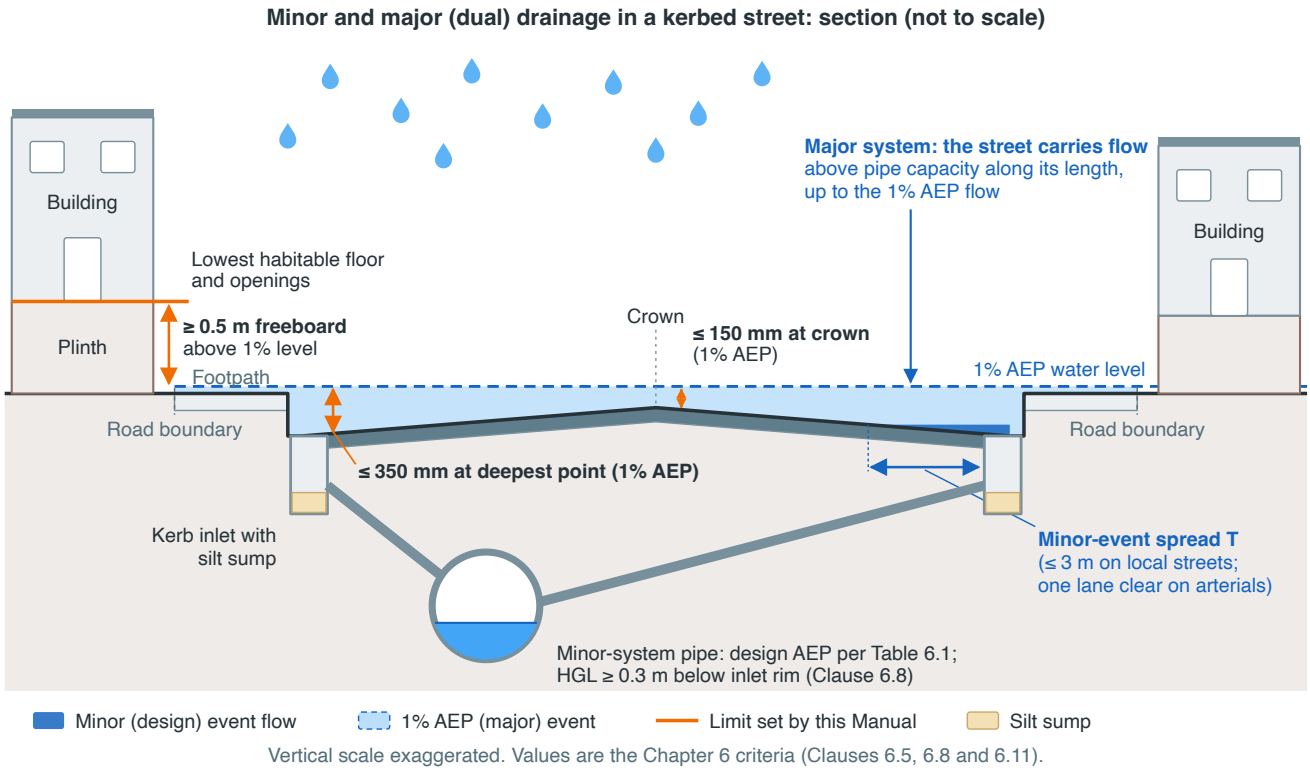


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

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 Tripura 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:

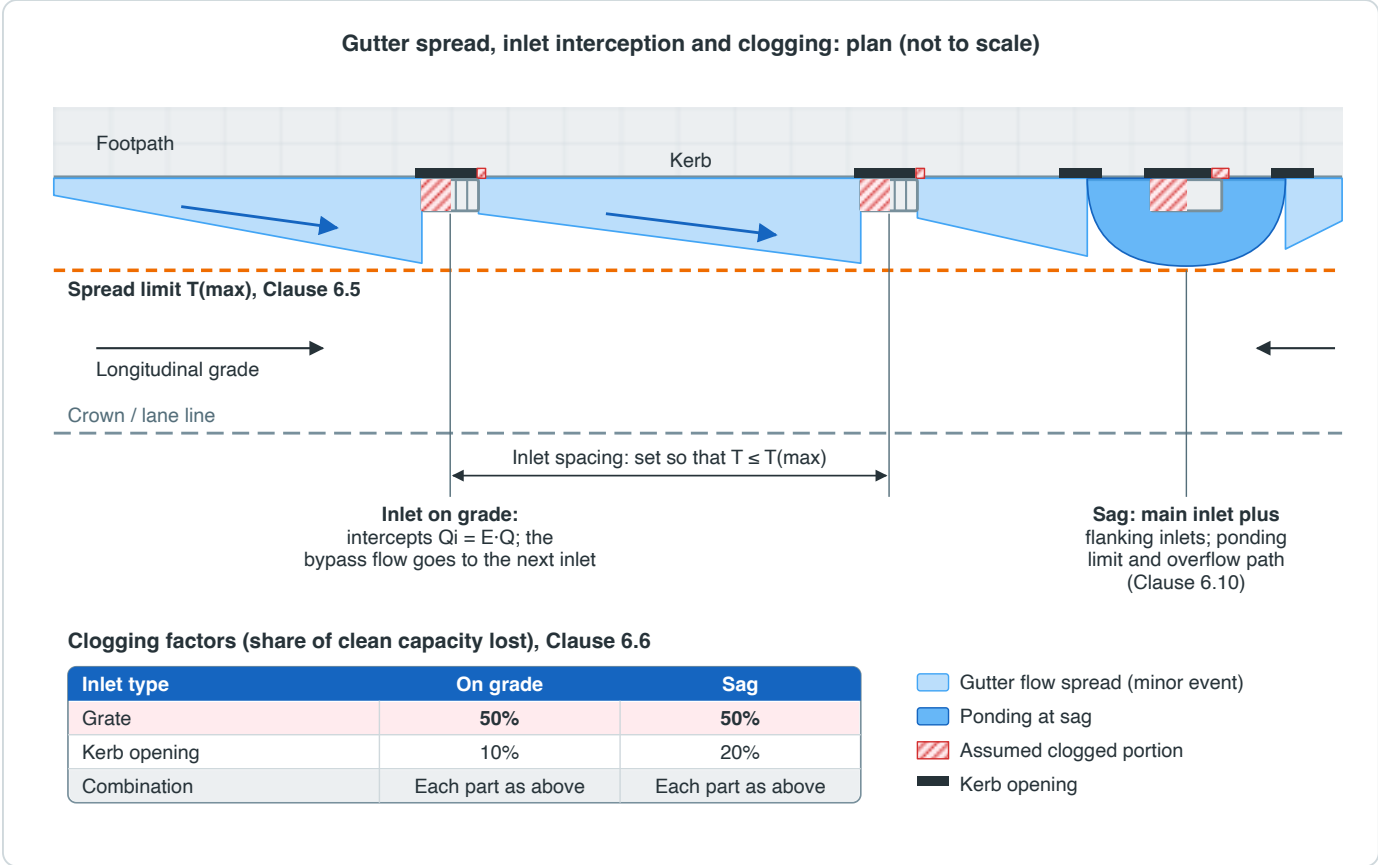
- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass 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 Tripura 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 (R&B), of the Agartala Municipal Corporation, of Agartala Smart City Ltd or of any other local body in the State was found during research [TBC]; the Tripura Building Rules 2017 ask only for "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" (TBR 2017, r.14) and, in a sub-division, "drainage facilities with pucca drain ensuing drainage of each individual plot … leading to existing public drain or natural drainage channels" (r.10(2)(f)). 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 lunga floors and flood plains of Tripura's valleys, and in Agartala's flat central saucer, are very flat, which shortens the calculated spacing anyway; on the steep roads of the hill ranges and through tilla cuts, 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 settlements of the Jampui hills (Vangmun), Gandacherra and Chhamanu, in any ULB in the hill areas under Part X of the Tripura Building Rules 2017 (which the rules do not list [TBC]) 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

Drain	Minimum freeboard	Source
Q 300 to < 3,000 m³/s	1,200 mm	As above
Q ≥ 3,000 m³/s	1,500 mm	As above
Any roadside drain	Not less than 150 mm	IRC:SP:42-2014
Steep (supercritical) channels	Equal to the flow depth	CPHEEO 2019 §5.3.2

At bends, the freeboard shall be measured from the water level on the outside of the bend, including the superelevation $\Delta y = V^2 T / (2\,g\,r_c)$, where T is the top width and r_c the centreline radius (CPHEEO 2019, Eq. 5.29).

6.7.10 **Bends and junctions.**

- (a) The centreline radius of a bend in a drain shall be at least 3 times the drain width (CPHEEO 2019 §5.3.3). In engineered channels it shall be at least 2 times the top width and not less than 30 m (CPHEEO 2019 Table 5.11).
- (b) Where drains meet, a junction sump shall be provided with an internal width of at least twice the width of the outgoing drain. Incoming drains shall enter at less than a right angle to the outgoing flow, and the outgoing invert shall be below the sump floor so that water does not stand in the sump (CPHEEO 2019 §5.3.4).

6.7.11 **Manholes and access chambers on pipes.** Manholes shall be provided at every junction, change of size, alignment or gradient, and at the head of every pipe. Spacing on straight runs shall not exceed Table 6.8.

Table 6.8 — Maximum spacing of manholes on straight pipe runs

Pipe diameter	Maximum spacing
300–600 mm	40 m
700–1,000 mm	100 m
1,050–1,400 mm	150 m
1,500 mm and above	300 m

Source: CPHEEO 2019 Table 11.5. Manhole sizes, drops and covers: Chapter 9, Clause 9.12.

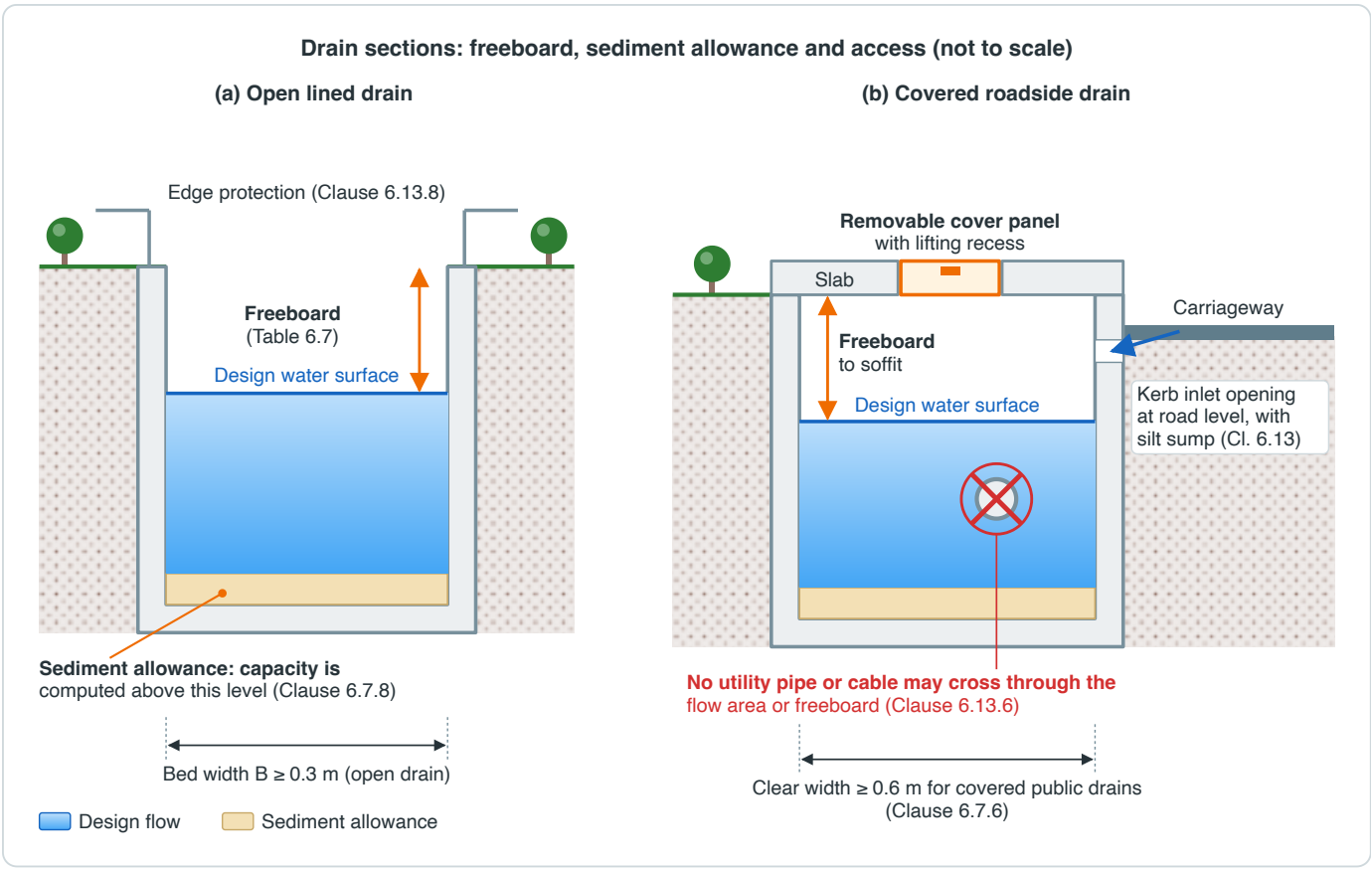


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

Commentary. The n values are those of CPHEEO (2019) Table 5.1. The higher minimum design values have no direct precedent; this Manual sets them because CPHEEO notes that the 0.011 value for spun pipes "may be taken as given by the manufacturer". That is a clean-pipe value, and Tripura 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 Agartala floods of 17–19 June 2022 and of 31 May–1 June 2025, when a man died in a manhole (as reported), in a city whose "feeder drains are earth-lined and in a poor condition with silt and vegetation choking them" (ADB IEE, 2020) and where the CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report for the year 2022-23), and on NH-108B and NH-208, where inspections for the High Court found an "RCC drain hole blocked with mud, vegetation" and culverts blocked "by silt, vegetation, debris" (WP(C)(PIL) No. 06 of 2026, judgment of 8 September 2026). 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. Agartala'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 Tripura most town drains end at a sluice in an embankment, behind which the river stands higher than the drain in a flood, at a pumped outfall, or in a pukur, dighi or lunga that is already full (Clause 5.8.5). Agartala's centre lies "at a lower level than other areas giving it the appearance of a saucer", and its worst floods come when "the waters in the Haora and Katakhal Rivers" are "higher than the city", so that "Several pumps have been provided to lift the water out of the city" (ADB IEE, 2020). The Haora's highest level at the CWC Haora site is reported as 12.42 m (22 August 2024) against a danger level of 10.70 m (as reported, datum not stated (TBC)), and the river stood above that danger level in June 2022 and in August 2026 (as reported). No design level for any 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, the pumps or the full pukur 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

Internal width of drain, W	Open drain	Closed (covered) drain
more than 25.0 m	W + 12.0 m	W + 3.0 m

For an open drain, the larger part of the margin shall be on the side used for maintenance access.

6.9.8 **Use and protection.**

- (a) The reserve shall be shown as a separate plot on the layout or site plan and transferred to the Approving Authority free of cost, as roads and open space reservations are. Where the drain is a PWD (WR) channel, the reserve is transferred to PWD (WR).
- (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.

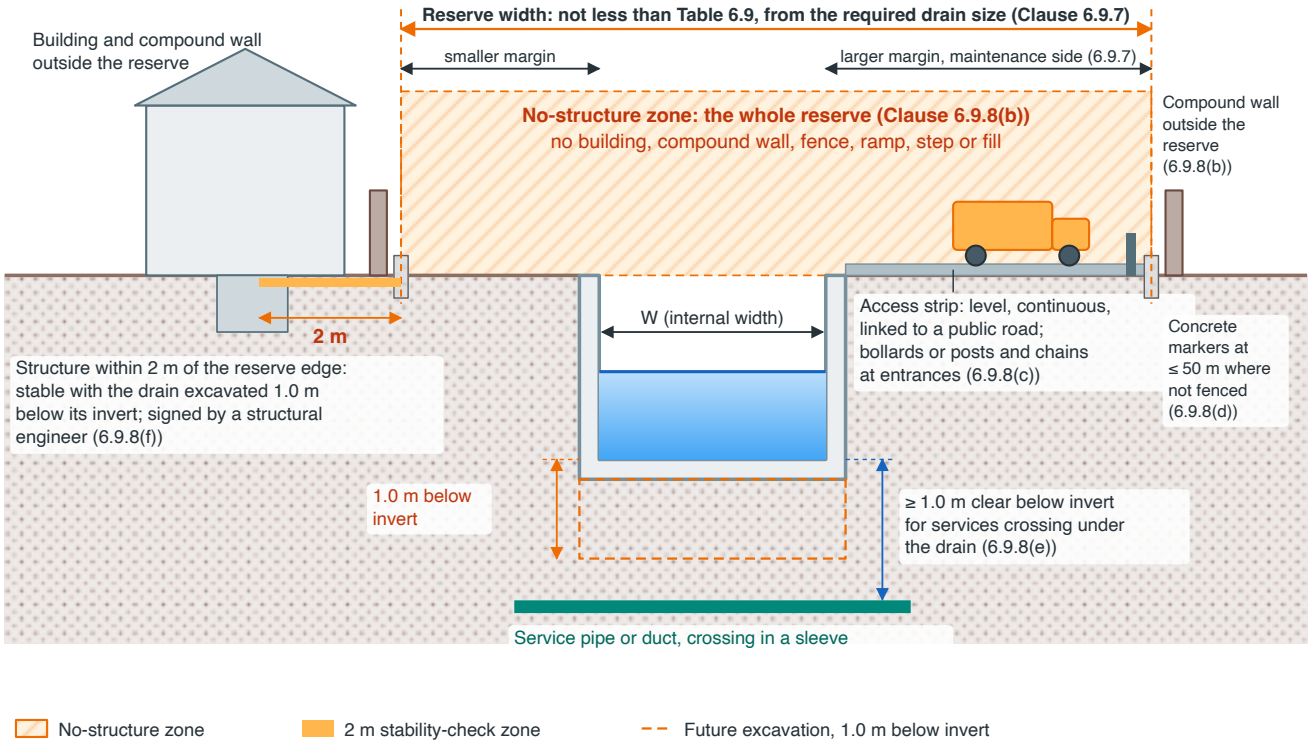


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Tripura, 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. Tripura has statutory lines along rivers and round tanks, but no reserve width along a drain, no no-build setback from a river in the plains, and no flood-plain zoning law. The lines are those of the Tripura Building Rules 2017: no "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts shall be filled up", except where the Local Body, with the prior approval of the State Government and for reasons recorded in writing, allows a canal, pond, rivulet, stream, river or "flood plain area to be filled up" (TBR 2017, r.9(3)); "In the case of a building in the zone of river (within 15 metres from river bank) or other water fronts of large water bodies (more than 1000 acres)", a building may be no more than 5.00 m high (6.50 m on stilts, the stilts not more than 3.00 m and not walled up), no more than 20.00 m long along the water, at least 50.00 m from the next and no more than 200.00 m² in covered area (r.9(4)), which is a regulated zone, not a no-build line; within 5.00 m of a tank the owner shall prevent drainage from the building passing into it (r.4(1)(e)), which is a drainage rule, not a setback; and in the ULBs in the hill areas no site may be "within five meters in any direction of the outside edge of such water courses" (r.90(1)(i)), the only no-build distance from a watercourse in the rules, with protective works within 5.0 m of a tank, reservoir, jhora or spring, water source or natural drain and where the site is within 30 m of a jhora (r.90(1)(m)). The site plan shall show the "natural drainage channel/jhora" (r.5(1)(p)), a sub-division needs a pucca drain to each plot leading to a public drain or natural drainage channel (r.10(2)(f)), and a notice in Form I is required before drains are covered (r.38). The Municipality holds "all public tanks, streams, reservoirs" and "all public sewers, drains, channels, tunnels, culverts and water courses in, alongside, or under any street" (Tripura Municipal Act, 1994, s.91), and may demolish an unauthorised drain and act against encroachment of its drains (ss.162 and 166). The rules do not define "river bank" or "outside edge of water course" (NEER reading). The DST&E's "Statutory Guidelines for protection and preservation of lakes, ponds and water bodies in Tripura" (as cited) were not read and give no line here, a direction against construction "within 75 Mtrs. of the end of the lake" is of unverified source and scope and is not a rule, and the buffers, if any, of the Master Plan for the Agartala Planning Area 2045 were not read [TBC]. Tripura has no flood-plain zoning law: the rules' "Natural Hazard Prone Areas" include flood-prone areas in river plains shown in the Flood Atlas of India of CWC and areas flooded by "heavy intensity rains, inadequate drainage, etc. as identified through local surveys in the Development Plan" (r.2(44)), and PWD (WR) has mapped flood-plain-zone localities on the Haora for the NGT (map, return period and status not known). None of these gives a reserve width along a chhara, khal 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 pukur, dighi or beel is the higher of its full level and its monsoon water line (Chapter 7); every chhara, khal, lunga flow path 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) on tilla and hill land (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 pukur, dighi and beel 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 pukur, dighi or beel) and a Zone 2 to the 1% AEP extent plus 10 m, whichever line is wider governing; where a rule, the Master Plan 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 rules' "river bank", "outside edge" of a water course or side of a tank, with the rules' distance; the top of bank or full level, with Zone 1; and the 1% AEP extent, with 10 m. Zone 1 is no-build, so the corridor is stricter than r.9(4) everywhere, because r.9(4) allows buildings within 15 m of

a river bank, capped in height, length and cover; it is three times the 5 m of r.90(1)(i) in the hill ULBs; and it adds a corridor round tanks and along chharas, khals and lungas where the rules set only a drainage duty (r.4(1)(e)) or protective works (r.90(1)(m)). 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. 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 in the land records by district, sub-division, revenue circle and mouza, 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 TTAADC area it is secured only 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 the Agartala Planning Area 2045 and in the plans of the Local Planning Areas as land kept free along drainage lines, and checked at the building permit, where the plans already have to show "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" (r.14), and at the self-certification of a low-risk building by its empanelled professional (r.13(3), 2025), rather than made a new NOC.

The reserve matters because the drains of Tripura's towns are divided among owners, and no rule divides them. In law the drains are the Municipality's: s.91 of the Tripura Municipal Act, 1994 vests "all public sewers, drains, channels, tunnels, culverts and water courses in, alongside, or under any street" in it "unless the State Government otherwise directs by a notification", and s.156(1) makes it "provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall in or outside the Municipal area", with power to hand trunk sewers, treatment plants and pumping stations to a Government agency (s.156(2)), to cleanse its drains (s.157), to drain sudden waterlogging across private land without prior notice (s.160), to permit connections in writing (s.161), to demolish unauthorised drains (s.162) and to require separate drainage of sewage (s.164), and with the State able to hand inefficient drainage works to another agency (s.165). In practice the capital works are built by others. In Agartala the major AMRUT works "(98 per cent)" are "being implemented by the UDD and State PWD (DWS)", with "only a few minor works" by the Corporation and no tripartite agreement, and PWD (R&B) builds the major roads and drains (CAG, Audit Report 2019-20); Agartala Smart City Ltd builds storm drains and flood pumps, the Ujjayanta and MBB College lakes, the Akhaura canal and Katakhal works and the Akhaura sewage treatment plant (as reported and as cited); PWD (WR) holds the river embankments, the Katakhal sluice and the Haora flood-plain mapping; PWD (DWS) the drainage pump houses and, with the UDD, the sewage treatment plants (as cited); and NHIDCL the drains of the national highways in the High Court's PIL 06/2026. No formal allocation order, and no notification under s.91, s.156(2) or s.165, was found (NEER reading). For the purposes of this Manual, and until the State issues an allocation [TBC], the drains are assigned as follows: the municipal drains, public tanks, streams and water courses of a ULB to the **Municipality** (ss.91 and 156–166 of the 1994 Act), in Agartala the **Agartala Municipal Corporation**; capital drainage works built in Agartala by the UDD, PWD (DWS), **Agartala Smart City Ltd** or under the ADB project, to their builder until they are handed over to the Corporation in writing, and then to the Corporation; major roads and their drains to **PWD (R&B)**, and the national-highway drains it builds to **NHIDCL**; river embankments, sluices, anti-erosion works and flood-plain mapping, the Katakhal double-barrel sluice among them, to **PWD (WR)**; drainage pump houses and sewage treatment plants to **PWD (DWS)** with the UDD; and, in the TTAADC area, 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 (khas or other government land, private land, or Council land), whether it is a vested municipal drain, an embankment drain or sluice of PWD (WR), or a natural chhara, khal or lunga flow path, whether it carries sewage and is intercepted to a sewage treatment plant, and its outfall (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to PWD (WR) is transferred to, or secured for, PWD (WR). Where a channel's status is disputed, the corridor follows the channel and not its name: Agartala's khals are at once storm drains, carriers of sewage, embankment drains behind a PWD (WR) sluice and border reaches to Bangladesh. No approved city drainage master plan with a design return period was found for any town in the State. A drain sized to fit the land left beside it cannot be enlarged, which is why the reserve is based on the required size. Until a Basin Stormwater Master Plan is adopted (Clause 6.9.6(b)), the required drain size of Clause 6.9.7 is the size computed by the designer under this chapter. This Manual does not prescribe a lined or an unlined section, except

where Clause 6.3.6(j) and 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 Tripura 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 Tripura was found during research [TBC]. The roads already act as the major system: in August 2026 Chandrapur, Baldakhal and Aralia in Agartala were flooded (as reported); in Agartala's flood of 31 May–1 June 2025 a man died in a manhole (as reported); and inspections for the High Court on NH-108B and NH-208 found "No proper drainage system … water logging everywhere" (WP(C)(PIL) No. 06 of 2026). 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.

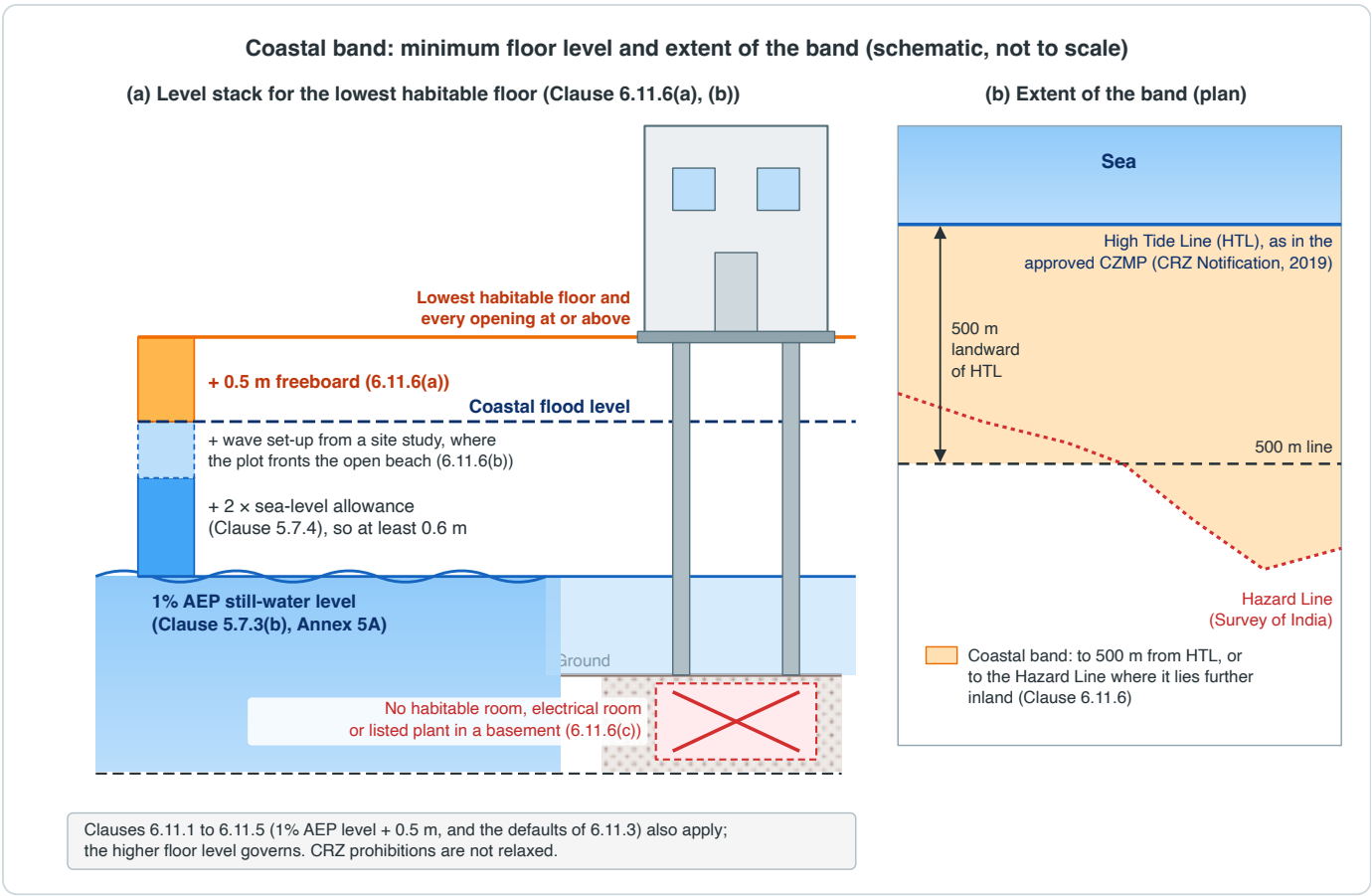


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Tripura 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 Tripura Building Rules 2017 set the plinth "so located with respect to the crest of the road level that adequate drainage of the site … assured and it shall in no case be at a height less than 60 centimeters", inner courtyards at least 15 cm above the centre of the nearest street, and a plinth of not less than 15 cm where parking is on the ground floor (TBR 2017, r.55); they allow no kitchen, bathroom or water closet in a basement unless "there is no chance of back flow and flooding of sewerage", with drainage and pumping plans (r.66(5)), require every basement to keep surface drainage out, to have pumping and to have water-tight walls and floors (r.66(6)(b) and (c)), and since 2025 set the basement ceiling between 0.8 m and 1.2 m above the average road level on the front of the building (r.66(6)(h)); and on recently filled pond, lake or marshy land the Mayor or Chairperson may seek a soil test, restrict the height or refuse the building (r.32). No rule in the State fixes a highest flood level to build to, and no flood-plain zoning law exists. For this Manual, the level is the 1% AEP flood level of Clause 6.11.2 at the site, computed with the river-locked, pumped 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 plinth of r.55 (set by this Manual). Behind an embankment the level is that of the ponded area with its sluices closed and its pumps at their confirmed capacity, and for a breach, the river level beyond the embankment (Clause 5.8.5(a) and (b)): Agartala's central saucer lies between the Haora embankment and the Katakhal, with ground from 25–30 m down to 8 m (ADB IEE, 2020), below the Haora's reported highest level of 12.42 m (as reported, datum not stated (TBC)). 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 rules; where the rules refuse a basement or a building, the refusal governs. On a hill or tilla 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, chharas, khals and lunga flow paths and round the pukurs and dighis, 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 Tripura 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 Tripura 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 Tripura that date is also the start of the wet season. The south-west monsoon's normal onset over the State is about 5 June, inferred from two press reports of the Meteorological Centre Agartala's dates (7 June 2026 "two days later than its normal" and 26 May 2025 "10 days before its normal date", as reported; NEER reading), while another report gives 10 June (as reported); the conflict stands until IMD's revised normals are read [TBC], and no withdrawal date for Tripura was found [TBC]. But the storms come earlier: Kailashahar's wettest months on record are May (1,175.0 mm, May 1991) and April (1,012.8 mm, April 1977), its April 24-hour record is 257.1 mm (19 April 2004) and its May record 231.2 mm (3 May 1993), and Agartala's April record is 198.0 mm (11 April 2007) (IMD *Extremes*); the Dhalai at Kamalpur and the Juri at Nutan Bazar set their highest levels on 15 May 1984 (CWC levels as reported); Cyclone Remal brought 252.4 mm to Unakoti district in 24 hours on 27–28 May 2024 (district value, as reported); and the ADB IEE, citing the district disaster management plan, records storms "during April & May and during October & November in terms of Kalbaisakhi" (ADB IEE, 2020). Storms also come outside the season: Agartala 142.2 mm on 19 February 1993 and Kailashahar 112.4 mm on 25 March 1994; Agartala 183.6 mm on 11 October 1989 and Kailashahar 182.0 mm on 9 October 1986; Agartala 104.6 mm on 9 November 1955 and Kailashahar 104.2 mm on 10 November 1986 (IMD *Extremes*). No order with a completion date for desilting town drains was found during research [TBC]: the Agartala Municipal Corporation desilts every year, with "super sucker" machines (as reported), PWD (WR) runs a pre-monsoon programme of embankment works (as reported), and TDMA's monsoon checklist of 2026 includes "urban drain de-silting" (as quoted), all without a date. 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, khals, chharas 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 tilla-foot 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. The research behind this Manual suggested testing pumps and gates by 15 April; that date is not used, because the April storms come before it (Agartala 198.0 mm on 11 April 2007). These dates are set by this Manual, and are those of the neighbouring North-East editions. Tripura's towns have no snow regime.

Building over drains is already restrained in law. A Municipality may demolish an unauthorised drain into a municipal drain or water course at the owner's cost and act against the encroachment of municipal drains (Tripura Municipal Act, 1994, ss.162 and 166); a notice in Form I is required before drains are covered (TBR 2017, r.38); and in the ULBs in the hill areas "except with the written permission of the ULB no covered drain shall be constructed and no existing open drain shall be covered in" and "no building shall be placed over any drain" (r.99(2)(e) and (f)). Natural chharas, khals and lunga flow paths 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: in Agartala's flood of 31 May–1 June 2025 a man died in a manhole (as reported).

Clause 6.13.7 is not yet the practice, and in Tripura it cannot be until sewers exist. Agartala's sewers, 103.6 km "with 4011 nos. household connection", are "only in the North Zone"; the Akhaura plant and every sewage treatment plant under construction "are designed to be connected through Interception & Diversion of Drains", which Agartala Smart City Ltd describes as "a temporary measure till the conveyance system is laid"; and the other 19 ULBs treat none of their sewage (State affidavit to the NGT in O.A. No. 606 of 2018, 6 July 2026). In 2020 the ADB IEE recorded that "Agartala city is not covered by an underground sewerage system at present" (ADB IEE, 2020); the North Zone network is recorded by 2026. 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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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Tripura 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, Ponds (Pukurs) 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 (pukur) 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 Tripura, a landlocked State, means the beels and haors of the valley floors (natural wetlands: the land records' "Watery land" and "Big watery land"), the marshy and swampy land (dhepa, utla) of the valley floors and flood plains, Rudrasagar (Ramsar site no. 1572), the land ponded behind embankments when their sluices close, 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 Tripura Building Rules, 2017 and the Tripura Municipal Act, 1994 under which they are made, the Tripura Urban Planning and Development Act, 2018 and the Master Plans and Local Planning Area notifications made under it, the Tripura Land Revenue and Land Reforms Act, 1960 and the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 made under it, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Tripura protects its waterbodies through its building rules, its municipal law and its land-revenue rules, with the wetland rules and the courts behind them; no law zones its flood plains. The **Tripura Building Rules, 2017** (UDD notification No. F.2(316)-UDD/GL/TCPO/2009 (Part-I)/371 of 10 November 2017, as cited in UDD's BRAP-2019 document [the 2017 gazette was not read — TBC]), as amended to the (Fifth Amendment) Rules, 2025 (F.No.2(466)-UDD/GL/TCPO/2018(P-V)/4009-20, 4 July 2025; Gazette No. 1294, 5 July 2025), are made by the Urban Development Department (UDD) under section 274 read with section 118 of the Tripura Municipal Act, 1994, and apply to "buildings in the Urban Local Bodies (ULBs) in Tripura" (r.1(2)), with "and Planning Areas" added in 2019. They forbid the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts", except by the Local Body with the prior approval of the State Government for reasons recorded in writing (r.9(3)); limit, but do not forbid, building in the "zone of river (within 15 metres from

river bank)" (r.9(4)); make the owner of a site within 5.00 m of a tank prevent drainage from the building passing into it (r.4(1)(e)); keep sites in the ULBs of the hill areas 5 m from the "outside edge" of water courses (r.90(1)(i)); let the Mayor or Chairperson ask for a soil test, limit the height or refuse a building on land "recently filled up … pond, lake, marshy" (r.32); and count "flood prone areas in river plains" among the Natural Hazard Prone Areas (r.2(44)) (Clause 7.4, Disclosure). The **Tripura Municipal Act, 1994** vests "all public tanks, streams, reservoirs, and wells" and the public drains, channels and water courses in the Municipality (s.91), forbids a new tank without its permission (s.232), and lets it make the owner of a private tank "cleanse it of silt, refuse or vegetation and … protect it from pollution by surface drainage" (s.234(1)); it "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (s.1(2)), so neither it nor the Building Rules made under it apply in the TTAADC area, about 68% of the State (as reported). In the land records a pond is a land class: the **Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025** (No. F.4(05)-RCC/2025, 2 June 2025; Gazette Extraordinary No. 1072, 3 June 2025) count the diversion of a water body to another purpose as a "Diversion of Land" (r.2(iii)), and their Appendix-I lists পুকুর "Tank/Pond", পুকুরপাড় "Bank of tank", দীঘি "Large tank", দীঘিরপাড় "Bank of large tank", ডোবা "Ditch", বিল "Watery land", হাওর "Big watery land", ছড়া "Streams", লুঙ্গা "Flat lands between tillas" and বাঁধ "Embankment" among the classes of land. The procedure of 2025 for diverting a water body was replaced by the (First Amendment) Rules, 2026 (6 March 2026; Gazette Extraordinary No. 2026350), which substituted rule 3 with online self-declaration and rule 4 with revocation within 30 working days and omitted rules 6 to 10; whether section 20 of the Land Revenue and Land Reforms Act, 1960 still bars the diversion of a water body was not established, and **this Manual does not state the current procedure** [TBC]. The Department of Science, Technology and Environment's "Statutory Guidelines for protection and preservation of lakes, ponds and water bodies in Tripura", notified after the High Court's order in PIL 2/2014 (as cited), were not read, and no distance from them is used. Wetlands are the concern of the **Wetland Authority of Tripura** (Clause 7.12, Commentary), and Rudrasagar is a Ramsar site. In this chapter **PWD (WR)** means the Public Works Department (Water Resources), which holds the river embankments, the sluices through them (among them the Katakhal double-barrel sluice at Agartala) and the minor-irrigation dams. A pukur, dighi or beel has no gate of its own unless it drains through a PWD (WR) sluice, so PWD (WR) is the custodian this chapter names where a clause speaks of levels, a datum, freeboard or an operating rule; the public tanks vest in the Municipality, the land records are the Revenue Department's, and every custodian is recorded one by one in the inventory (Annex 7A). Who regulates where in the TTAADC area, and who is the competent authority for the area, is set out in Chapter 1.

This Manual treats every recorded waterbody as drainage infrastructure. Six features set Tripura apart. The first is the **river that leaves India**: the Haora (also called Saidra in Kokborok, as reported), the Gomati, the Khowai, the Dhalai, the Manu, the Juri, the Deo, the Longai, the Muhuri, the Feni and the Burima (Bijoy) all cross into Bangladesh, and the valley towns stand behind river embankments (bandh, Bengali বাঁধ, the land records' "Embankment") and drain through sluices that close when the river is high, with no downstream Indian control and no level data from across the border (Chapter 5). The second is the **lunga** (Bengali লুঙ্গা: the flat land between tillas, the land records' "Flat lands between tillas"), the valley floor between the low hills, which is the natural flow path of the land and the place where towns are built and ponds filled. The third is the **tilla** (Bengali টিলা: a hillock, the land records' "Hillock"), the dissected terrace upland 10 to 30 m above the lunga, whose cutting for building silts the drains below and slides in heavy rain. The fourth is the **chhara** (Bengali ছড়া: a stream, the land records' "Streams"), the stream that comes down from the tillas and the hill ranges, with the **khal** (Bengali খাল: a canal or channel), such as the Katakhal, the Akhaura canal and the Kalapania Khal at Agartala, that carries the towns' water to the river. The fifth is the **pukur** (Bengali পুকুর: a tank or pond — the land records' "Tank/Pond"; plural pukurs) and the **dighi** (Bengali দীঘি: a large tank), the dug tanks of the towns, among them the palace-era and temple tanks, which this Manual treats as existing storage with heritage and fisheries constraints, not as detention to be drawn down. The sixth is the **beel** and the **haor** (Bengali বিল and হাওর, the land records' "Watery land" and "Big watery land"), the natural wetlands of the valley floors, with Rudrasagar the largest named. Tripura has no irrigation tank cascades; the tank clauses of this chapter apply to pukurs, dighis, the palace and temple tanks, the beels that drain through a khal, nala or sluice, the minor-irrigation dams and the Dumbur reservoir of the Gumti hydel project, and storage built under this Manual is a "detention pond", never a pukur. A doba (ডোবা, the land records' "Ditch") is a ditch, not a pond. Because the storm drains are also the sewers (Clause 8.9, Commentary), most pukurs and khals 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 Building Rules, the Municipal Act, the land-revenue rules, the Master Plans, the wetland procedures that record and protect them, or the directions of the High Court of Tripura, the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river (nadi), such as the Haora, the Gomati, the Khowai, the Dhalai, the Manu, the Juri, the Deo, the Longai, the Muhuri, the Feni and the Burima (Bijoy), all of which flow on into Bangladesh; khal (a canal or channel), such as the Katakhal, the Akhaura canal and the Kalapania Khal; chhara (a stream, the land records' "Streams"), such as the Nagichara and the Kalapani Charra, and the other natural channels of Agartala, such as the Bangeshwar Gang and the Debta Gang; nala (a water channel), doba (a ditch) or drain; the flow path of a lunga (the flat land between tillas); pukur (a tank or pond); dighi (a large tank); beel (watery land: a natural wetland) or haor (big watery land); marsh or swamp (dhepa, utla); the land ponded behind an embankment (bandh) when its sluice is closed; reservoir, such as the Dumbur reservoir of the Gumti hydel project; retention pond or basin built for flood storage; abandoned brick-field pit kept as a water body; supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (pukur)	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 nala, khal or sluice by which a pukur, dighi or 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 PWD (WR) 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 chhara, nala or khal)	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, regulator or flap gate, including a sluice through a river embankment (bandh))	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).

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

Term	Meaning in this Manual
Pukur	A dug tank or pond: পুকুর, "Tank/Pond", a class of land in Appendix-I of the Diversion of Land Rules, 2025 (item 9); "n. a pond, a tank, a pool" (Biswas, *Samsad Bengali-English Dictionary*, p. 653) (Annex 7E). First used in this Manual as "pukur (Bengali পুকুর: a tank or pond — the land records' 'Tank/Pond'; plural pukurs)". Bengali marks the plural with *-gulo* or *-guli*, so the English plural "pukurs" is a convention of this Manual. A pukur 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 pukur with no outlet has its FTL at the level at which it would spill to the ground around it, found by survey. Historic, palace and temple tanks keep their own names. Engineered storage built under this Manual is a "detention pond", never a pukur.
Dighi	A large tank: দীঘি (also written দিঘি), "Large tank" (Appendix-I, item 14); "n. a large and deep tank or pond" (Biswas, pp. 499, 501). First used as "dighi (Bengali দীঘি: a large tank)". Used for named large tanks, such as Banamalipur Dighi in Agartala; the tank clauses apply to a dighi as to a pukur.
Pukurpar; dighirpar	The bank of a tank: পুকুরপাড়, "Bank of tank" (Appendix-I, item 10), and দীঘিরপাড়, "Bank of large tank" (item 31), each a class of land of its own. Where the land records show a pukurpar or dighirpar plot, that plot lies within Zone 1 of its pukur or dighi, whatever the width given by Clause 7.4.3, and no fill, wall or building is placed on it under this Manual. This rule is set by this Manual.
Doba	A ditch: ডোবা, "Ditch" (Appendix-I, item 11); "n. a pit full of water; a small pool of water" (Biswas, p. 436). In Tripura a doba is recorded as a ditch, never as a pukur, and it is a channel or depression under this chapter, not a tank; a doba that holds water is recorded in the inventory (Annex 7A).
Beel; haor	A natural wetland: বিল, "Watery land" (Appendix-I, item 13), "... a fen; a marsh" (Biswas, p. 770); and হাওর, "Big watery land" (item 12), "n. an extensive marsh or quagmire or fen" (Biswas, p. 1050, as হাওড়). A beel or haor that drains through a khal, nala or sluice is a tank under Clause 7.2: its FTL is the crest of the control at the head of its outfall, 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 or haor with no outlet is a wetland under Clause 7.12. A natural wetland is never called a pukur. The marshy and swampy land of the land records (ঢেপা, dhepa, "Marshy land"; উতলা, utla, "Swampy land") is a marsh under Clause 7.12.
Chhara; jhora	A chhara (ছড়া) is a stream, "Streams" in Appendix-I (item 35); the dictionary gives the word no such sense, so this Manual cites the land records. The Building Rules call a hill stream a jhora (rr.5, 9, 90 and 99), and this Manual keeps "jhora" when it quotes them and writes "chhara" elsewhere. Every chhara, khal 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 drain or nala that carries a chhara's flow along the chhara's former line is treated as that chhara. A chhara from the tillas or the hill ranges carries silt 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.
Lunga; lunga flow path	A lunga (লুঙ্গা) is the flat land between tillas (Appendix-I, item 5; not in Biswas), the CGWB's "low lands ('loonga') of Holocene terrace" between "10 – 30 m high mounds with gullies in between them". The lowest line of a lunga, along which water runs in a storm whether or not a channel is cut, is its **flow path**: where it drains 8 ha or more it is a natural channel under Clause 7.4.1(b), its top of bank is the edge of the 50% AEP flow, and filling it is a loss of conveyance and storage under Clause 7.6.4. No infiltration is credited on a lunga floor (Clause 4.11, lunga rule). These readings are set by this Manual.

Term	Meaning in this Manual
Tilla	A low hill or terrace upland: টিলা, "Hillock" (Appendix-I, item 15); "n. a mound, a hillock, a knoll, a hummock" (Biswas, p. 424). Tilla tops and slopes take the tilla and hill rules of Clause 4.11; a tilla cut is earthwork under Clause 8.12.
Khal; nala	A khal (খাল, "Khal", Appendix-I, item 34; "n. a canal; a strait; a channel ...", Biswas, p. 281) is a canal or channel, such as the Katakhal, the Akhaura canal and the Kalapania Khal; a nala (নালা, "Water channel", item 7) is a natural or built channel; the land records class a drain in a municipal area separately (ড্রেন, "Drain in Municipal area", item 8). A khal that carries a natural channel's flow is a natural channel under Clause 7.4.1(b).
Embankment (bandh); sluice	An embankment is a river or pond embankment: বাঁধ, "Embankment" (Appendix-I, item 30); "n. a dam; a breakwater ... (geog.) a dyke" (Biswas, p. 735). A sluice is a gated outlet through an embankment, such as the Katakhal double-barrel sluice. No Tripura statute on embankments or drainage was found [TBC]; PWD (WR) holds them as owner.
Ponded area behind an embankment	The land inside an embankment-protected area that is flooded when its sluices are closed or its pumps stop, up to the level reached in the outfall-closed case of Clause 5.8.5(a) and (b) 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 pukurs, dighis, beels and channels within it, not to the ponded area as a whole. This definition is set by this Manual.
Recorded waterbody	A pukur, dighi, beel, haor, chhara, khal, nala, lunga flow path, river, marsh or ponded area shown in any source of Clause 7.3.3(a): a plot recorded in one of the water classes of Appendix-I, the 2020 list of urban water bodies, a Master Plan or Local Planning Area map, PWD (WR)'s records 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; the approval of the Local Body and the State Government under rule 9(3) of the Building Rules is still required. This definition and rule are set by this Manual.
Boundary of a pukur, dighi or beel	For this Manual, the boundary of a pukur, dighi or beel under Clauses 7.3.3 and 7.13.1 is the largest of its plot boundary in the land records, 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; a recorded pukurpar or dighirpar plot lies in Zone 1. 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 rules' line, the "river bank" of rule 9(4), the "outside edge" of a water course of rule 90(1)(i) or the side of a tank of rules 4(1)(e) and 90(1)(m), with the distance of that rule measured from it; (b) the FTL of a pukur, dighi or beel 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. The rules define neither the river bank nor the outside edge; where either cannot be identified on the ground it is taken as the top of bank. This rule is set by this Manual.
Palace-era and temple tanks	The Ujjayanta palace lakes, the tanks of the temples, such as Kalyan Sagar at Matabari, and the other historic tanks are existing storage with heritage and fisheries constraints. Their storage is modelled as it is, at FTL at the start of a storm, and is not drawn down, reshaped or counted under Clause 7.7 without the custodian's written consent and the permissions of Clause 7.12 where they apply. This rule is set by this Manual.
Private land and the TTAADC area	Land in Tripura is recorded by district, sub-division, revenue circle and mouza; some is government (khas) land. Zone 1 land that is private is reserved in the Master Plan or secured by a written agreement with the owner, and is not taken; in the TTAADC area, it is secured only through the District Council, whose 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 PWD (WR) and the Revenue Department, shall maintain a GIS layer of every waterbody in its area (Annex 7A). For each waterbody it shall record:

- (a) its type (Clause 7.2), name and survey numbers;
- (b) its custodian (the Agartala Municipal Corporation or another Municipal Council or Nagar Panchayat (for the public tanks, streams, reservoirs, drains, channels and water courses that vest in it under section 91 of the Tripura Municipal Act, 1994 "unless the State Government otherwise directs by a notification", and for the private tanks whose owners it may require to cleanse and protect them under section 234), Agartala Smart City Ltd (for the works it builds, among them the Ujjayanta palace lakes and the MBB College lake, until they are handed over

[TBC]), TUDA (for the water bodies of the layouts it approves in a Local Planning Area), PWD (WR) (for the river embankments, the sluices, among them the Katakhal double-barrel sluice, the anti-erosion works and its minor-irrigation dams), PWD (R&B) or NHIDCL (for the drains and culverts of their roads), PWD (DWS) (for drainage pump houses and sewage treatment plants), the operator of the Gumti hydel project (for the Dumbur reservoir; TSECL, as reported), the Forest Department or the Fisheries Department (for Rudrasagar, whose managing agency the sources give differently), the Revenue Department (for government (khas) land recorded as pukur, dighi, beel, haor, chhara or other water), the Gram Panchayat or Village Committee, a religious institution (for its tank), a private owner (for a pukur or dighi on private land), the District Council in the TTAADC area (not researched [TBC]), the Wetland Authority of Tripura (for a notified wetland; none was found notified under rule 4 of the 2017 Rules), 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 Department, kept by district, sub-division, revenue circle and mouza (the plot numbering was not confirmed [TBC]), with each plot's land class under Appendix-I of the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025, among them pukur ("Tank/Pond"), pukurpar ("Bank of tank"), dighi ("Large tank"), dighirpar ("Bank of large tank"), doba ("Ditch"), beel ("Watery land"), haor ("Big watery land"), chhara ("Streams"), lunga ("Flat lands between tillas"), khal ("Khal"), nala ("Water channel") and bandh ("Embankment"), including government (khas) land recorded as water; the list of 180 urban water bodies on government land that the ULBs geo-tagged for the National Green Tribunal in 2020, of which 30 were prioritised (as reported); the Agartala Municipal Corporation's zone-wise affidavit on the encroachment of water bodies before the High Court of Tripura (2017, as cited); PWD (WR)'s records of its embankments, sluices and anti-erosion works and its mapping of the Haora flood-plain zones; the land-use maps of the Master Plan for the Agartala Planning Area 2045 (text not read [TBC]) and the layouts of the Local Planning Areas; the records of the Wetland Authority of Tripura for Rudrasagar; in the TTAADC area, the land records of the District Council (not researched [TBC]); and each town's drain register (Chapter 6);
- (b) PWD (WR) and Gram Panchayat or Village Committee 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 PWD (WR) records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> Commentary. Tripura has no flood line in law. No flood-plain zoning Act was found, either in the High Court of Tripura's index of the State's Acts or elsewhere (NEER reading), and press reports of the Union's position say that only four States have enacted such a law, without naming them (as reported). The Building Rules count among their Natural Hazard Prone Areas the "flood prone areas in river plains (unprotected and protected) area indicated in Flood Atlas of India prepared by the Central Water Commission" and areas flooded "under conditions of heavy intensity rains, inadequate drainage, etc. as identified through local surveys in the Development Plan of the area" (r.2(44)), and they let the Local Body, with the State Government's prior approval, allow a "flood plain area to be filled up" (r.9(3)); no map made under either was found [TBC]. PWD (WR) has mapped flood-plain zones on the Haora for the National Green Tribunal, naming Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat) (State affidavit in O.A. 673/2018); the map, its return period and its legal status were not found [TBC]. The Master Plan for the Agartala Planning Area 2045 was declared final by the UDD on 24 February 2026 with "statutory zoning and development control regulations" (as reported), but its text was not read [TBC]. The levels that exist are the river gauges', and they disagree: for the Haora at Agartala, danger levels of 10.48 m, 10.50 m (the State's gauge at Jahar Bridge) and 10.70 m (CWC), and highest flood levels of 11.08 m (2004), 12.14 m (24 June 2004), 12.4 m (11 August 2017) and 12.42 m (22 August 2024) (all as reported, the CWC values as transcribed by SANDRP; probably different gauges or datums, and no datum is stated for any of them [TBC]); and for the Manu at Kailashahar a CWC highest flood level of 25.79 m (7 June 1993), passed at 25.95 m on 13 June 2018 (as reported; Chapter 5). Flood plains already hold public works: the National Green Tribunal found that the 5 MLD sewage treatment plant at the Kalapania Khal and the 8 MLD plant on the Haora bank lie near or on the flood plain, which "may lead to flooding of the STP and flowing of untreated sewage in the river during the monsoon" (order of 13.04.2026, as quoted in the State's affidavit of 06.07.2026 in O.A. 606/2018). The plinth rule sets the plinth, with respect to the crest of the road, "in no case … at a height less than 60 centimeters" (r.55), with no flood level in it. The land records' water classes and PWD (WR)'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 local surveys of rule 2(44) and to the Master Plans, 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 behind an embankment, and in Agartala's saucer, the flood extent is set by the ponding behind a shut sluice or a stopped pump as often as by the river. Levels shall be stated to one datum (Clause 7.3.5) and tied to the CWC or State gauge, naming the gauge with every value. 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, chharas, khals and lunga flow paths included, and round every pukur, dighi and beel (wider lines govern under Clause 7.4.5 where they bind: the Tripura Building Rules 2017 regulate building, without forbidding it, in the "zone of river (within 15 metres from river bank)" and along water bodies of more than 1000 acres (r.9(4)); they forbid a site within 5 m of the outside edge of a water course only in the ULBs of the hill areas (r.90(1)(i)); near a tank they set only a drainage duty within 5.00 m (r.4(1)(e)) and, in the hill areas, protective works within 5.0 m and within 30 m of a jhora (r.90(1)(m)); no distance from an embankment was found; and no flood-plain 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 a condition of PWD (WR) as the owner of an embankment, sluice or anti-erosion work (no statute on embankments was found [TBC]); a condition of the Local Body's approval, with the prior approval of the State Government, to fill a water body under rule 9(3) of the Tripura Building Rules, 2017; a condition of a decision of the District Magistrate and Collector on the diversion of a water body under the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025, as amended in 2026 (the procedure after March 2026 was not established [TBC]); the views or permission of the Wetland Authority of Tripura for a work in or next to Rudrasagar or a notified wetland; a line of the Master Plan for the Agartala Planning Area 2045 or another Master Plan; or a direction of the High Court of Tripura, 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

Waterbody	Total setback (Zone 1 + Zone 2)	Of which Zone 1
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. Tripura's distances from water are in its building rules, the Tripura Building Rules, 2017 as amended to the Fifth Amendment of 2025, which apply only in the Urban Local Bodies and the Local Planning Areas. Rule 9(4) sets a regulated "zone of river (within 15 metres from river bank)", and the same along "other water fronts of large water bodies (more than 1000 acres)", in which a building may stand but is limited to 5.00 m in height (6.50 m on stilts), 20.00 m in length along the water and 200.00 m² of covered area, with a clear gap of 50.00 m between buildings: it is not a no-build line. The only no-build distance from water in the rules is in the ULBs of the hill areas, where no site may lie "within five meters in any direction of the outside edge of such water courses" (r.90(1)(i)); there, within 5.0 m of a tank, reservoir, jhora, spring, water source or natural drain, and where the site is within 30 m of a jhora, the owner takes protective measures (r.90(1)(m)); and in the plains, within 5.00 m of a tank, the owner prevents drainage from the building passing into it (r.4(1)(e)). Rule 9(3) forbids the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the prior approval of the State Government. The 15 m floor equals the width of the r.9(4) zone but keeps all building out of it; it is three times the 5 m of the hill rule; and it puts a corridor round every pukur, dighi and beel and along every chhara, khal and lunga flow path draining 8 ha or more, where the rules set only a drainage duty or protective works. The rules measure from the "river bank" or the "outside edge" of a water course, neither of which they define; 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 private, 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 Tripura flood maps are mostly coarser than US maps, the valley towns stand on the flat lungas and flood plains between the tillas, and the centre of Agartala is "at a lower level than other areas giving it the appearance of a saucer" (ADB, 2020) (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).

Tripura's distances from water are in its building rules, which apply only in the ULBs and the Local Planning Areas. Rule 9 of the Tripura Building Rules, 2017, "Control of development of parks, public open space, ponds, wetlands, canals, river and other water front and brick fields", forbids the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts", unless the Local Body, "with the prior approval of the State Government" and "for reasons to be recorded in writing" after considering "the drainage slope, slip, landslide, ecology, culture, environment, pisciculture, fire fighting or any other material consideration", allows a "canal pond, rivulets, streams, rivers, flood plain area to be filled up" (r.9(3)). For "a building in the zone of river (within 15 metres from river bank) or other water fronts of large water bodies (more than 1000 acres)" it limits the height to 5.00 m (6.50 m on stilts of not more than 3.00 m, which may not be walled), the length "alongside the river or other water fronts" to 20.00 m with "a clear linear gap of 50.00 metres between the two buildings", and the covered area to 200.00 m² (r.9(4)): a regulated zone, not a no-build line. It keeps the area of a water body out of the area of a park (r.9(2)) and makes the owner of an abandoned brick-field pit keep it "as water bodies" (r.9(5)). In the plains, "where the site is within 5.00 meters of any side of a tank, the owner will take such measures as shall prevent any risk of drainage from such building passing into the tank" (r.4(1)(e)), which is a drainage duty, not a setback. In the ULBs of the hill areas (Part X, rr.88 to 101, whose ULBs the rules do not list [TBC]), no site may be "located within five meters in any direction of the outside edge of such water courses" (r.90(1)(i)), the only no-build distance from water in the rules, and the owner takes protective measures within "5.0 (five) meters of any side of a tank, water reservoir, jhora/ natural spring, water source or natural drain", within 2.0 m of a water pipe or sewer, and where the site is within 30 m of a jhora (r.90(1)(m)). The site plan shows the "natural drainage channel/jhora" (r.5(1)(p)), a sub-division drains each plot by "pucca drain" to a public drain or natural channel (r.10(2)(f)), and notice is given before a drain is covered (r.38). The Tripura Municipal Act, 1994 forbids a new tank without the Municipality's permission, on pain of a fine of up to ₹2,000 (s.232), and lets the Municipality make the owner of a private tank protect it "from pollution by surface drainage" (s.234(1)). Two other lines are cited but are not rules: the Department of Science, Technology and Environment's "Statutory Guidelines for protection and preservation of lakes, ponds and water bodies in Tripura" (as cited; not read, so no distance from them is used), and a direction "that no construction is raised within 75 Mtrs. of the end of the lake", in a file whose source and scope were not established (as cited) — it is not used as a rule. The buffers of the Master Plan for the Agartala Planning Area 2045 were not read [TBC], and **no setback distance from an embankment was found** [TBC]. The rules leave gaps for drainage: rule 9(4) allows building within 15 m of a river bank; its "river bank" and rule 90(1)(i)'s "outside edge" are not defined; a pukur, dighi or beel in the plains gets only the drainage duty of rule 4(1)(e), and a chhara, khal or lunga flow path in the plains gets nothing beyond the ban on filling; nothing keeps building back from an embankment; and outside the ULBs and Local Planning Areas, and in the TTAADC area, the rules do not apply at all. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere the Manual applies.

Disclosure. Tripura **has distances from water in its building rules, but only one of them keeps building out, and only in the hill ULBs**: rule 9(4) of the Tripura Building Rules, 2017 sets a **15 m "zone of river"** from the river bank, and the same along water bodies of more than 1000 acres, in which buildings are **limited** in height (5.00 m, or 6.50 m on stilts), length (20.00 m, with 50.00 m gaps) and covered area (200.00 m²) but **allowed**; rule 90(1)(i) keeps sites **5 m** from the "outside edge" of water courses in the ULBs of the hill areas; near a tank the rules set only a **drainage duty within 5.00 m** (r.4(1)(e)) and, in the hill areas, **protective works within 5.0 m, and within 30 m of a jhora** (r.90(1)(m)); rule 9(3) bars **filling** without the Local Body's approval with the State Government's prior approval; the rules apply in the ULBs and Local Planning Areas, not in the TTAADC area; **no distance from an embankment was found**; and **no flood-plain 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, river, chhara, khal or lunga flow path, whether or not a plan marks it, and round every pukur, dighi and beel. 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 pukur, dighi or beel and of its recorded pukurpar or dighirpar, of the lunga flow path and of the ponded area behind an

embankment (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule**, and no government body, Authority, Local Body, committee or the District Council has adopted or endorsed them. Zone 1 is a no-build zone, so it is **stricter than rule 9(4)** along every river, which allows building within 15 m of the bank; it is **three times the 5 m of rule 90(1)(i)** in the hill ULBs; and it **adds a corridor round every pukur, dighi and beel and along every chhara, khal and lunga flow path**, where the rules set only a drainage duty (r.4(1)(e)) or protective works (r.90(1)(m)), or nothing beyond the ban on filling. 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 private, it is **reserved in the Master Plan or secured by agreement with the owner, not taken** (in the TTAADC area, only through the District Council [TBC]). The rules measure from the "river bank" or the "outside edge" of a water course, which they do not define; 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 every river, chhara, khal and lunga flow path and round every pukur, dighi and beel, and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The Tripura Building Rules, 2017, as amended to 2025.** The zone of rule 9(4), within which the limits on height, length, gap and covered area apply to any building that the Manual's wider lines allow; the 5 m of rule 90(1)(i) and the protective works of rule 90(1)(m) in the hill ULBs, which the Applicant states on Form 7-1 and which never govern alone where Zone 1 is wider; the ban on filling of rule 9(3) and the approval it requires, which no design under this Manual replaces; rule 32, under which the Mayor or Chairperson may ask for a soil test, limit the height or refuse a building on a recently filled pond, lake or marsh; rule 55, which sets the plinth, with respect to the crest of the road, "in no case … at a height less than 60 centimeters", and this Manual's floor of the 1% AEP level plus 0.5 m (Clause 7.6.6(b); Chapter 6), which governs where it is higher; and rule 66, which keeps kitchens, baths and water closets out of a basement unless there is "no chance of back flow and flooding of sewerage", asks for surface drainage to be kept out and pumping arranged, and, since 2025, sets the basement ceiling 0.8 to 1.2 m above the average front road level (r.66(5), (6)(b) and (6)(h)).
- **The Municipal Act.** The vesting of public tanks, streams and water courses in the Municipality (s.91), the permission required for a new tank (s.232) and the Municipality's power over private tanks (s.234), with which every design keeps.
- **The land records and the Diversion of Land Rules.** The water classes of Appendix-I of the Diversion of Land Rules, 2025, which record a plot as pukur, pukurpar, dighi, dighirpar, doba, beel, haor, chhara, khal, nala or bandh; a change of class is a diversion of land, and the procedure for a water body after the amendment of 6 March 2026 was not established [TBC], so this Manual does not state it.
- **The Master Plans.** The zoning and development control regulations of the Master Plan for the Agartala Planning Area 2045 (declared final on 24 February 2026, as reported; not read [TBC]) and the layouts of the Local Planning Areas.
- **Embankments.** PWD (WR)'s conditions as owner of an embankment, sluice or anti-erosion work; no statute and no setback distance were found [TBC].
- **Wetlands, courts and custodians.** Rudrasagar, Ramsar site no. 1572, and any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was found notified); the orders of the High Court of Tripura, the National Green Tribunal and the Supreme Court as they stand, among them the High Court's order of 2016 in PIL 2/2014 on pond filling at Kalyan Sagar (as cited); and the custodians' lines at their tanks and outlets.

This Manual sets 15 m as the floor because rule 9(4), the only plains distance from a river, allows building in it; because a pukur, chhara, khal or lunga flow path in the plains gets no distance at all; because 15 m is the rules' own width for the zone of a river 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: in Agartala "the central part of the city is located at a lower level than other areas giving it the appearance of a saucer", the feeder drains are "earth-lined and in a poor condition with silt and vegetation choking them" (ADB, 2020), and "there is frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report 2022-23); ponds have been filled

for housing in Barjala and Lanka Basti (as reported); the High Court found pond filling and walls on the banks of Kalyan Sagar and ordered 110 m of cement embankment removed (PIL 2/2014, as cited); and ring roads in Rudrasagar "reduced the water level and compromised the ecological balance" (CAG, Audit Report 2021-22). Until an amendment of the Building Rules, a Master Plan, a decision under the land-revenue rules or a court adopts it, the 15 m minimum is this Manual's recommended standard, and the Building Rules, the Master Plans, the land-revenue rules and the orders above remain the only legal minimum. Approving authorities should state in each approval which was applied.

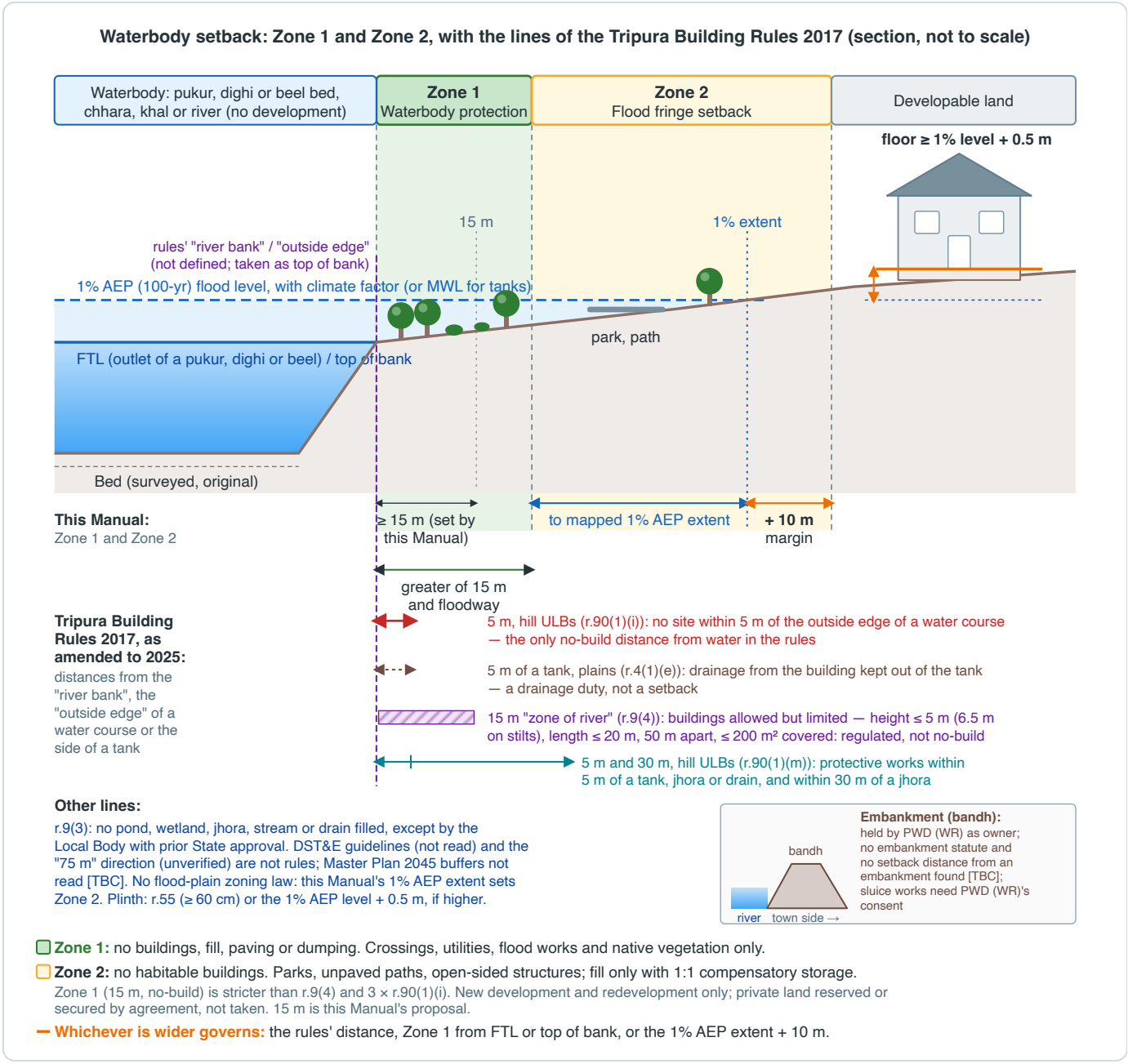

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 Tripura Building Rules 2017, 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 Tripura 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 lungas and flood plains on which Tripura's towns stand are flat, central Agartala is a saucer between the embanked Haora and the Katakhal, and the land behind the embankments ponds when the sluices close, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Tripura the Building Rules measure from a "river bank", an "outside edge" or the "side of a tank", none of which they define, and the land records fix a pukur or dighi by its plot, with its bank recorded as a separate class (pukurpar, dighirpar); neither gives a line for the edge of a pukur, dighi or beel whose water spreads and shrinks through the year. The difference matters because the waterbodies are shrinking: ponds have been filled for housing in Barjala and Lanka Basti (as reported); the High Court found pond filling and walls on the banks of Kalyan Sagar (PIL 2/2014, as cited); the ring roads built in Rudrasagar without the Wetland Authority's permission "reduced the water level" (CAG, Audit Report 2021-22); and the Dumbur reservoir's water spread is estimated to

have fallen from about 4,500 ha to 3,049.3 ha by 2012 (ICAR). A line drawn from the edge of the water in the dry months would leave the pukur's own flood storage open to filling, and one drawn from today's edge would give up its lost area for good. This Manual gives every pukur, dighi and beel 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, its recorded plot and its recorded pukurpar or dighirpar are part of its boundary or its Zone 1 (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 Agartala's central saucer between the Haora embankment and the Katakhal, of the Haora flood-plain-zone localities that PWD (WR) has mapped (Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar), of Chandrapur, flooded in August 2026 (as reported), and of the valley towns behind their embankments, such as Kailashahar on the Manu and Belonia on the Muhuri 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.

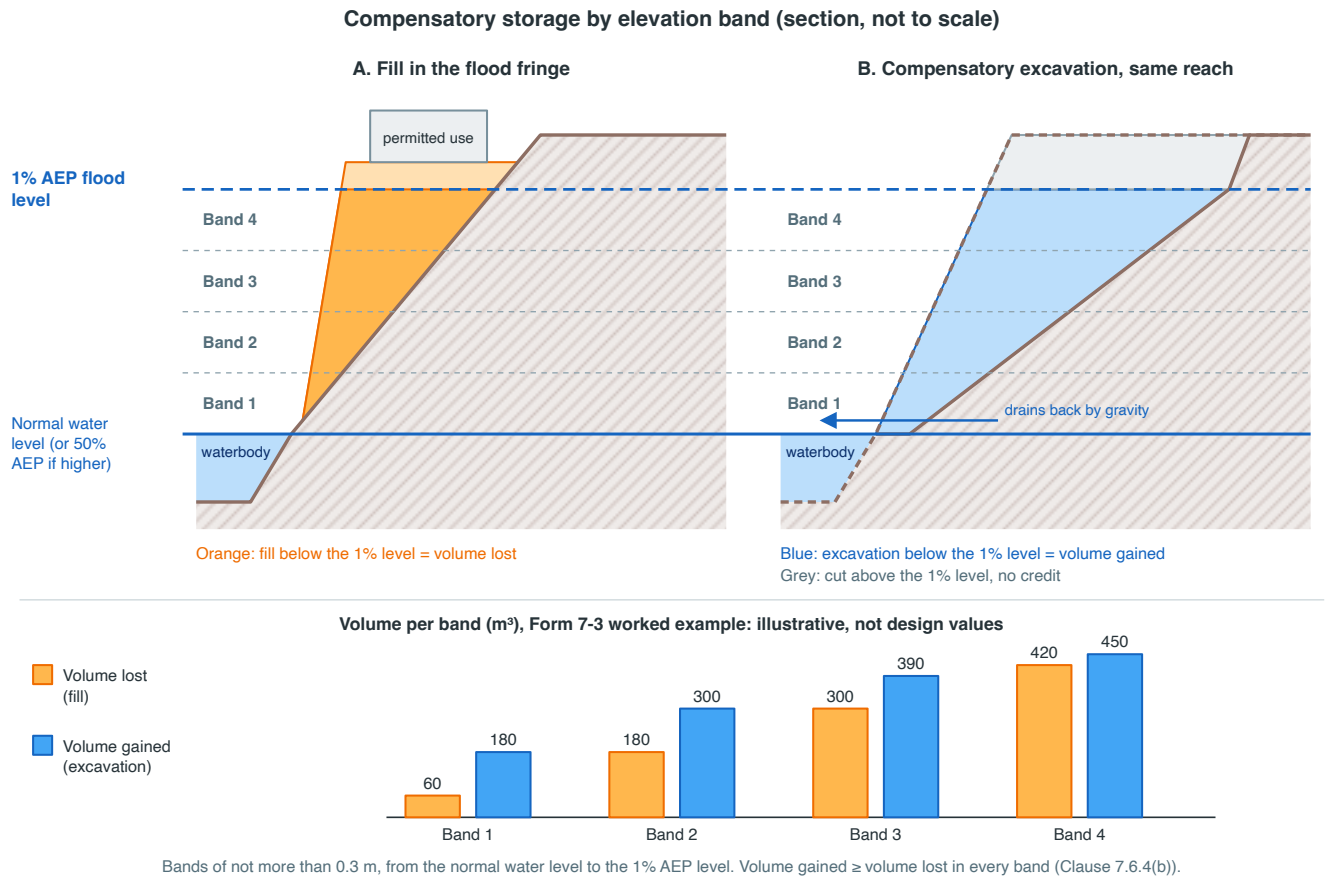

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation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

Tripura has no tank Act and no irrigation tank cascades, and its standing waters range from a doba to the Dumbur reservoir. The storages that matter for urban drainage are of six kinds. The first is the **pukurs and dighis** of the towns. About 65 water bodies in Agartala have been cleaned and developed under city schemes (the Mayor, as reported); 180 urban water bodies on government land were geo-tagged under the ULBs for the National Green Tribunal in 2020, of which 30 were prioritised for restoration (as reported); Agartala Smart City Ltd has projects at the Ujjayanta palace lakes and the MBB College lake (as cited); the ADB names the College Tilla lake "among the 7 important inland" water bodies (IEE, 2020); Banamalipur Dighi lies in ward 21 of the Agartala Municipal Corporation (as cited from a tender list); Kalyan Sagar at Matabari, near Udaipur, was the subject of the High Court's PIL 2/2014 (as cited); ponds have been filled for housing in Barjala and Lanka Basti (as reported); and the State's claim that "682 water bodies" have been created is a headline only (as reported). **No Agartala-wide pond inventory, and no level, area or outlet record for any pukur or dighi, was found** [TBC], so their storage is modelled as an existing feature and not counted unless Clause 7.7.1 is met; the plots that the land records class as pukur and dighi, with their pukurpar and dighirpar, are the first source for finding them and for the inventory of any storage that Clause 7.7.1 would count (Annex 7A); the palace-era and temple tanks are existing storage with heritage and fisheries constraints, not detention to be drawn down (definitions after Clause 7.2). The second is the **beels and haors** of the valley floors and the marshy land of the lungas, modelled as existing features where they intercept runoff but never counted as storage unless surveyed with a controlled outlet, because they are full by the time of the peak storm; no inventory of them was found [TBC]. The third is the **ponded area behind an embankment**, which stores the town's runoff while its sluices are shut, and Agartala's saucer between the Haora embankment and the Katakhal, which drains by pumps when the rivers are high (definitions after Clause 7.2; Clause 5.8.5(b)). The fourth is **Rudrasagar**, Ramsar site no. 1572 in Sepahijala district, a wetland under Clause 7.12. The fifth is the **reservoirs**: the Dumbur reservoir of the Gumti hydel project at Tirthamukh, whose dam is 30 m high, whose spillway capacity is 481.38 m³/s and whose FRL is 93.55 m, against a "danger level of 94 m" reached at 93.85 m in August 2024 (all as reported; the two levels conflict, and 94 m is used until the operator confirms), whose water spread was about 4,500 ha when built and 3,049.3 ha by 2012 (ICAR) but is also given as "41 sq km" (as reported) and as 0.709 km² (CWC's National Register of Large Dams, as quoted, which cannot be right for a live storage of 0.312 BCM); and PWD (WR)'s minor-irrigation earth dams, such as the Kashari Cherra earth dam of its Belonia division (CAG, Audit Report 2022-23). Dumbur is not a Ramsar site. Its storage is the operator's and is not counted under this Manual; the Gomati below it is a release reach (Clause 5.8.5(d)). The sixth is the **retention ponds** built for flood storage, which are detention ponds, never pukurs. These are the waterbodies for which Figure 7.3 and Clause 7.8 matter: in a valley town every drain ends in a nala, a khal or a pukur, and every khal in a sluice through the embankment that the river closes, or in the river at a border reach. Any pukur, dighi, beel or pond whose storage is to be counted is subject to Clause 7.7.1 in full, with PWD (WR) 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.** PWD (WR), 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 valley town on a lunga behind an embankment, every pukur and dighi that stores its runoff, the chharas that come down to it from the tillas, the lunga flow paths and nalas that join them to a khal, 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 PWD (WR)'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 Tripura the starting level of a pukur, dighi or beel is its outlet level because the outlet is shut when the river is high. In Agartala, "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded", and when the Haora and the Katakhal run higher than the city "Several pumps have been provided to lift the water out of the city during these seasons" (ADB, IEE, 2020); the city's flood pumps, 18 of up to 900,000 litres an hour each and 6 diesel pumps in 2024 (as reported; about 0.25 m³/s each, NEER arithmetic), lift the water over the embankments by pipeline. In August 2024 the flood ran from 19 to 24 August and the Haora peaked at 12.42 m at the CWC site on 22 August (as reported; datum not stated [TBC]); the rivers leave the State into Bangladesh, and no level from across the border was obtained. This Manual therefore closes every sluice-locked or pumped outfall for the whole 72-hour storm and, where no stage record exists, for a further 72 hours, and starts every receiving pukur, dighi and lunga storage full to its outlet level (Clause 5.8.5(a), (b) and (e)). The Manual's season begins on 1 April because large falls come before the south-west monsoon as well as during it (Kailashahar 257.1 mm on 19 April 2004 and Agartala 198.0 mm on 11 April 2007, IMD), so a pukur or beel may be full at any time from April to October. No record of how long any pukur or beel stays at or above its outlet level in a wet spell, or of how long the Katakhal sluice or any other sluice stays closed, was found [TBC]. While a pukur is full and its outlet shut, it stores nothing more below FTL, and the drains and nalas 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.

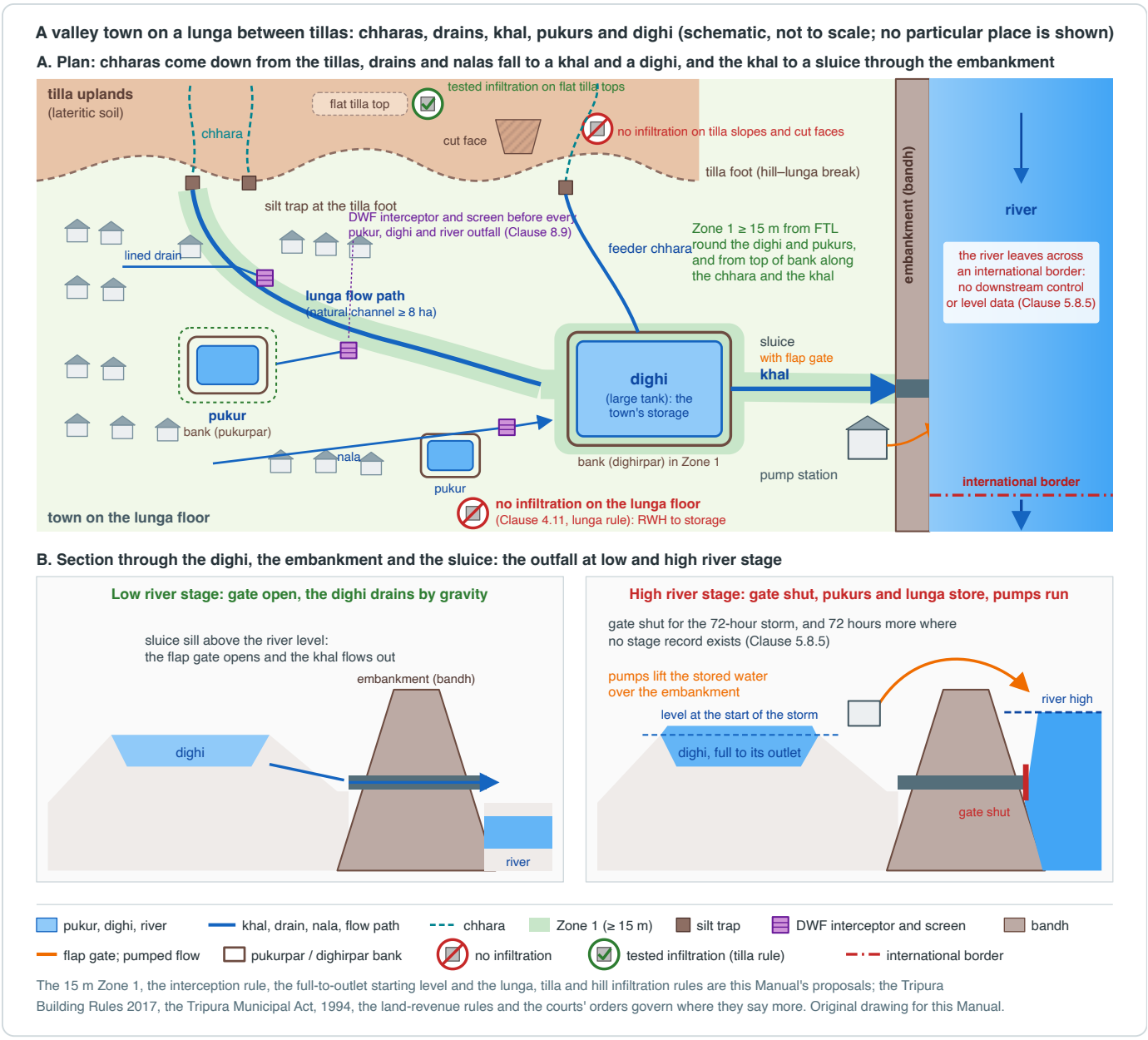

Figure 7.3 — A valley town on a lunga between tillas: its chharas, drains, khal, pukurs and dighi, and the outfall sluice at low and high river stage (schematic, not to scale; no particular town, river, tank, sluice or landmark is shown). A: in plan, chharas (streams) run down from the tilla uplands, whose soils are lateritic, and pass silt traps at the tilla foot before they reach the town (Clauses 6.3.6(m) and 8.12). One chhara continues across the lunga, the flat land between the tillas, as its flow path, a natural channel under Clause 7.4.1(b), to a khal. The town's lined drains and nalas fall to the flow path, the khal and a dighi (a large tank), which with the pukurs (tanks or ponds) is the town's storage; each tank has its bank (pukurpar or dighirpar), which lies in Zone 1. Every drain outfall to a pukur, the dighi, the khal and the river has a dry-weather-flow interceptor and a screen, because the drains carry sewage (Clause 8.9). The khal runs to a sluice through the river embankment (bandh), with a flap gate on the river side and a pump station beside it (Clause 5.8.5; Chapter 9), and the river flows on across an international border, below which there is no Indian control and no level data. Zone 1 is at least 15 m from the top of bank of the chhara, the flow path and the khal, and from the FTL of the dighi and the pukurs, and Zone 2 runs to the 1% AEP extent plus 10 m (Clause 7.4). No infiltration is credited on the lunga floor (Clause 4.11, lunga rule) or on tilla slopes and cut faces (Clause 4.11, hill rule); tested infiltration is allowed on flat tilla tops (Clause 4.11, tilla rule). B: in section through the embankment, at low river stage the gate is open and the dighi drains by gravity; at high stage the gate is shut, for the 72-hour storm and for 72 hours more where no stage record exists, the dighi and the pukurs start full to their outlet level and, with the lunga, store 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 rules are this Manual's proposals; the Tripura Building Rules 2017, the Tripura Municipal Act, 1994, the land-revenue rules 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, TDMA 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 PWD (WR) control, the operating rule shall be PWD (WR)'s rule. This Manual does not authorise any other body to operate a PWD (WR) tank.

> **Commentary.** No pukur, dighi or beel in Tripura was found with a written operating rule, and most have no gates to operate. Where one drains through an embankment, its only controllable outlet is a sluice that PWD (WR) holds, such as the Katakhal double-barrel sluice, and PWD (WR)'s sluice operating rules and closure periods were not found [TBC]; the sluices close because the river rises, not because a forecast is issued. At Rudrasagar the High Court has asked for reports on the water level and the sluice gate (PIL 05/2017; a minimum level of 11 m RL is reported to have been set, and a level of 9.08 m RL was reported in 2020, all as reported), but no operating rule was found [TBC]. The town's pumps at the outfall are the only means of drawing a pukur or the saucer down while the river is high, and their capacity is not known: in Agartala 18 flood pumps of up to 900,000 litres an hour each and 6 diesel pumps (2024), 6 new pumps (2025) and three more pumping stations proposed (2026) (all as reported; about 4.5 m³/s for the 18, NEER arithmetic; no design capacity was found [TBC]). The Dumbur reservoir is released by flap gates ("two flap gates fully open and one at 50%" on 21 August 2024, as reported), and its operator's levels and release rules were not found [TBC]. Without an agreed rule with dates, levels, pumping rates and a named operator, storage in a pukur or 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 and July 1993 and August 2024, 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 pukur, dighi or beel 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 nala or khal 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). Pukurs are used for pisciculture, which rule 9(3) of the Building Rules names among the matters to be weighed before any filling, and some 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; the palace-era and temple tanks are not drawn down at all (definitions after Clause 7.2); and no detention pond built under this Manual is called a pukur.

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 Tripura State Pollution Control Board (TSPCB) 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, khals, chharas or pukurs was found: the Agartala Municipal Corporation desilts its drains every year, by machine where it can (as reported); PWD (WR) runs a pre-monsoon programme on its embankments (as reported) and the Katakhal was cleaned in March 2026 (as reported); and the Tripura Disaster Management Authority's monsoon checklist of 2026 includes "urban drain de-silting" (as cited), all without a date. The need is recurrent: the ADB found Agartala's feeder drains "choked up with solid waste and silt" (IEE, 2020), and the CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste", with waste reaching the Haora near Battala and the Katakhal near Abhoynagar bridge (Audit Report 2022-23). The date of 31 March in this Manual is set by this Manual, before its season begins on 1 April, because large April falls come early (Agartala 198.0 mm on 11 April 2007 and Kailashahar 257.1 mm on 19 April 2004, IMD); because storms also follow, the inlets, screens and silt traps are cleared again by 31 May, before the south-west monsoon arrives, and after it by 15 November (Chapter 10). PWD (WR)'s works dates for embankments remain PWD (WR)'s. To dredge a tank is পুকুর ঝালানো (Biswas, p. 653); excavation to "increase capacity" is governed by Clause 7.9.3. In a pukur 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 pukur is laden with sewage: every desilting of a pukur, dighi or khal that receives town drains tests the silt under Clause 7.9.1(c) and disposes of it as the TSPCB directs, and no work in Rudrasagar or a notified wetland 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 Tripura 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 Tripura the public drains, channels, culverts and water courses "in, alongside, or under any street", and the public tanks and streams, vest in the Municipality "unless the State Government otherwise directs by a notification" (Tripura Municipal Act, 1994, s.91), which "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall in or outside the Municipal area" (s.156(1)), cleanses its drains (s.157), may drain sudden waterlogging across private land without notice (s.160), allows a private drain to join a municipal drain only "after obtaining the written permission of the Municipality" (s.161), may demolish an unauthorised drain (s.162) and acts against the encroachment of its drains (s.166); the Act counts "any river, stream or channel" as a watercourse (s.2). The Building Rules forbid the filling of "canals, … river lets, jhora, … streams, drains, culverts" without the Local Body's approval with the State Government's prior approval (r.9(3)), require notice before a drain is covered (r.38) and, in the ULBs of the hill areas, forbid the covering of an open drain without written permission and any building over a drain (r.99(2)(e) and (f)). In practice the capital works are built by others: in Agartala the UDD and PWD (DWS) carry out 98% of the AMRUT works "and only a few minor works … by AMC" (CAG, Audit Report 2019-20), PWD (R&B) builds the major roads and their drains (CAG), Agartala Smart City Ltd builds storm drains, flood pumps and works on the Akhaura canal and the Katakhal (as cited), and PWD (WR) holds the embankments and the Katakhal double-barrel sluice; no formal allocation among them was found [TBC], and Chapter 6 gives this Manual's working split and each town's drain register. The record shows a network that is partial and choked: "Partial drainage system is present in Agartala Municipal Corporation" (State affidavit to the National Green Tribunal, O.A. 673/2018); "Most of the main drains are masonry-lined, but the feeder drains are earth-lined and in a poor condition with silt and vegetation choking them", and the Akhaura canal "running along the Akhaura road serves mainly the central area" (ADB, IEE, 2020), which also names the Bangeshwar Gang, the Debta Gang, the Nagichara and the Kalapani Charra among the city's channels; and on NH-108B and NH-208 the District Legal Services Authority found "No proper drainage system … water logging everywhere; RCC drain hole blocked with mud, vegetation; Earthen drain damage & blocked", with "culvert block by silt, vegetation, debris" (High Court of Tripura, WP(C)(PIL) No. 06 of 2026, judgment of 08.09.2026, para 44). None of these keeps a chhara, khal or lunga flow path 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 pukur 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 Tripura no shared form of storage is required by the building rules: the Tripura Building Rules, 2017 ask that public open spaces above 500 m² "shall have arrangements for complete utilization and capture of storm water", including "Artificial or natural storage of storm water runoff from larger sites" (r.110(4)), and ask for rainwater harvesting, but have no detention, peak-flow or design-storm rule (Chapter 4). The public storage works found are restorations of existing tanks, such as Agartala Smart City Ltd's projects at the Ujjayanta palace lakes and the MBB College lake (as cited), and the city's flood pumps; a proposal of about ₹1,000 crore for "two protective embankments and installation of three additional pumping stations" in Agartala is to be "implemented in phases, depending on the availability of funds" (July 2026, as reported). The sectoral plans of the Master Plan for the Agartala Planning Area 2045 (not read [TBC]) and the ADB-assisted drainage works (48.2 km of new or rehabilitated drains under project 53262, IEE, 2020) 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 Wetland Authority of Tripura;
- (b) any wetland notified under the 2017 Rules, to its notified boundary (none was found notified), and Rudrasagar, Ramsar site no. 1572 (240 ha; designated on 8 November 2005 by the Ramsar listing, or on 29 February 2007 by the Forest Department, as cited), to the larger of its Ramsar boundary and the boundary of its water in the season of 1 April to 31 October;
- (c) every beel and haor, and the other marshy and swampy land (dhepa, utla) of the valley floors and flood plains, within the 1% AEP extent of Clause 7.3.4, and every plot recorded as beel, haor, dhepa or utla in the land records (a river, chhara, khal, pukur or dighi itself is a waterbody under the rest of this chapter); and
- (d) any other beel, marsh or wetland that the Authority notifies, that the Wetland Authority of Tripura lists, or that the High Court of Tripura, 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. Tripura's wetlands are the concern of the **Wetland Authority of Tripura**, constituted by notification No. F.17(54)/For-Dev/WATIL/2017/24661-686 of 05.09.2018 under the Wetlands (Conservation and Management) Rules, 2017 and reconstituted on 04.04.2022 and 18.06.2022, with a Technical Committee under rule 6 and the Principal Chief Conservator of Forests as Member Secretary (as cited; the notifications were not read [TBC]); no wetland notified under rule 4 of the Rules was found. Its one listed Ramsar site is **Rudrasagar** (Neermahal, Sepahijala district), site no. 1572, of 240 ha, with a catchment of 6,052 ha (as cited). The dates and the managers conflict: the Ramsar information sheet gives designation on 8 November 2005, and the Forest Department says the lake was identified on that date and "officially designated" on 29 February 2007; the Ramsar factsheet names the Fisheries Department as managing agency and the State's page the Forest Department (both as cited). Its Kokborok name is given as *Twijilikma* (as reported). The High Court has heard it as a suo motu PIL (WP(C)(PIL) 05/2017): status reports on the water level in 2020 (9.08 m RL reported, against a minimum of 11 m RL reported to have been set), on the sluice gate in 2022, and an affidavit of the Chief Secretary on restoration in 2023 (all as reported); and the CAG found that ring roads were built in "a Ramsar site" without the Wetland Authority's permission, wasting ₹1.75 crore, a decision that "also reduced the water level and compromised the ecological balance" (Audit Report 2021-22, para 3.6). The Wetland Authority prepared an Integrated Master Plan for the lake (as cited; not read [TBC]). The Dumbur reservoir is not a Ramsar site. No inventory of the beels and haors of the valley floors was found [TBC]; the land records class them as "Watery land" and "Big watery land" (Annex 7E). A drain outfall, desilting, diversion or gate operation in or next to Rudrasagar or a notified wetland therefore needs the views or permission of the Wetland Authority of Tripura where the Rules reach it, as well as compliance with this chapter; for the beels, haors and marshes they do not reach, this chapter, rule 9(3) of the Building Rules and the land-revenue rules 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 Tripura's pukurs, khals and rivers through the drains (Clause 8.9, Commentary). The Haora at Dashamighat is in Priority V of the CPCB's list of polluted stretches (BOD 3.3 mg/L, 2025), five drains are reported to carry 0.648 MLD of sewage into it (as cited), and the new treatment plants on the Katakhal and the Kalapania Khal are to be fed by intercepting the drains (State affidavit to the National Green Tribunal, O.A. 606/2018, 06.07.2026). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by most existing outfalls in Agartala. In Tripura they apply in full to every new outfall, and every existing outfall to a pukur, a dighi, a beel, a khal or a river 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; no new drain is led into the catchment of Rudrasagar without that interception. Where a drain comes

down from the tillas, every drain that enters a pukur, dighi or beel also passes a silt trap at the tilla foot first (Figure 7.3; Clause 6.3.6(m)), because the pukur is the end of the slope's drainage and loses its storage to the silt of tilla 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. Tripura's controls on building and filling in its waterbodies have come mostly from the courts. In WP(C)(PIL) No. 2 of 2014, *Bibash Ch. Saha v. State of Tripura*, the High Court of Tripura heard that local bodies had let ponds be filled and brick or concrete walls be built on their banks, at Kalyan Sagar, Matabari, among other places; it directed the State and the local bodies to "strictly follow the environmental laws", directed the State to frame a guideline on the protection of water bodies and notify it within six months, and ordered 110 m of cement embankment at Kalyan Sagar to be removed (orders of 22.06.2015 and 13.07.2015, as cited from a copy dated 16.08.2016). The Department of Science, Technology and Environment's "Statutory Guidelines" followed, with State and sub-divisional monitoring committees formed in April 2018 (as cited; not read [TBC]). On 28.06.2017 the High Court took a zone-wise affidavit from the Agartala Municipal Corporation on the encroachment of the city's water bodies and gave it six months (as cited; the case number was not confirmed [TBC]). It has heard Rudrasagar as a suo motu PIL since 2017 (Clause 7.12, Commentary). The Tripura Human Rights Commission in 2025 took up the illegal filling of a water body at Gol Bazar, naming Agartala Smart City Ltd and the Corporation (as reported). Before the National Green Tribunal the State reported in 2020 that of 180 urban water bodies on government land only 30 had been prioritised for restoration (as reported; the application is identified as O.A. 325/2015 by NEER from the case name). Ponds have been filled for housing in Barjala and Lanka Basti (as reported). The statutes' penalties are slight: a fine of up to ₹2,000 for a tank made without the Municipality's permission (Tripura Municipal Act, 1994, s.232), the Municipality's powers against the encroachment of its drains (s.166), and the revocation, within thirty working days, of a change of land class made in breach of the Land Revenue and Land Reforms Act (Diversion of Land Rules, as amended on 6 March 2026, r.4). The CAG found ring

roads built in Rudrasagar without the Wetland Authority's permission (Audit Report 2021-22). 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. Tripura's river embankments, given by PWD (WR) as "154.41 Km of embankment and 98.00 Km of anti-erosion" protecting 28,000 ha and, elsewhere, as "41 nos. (134.55 Km) of flood protection embankment" (as cited; the figures conflict and their dates are not known), are flood embankments, which the Act excludes. The dam of the Gumti hydel project at Dumbur, 30 m high and 103 m long (as reported from the National Register of Large Dams), is a dam across a river under the Act; whether it is listed as a specified dam was not checked [TBC]. The heights of PWD (WR)'s minor-irrigation earth dams, among them the Kashari Cherra dam (CAG, Audit Report 2022-23), were not obtained [TBC]. No pukur, dighi or beel in

> Tripura 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 pukur, dighi or beel 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 Tripura the embankment hazard is leakage and the breach. The State's pre-monsoon programme of 2025 was reported to cover 44 embankments on 12 rivers, with 6 km of leakage repairs on the Haora embankment at Agartala, 16.8 km of the Manu embankment at Kailashahar raised and 7.47 km of the Muhuri embankment at Belonia (as reported), and the Tripura Disaster Management Authority's monsoon checklist of 2026 lists 42 vulnerable embankment points (as reported). The CAG found that sand extraction outside the approved blocks "caused weakening of river embankment and erosion of riverbed", and that ₹3.09 crore had been spent unfruitfully on the Kashari Cherra minor-irrigation earth dam, which heavy rain eroded in September 2017 (Audit Report 2022-23). Releases from the Dumbur reservoir are the other hazard: on 21 August 2024 the Gomati district administration reported "two flap gates fully open and one at 50%", the first release since 1993 by one account, while the State's power minister said that no gate had opened, and the Ministry of External Affairs said that the releases were "automatic" and that the floods in Bangladesh came from rain below the dam (all as reported or as quoted); the Gomati at Udaipur stood at 22.05 m against an "extreme danger" level of 22.00 m that afternoon (State gauge, as reported). No breach map or emergency action plan for any embankment, dam, pukur or dighi 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 the Gomati release reach 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 Bengali 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 Tripura 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 Tripura 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 Tripura, 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 Tripura 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 Tripura, 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.

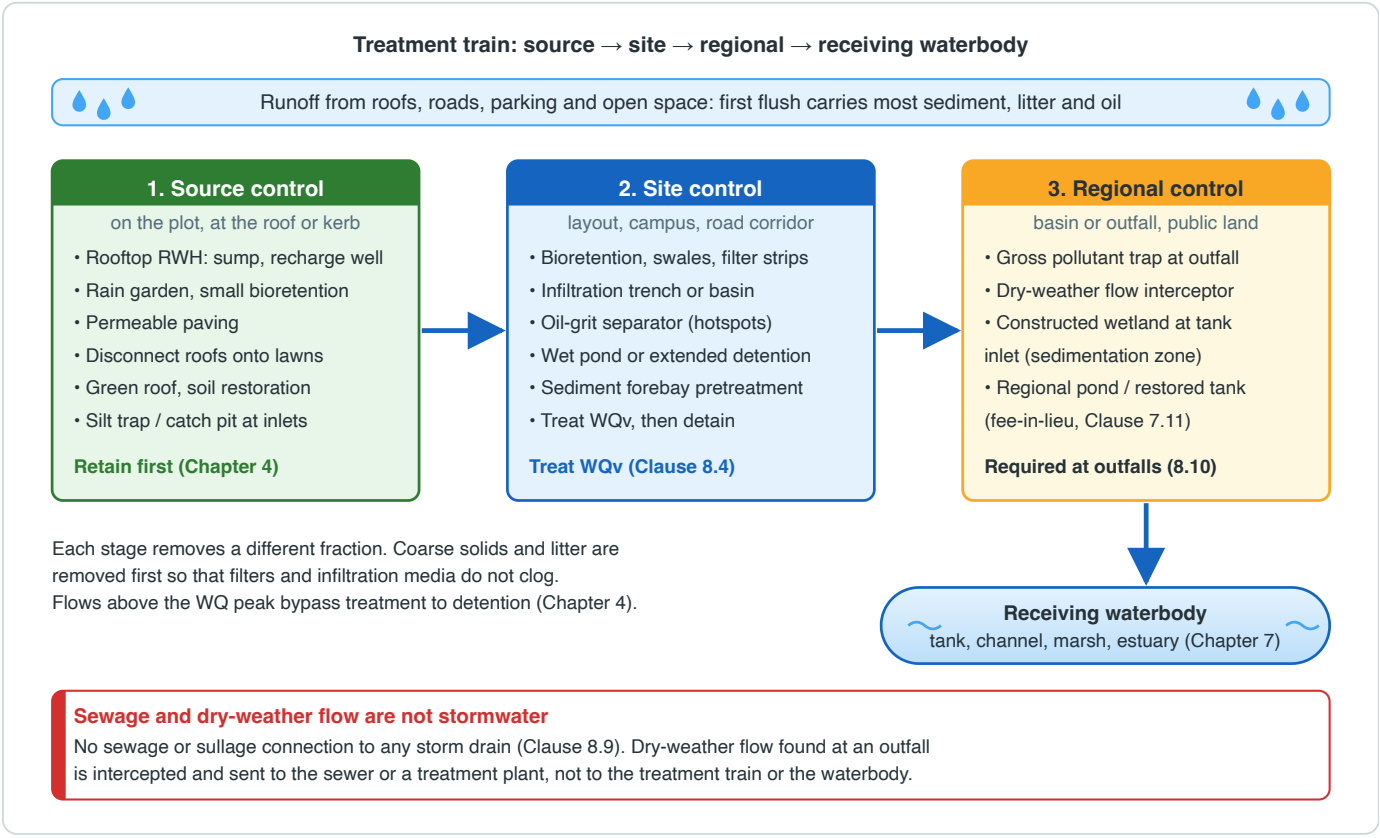


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater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

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Tested flat tilla tops and benches (tilla rule)	Laterite / hard rock	Lunga floors, flood plains, pukur, dighi and beel margins / high water table	Tripura 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	Tested flat tilla tops and benches (tilla rule)	Laterite / hard rock	Lunga floors, flood plains, pukur, dighi and beel margins / high water table	Tripura 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 Tripura 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. Tripura 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.

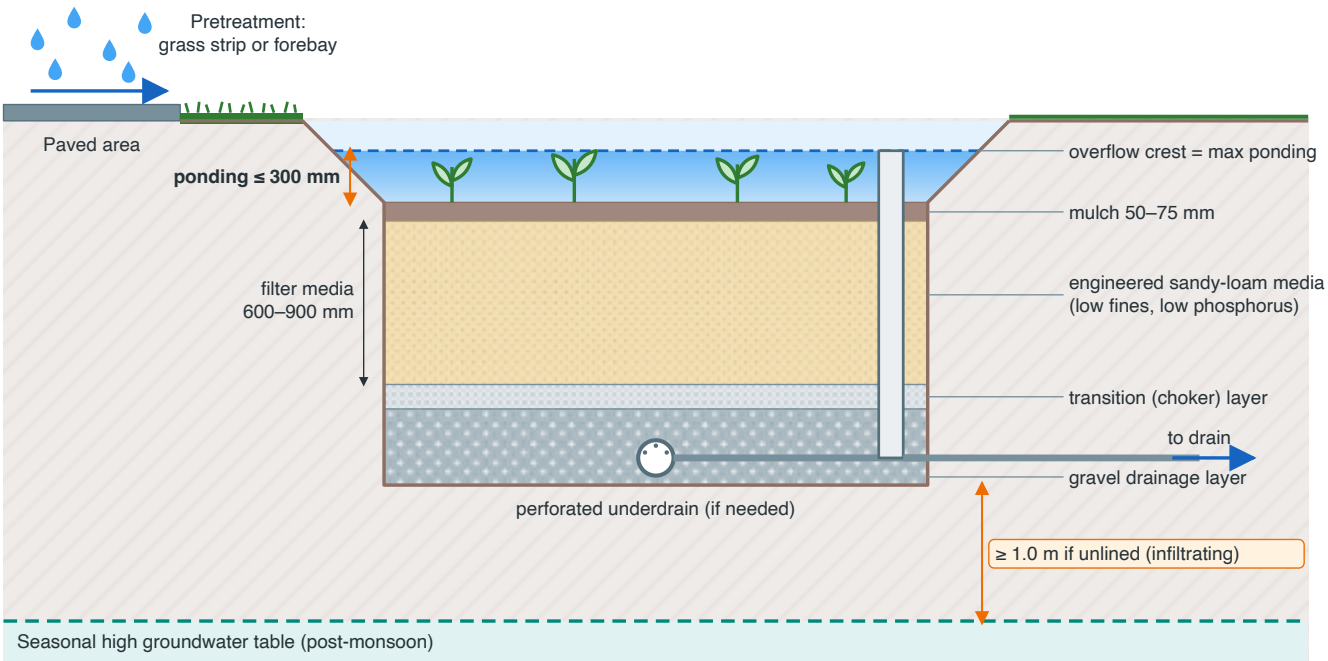
> **Commentary.** The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in Tripura. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Tripura. 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 Tripura's rain falls in the monsoon season of 1 April to 31 October: the CGWB finds "70 to 80 percent of rainfall" from May to September in West Tripura, with five-year averages of 1,851 mm at Agartala and 1,505 to 2,020 mm at the other stations of the district on 77 to 91 rainy days (NAQUIM), and

the ADB gives 1,922 to 2,855 mm a year across the State, increasing from south-west to north-east (IEE, 2020); the figures conflict, and IMD's normals were not obtained [TBC]. December to February is the dry season and the works window (Chapter 10), though large falls come outside the season too (Agartala 142.2 mm on 19 February 1993, IMD). From November to March the pukurs (Bengali পুকুর: tanks or ponds) and dighis (large tanks) fall, though on the lungas (the flat land between the tillas, the low hills) and the flood plains 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, nala, chhara (stream) or khal (canal) 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 lunga floors, 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; pukurs, dighis, beels 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 Tripura drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

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

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



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

Dimensions as set in Clause 8.7.2.

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

8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Tripura, 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). Tripura needs the three rules of Clause 4.11 here, and Clause 8.8.1 applies with the following. **(i) No infiltration on the lunga floors and flood plains (Clause 4.11, lunga 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 the recent flood plains and lunga floors (lunga: the flat land between tillas, the land records' "Flat lands between tillas" and the CGWB's "low lands ('loonga') of Holocene terrace"); on land below the 1% AEP flood level of a river, chhara or khal; inside embankment-protected land that ponds when its sluices close or its pumps stop; on the margins of a pukur, dighi, beel or haor (its Zone 1 and Zone 2 under Chapter 7); on filled ponds and lunga fills (TBR 2017, r.32) and on clayey urban fill; 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. In West Tripura the CGWB found the dug wells at 1.63 to 10.30 m below ground in March 2017 and at 0.22 to 6.64 m in November 2017 (NAQUIM); the post-monsoon depths of 2008 were 0.90 to 5.10 m in South Tripura and 1.20 to 4.37 m in North Tripura (as cited by CGWB); under central Agartala lies "a soft to medium/stiff, silty clay/clayey silt layer" and "The ground water table being very high" (ADB, 2020); and the shallow groundwater carries iron from 0.00 to 4.99 ppm "due to the ferruginous nature of Tipam sandstones" (CGWB), which clogs infiltration media (NEER reading). **(ii) Infiltration only on tested tilla tops (Clause 4.11, tilla rule).** On the dissected terrace uplands (tilla: the land records' "Hillock"), infiltration is allowed, with pretreatment, the field test of Clause 8.8.3 and the separation of this Clause, only on tilla tops and benches whose natural slope is not steeper than 10% and where the seasonal high water table is more than 3 m below ground, set back from the tilla edge by twice the height of the slope below; never on tilla slopes, cut faces or fill, within twice the height of a cut or retaining wall upslope of it, or on the lunga below. The weathered Tipam sandstone is "very porous and permeable", with a rainfall infiltration factor of 0.16 approved by the CGWB's research committee; the Dupitila sandy clays with laterite are slower (CGWB; NEER reading). **(iii) No infiltration on hill slopes (Clause 4.11, hill rule).** In sub-area TR-E, on any natural slope steeper than 20% elsewhere, and on tilla slopes and cut faces, no deliberate infiltration practice shall be built or credited, nor on colluvium, fill or slide debris, in a mapped landslide zone or at a landslip location, or upslope of a cut slope or retaining wall within twice its height, unless, on the slopes of the hill ranges, a geotechnical certificate shows that the added water will not destabilise the slope; no certificate makes one acceptable on a tilla slope, a cut face or fill. 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 20% threshold is the CGWB's own: "Area with more than 20% slope has been excluded for the recharge computation" (NAQUIM, West Tripura), a resource-assessment convention used here as the line between ground types. In the ULBs of the hill areas the Building Rules already bar a site "within 200 meters from the boundary of a sinking or probable slip zone" or where there is "high water table and fully saturated soil" (r.90(1)(h)), and ask for the diversion of the water coming from uphill away from the foundation (r.91(r)); 2,032 landslip locations were reported in August 2024 (as reported). **(iv) Recharge is not a design objective.** The stage of groundwater extraction was 9.48%, with every assessment unit Safe, in the assessment of 2024 (as quoted by CGWB) and 9.92% in 2023 (as quoted). No recharge or injection well shall be built on lunga land or on any land under rule (i), and recharge pits and trenches only under rule (ii). Where rule 110(5) of the Building Rules makes recharge mandatory on a plot of more than 500 m² and the plot falls under rule (i) or rule (iii), this Manual states the conflict, requires storage for use in place of the recharge structure, and leaves the Applicant to seek the ULB's relaxation of the rule, which this Manual does not override. **(v) Quality.** No runoff from roads with heavy traffic, fuel stations, workshops, industrial yards or solid-waste sites, no water from a drain that carries sewage, and no overflow from a septic tank or soak pit, is led to any recharge structure, and a recharge structure on a tilla top takes only roof water or runoff that has passed a filtering BMP; rule 110 already asks that contaminated water not be injected into recharge structures and that they be kept "away from sewer lines. Septic tanks, soak pits, landfill". The 2.0 m and 3 m

limits, the 10% and 20% slopes, the April–November record and these conditions are set by this Manual; no Tripura 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. Tripura has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The sands and silty sands of the river flood plains and the porous Tipam sandstone are not coastal sand areas: Clause 8.8.1 applies there in full, with the lunga, tilla and hill rules of Clause 4.11, and the reduced separation of item (d) does not. In coastal sand areas:

- (a) infiltration is the preferred means of meeting retention and the WQv wherever Clause 8.8.1 is met;
- (b) storm drains shall not be designed to lower the groundwater table: inverts below the seasonal high groundwater table shall be watertight, with no weep holes or subsoil drains that discharge groundwater to the outfall, unless a hydrogeological report shows no harm to the freshwater aquifer;
- (c) no long-term pumping of groundwater into storm drains shall be approved (for example basement dewatering); and
- (d) in notified coastal sand areas, **roof-only runoff** may be infiltrated with a separation of not less than **0.5 m** to the seasonal high groundwater table, provided a groundwater mounding check shows that the mound stays at least 0.3 m below the facility base and does not reach adjacent foundations or basements. No other runoff may use this reduced separation;
- (e) where neither the 1.0 m separation nor clause (d) can be met, the site shall use surface retention that does not infiltrate below ground (for example shallow vegetated depressions, disconnection of roofs onto lawns, and reuse), and detention under Chapter 4.

8.8.10 **Laterite and hard-rock areas.** In laterite and hard-rock terrain (for example the lateritic Dupitila sandy clays and the weathered Tipam sandstone of the tilla uplands, and the sandstone and shale of the Baramura, Atharamura, Longtharai, Sakhan and Jampui ranges (CGWB); none of the sources read describes crystalline rock in the State; on tilla slopes, cut faces and in sub-area TR-E the hill rule of Clause 4.11 applies first under Clause 8.8.1, and on tilla tops the tilla rule):

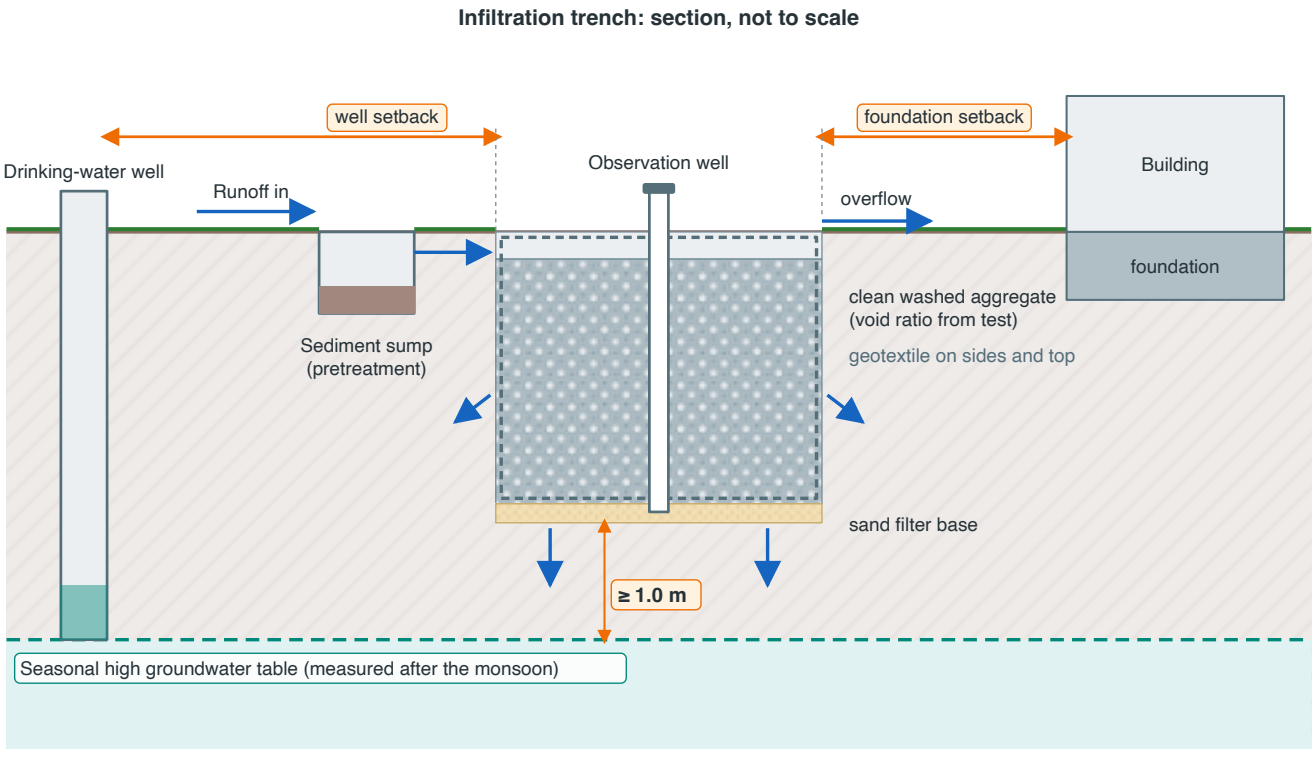
- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes shall be checked for slope stability.

8.8.11 **Delta clays and black cotton soils.** In the silty clays and clayey silts of the recent flood plains and lungas of the Haora, Gomati, Khowai, Dhalai, Manu, Juri and Muhuri valleys, the silted beds of pukurs, dighis and beels, filled ponds and clayey urban fill, and the shales of the hill ranges, 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 Tripura precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Tripura 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 Tripura, 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. The CGWB describes "Quaternary & Upper Tertiary groups of rocks": recent alluvium of silt, sand, clay and gravel; the Dupitila, "Brown to buff sandy clay … clayey sandstone with ferruginous materials & laterites"; the Tipam, "Massive medium to coarse sandstone with sandy shale"; and the Surma below, folded into the "almost N – S" ranges of Baramura and Atharamura, "varying from 150 – 445m above MSL". Between the ranges lie three landforms: "(1) table lands (tilla lands) and rolling mounds formed by the Upper Pleistocene terraces …; (2) low lands ('loonga') of Holocene terrace comprising stabilized, undissected, higher flood plains; (3) recent flood plains constituting the present-day flood-prone belts fringing the rivers"; "The undulation formed by 10 – 30 m high mounds with gullies in between

them, locally called 'loonga'". The soils are "acidic in nature", and the lithologs show 3 to 10 m of reddish-brown lateritic soil, sandy loam or reddish clay at the surface (CGWB, NAQUIM, West Tripura). Under central Agartala the Haora's alluvium is "a top soil underlain by a soft to medium/stiff, silty clay/clayey silt layer" over silty sand, with a bearing capacity of 4 to 6 t/m², and "The sandstones are highly porous underlain by impermeable shales or clay" (ADB, IEE, 2020). The water is shallow on the plains: in West Tripura the dug wells stood at 1.63 to 10.30 m below ground in March 2017 and at 0.22 to 6.64 m in November 2017, and in Agartala "The ground water table being very high" (CGWB; ADB). "Within a few hours most of the rainwater goes as run off and finally enters Bangladesh" (CGWB). Groundwater is not short: the stage of extraction was 9.48%, with every assessment unit Safe, in the assessment of 2024 (as quoted by CGWB). Quality is the constraint: the shallow groundwater carries iron from 0.00 to 4.99 ppm "due to the ferruginous nature of Tipam sandstones" (CGWB), with iron above the permissible limit "in most of the places in the phreatic aquifer" by an older State assessment (as cited). The CGWB's rainfall infiltration factor for the Tipam sandstone, "very porous and permeable", is 0.16, a fraction of rainfall and not an infiltration rate. This Manual's interim soil groups follow from these (Chapter 3): the recent flood plains and lunga floors D; the Holocene terraces and higher flood plain C to D; the tilla uplands of Dupitila sandy clay with laterite C (B on sandy tops); the weathered Tipam sandstone B to C; the hill ranges D for design; and urban fill C (D if clayey). **The State therefore needs three rules, not one** (Clause 4.11). On the lunga floors and flood plains, where most towns stand, no water is put into the ground on purpose, under the lunga rule, because in the storms that matter it would go into saturated ground. On tilla slopes, cut faces and the hill ranges, no water is put into the ground on purpose, under the hill rule. On flat tilla tops, tested infiltration is allowed under the tilla rule, as a choice rather than a duty. 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 Tripura, which has no coast.



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 Tripura State Pollution Control Board (TSPCB) 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 Tripura. 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 Tripura the storm drains are the sewers, and this Clause is the normal case, not the exception. Agartala's sewer network, "103.6 Km … with 4011 nos. household connection", lies "only in the North Zone"; the Agartala Municipal Corporation area generates 61.0 MLD of sewage against 17.4 MLD of treatment capacity (8 MLD at Chandanimura, 8 MLD at the Akhaura ICP and 1.4 MLD of in-situ treatment of the drains that reach the Haora), a gap of 43.6 MLD; the 19 other ULBs generate 21.4 MLD and treat none; and the State generates 82.4 MLD against the same 17.4 MLD (State affidavit to the National Green Tribunal in O.A. 606/2018, 06.07.2026). Before the

Central Monitoring Committee the State asked the CPCB to consider a generation of 227.43 MLD (minutes of the 20th meeting, 19.08.2025): the two figures conflict, and neither is used here as a design value. In 2020 "Agartala city is not covered by an underground sewerage system at present" (ADB, IEE, November 2020), and the State reported "only one 8 MLD STP in entire State … commissioned in the year 2017", receiving 1.5 to 2.0 MLD (action-taken report in O.A. 606/2018, 2020); by 2026 the North Zone network exists. The plants are fed from the drains: the Akhaura plant and all those under construction "are designed to be connected through Interception & Diversion of Drains", which Agartala Smart City Ltd calls "a temporary measure till the conveyance system is laid"; 39.5 MLD is being built, at Joypur on the Kalapania Khal (5 MLD), at Ranjit Nagar (10 MLD), Abhaynagar Bridge (15 MLD) and Astabal Bridge (1.5 MLD) on the Katakhal, with a target of March 2027, and on the Haora bank (8 MLD), with a target of 31.05.2027 (affidavit, 2026). The National Green Tribunal's view, as quoted in the affidavit, is that "storm water drains are being tapped and taken to STPs which is not legal. If surface drains are used as open conduit, then storm water flows should have separate conveyance system. Sewage and storm water mixing particularly during monsoon will not only upset functioning of STP but, will also lead overflow of untreated sewage" (attributed to the hearing of 16.09.2025, NEER reading); and its order of 13.04.2026 records that the 5 MLD plant at the Kalapania Khal and the 8 MLD plant on the Haora bank lie near or on the flood plain, which "may lead to flooding of the STP and flowing of untreated sewage in the river during the monsoon" (as quoted). The State's plans include a survey of "Toilets discharging directly into drains/water bodies", an ADB-assisted project of about ₹1,200 crore of which about a third is "shallow/sub-surface sewer pipelines to intercept sewage presently flowing into open drains" (target 2030), soak pits "to prevent overflow into storm water drains", and the desludging of a third of the septic tanks each year (affidavit, 2026). The Haora at Dashamighat remains in Priority V, with a BOD of 3.3 mg/L (CPCB, 2025), and five drains are reported to carry 0.648 MLD of sewage into it (as cited). The law already points the same way: the Municipality may "require separate provisions to be made for drainage of sewage and other offensive matters as distinct from rain-water" (Tripura Municipal Act, 1994, s.164), and in the ULBs of the hill areas drains "for surface water only … shall not be connected with any drain carrying sullage water or sewage" (TBR 2017, r.99(2)(d)). The drains also carry litter: without the "wire nets" on the drains that the National Green Tribunal had asked for, "solid waste or plastic waste reached to the river", and "there is frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report 2022-23), so every screen and trash rack under Clauses 8.9.5 and 8.10 is sized for that load, with the 50% blockage of Chapter 6. In Tripura, therefore: **(i)** every storm-drain, nala and chhara outfall to a pukur, a dighi, a beel, the Haora, the Katakhal, the Akhaura canal, the Kalapania Khal or any other river or khal 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)** every interceptor that feeds a sewage treatment plant is sized on the measured dry-weather flow of its drain, with a defined bypass that returns the storm flow above that rate to the drain or khal in the monsoon, so that storm flows are kept out of the interception-fed plants; no new plant, interceptor or chamber is placed within the 1% AEP extent unless it is raised above the 1% AEP level or made watertight; **(iii)** no new storm drain shall discharge into a pukur, a dighi, a beel or the catchment of Rudrasagar unless its dry-weather flow is intercepted and its first flush treated under Clause 8.10; **(iv)** no septic-tank or soak-pit overflow and no sullage pipe is connected to a storm drain, nala or chhara on any site approved under this Manual (Clauses 8.9.1 and 8.9.2), and storm and foul water are collected separately on every site, each with its own last inspection chamber at the boundary, so that the site can be connected to a separate storm drain without rework when one is built (Clause 6.3.6(a)); **(v)** 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; **(vi)** where no sewer or treatment plant exists to receive the intercepted flow, the interceptor delivers it to an interim treatment unit that the TSPCB approves, never to a pukur, dighi, beel or khal; and **(vii)** a pukur, dighi, retention pond or lunga storage that holds storm water mixed with sewage 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 TSPCB directs; and leaves no isolated pool standing more than 72 hours after drawdown, because of mosquitoes (Tripura Municipal Act, 1994, s.233). The palace-era and temple tanks are not drawn down for this purpose; they

are protected by interception at every inlet. At an outfall that a sluice closes when the river is high, the interceptor and its chamber are placed above the 1% AEP level or made watertight, and work with the gate shut. The sizing on dry-weather flow with a monsoon bypass, and 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 Tripura 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 Tripura Building Rules 2017 (rule 110: "All building having plinth area not less than 200 sq.m., while submitting the building plans for sanction, shall mandatorily include the complete proposal of rainwater harvesting", for group housing, public and semi-public and industrial buildings of all sizes and for commercial and mixed use from 50 m², with "emphasis on both storage and reuse" for plotted housing; "permeable materials … for all open parking spaces" in group housing; "complete utilization and capture of storm water" in public open spaces above 500 m² (r.110(4)); recharge "mandatory" on plots of more than 500 m² (r.110(5)); a Rainwater Harvesting Cell in each ULB, inspection before the completion certificate and annual verification of every building above 1,000 m² (r.110(6)); and, in the ULBs of the hill areas, the gutters, pipes and drains of rule 99) continues to apply, subject to the limits of Clause 8.8.1: where a recharge pit, trench, well or shaft that rule 110

asks 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 ULB's relaxation of the rule, 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. Tripura's building rules make rainwater harvesting compulsory for most buildings, but they size nothing. Rule 110 of the Tripura Building Rules, 2017 reads: "All building having plinth area not less than 200 sq.m., while submitting the building plans for sanction, shall mandatorily include the complete proposal of rainwater harvesting", with components that include "Storage Tanks/ Pits/ sumps" and "Ground Water recharge structures"; its table asks for an RWH structure, with "emphasis on both storage and reuse", on plotted housing of 200 m² of plinth and above, and for RWH on group housing, public and semi-public and industrial buildings of all sizes and on commercial and mixed-use buildings of 50 m² and above, with recharge wells, recharge pits or percolation pits for most of them; public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water" (r.110(4)); recharge is "mandatory" on plots of more than 500 m² (r.110(5)); and each ULB keeps a Rainwater Harvesting Cell and inspects the structures before the completion certificate (r.110(6)). The 200 m² threshold replaced the 300 m² of the rules of 2004 (PIB, as reported; date not checked). No storage volume, rate per square metre of roof or infiltration test is set (NEER reading), and ground coverage of 70% for every use, and 100% for some industrial and commercial plots, has been allowed since 2025 (r.46(1) and r.51(2)), with landscaping of only 1 to 7.5% of the plot (r.113). In Tripura a recharge pit on a lunga floor, standing in ground that is saturated through the monsoon and

fed by water that may carry sewage, is a soakaway, not storage; and recharge is not needed, with the stage of groundwater extraction at 9.48% (as quoted by CGWB). This Manual therefore treats rainwater harvesting as **storage for use** for the dry months from December to March, and as storage on lunga and hill sites: where the lunga or hill rule of Clause 4.11 bars infiltration, the RWH structure is a storage tank of at least 25 L per m² of roof (about 25 mm over the roof), and the recharge structures of rule 110 are replaced by storage of the same kind (Chapter 4); the store is 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 tested flat tilla tops, recharge may be one function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); where rule 110 asks for a recharge structure on a site where Clause 4.11 bars infiltration, this Manual states the conflict, requires storage in its place, and leaves the Applicant to seek the ULB's relaxation of the rule (Clause 8.11.1). The "permeable materials … for all open parking spaces" of group housing are laid, on lunga and hill land, on a lined base with an underdrain, and earn no infiltration credit (Chapter 4). 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 and July 1993 and August 2024, 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 Tripura'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 Tripura the silt of tilla cutting travels with it: the tillas stand 10 to 30 m above the lungas with gullies between them (CGWB), and the gully erosion of their cut faces silts the valley drains (NEER reading); Agartala's feeder drains are "choked up with solid waste and silt" (ADB, IEE, 2020); the CAG found "frequent water logging of different areas due to blockage of drains and canals by plastic waste" (Audit Report 2022-23), and that sand extraction outside the approved blocks "caused weakening of river embankment and erosion of riverbed" (Audit Report 2022-23); on NH-108B and NH-208 the culverts were found blocked "by silt, vegetation, debris" (High Court of Tripura, WP(C)(PIL) No. 06 of 2026); and 2,032 landslip locations were reported in August 2024 (as reported). The Building Rules already ask, in the ULBs of the hill areas, for a soil test and a slope-stability certificate on slopes of 30° and above (r.90(1)(f)), for drainage that carries water away "without stagnation, avoiding any possibility of erosion, slope failure" (r.99(1)(c)), for the diversion of uphill water from foundations (r.91(r)), for outfalls that are "protected and guided" with filters where necessary (r.99(2)(h)) and for breast and retaining walls with weep holes and filters (r.100); they give no size, area, date or inspection for sediment control, which Clause 8.12 supplies. The stabilisation date of 31 March, which covers tilla cuts, is set by this Manual, before its season begins on 1 April, because the April and May storms come before the south-west monsoon (Agartala 198.0 mm on 11 April 2007; Kailashahar 257.1 mm on 19 April 2004, IMD; 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 NIH-DHAARA reanalysis gives about 91 to 133 mm across the State's cells (117 mm at Agartala; comparison values only, not design values; Chapter 2), and AMC III applies through much of the season (Chapter 3); the rule of Clause 8.12.3(c) is kept unchanged everywhere. In Tripura 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 every lunga floor, tilla slope and cut face; no spoil, silt or debris from a site is placed in a pukur, dighi, beel, chhara or khal, within its Zone 1, or on an embankment; and a site on a tilla keeps its sediment behind a silt trap at the tilla foot (Clause 6.3.6(m)) before any drain reaches the lunga, a pukur or a khal.

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 Tripura programme of stormwater quality monitoring was found during research for this Manual, and CPHEEO (2019) sets no Indian targets. The monitoring in Clause 8.13 is the minimum needed to calibrate Table 8.3 and to show whether DWF interception and source removal are working. The parameter list follows the key pollutants named in CPHEEO's WSUD procedure (TSS, nitrogen, phosphorus and gross pollutants), with BOD and faecal coliform added because of sewage contamination. The monitoring frequencies are set by this Manual.

8.14 Submittal requirements

Every drainage report under this chapter shall include:

1. the **Water Quality Sheet (Form 8-1)**: P_ret, P_3m and P_wq; the WQv and Q_wq for each drainage area; the volume retained under Chapter 4; and the BMP serving each area;
2. for Tier A: the LoS calculation (ΔCN, required LoS) and the composite VR (Clause 8.6);
3. the design of each BMP to Clause 8.7 and Annex 8D, with pretreatment;
4. for infiltration and recharge: the **Infiltration Test Record (Form 8-2)**, the seasonal high groundwater level and its source, the design rate, the drawdown time, and the setbacks of Clause 8.8.6;
5. the sewage and sullage connection plan and the dye or smoke test record of Clause 8.9.2;
6. the GPT and first-flush design for any outfall to a waterbody (Clause 8.10);
7. the RWH layout, separating harvesting, recharge and detention (Clause 8.11); and
8. the ESC plan (Clause 8.12).

8.15 Review and update

8.15.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). Table 8.3 shall also be reviewed when the calibration programme of Clause 8.13.4 reports, and in any case within 5 years of notification.

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- Central Ground Water Board, North Eastern Region. *Aquifer Mapping and Management Plan of West Tripura District* (NAQUIM, AAP 2017-18) (Chapter 7 references); the district profiles of South and North Tripura (2008 data, as quoted); and *Dynamic Ground Water Resources*, assessments of 2023 and 2024 (State compilation of February 2025, as quoted; not read).
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- National Green Tribunal. O.A. 606/2018, affidavit of the Government of Tripura filed on 06.07.2026, and the State's action-taken report of 2020, https://www.greentribunal.gov.in/sites/default/files/news_updates/REPORT%20BY%20GOVT.%20OF%20TRIPURA%20IN%20OA%20NO.%20606%20of%202018%20FOR%20STATE%20OF%20TRIPURA%20(COMPLIANCE%20OF%20MSW%20MGT.%20RULES,%202016).pdf ; O.A. 673/2018, State affidavit and CPCB report in E.A. 35/2023, https://www.greentribunal.gov.in/sites/default/files/news_updates/REPORT%20BY%20CPCB%20IN%20EA%20NO.%2035%20OF%202023%20AND%20MA%20NO.%2092%20OF%202023%20IN%20OA%20NO.%20673%20OF%202018%20News%20item%20published%20in%20%E2%80%9Cthe%20Hindu%E2%80%9Dauthored%20by%20shri%20Jacob%20Koshy%20titled%20more%20river%20stretches.pdf (Chapter 7 references).
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Annexes and forms

Annex / Form	Content
8A	3-month ARI 24-hour depth and IDF by zone
8B	Redevelopment LoS table and treatment-train composite VR
8C	Tripura 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 khal (Bengali খাল: a canal or channel), a chhara (Bengali ছড়া: a stream, the land records' "Streams"), a pukur, a dighi, a beel 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 into the Gomati from the Dumbur reservoir of the Gumti hydel project, whose spillway capacity is given as 481.38 m³/s (as reported; Clause

5.8.5(d)); 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 Agartala that reach the Haora and the Katakhal through sluices and flap gates or by pumping (Clause 5.8.5(b)), for Kailashahar on the Manu, Belonia on the Muhuri, Udaipur and Sonamura on the Gomati and every other town whose drains reach a river through a sluice in an embankment of PWD (WR) (Clause 5.8.5(a)), and for every outfall on a river that flows on into Bangladesh, where no downstream level is known (Clause 5.8.5(c)); for an outfall to a pukur, a dighi or storage on a lunga (Bengali লুঙ্গা: the land records' "Flat lands between tillas"), its level full to its outlet at the start of the storm (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 sites that govern the larger towns the recorded peaks stand above the danger levels: the Haora at the CWC Haora site, Agartala, danger level 10.70 m and high flood level 12.42 m (22 August 2024), with other published danger levels of 10.48 m and 10.50 m and high flood levels of 11.08 m, 12.14 m and 12.4 m, probably on different gauges or datums, the higher governing until CWC confirms the gauge and datum (Clause 5.8.5(b)); the Manu at Kailashahar, danger level 25.34 m and 25.95 m (13 June 2018), with 24.00 m and a "critical level" of 23.05 m given in State press, a conflict; the Gumti at Sonamura, 12.5 m and 14.43 m (23 July 1993); the Muhuri at Belonia, a new high of 18.81 m on 22 August 2024 against the 16.98 m of 1983; and the Gomati at Udaipur, 22.05 m on 21 August 2024 against an extreme danger level of 22.00 m on the State gauge (CWC levels as transcribed by SANDRP and State levels, all as reported; the datum of none is stated [TBC]). No document found sets a design river level at any outfall in Tripura; 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.

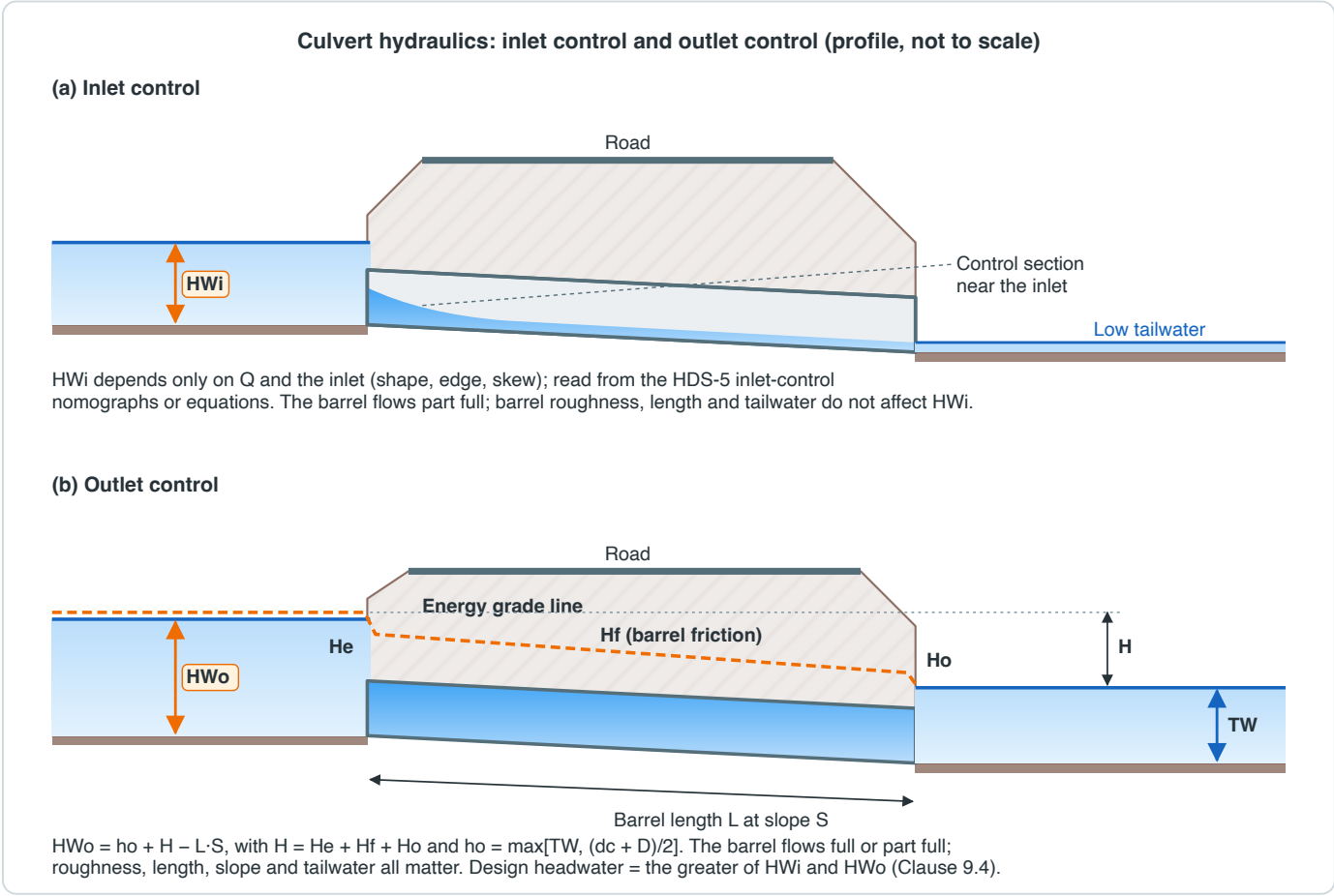

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

> **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 Tripura 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 Agartala's central saucer that reach the Haora and the Katakhal through sluices and flap gates or by pumping, on the drains of Kailashahar, Belonia, Sonamura, Udaipur and the other embanked towns, on the drains to pukurs, dighis and lunga storage that a closed sluice holds full, and on the

flat lungas of the valley floors is the normal case, as it is on the steep drains that come down the slopes of the tillas (Bengali টিলা: a hillock) and the hill ranges and on every chhara 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 Tripura (the silty clays and clayey silts of the flood plains and lungas of the Haora, Gomati, Khowai, Dhalai, Manu, Juri and Muhuri valleys, with the soft to stiff silty clay over silty sand of central Agartala, the reddish-brown lateritic sandy loams and sandy clays of the Dupitila tilla uplands, the weathered Tipam sandstone, the sandstone and shale of the hill ranges, and the urban fill over filled ponds and lungas (this Manual's reading of CGWB's aquifer mapping report for West Tripura and of ADB's initial environmental examination for Agartala, 2020; 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 Tripura 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

Class	D50 (mm)	Apron length	Apron thickness
5	500	7D	2.0 D50
6	550	8D	2.0 D50

Source: FHWA HEC-14 (2006), §10.2 and Table 10.1, as reproduced in state-agency design worksheets. Where the computed D50 exceeds Class 6, a riprap basin or a structural stilling basin shall be used.

9.6.4 **Riprap filter and grading.** Riprap shall be placed on a granular filter or a geotextile. Stone shall be angular, durable and graded so that the D50 of Clause 9.6.3 is met.

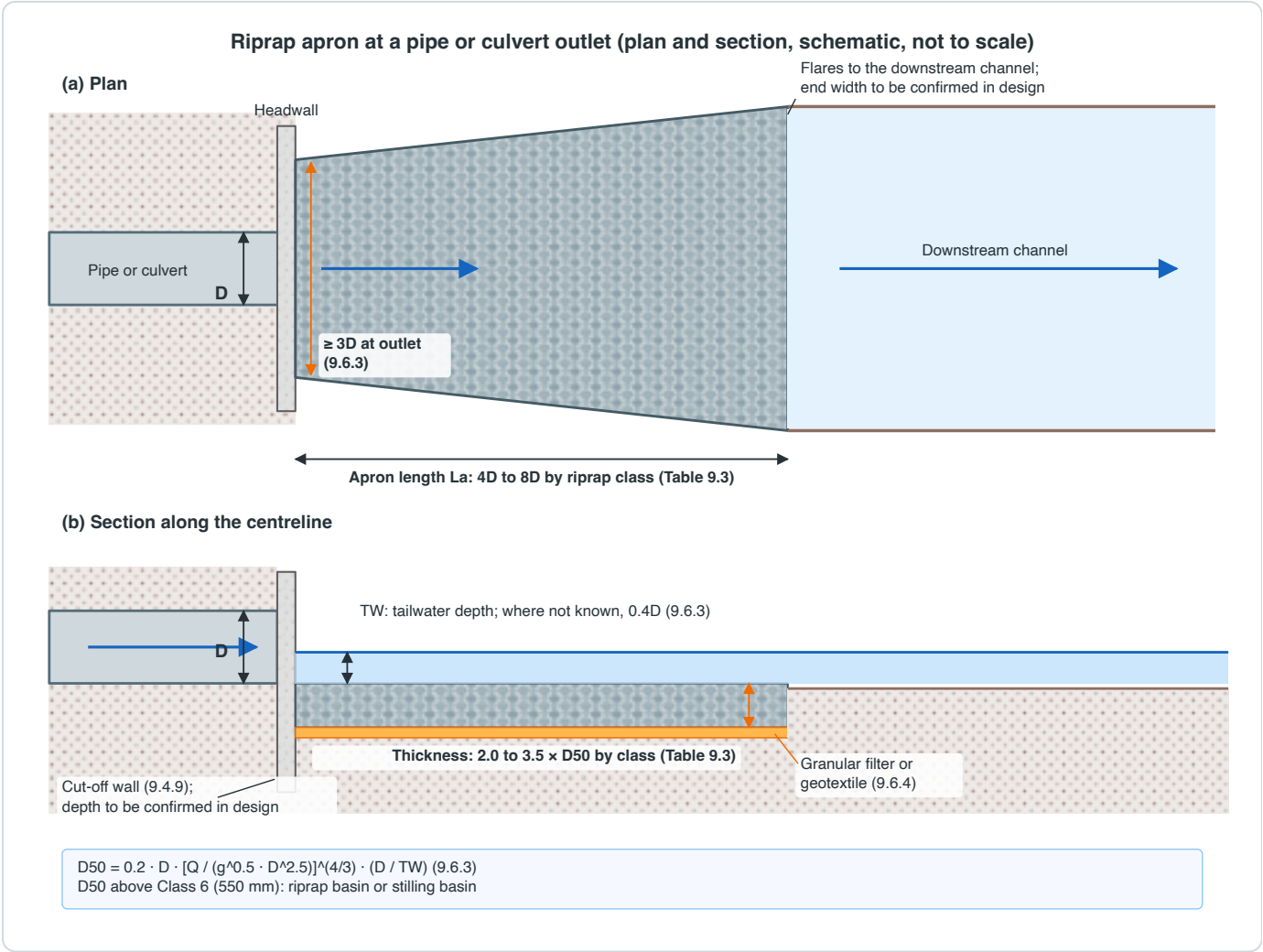

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC-14 (3rd ed., 2006), §10.2.

9.6.5 **Stilling basins.** Where velocities or Froude numbers are above the range of riprap aprons and basins, a structural stilling basin or impact basin shall be designed from HEC-14 or from the US Bureau of Reclamation basin types it describes.

9.6.6 **Drop structures.** Drop structures shall be used where the channel slope would otherwise exceed Clause 9.5.4 or the velocity limit of Table 9.2.

- (a) For a straight vertical drop, the drop number $D = q^2 / (g\,h^3)$ shall be computed, where q is the unit discharge (m^2/s) and h is the drop height (m). The pool geometry shall be set from the Rand (1955) relationships: drop length Ld/h = 4.30 D^0.27; pool depth Yp/h = 1.00 D^0.22; sequent depths y1/h = 0.54 D^0.425 and y2/h = 1.66 D^0.27.
- (b) Baffled chutes and stepped drops shall be designed by HEC-14 or US Bureau of Reclamation methods.
- (c) The height of a single vertical drop in a public drain shall not exceed 1.5 m. Drops shall have edge protection under Chapter 6, Clause 6.13.8.

9.6.7 **Coastal and beach outfalls.** Outfalls onto beaches or into estuaries shall be protected against wave action and scour. Where littoral sand can close the outfall, the outfall shall be designed so that it can be reopened by machine, and the drainage system shall be checked with the outfall closed under Chapter 5.

> Commentary. HEC-14 (3rd ed., FHWA-NHI-06-086, July 2006) is the current FHWA energy-dissipator manual. The apron equation and the class table are from HEC-14 §10.2 (Equation 10.4 and Table 10.1). The equation and table are given here as reproduced in secondary design documents (a Tennessee handbook and a state-agency riprap worksheet). The 3D apron width is from the same sources. A Purdue study (JTRP) found the HEC-14 apron method somewhat conservative within its range of application. The Rand (1955) drop relationships are standard and are reproduced in Chow (1959). The 1.5 m limit on a single vertical drop has no direct precedent; this Manual sets it for public safety in urban drains.

9.7 Detention outlet structures

9.7.1 **Primary outlet.** The primary outlet of a detention facility shall:

- (a) produce the release rates and drawdown times of Chapter 4;
- (b) work without mechanical parts or operator action, except in pumped facilities (Clause 9.9);
- (c) have no orifice smaller than **50 mm**, and every orifice shall be protected by a trash screen (Clause 9.8.5); and
- (d) be accessible for cleaning from the surface.

9.7.2 **Orifices.** Orifice flow shall be computed as:

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

where A is the orifice area (m^2) and h is the head (m) on the centroid of the orifice, or the difference between the upstream and downstream water levels where the orifice is submerged. Cd shall be 0.60 for a sharp-edged orifice in a thin plate. Other edge conditions shall use published tested values.

9.7.3 **Weirs.** Weir flow shall be computed as $Q = C_w \cdot L \cdot H^{1.5}$, 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 m³/s.

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

> Commentary. CPHEEO (2019, §8.3.1.3) describes pump-station bar screens with a spacing of "approximately 58 mm", built in modules, with an emergency overflow in case of clogging. Clause 9.8.6 follows that approach but links the spacing to the pump's solids-passing size, which varies by pump. The 50% blockage check matches the grate clogging factor of Chapter 6. The Kirschmer equation and its shape factors are standard (Kirschmer 1926, as reproduced in hydraulic handbooks). The rack spacing, area ratio, through-velocity, the 30 m conduit length trigger, the 10× screen area for orifices and the 1 m³/s trigger for mechanical raking have no direct precedent and are set by this Manual.

9.9 Pumps and sumps

9.9.1 **When pumping is used.** Pumping shall be used only where gravity drainage cannot meet the requirements of Chapters 5 and 6, for example at road underpasses (Chapter 6, Clause 6.10.5), basements, low-lying areas and outfalls that are tide-locked under the outfall-closed check of Chapter 5.

9.9.2 **Design inflow and storage.** The station shall be designed with the inflow hydrograph routed through the catchment and any upstream storage. Pump capacity and storage shall be chosen together:

- (a) the station shall meet the design AEP of the element it serves (for underpasses, the 2% AEP with a 1% AEP check);
- (b) where the station serves a tidal outfall, storage plus pumps shall hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default: two consecutive high tides of 6 h each), as required by Chapter 5; and
- (c) the pumps shall be selected for the full range of static head between the lowest sump level against the lowest tailwater, and the highest tailwater (HAT plus surge plus 0.3 m).

9.9.3 **Wet-well volume.** The effective wet-well volume (between the pump-stop and the lowest pump-start level) shall be the greatest of:

- (a) where variable-speed drives and automatic controls are installed, 5 minutes of the minimum inflow (CPHEEO 2019, §8.3.3);

- (b) otherwise, 10 to 15 minutes of the peak inflow, or the volume needed for the pump manufacturer's minimum cycle time, from $V = Q \cdot t$ (CPHEEO 2019, Eq. 8.1); and
- (c) for constant-speed pumps, the volume $V = \Theta \cdot q / 4$ for each pump, where Θ is the minimum cycle time recommended by the motor manufacturer and q is the pump capacity (FHWA HEC-24, 2001).

9.9.4 **Duty and standby.**

- (a) Duty pumps shall be of the same size where practicable (CPHEEO 2019, §8.3.3).
- (b) Standby capacity shall be at least equal to the largest duty pump, and not less than 50% of the number of duty pumps.
- (c) Duty and standby roles shall alternate automatically.

9.9.5 **Pump type.** Pumps shall be solids-handling (non-clog) types suited to stormwater with sand and debris. Axial-flow pumps shall be used only behind a screen that meets Clause 9.8.6, because they cannot handle debris (CPHEEO 2019, §8.3.2).

9.9.6 **Sump and intake design.** Sump geometry, pump spacing, minimum submergence and approach flow conditions shall follow the pump manufacturer's requirements and ANSI/HI 9.8 (Rotodynamic Pumps for Pump Intake Design). A physical hydraulic model study shall be carried out where any pump exceeds 1 m^3/s, or where the sump does not follow standard ANSI/HI 9.8 geometry. The minimum clear space between adjacent pumps or motors is 0.6 m for small and medium units and 1.0 m for large units (CPHEEO 2019, §8.2.5).

9.9.7 **Silt and screens.** A silt trap and a bar screen shall be provided upstream of the wet well (Clause 9.8.6; Chapter 6, Clause 6.13.3).

9.9.8 **Controls and monitoring.**

- (a) Pumps shall be controlled by a primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up.
- (b) High-level and pump-fault alarms shall be sent by telemetry to the local body's control room.
- (c) Sump levels, pump run hours and power status shall be logged and kept for at least 5 years.

9.9.9 **Power supply.**

- (a) The station shall have two independent power sources: the grid supply and a standby generator (or a second independent grid feeder) able to run all duty pumps at once (CPHEEO 2019, §2.4.2.3(j)).
- (b) Fuel for at least **72 hours** of continuous operation of all duty pumps shall be stored on site, above the flood level of Clause 9.9.10.
- (c) Changeover to standby power shall be automatic.

9.9.10 **Flood protection of the station.** The floor of the electrical and control room, the generator and the transformer shall be at least 0.5 m above the 1% AEP flood level at the station (Chapter 6, Clause 6.11). Access to the station for maintenance vehicles shall remain usable in the 1% AEP event.

9.9.11 **Discharge.** Each pump shall have its own rising main, or a non-return valve and an isolating valve where mains combine. Rising mains shall discharge into a delivery chamber or outfall fitted with a flap gate or non-return valve under Clause 9.10. Discharge piping shall be sized by a recognised friction formula (CPHEEO 2019, §8.3.9).

9.9.12 **Emergency connections.** Every station shall have a hard-standing area and a quick-coupling connection for mobile pumps to discharge into the delivery chamber.

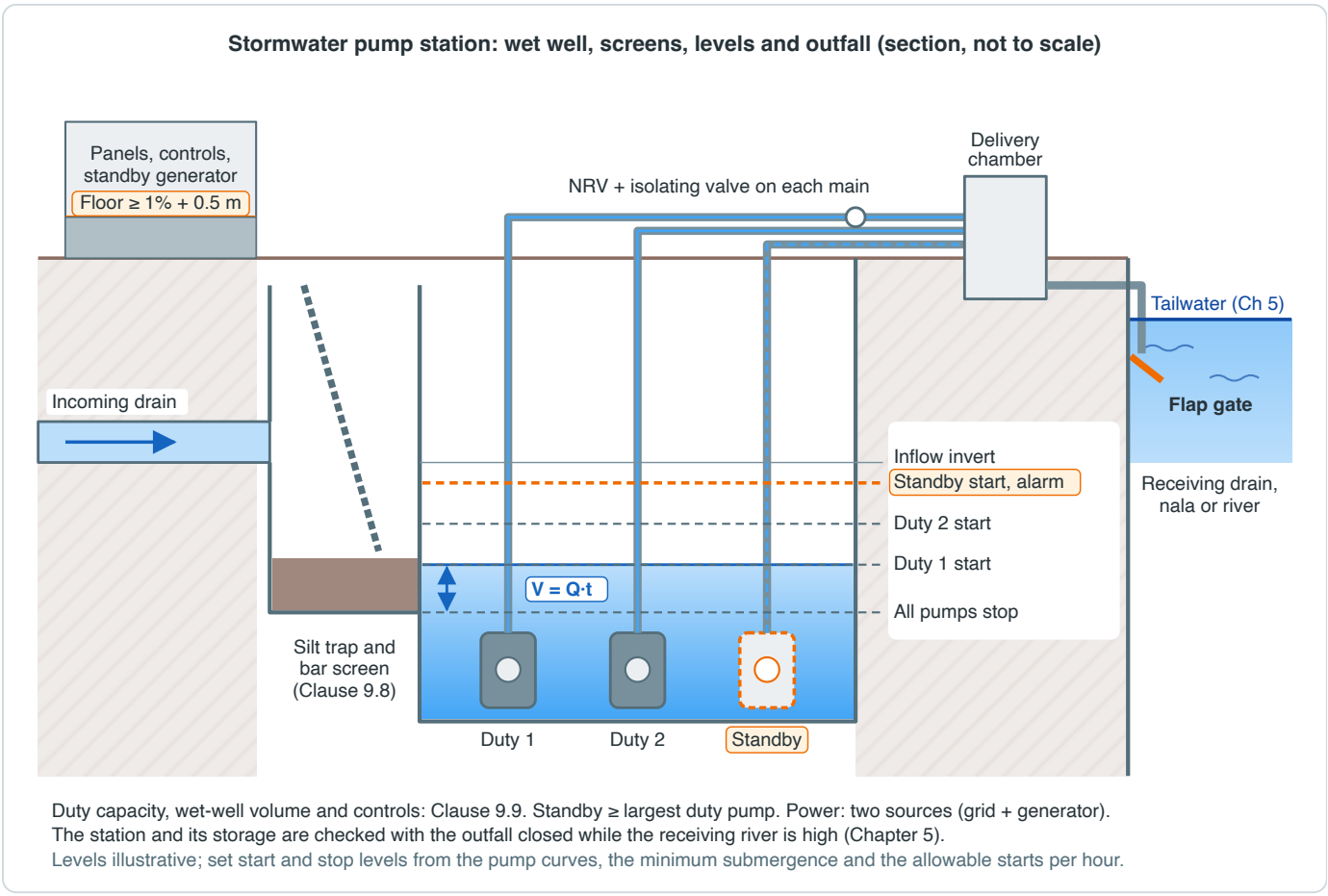

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **Commentary.** CPHEEO (2019) Chapter 8 covers stormwater pumping: wet-well sizing (§8.3.3), pump types (§8.3.2), trash screens (§8.3.1.3), space requirements (§8.2.5) and the need for generator sets "as standby for emergency operation during failure of electricity" (§2.4.2.3). It recommends standby units of "minimum 50% of the duty pump units". Clause 9.9.4(b) is stricter: the standby must at least equal the largest duty pump, so the station still meets its design duty with its largest pump out of service. This stricter rule is set by this Manual. FHWA HEC-24 (*Highway Stormwater Pump Station Design*, FHWA-NHI-01-007, 2001) is the FHWA pump-station manual. The 72 h fuel storage is set by this Manual to match the 72 h design storm of Chapter 2. The model-study trigger, the telemetry and data-retention requirements, and the emergency connection have no direct precedent and are set by this Manual.

9.10 Tide gates, flap gates and non-return valves

9.10.1 **Where required.** Flap gates, tide gates or non-return valves shall be provided on every outfall whose invert is below the 1% AEP still-water level of the receiving water (Chapter 5).

9.10.2 **Types.** Acceptable devices are:

- (a) hinged flap gates (cast iron, ductile iron, stainless steel, HDPE or composite);
- (b) elastomeric in-line or end-of-pipe check valves (duckbill type); and
- (c) penstocks or sluice gates, manual or motorised, as a secondary closure.

9.10.3 **Secondary closure.** Outfalls of 900 mm or more, and every outfall serving a pumped or storage system, shall have a penstock or stop-log slot upstream of the flap gate so that the gate can be maintained, and as a back-up if the gate jams open.

9.10.4 **Hydraulics.** The head loss through the device in the open position shall be taken from the manufacturer's tested data and included in the HGL (Chapter 6, Clause 6.8.7). Flap gates shall open at a small head difference (CPHEEO 2019, §6.3.10.1).

9.10.5 **Sand and debris.** At beach, estuary and creek outfalls where sand or debris can hold a gate open or shut:

- (a) the gate shall be housed in a chamber with surface access, or elastomeric check valves shall be used; and
- (b) the gate shall be inspected after every high-tide or surge event during the monsoon season (Chapter 10).

9.10.6 **Materials.** Hinges, pins, links and fixings shall be of corrosion-resistant material (CPHEEO 2019, §6.3.10.1). In coastal and tidal locations this means stainless steel grade 316, bronze or a non-metallic material (Clause 9.13).

9.10.7 **Storage behind gates.** Where gates close during a storm, the storage or pumping behind them shall meet the outfall-closed check of Chapter 5.

> Commentary. CPHEEO (2019, §6.3.10.1) describes flap gates and flood gates at outfalls to tidal waters. It notes that "adequate storage may be necessary if pumping is to be avoided during the closure of the gate" and that hinge pins and links "should be of corrosion-resistant materials". Tripura 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, khal, pukur, dighi or ponded level of Chapter 5. The rivers close the outfalls instead, and every one of them flows on into Bangladesh, with no Indian control downstream and no level across the border known to this Manual. Agartala is the model. Its centre "is located at a lower level than other areas giving it the appearance of a saucer", between the Haora embankment on the south and the Katakhal on the north; "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded", and when the Haora and the Katakhal run higher than the city "Several pumps have been provided to lift the water out of the city during these seasons" (ADB, initial environmental examination for Agartala, 2020). The Agartala Municipal Corporation was reported in August 2024 to run 18 flood pumps of "up to 900,000 liters" per hour each, about 0.25 m³/s each and 4.5 m³/s together by this Manual's arithmetic, and 6 diesel pumps, discharging by pipeline to the Katakhal on the north and the Haora on the south; 6 new flood pumps were reported in August 2025, and in July 2026 a proposal of ₹1,000 crore for "two protective embankments and installation of three additional pumping stations", to be "implemented in phases, depending on the availability of funds" (all as reported). The installed and working capacity of the pumps, the volume of their sumps and the hydraulics of the Katakhal and the Akhaura canal were not found [TBC]. PWD (WR) runs the double-barrel sluice in the Katakhal embankment near Bhuturia (PWD (WR), as quoted), and the Akhaura canal, which serves the central area along the Akhaura road, flows on to Bangladesh (ADB, 2020). Pumps, sumps and gates under Clauses 9.9 and 9.10 are therefore the normal monsoon case in Agartala, and the outfall-closed check of Chapter 5, for local rain with the outfalls shut (Clause 5.8.5(b)), sizes them. The Haora at the CWC Haora site reached 12.42 m on 22 August 2024 against a danger level of 10.70 m, and stood above its danger level again in June 2022 and on 24 August 2026 (CWC levels as reported; the datum is not stated [TBC]), so these gates stay closed for days at a time. The other valley towns sit behind embankments on rivers that cross the border: Kailashahar on the Manu, where 16.8 km of embankment was reported raised in 2025, Belonia on the Muhuri, with 7.47 km, Udaipur and Sonamura on the Gomati, and Dharmanagar on the Juri, and the Haora embankment at Agartala needed 6 km of leakage repairs (all as reported); the drains and sluices of these towns were not researched [TBC]. The embankments themselves are counted in two ways, "154.41 Km of embankment and 98.00 Km of anti-erosion" or "41 nos. (134.55 Km) of flood protection embankment" (PWD (WR), as quoted; dates unknown), TDMA's checklist for the monsoon of 2026 is reported to list 42 vulnerable embankment points, and the CAG found that sand extraction outside approved blocks "caused weakening of river embankment and erosion of riverbed" (Audit Report for the year 2022-23).

In Tripura the following are set by this Manual for every outfall that passes through an embankment, sluice or flood-protection work of PWD (WR), 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 the river sluice is closed 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 State gauge (Clause 10.4.4(d)), and on the Katakhal and the Akhaura canal, which have no gauge, to surveyed flood marks; (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, the whole of the 72-hour design storm and, where no stage record exists, as on every border reach, the Katakhal and the Akhaura canal, a further 72 hours (Clause 5.8.5(a) to (c)), with the receiving pukur, dighi or lunga storage full to its outlet at the start of the storm (Clause 5.8.5(e)), and the pumps selected for the full range of static head up to the design river level at the governing site, which on the Haora is 12.42 m at the CWC Haora site until CWC confirms the gauge and datum (Clause 5.8.5(b)); (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 for the rest of the closure, 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, leak or overtopping, such as the flood marks of August 2024, because the stations must keep running when the land around them floods; and (e) the work needs the consent of PWD (WR) as owner of the embankment or sluice, since no Tripura embankment or drainage statute was found [TBC], and the gate is operated only by the body that runs it, under a written rule. Gates are also required where an outfall reaches the Gomati below the Dumbur reservoir of the Gumti hydel project at Tirthamukh, whose spillway capacity is given as 481.38 m³/s and full reservoir level as 93.55 m, against a "danger level of 94 m" given by the project and a level of 93.85 m reached in August 2024 (all as reported, a conflict; this Manual uses 94 m until the operator confirms, Clause 5.8.5(d)); its releases are made through flap gates, "two flap gates fully open and one at 50%" on 21 August 2024 by the district's account, which the power minister denied (as reported, a conflict), and no release rule or warning procedure was found [TBC]. An outfall to that 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. The dam is designed to dam-safety standards, not to this chapter, but its releases are this chapter's boundary conditions.

The chharas and the tilla slopes set the other half of this chapter. Tripura's valleys are not flat throughout: between the lunga floors rise tillas, "10 – 30 m high mounds with gullies in between them" (CGWB, aquifer mapping report for West Tripura), and the valleys are bounded by north–south ranges, the Baramura, Atharamura, Longtharai, Sakhan and Jampui, through whose cuttings NH-8 runs (sub-area TR-E). Cut tillas and hill roads silt the drains below them: on NH-108B and NH-208 the High Court of Tripura recorded the District Legal Services Authority's findings of "culvert block by silt, vegetation, debris" and "RCC drain hole blocked with mud, vegetation; Earthen drain damage & blocked" (WP(C)(PIL) No. 06 of 2026, judgment of 8 September 2026), and the rains of August 2024 were reported to have opened 2,032 landslip locations (as reported). The TBR 2017 ask, in the ULBs of the hill areas, for drains that carry water away "without stagnation, avoiding any possibility of erosion, slope failure" (r.99(1)(c)), slopes "not less than 1 : 60" round buildings (r.99(2)(a)), outfalls "protected and guided", with filters "where necessary" (r.99(2)(h)), and breast and retaining walls with weep holes (r.100), but they set no design for a structure, and which ULBs are in the hill areas is not listed [TBC]. In Tripura the following are therefore set by this Manual, as in the hill editions of this series, for a structure on a drain whose catchment includes an undeveloped tilla or hill slope, a tilla cut, a hill road or a chhara, in sub-area TR-E and on the tilla uplands of every valley: (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, silt, plastic and garbage in the bed and not less than that of Clause 9.8.2(a), and a silt trap upstream of the rack, sited at the tilla foot or the hill–lunga break, where the chharas drop their load (Clause 6.3.6(m)); the trap volume shall be estimated from the silt and debris deposited at the site in past floods and a stated sediment-yield method, counting every tilla cut, hill road, slide scar and building site in the catchment as a source, because no Indian or Tripura guidance on sizing silt traps or debris basins and no Tripura silt or bulking allowance was found [TBC]; its spillway shall pass the 1% AEP inflow with the trap full, as for Clause 9.7.6, and it

shall have a ramp for the machines that empty it; (c) a culvert on a chhara 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 tilla cuts, hill roads, earthworks or building sites shall have a silt trap before it joins a public drain, a khal, a chhara, a pukur or a dighi; and (e) a lining in a steep drain shall be designed for the abrasion of the gravel and sand it carries as well as for the velocity of Table 9.2. No structure of this chapter is designed to pass a debris flow or a landslide: on any drain below a mapped landslide zone, a tilla cut or a hill-road cutting, in the breach path of an embankment or on the Gomati below the Dumbur reservoir, 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 recent flood plains and lungas, below the 1% AEP flood level, behind an embankment that ponds when its sluices close or its pumps stop, on pukur, dighi and beel margins, on filled ponds and lunga fills or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, lunga rule), or in sub-area TR-E, on natural slopes steeper than 20%, on tilla slopes, cut faces, fill or slide debris (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, plastic and garbage: Agartala's sewers, 103.6 km "only in the North Zone", serve part of one city, its treatment plants "are designed to be connected through Interception & Diversion of Drains", and the 19 other ULBs treat none of their sewage (State affidavit to the National Green Tribunal in O.A. No. 606 of 2018, 6 July 2026), which the Tribunal is quoted as calling "not legal" where storm water drains are tapped; and the CAG found plastic waste reaching the Haora and the Katakhal from drains with no nets (Audit Report for the year 2022-23). A screen on a pump sump or a gate in Tripura is therefore 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 pukur, a dighi, the Haora, the Katakhal or the Akhaura canal (Chapter 6, Clause 6.3.6(e); Chapter 8, Clause 8.9). No inventory of the sluices, flap gates, screens and pumping stations on the drains of any Tripura town, with their sills, capacities and operating rules, no rule of PWD (WR) 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, plastic, garbage or debris, lets the Haora, the Katakhal or another river in flood back into the drain network, and one jammed shut blocks it. The drains of Tripura towns carry silt, plastic and sewage to their outfalls: for want of "tapping of drains with wired nets", "solid waste or plastic waste reached to the river", with photographs of the Haora near Battala and the Katakhal near Abhoynagar bridge, and "there is frequent water logging of different areas due to blockage of drains and canals by plastic waste" (CAG, Audit Report for the year 2022-23, performance audit of solid waste management in the urban areas of Tripura); Agartala's sewers serve only its North Zone and its treatment plants are fed by intercepting the drains (State affidavit to the National Green Tribunal, 6 July 2026); and its feeder drains are "earth-lined and in a poor condition with silt and vegetation choking them" (ADB, initial environmental examination for Agartala, 2020), 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 Haora at Agartala reached 12.42 m on 22 August 2024, 1.72 m above the CWC danger level of 10.70 m, in a flood that ran from 19 to 24 August, and stood above its danger level again in June 2022 and August 2026 (all as reported; difference computed for this Manual), a gate that leaks or jams can be exposed for days, and no Tripura embankment or drainage statute was found that governs the operation of a sluice, so only the body that runs a gate, PWD (WR) at the Katakhal sluice and the sluices in its embankments, operates it, under a written rule.

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 Tripura 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 Tripura 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 Tripura 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 Tripura 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 Tripura the failure is one of missing criteria, of drains split among many hands and of a permit route that now relies on self-certification. No document of the Urban Development Department (UDD), the Tripura Urban Planning and Development Authority (TUDA), the Agartala Municipal Corporation, any other ULB, Agartala Smart City Ltd, PWD (R&B) or PWD (WR) stating a design return period, intensity or runoff coefficient for the storm drains of any town was found. The drains vest in the Municipality, which "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient out-fall" (Tripura Municipal Act, 1994, ss.91 and 156(1)), but the works are built by others: in Agartala the major AMRUT works "(98 per cent)" were implemented "by the UDD and State PWD (DWS) and only a few minor works … by AMC", with no tripartite agreement, and PWD (R&B) builds the major roads and their drains (CAG, Audit Report for the year 2019-20); Agartala Smart City Ltd builds storm drains, flood pumps and the works on the Akhaura canal and the Katakhal, and PWD (WR) the embankments and the Katakhal sluice; no order allocating the drains among them was found. The approval route shapes this chapter. The TBR 2017 apply in the ULBs and, since 2019, in the Local Planning Areas; TUDA gives the building permission and occupancy certificate in a notified Local Planning Area and for a building or township of 50 or more flats or of one acre or more inside a ULB (r.13(3), as inserted in 2020), and the ULB elsewhere. Applications go through a "unified digital platform / online single window system having application tracking facility" (r.14(1), as substituted in 2025). The plans already carry much of what a drainage submittal needs: the site plan shows "the means of drainage of the proposed building leading to existing public drains or drainage channels" and the "natural drainage channel/jhora" (r.5(1)(k) and (p)); the building plans show "the house drainage plan, and site drainage plan up to nearest Nagar Panchayat or Municipality or natural outfall" and "the roof plan indicating the drainage and slope of the terrace", and the specification "the manner in which roof and house drainage and the surface drainage of the site will be disposed of" (r.14); a basement with a kitchen, bath or water closet needs "Detailed plans showing arrangement for drainage including pumping system" (r.66(5)); a plot of 200 m² of plinth

or more needs "the complete proposal of rainwater harvesting" (r.110); a site on a "recently filled up … pond, lake, marshy" soil may be asked for a soil test, restricted or refused (r.32); and notice in Form I precedes the covering of a drain (r.38). Since the Fifth Amendment of 2025, low- and very-low-risk buildings are permitted on a "Self-Certification Proforma" by an empanelled professional, "on a trust-based approach" (r.13(3)); their occupancy certificate is issued within 7 working days by that professional in Form H1 (r.34); and "Inspection for self-certified buildings is hereby waived. However, 10% to 15% of total applications shall be randomly selected" (r.34(9)). Rainwater-harvesting structures are inspected "before issuing Completion Certificates" (r.110(6)(ii)). A private drain joins a municipal drain only "after obtaining the written permission of the Municipality" (Tripura Municipal Act, 1994, s.161). An outfall through an embankment or sluice needs the consent of PWD (WR) as its owner, since no embankment or drainage statute was found [TBC]; a notified wetland, the Wetland Authority of Tripura; and the filling of any canal, pond, water body, wetland, jhora, stream, drain or culvert, the Local Body with the prior approval of the State Government (r.9(3)). The TBR 2017 are made under the Municipal Act, which "extends to the whole of the State of Tripura except the areas under the Tripura Tribal Areas Autonomous District" (s.1(2)), so they do not apply in the council area, about 68% of the State (as reported), and no building or land-development regulation of the TTAADC was found [TBC]. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a design storm, and the "site drainage plan up to nearest … natural outfall" has no method to follow. Every stormwater item in this chapter is therefore written so that the professional who signs the drawings 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 TBR 2017 already require. Where a building is self-certified, the Manual's submittal and its certificate sit with that empanelled professional, as the permit and Form H1 do, and the Authority's check is the random selection of r.34(9) and the inspections of Clause 10.12, not a review before the permit; for every other building the site drainage plan of r.14 carries the Stage 1 and 2 submittals, the basement drainage plan of r.66 the pumped and gated items, the inspection of r.110(6)(ii) the Stage 4 check at the completion certificate, and the permission of s.161 the connection to the public drain, with the consent of PWD (WR) for any outfall through an embankment or sluice. 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 Tripura Building Rules 2017 (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.

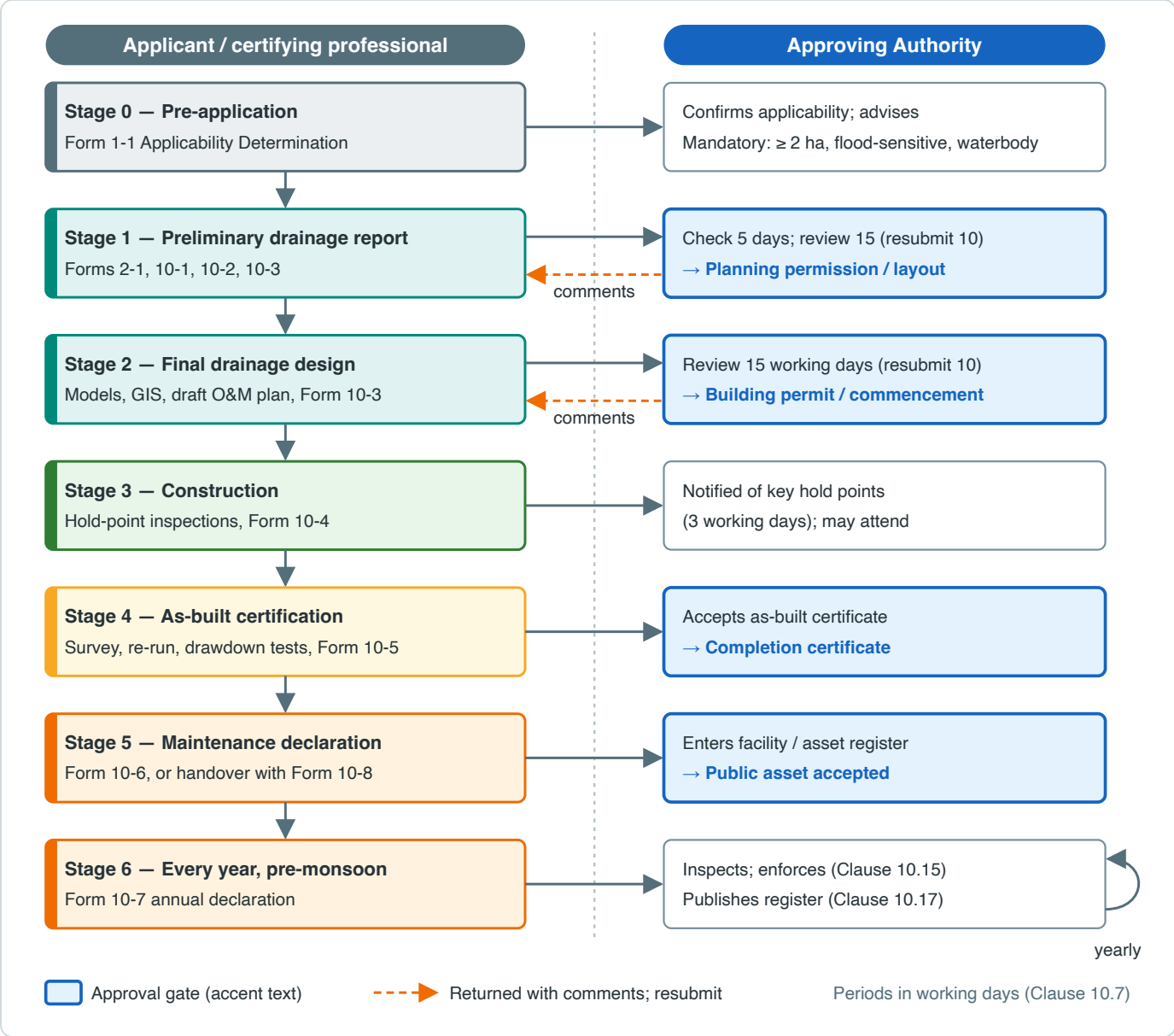

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **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 TBR 2017 steps a Tripura 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 the whole State, which lies between about 22°56' and 24°32' N and 91°09' and 92°20' E, as quoted from State pages, inside zone 46N's 90°–96° E; Agartala is given at 91°30' E or 91°17' E, a conflict, both in 46N; every project uses 46N for all its layers), with attributes as listed in Annex 10B.
- (d) Levels shall be stated relative to a named vertical datum. The relationship to the river datums of the CWC level-forecasting and level-monitoring sites on the Haora, the Gumti (Gomati), the Manu, the Khowai, the Dhalai, the Juri, the Muhuri and the Burima (not stated in any source found [TBC]), of the State gauges, such as the gauge at Jahar Bridge on the Haora and those at Udaipur and Amarpur on the Gomati, of the embankment crests, sluice sills and gate-closing levels of PWD (WR), of the levels of the Dumbur reservoir (full reservoir level given as 93.55 m, as reported, on a datum not stated), and of the flood marks surveyed on the Katakhal, the Akhaura canal and the other ungauged channels, streams, ponds and tanks 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. Tripura has no notified design return period or design storm for its urban drains. No document found, among them the ADB-funded Agartala City Urban Development Project's initial environmental examination (project 53262-001, draft of November 2020), the State's filings before the National Green Tribunal and the press, states a return period, design intensity, runoff coefficient or time of concentration for any Tripura drain; the TBR 2017 defer to "the latest edition of National Building Code and other relevant Indian Standards" for what they do not cover (r.3A), and roads follow IRC:SP:42-2014 and IRC:SP:48. ADB's drainage upgrade for Agartala is reported to aim to cut the time the city takes to drain "from one to two hours to about 15–30 minutes" (as reported); its project report was not read [TBC]. The rainfall studies do not supply a design storm either. No intensity–duration–frequency relation with published constants was found for any Tripura station; IMD's national study (Das et al., 2022) prints no panel for any Tripura station, and its North-East panels, all for stations outside Tripura, are not used; and no CWC Flood Estimation Report covers any part of the State, which by elimination lies in subzone 2(c), "Barak and others", for which CWC has published no report (this Manual's reading [TBC]). IMD's *Extremes* holds two Tripura stations, Agartala (A), whose largest day is 257.2 mm (22 July 1993), and Kailashahar (A), 377.2 mm (6 June 1993). The storms on record exceed the estimates: Bagafa (IMD) recorded 49 cm in the 24 hours to 08:30 IST on 22 August 2024 (IMD press release, Annexure I), more than every NIH-DHAARA 100-year 24-hour depth in the State, the largest of which is 435.1 mm at Sabroom, and Belonia's 32 cm and Amarpur's 31 cm on 20 August 2024 exceed their cells' 50-year depths; the claims of "about 200 mm in 3 hours" at Agartala on 17–19 June 2022 and 31 May 2025 are press reports with no IMD value behind them (as reported). The State's design values are therefore those of Chapter 2: NIH-DHAARA as modified by Clause 2.3.6, raised to the governing cell of the site's sub-area (Clause 2.3.6(c)), with the 2(a) ratio as a lower bound on the short durations (Clause 2.3.6(f)), the short-storm floors of Clause 2.3.6(g) and the zone-bounded record check of Clause 2.3.6(h), which sets 490 mm at 1% AEP in sub-area TR-D1; and each submission must state its own design basis on Form 2-1. Form 2-1 and Form 10-2 ensure that every design states its inputs.

10.5 Compliance calculator

10.5.1 The State Stormwater Technical Committee shall issue and maintain a **compliance calculator**: a version-controlled spreadsheet or web tool that, for a given site:

- (a) applies the applicability tests of Clause 1.5;
- (b) computes the retention volume from the Annex 2E depth, and the water quality volume (Chapter 8);

- (c) applies the credits for preserved areas and retained volume against detention (Chapter 4);
- (d) on the design-aid route (Clause 1.7, S-1), gives retention and detention volumes from the unit-storage tables;
- (e) on alternative S-2, gives the permissible site discharge for each AEP; and
- (f) produces the **Compliance Calculator Summary (Form 10-2)**.

10.5.2 **Use.**

- (a) Every Stage 1, 2 and 4 submittal shall include Form 10-2 from the current version of the calculator.
- (b) On the design-aid route, the calculator may be the only storage calculation.
- (c) Outside the design-aid route, the calculator is a summary and a screening check. It does not replace the hydrograph analysis of Chapter 3. Where a model result differs from the calculator screen by more than the tolerance stated in the calculator guide, the report shall explain why.

10.5.3 **Version control.** The calculator shall record its version in every output. A new version applies to new submittals 6 months after release, in line with Clause 2.14.2. A submittal shall use one version throughout Stages 1 to 4, unless the Applicant elects a later one.

10.5.4 **Openness.** The calculator, its user guide, and the source of every table in it shall be published free of charge.

> Commentary. The Mid-America Regional Council issued a Compliance Calculator (.xlsm) and a Calculator Start-Up Guide with APWA 5600 Version 2025.01, together with a site activity plan template and the Policy Supplement (MARC stormwater management page, 2025). The calculator turns a layered standard with credits into one consistent set of numbers that a reviewer can check quickly. Singapore achieves a similar effect with a much simpler rule: a single allowable C value of 0.55 for 10-yr storms up to 4 h, applied by formula (PUB Code of Practice, cl. 7.1.5). A Tripura 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 UDD:

- (a) Tier A sites of 1 ha or more;
- (b) any site in a flood-sensitive catchment;
- (c) any facility with an embankment, or a high-hazard basin checked for the 0.2% AEP (Chapter 4); and
- (d) any pumped facility, tide gate or regional facility.

10.6.2 **Empanelment criteria** shall be issued by UDD and shall include a civil engineering degree, relevant experience in drainage design, and completion of a training course on this Manual.

10.6.3 **Certificate.** The signatory shall complete the **Professional Design Certificate (Form 10-3)**, certifying that:

- (a) the design complies with this Manual, except for variances listed and approved;
- (b) the rainfall, soils and tailwater inputs are as recorded in Forms 2-1 and 10-2; and
- (c) the models submitted reproduce the results reported.

10.6.4 **Independent check.** Facilities under Clause 10.6.1(c) and (d) shall be checked by a second empanelled professional who is independent of the designer. That professional shall sign Form 10-3 as checker.

10.6.5 **False certification.** A false or negligent certificate is an offence under Clause 10.15.

> Commentary. Singapore requires that its ABC Waters design features used for peak control be endorsed by an ABC Waters Professional who is also a Professional Engineer (Civil) (PUB Detention Tank Guide, 2024). India has no statutory register of professional engineers comparable to Singapore's, so this clause uses the TBR 2017 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 UDD list. The empanelled reviewer shall not have worked on the same site. The Authority remains the decision-maker.

10.7.5 **Concurrent clearances.** Where the consent of PWD (WR), as owner, for any work that cuts, crosses, alters or discharges through an embankment, sluice or flood-protection work in its charge, or for a work on a river in its charge (no Tripura embankment or drainage statute was found, so the consent is the owner's [TBC]), the written permission of the Municipality to connect a private drain to a municipal drain (Tripura Municipal Act, 1994, s.161), the prior approval of the State Government under which the Local Body may allow a canal, pond, water body, wetland, jhora, stream, drain or culvert to be filled (TBR 2017, r.9(3)), the decision of the District Magistrate and Collector on a change in the classification of land recorded as a water body under the Diversion of Land Rules, 2025 (the procedure after their amendment of 6 March 2026 was not established [TBC]), the permission of the Wetland Authority of Tripura for a work in or draining to a notified wetland or Rudrasagar, a Ramsar site (the CAG faulted ring roads built there without it, Audit Report for the year 2021-22), the consent of PWD (R&B) or NHIDCL for a discharge to a side drain or culvert of one of their roads, the consent of TSPCB 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 Agartala, the Agartala Municipal Corporation, Agartala Smart City Ltd, PWD (R&B), PWD (WR) or PWD (DWS)), 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.

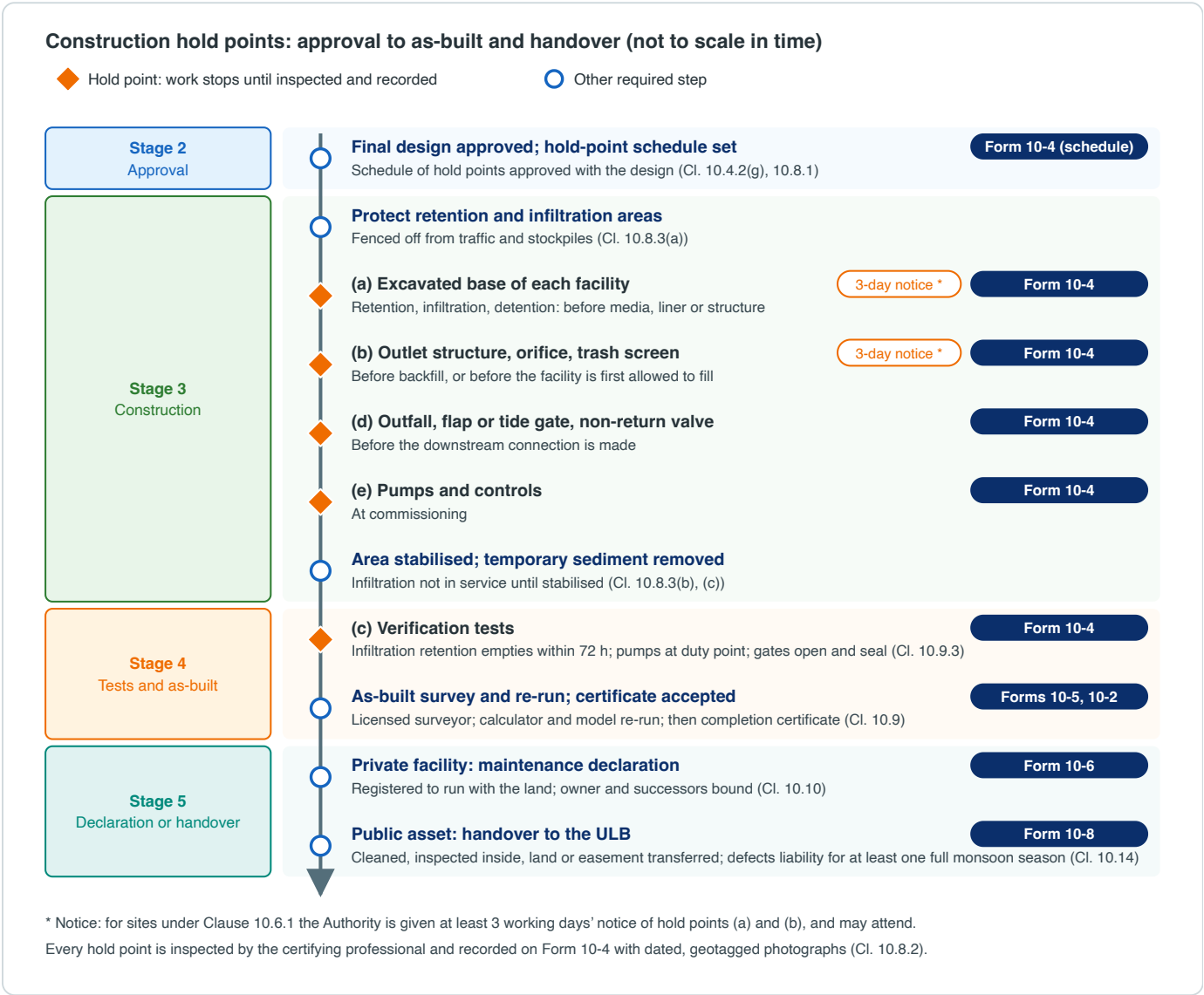

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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 Tripura 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 Tripura 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. Tripura has no dated State or municipal order fixing pre-monsoon desilting. The Agartala Municipal Corporation desilts its drains every year, ward by ward and with mechanised "super sucker" machines, under a flood strategy it dates to 2018 (as reported); PWD (WR) runs a pre-monsoon programme of embankment works, of ₹150 crore on 44 embankments on 12 rivers in 2025 (as reported), and cleaned the Katakhal and built a 650-m embankment on the Haora in March 2026, with the Corporation and Agartala Smart City Ltd (as reported); and TDMA's checklist for the monsoon of 2026 includes "urban drain de-silting", sluice gates and 42 vulnerable embankment points (as quoted) — none with a date. The drains are run by several hands, and no order divides

them: the drains, tanks and water courses vest in the Municipality "unless the State Government otherwise directs by a notification" (Tripura Municipal Act, 1994, s.91), which must have them "cleansed, flushed and emptied from time to time" (s.157) and may, in "sudden waterlogging", drain water across private land "without prior service of any notice" (s.160); the UDD and PWD (DWS) built the AMRUT works and PWD (R&B) the major road drains (CAG, Audit Report for the year 2019-20); Agartala Smart City Ltd built storm drains and flood pumps; and PWD (WR) holds the embankments and the Katakhal double-barrel sluice. The flood pumps of Agartala, 18 flood pumps and 6 diesel pumps in August 2024, discharge by pipeline to the Katakhal and the Haora, and the Corporation watches the city through an Integrated Command and Control Centre with rain and level sensors (as reported); no operating rule for the pumps or for the Katakhal sluice, linking them to a river stage or a rainfall warning, was found [TBC]. Sewage shares the drains: Agartala's treatment plants are fed by interception and diversion of drains, "a temporary measure till the conveyance system is laid" (Agartala Smart City Ltd, in the State affidavit to the National Green Tribunal, 6 July 2026), so the pukurs and channels that hold storm water mixed with sewage need their own operating rules. The Dumbur reservoir upstream of Udaipur and Sonamura is operated for power, and its release rules and warning procedures were not found [TBC]. No operating rule for any sluice, flap gate or pumping station in a Tripura 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 Tripura, the pre-monsoon inspection of sluice gates, flap gates, non-return valves, screens, silt traps and pumped facilities, including the Katakhal sluice, the gates and flood pumps on Agartala's outfalls to the Haora and the Katakhal and the gates and pumps on every outfall through an embankment of PWD (WR), with the desilting of every drain, nala (Bengali নালা: a water channel), khal (Bengali খাল: a canal or channel) and chhara (Bengali ছড়া: a stream), the clearance of inlets, silt traps, screens and the silt traps at the foot of every tilla (Bengali টিলা: a hillock), 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 operated through its full travel, by or with PWD (WR) 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 tilla-foot traps shall be cleared again by **31 May**, of the silt, plastic and debris of the April and May storms, before the south-west monsoon arrives, and every public drain, nala, khal and chhara, 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).

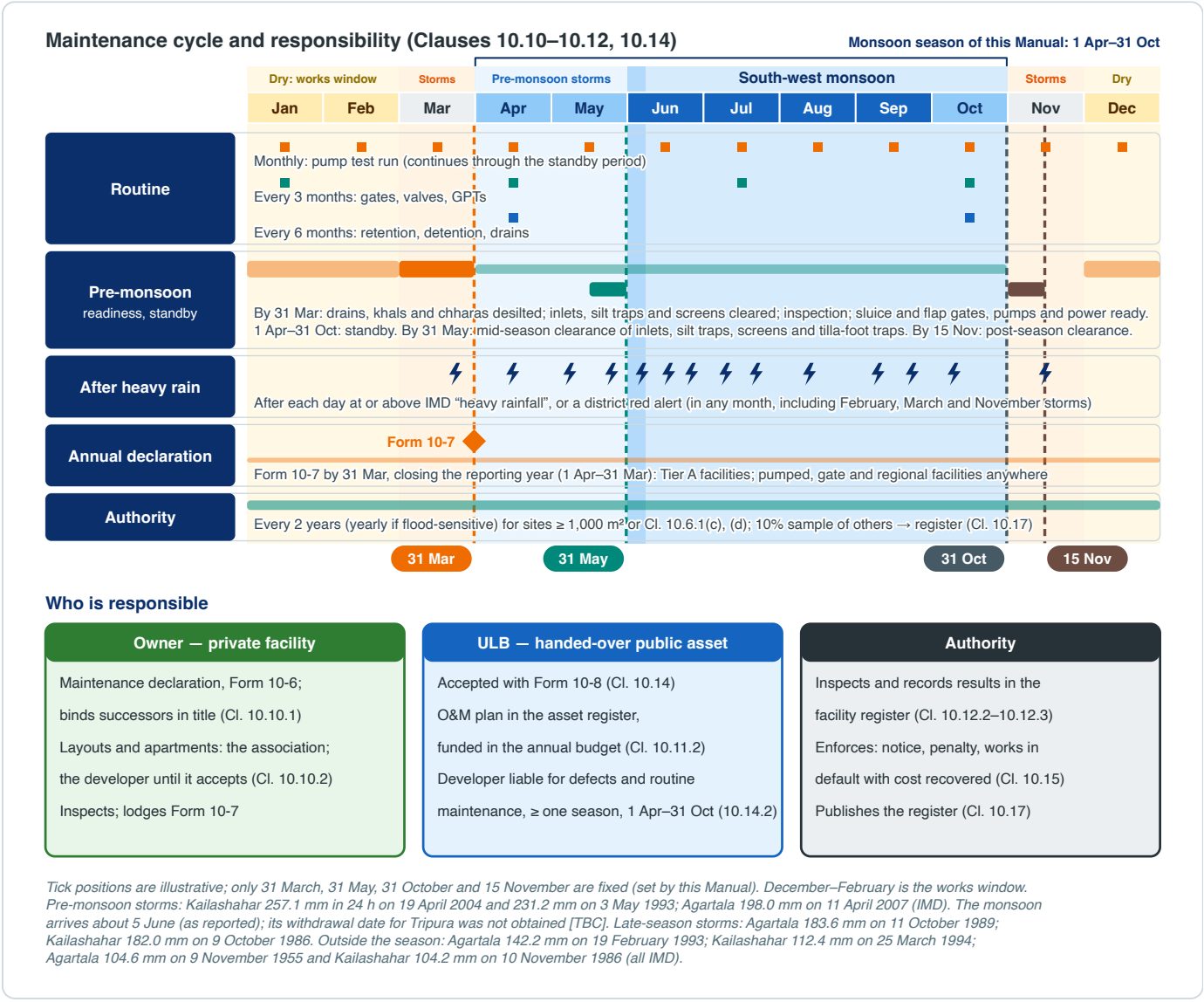

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 March) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the monsoon season (April–October); 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: Kailashahar's wettest month on record is May (1,175.0 mm in 1991) and its next is April (1,012.8 mm in 1977); its April 24-hour record is 257.1 mm (19 April 2004) and its May record 231.2 mm (3 May 1993); and Agartala's April record is 198.0 mm (11 April 2007), with a wettest May of 723.8 mm (1984) (IMD, *Extremes*). The rivers rise with them: the Dhalai at Kamalpur and the Juri at Nutan Bazar set their high flood levels, 33.85 m and 20.435 m, on 15 May 1984 (CWC levels as transcribed by SANDRP, as reported); Cyclone Remal brought 252.4 mm to Unakoti, 248.3 mm to Dhalai and 242 mm to North Tripura district in 24 hours on 27–28 May 2024 (district values, as reported); and Agartala flooded on 31 May–1 June 2025 (as reported). ADB's initial environmental examination for Agartala, citing the district disaster management plan of 2016-17, records cyclones "during April & May and during October & November in terms of Kalbaisakhi" (wording as printed) and a summer that "starts from middle of March" (2020). NDMA (2010) sets 31 March for pre-monsoon desilting nationally, and this Manual keeps that date. One date applies statewide, the same as in the neighbouring North-East editions of this series, because the Manu, the Juri and the Longai run north into the same Kushiyara plain as the Barak valley, and one calendar keeps catchments that cross a border on one cycle of inspection (set by this Manual). No Tripura order fixes a date for drains: the Agartala Municipal Corporation desilts every year, PWD (WR) runs a pre-monsoon programme of embankment works and TDMA's checklist for the monsoon of 2026 includes "urban drain de-silting", none with a date (as reported or as quoted); PWD (WR)'s programme is for its embankments, while this Manual's 31 March covers the drains, sluice gates, flap gates and pumps of the drainage system. The research for this edition suggested testing pumps and gates by 15 April; that date is not used, because the April storms come before it (Agartala 198.0 mm on 11 April 2007), and 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 Tripura is about 5 June, inferred from two reports of the Meteorological Centre Agartala's dates, 7 June 2026 "two days later than its normal" and 26 May 2025 "10 days before its normal date", while another report gives "June 10" (all as reported, a conflict; IMD's revised normals were not read [TBC]). Inlets, silt traps, screens and tilla-foot 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 Tripura was not obtained [TBC] (over the North East it was reported "close to its normal date" on 15 October 2026), but storms continue to the end of October: Agartala 183.6 mm (11 October 1989) and Kailashahar 182.0 mm (9 October 1986) (IMD); pumps, gates and screens are therefore kept on standby to 31 October (Figure 10.3). Large falls also come outside the season: Agartala 142.2 mm on 19 February 1993 and 98.6 mm on 1 March 1960, Kailashahar 112.4 mm on 25 March 1994, and Agartala 104.6 mm on 9 November 1955 and Kailashahar 104.2 mm on 10 November 1986 (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. December to February is the works window. 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 Tripura 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 Tripura 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.
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 Tripura Building Rules 2017 are made and from the municipal Acts. The graduated steps are set by this Manual. In Tripura the courts, the National Green Tribunal and the CAG have become the working regulators of drains and water bodies. The High Court of Tripura, in its suo motu WP(C)(PIL) No. 06 of 2026 on NH-108B and NH-208, recorded the District Legal Services Authority's finding of "No proper drainage system … water logging everywhere" and "culvert block by silt, vegetation, debris", and directed NHIDCL to report every two weeks, a BRO audit by 30 January 2027 and a Union inquiry by 1 December 2026 (judgment of 8 September 2026); in WP(C)(PIL) No. 2 of 2014 (*Bibash Ch. Saha v. State of Tripura*), on ponds filled and walled at Kalyan Sagar, Matabari, it directed the State to notify a guideline on protecting water bodies within six months and 110 m of cement embankment to be demolished (as cited from a third-party copy dated 16 August 2016); in an order of 28 June 2017 it took up the encroachment of Agartala's water bodies on a zone-wise affidavit of the Agartala Municipal Corporation (case number unconfirmed, as cited); and in suo motu WP(C)(PIL) No. 05 of 2017 it has watched the level of Rudrasagar (as reported). The Tribunal has dealt with the Haora as a polluted river stretch, now the State's only listed stretch, with in-situ treatment of five drains (O.A. No. 673 of 2018), the State's water bodies, of which 180 urban water bodies were identified and 30 prioritised (O.A. No. 325 of 2015, State report of 26 May 2020, as reported), and the sewage gap, where storm drains tapped to feed treatment plants are quoted as "not legal" and two plants were found on or near flood plain, where they "may lead to flooding of the STP and flowing of untreated sewage in the river during the monsoon" (O.A. No. 606 of 2018, order of 13 April 2026, as quoted in the State affidavit of 6 July 2026). The statutes reach drains and tanks but carry small penalties. Under the Tripura Municipal Act, 1994 a private drain may join a municipal drain only with the Municipality's written permission (s.161), an unauthorised drain into a municipal drain or water course may be demolished at the owner's cost (s.162), the Municipality may require "separate provisions … for drainage of sewage and other offensive matters as distinct from rain-water" (s.164), encroachment on municipal drains is

dealt with under s.166, and a well or tank made "without the permission of the Municipality" may be filled up or demolished, with a fine of up to ₹2,000 (s.232), a nominal sum by today's values. The TBR 2017 bar the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the State's prior approval for reasons recorded in writing (r.9(3)), and their self-certification route of 2025 waives inspection for low-risk buildings, with 10–15% of applications "randomly selected" (r.34(9)), so a false certificate is found only by that sample or by a flood. The Diversion of Land Rules, 2025, as amended on 6 March 2026, let a change in the classification of land be made by online self-declaration and revoked by the Competent Authority "within thirty working days" if made in contravention of s.20(3) and (4) of the Tripura Land Revenue and Land Reforms Act, 1960 (rules 3 and 4, as substituted); whether s.20 still bars the diversion of a water body was not established, and this Manual does not state the current procedure [TBC]. No embankment or drainage statute, and so no offence of cutting an embankment or operating a sluice, was found [TBC]. The CAG found drains without wire nets letting plastic waste reach the Haora and the Katakhal, with "frequent water logging … due to blockage of drains and canals by plastic waste" (Audit Report for the year 2022-23), ring roads built in Rudrasagar, a Ramsar site, without the Wetland Authority's permission, which "reduced the water level" (2021-22), ₹3.09 crore spent unfruitfully on the Kashari Cherra minor irrigation earth dam, eroded by heavy rain in September 2017 (2022-23), and the AMRUT works of Agartala implemented almost entirely by the UDD and PWD (DWS) rather than the Corporation (2019-20); no CAG audit of flood control, embankments, Agartala Smart City Ltd or storm drainage was found. 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 Haora, the Gomati, the Manu, the Muhuri, the Juri, the Khowai or another) 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 State gauge, such as the Haora at Jahar Bridge or the Gomati at Udaipur, kept apart from the CWC levels; the level in the Katakhal, the Akhaura canal and any other ungauged khal, from a staff gauge where one exists or from surveyed flood marks; the times at which each sluice and flap gate on the outfall and on the drain upstream of it closed and reopened, among them the Katakhal sluice, the level in the receiving pukur, dighi or lunga storage, the hours each flood pump ran and the river it discharged to, any loss of power and the fuel used; any breach, leak or overtopping of an embankment, with its time and the level the water reached inside it; and the releases from the Dumbur reservoir that set the level of the Gomati, 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), TDMA, 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. Tripura's floods have been counted more often than they have been reviewed, and the counts conflict. The floods of 19–24 August 2024, the State's flood of record in most basins and reported as the worst since 1983, killed 36 by the count of the Inter-Ministerial Central Team (as cited in a Lok Sabha answer) or about 38 by the Chief Minister's account in the Assembly, after earlier counts of 24 and 31; about 17 lakh people were affected, the number of relief camps rose from 450 to 822 as the days passed, and 2,032 landslip locations were reported (all as reported). The State put its preliminary losses at ₹14,247 crore and sought ₹7,080.55 crore of assistance from the National Disaster Response Fund in its memorandum of 13 September 2024 — a loss estimate and a request for assistance, not two estimates of one thing (as reported). On the night of 31 May 2025 a man died in a manhole in Agartala and about 1,300 families went to camps in West Tripura (as reported); the Agartala flood of 17–19 June 2022 sent 2,057 families, more than 10,000 people, to 39 camps by one account and 1,623 families, 7,109 people, by another, a conflict (as reported); and in June 2018 about 21,000 people were left homeless in Kailashahar when the Manu rose above its high flood level, with 173, 189 or 224 camps given in different reports (as reported). The benchmark is still the flood of 3–5 August 1983, with "about thirty" deaths and "around five lakh" people affected (Lok Sabha debates, as quoted). TDMA's final report on 2024 was not obtained [TBC]. No review of any flood in a Tripura town, and no record of flood extents, depths or durations kept by the Agartala Municipal Corporation, another ULB or TDMA, was found. The rainfall record shows why reviews need more than one gauge: on 20 August 2024 co-located gauges disagreed, Belonia 32 cm against Belonia ARG 25 cm and Belonia CWC 15 cm, Bagafa 38 cm against Bagafa AWS 13 cm, and Amarpur 31 cm against Amarpur CWC 27 cm (IMD press release, Annexure I), so every value in a review names its gauge. 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 Tripura's drainage record is public: the TBR 2017 as amended to the Fifth Amendment of 2025, the Tripura Municipal Act, 1994, the Tripura Urban Planning and Development Act, 2018, the Diversion of Land Rules, 2025 with their amendment of 2026 and the

Official Language Act, 1964, in the High Court of Tripura's library of State legislation; the High Court's judgment in WP(C)(PIL) No. 06 of 2026; the State's affidavits and CPCB's reports before the National Green Tribunal; the CAG's audit reports for 2019-20, 2021-22 and 2022-23; ADB's initial environmental examinations for the Agartala City Urban Development Project; CGWB's aquifer mapping report for West Tripura; IMD's station extremes and its press releases of August 2024; and the TUDA notification of the Local Planning Areas of 2019. Several of these were read only from archived or third-party copies, because the State's websites refused connections while this edition was prepared. Much else could not be found in the public domain: the text, notification and zoning regulations of the Master Plan for the Agartala Planning Area 2045; the original gazette of the TBR 2017 and the number of their Second Amendment; any drainage master plan or project report with a design storm, from the Agartala Municipal Corporation, Agartala Smart City Ltd, ADB or PWD (WR), including the ₹1,000 crore flood-protection proposal of 2026; the capacity of Agartala's flood pumps and the hydraulics of the Katakhal and the Akhaura canal; an inventory of PWD (WR)'s embankments and sluices with their sills and operating rules; CWC's site sheets and gauge datums; the release rules of the Dumbur reservoir; the DST&E's guidelines for the protection of lakes, ponds and water bodies; s.20 of the Land Revenue and Land Reforms Act as now amended; any building or land-development regulation of the TTAADC; an inventory of Agartala's pukurs and dighis; the archives of the State's and the Corporation's rain gauges; and TDMA's final report on the floods of 2024. 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)

- Government of Tripura, Urban Development Department. *Tripura Building Rules, 2017* (UDD notification No. F.2(316)-UDD/GL/TCPO/2009 (Part-I)/371 of 10 November 2017, as cited in UDD's BRAP-2019 document; the 2017 gazette was not read [TBC]), as amended by the Tripura Building (Amendment) Rules, 2019 (No. F.2(466)-UDD/GL/TCPO/2018/599-627, 19 February 2019; Gazette Extraordinary No. 482, 25 February 2019), the (Second Amendment) Rules, 2020 (dated 15 February 2020, Gazette 24 February 2020; number garbled in the copy read [TBC]), the (3rd Amendment) Rules, 2022 (No. F.01(24)-TUDA/Estt/2022/4902-30, 29 November 2022; Gazette 2 December 2022), the (Fourth Amendment) Rules, 2024 (No. F.1(23)-TUDA/ESTT/2024/66, 15 January 2025; Gazette No. 95, 17 January 2025) and the (Fifth Amendment) Rules, 2025 (F.No.2(466)-UDD/GL/TCPO/2018(P-V)/4009-20, 4 July 2025; Gazette No. 1294, 5 July 2025), made under section 274 read with section 118 of the Tripura Municipal Act, 1994: rules 1, 3A, 4, 5(1)(k) and (p), 9(2)–(4), 13(3), 14, 14(1), 16, 17, 32, 34, 34(9), 38, 46, 51(2), 55, 57, 66, 88–101 (Part X), 110 and 113. https://thc.nic.in/Tripura%20State%20Lagislation%20Rules/Building%20Rules,%20Tripura,%20%202017%20(As%20Amended%20upto%205th%20Amendment%20dt.%2005.07.2025).pdf
- *Tripura Municipal Act, 1994*, as amended to the Ninth Amendment (7 May 2025): ss.1(2), 2, 91, 156–166, 232–235. https://thc.nic.in/Tripura%20State%20Lagislation%20Acts/Municipal%20Act,%20Tripura,%201994.pdf
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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, pukur 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. Tripura's towns have a master plan, drainage projects and court-supervised works, but no published storm-drainage master plan with a design storm. The Master Plan for the Agartala Planning Area 2045 was declared final by the UDD on 24 February 2026 under s.53(1) of the Tripura Urban Planning and Development Act, 2018, for 238.57 km² covering the Agartala Municipal Corporation and 49 gram panchayats, with "statutory zoning and development control regulations" and sectoral infrastructure plans (as reported); its notification and text were not read, and whether it designates drainage reserves, flood zones or water-body buffers is not known [TBC]. TUDA notified Local Planning Areas adjacent to 20 cities and towns in November 2019, the first the "Agartala-Ranibazar-Jirania Local Planning Area" (excluding the ULB areas), bounded on the west by the international border (TUDA notification under s.52(1)); no master plan for any other town was found. Agartala's drainage is being built project by project. The ADB-funded Agartala City Urban Development Project (53262-001) provides 48.2 km of new or rehabilitated storm-water drains (initial environmental examination, draft of November 2020), on a loan reported as $61 million in 2021, and a later loan of $100 million with 55 km of storm-water drains was reported in a year not confirmed (both as reported); a Tripura Urban Livability Improvement Project (53276-003) of $181.28 million is listed as "Proposed" (ADB, as quoted). The Agartala Municipal Corporation and Agartala Smart City Ltd were reported to plan about 50 km of new storm drains, and a storm-water share of about ₹5–6 billion in an Agartala programme of about ₹12 billion, aiming to cut the city's drainage time "from one to two hours to about 15–30 minutes" (as reported); and in July 2026 a ₹1,000 crore Agartala flood-protection proposal of two embankments and three pumping stations was reported, to be "implemented in phases, depending on the availability of funds" (as reported). None of the documents read states a return period, design intensity, runoff coefficient or time of concentration, or sizes a drain against a river level; the project reports were not read [TBC].

Outside Agartala nothing was found. This chapter supplies the design storm, levels of service, storage and buffer criteria that such a plan needs, with the design storms of Chapter 2 and the levels of service of Clause 11.6; it has not been adopted by the UDD, TUDA, the Agartala Municipal Corporation, any Municipal Council or Nagar Panchayat, Agartala Smart City Ltd, PWD (WR), TDMA, the TTAADC, ADB or any other body, and it does not replace the plans and project reports they are preparing. A site-level manual cannot fix basin-level problems: lost tank storage, pukurs, dighis and lungas (lunga, Bengali লুঙ্গা: the land records' "Flat lands between tillas") filled for building, as reported at Barjala and Lanka Basti in Agartala, cuts in the tillas (tilla, Bengali টিলা: a hillock) and hill roads that silt the valley drains and slide in the rain, drains that are the sewers of towns in which sewers serve only Agartala's North Zone, and carry their sewage to the pukurs, the Haora and the Katakhal, outfalls that the Haora, the Katakhal and the other embanked rivers close for days, so that a town drains only as fast as its pumps run, rivers that leave the State for Bangladesh with no downstream level known, and channels split between the Agartala Municipal Corporation, Agartala Smart City Ltd, PWD (R&B), PWD (WR) and PWD (DWS), 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 Tripura, the first State of the series whose whole area lies outside every published CWC Flood Estimation Report and whose every river leaves the State for Bangladesh: to towns built on the lungas and flood plains of the valley floors, between the tillas and the north–south hill ranges; to Agartala, a saucer between the embanked Haora and the Katakhal that drains by pumps when they are high, and to Kailashahar, Belonia, Udaipur, Sonamura and Dharmanagar on rivers that cross the border with no Indian control downstream and no level data from across it; to the Gomati below the Dumbur reservoir, a release reach; to pukurs and dighis that hold the towns' storage and are being filled, and to lungas that are both the natural flow paths and the places where towns are built; to chharas (chhara, Bengali ছড়া: a stream) that bring down the silt of cut tillas and hill roads, and khals (khal, Bengali খাল: a canal or channel) that carry the towns' drains on to the rivers; to drains that are the sewers of towns in which sewers serve only part of one city; to rainfall that no CWC report covers, with a measured day, 49 cm at Bagafa on 22 August 2024 (IMD), above every estimate; to a water table near the surface across the valley floors, where infiltration is not credited; to embankment breach paths, landslide ground and the release reach, where no drain is the answer; to drains split among the Agartala Municipal Corporation, Agartala Smart City Ltd, PWD (R&B), PWD (WR) and PWD (DWS) with no order dividing them; and to the Sixth Schedule area of the TTAADC, about 68% of the State (as reported), where the TBR 2017 do not apply, 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.
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).

Term	Meaning in this Manual
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 Tripura town; the drainage project reports for Agartala were not read [TBC]. 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:

- **Agartala, central saucer and Akhaura canal:** the Central zone of the Greater Agartala Planning Area, between the **Haora** embankment on the south and the **Katakhal** on the north, the erstwhile area of the Corporation, whose centre lies lower than the rest of the city (ADB, initial environmental examination, 2020), with its channels, among them the Bangeshwar Gang, the Debta Gang, the Nagichara and the Kalapani Charra, and the **Akhaura canal**, which serves the central area along the Akhaura road and flows on to Bangladesh (ADB, 2020); modelled with the design rainfall of sub-area TR-A (Clause 2.3.6(c)), the flood pumps with their discharge pipelines to the Haora and the Katakhal, and the case of local rain with the outfalls shut as a design case (Clause 5.8.5(b)), with the drains that carry sewage in the 1D network;
- **Agartala, the Katakhal:** the North zone and the channel to the **Katakhal double-barrel sluice** near Bhuturia, run by PWD (WR) (as quoted), with the **Kalapania Khal**; the Katakhal has no gauge, so its levels come from surveyed flood marks, and until they are surveyed the Haora level is used at its outfalls (Clause 5.8.5(b)); the treatment plants being built on its banks, 10 MLD at Ranjit Nagar, 15 MLD at Abhaynagar Bridge and 1.5 MLD at Astabal Bridge, and 5 MLD at Joypur on the Kalapania Khal, all fed by intercepting drains (State affidavit to the National Green Tribunal, 6 July 2026), are shown with their interception points;
- **Agartala, the Haora:** the whole catchment of the **Haora**, 46 km long and 414 km², which rises in the Baramura range, flows west through the Agartala–Sonamura valley and enters Bangladesh near Agartala (CGWB, aquifer mapping report for West Tripura) and is "the only source of surface water for Greater Agartala" (ADB, 2020), its upper catchment in sub-area TR-E under Clause 2.3.6(c); the South zone; the flood-plain localities mapped by PWD (WR), Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat) (State affidavit to the National Green Tribunal in O.A. No. 673 of 2018; map, return period and status not known [TBC]), and Chandrapur, flooded in August 2026 (as reported); the 8 MLD treatment plant being built on the Haora bank, which the Tribunal found on flood plain (order of 13 April 2026, as quoted); and the Haora at the CWC Haora site, design level 12.42 m (22 August 2024, as reported; datum not stated), as the boundary, with the other published levels stated;
- **Kailashahar on the Manu:** the town behind the Manu embankment, 16.8 km of which was reported raised in 2025 (as reported), with its outfalls and any pumps, once surveyed [TBC], the Manu at Kailashahar (CWC), danger level 25.34 m and 25.95 m on 13 June 2018 (as reported; the State press figures of 24.00 m and 23.05 m stated as a conflict), as the boundary, the record check of Clause 2.3.6(h) (377.2 mm at 1% AEP within 25 km) and the river's run north into Bangladesh;

- **Belonia on the Muhuri:** the town behind the Muhuri embankment (7.47 km of works reported in 2025), with the Muhuri at Belonia, 18.81 m on 22 August 2024 against the 16.98 m of 1983 (as reported), as the boundary and the 490 mm record floor of sub-area TR-D1 (Clause 2.3.6(h));
- **Udaipur, Amarpur and Sonamura on the Gomati:** the towns on the release reach below the **Dumbur** reservoir, with the Gomati at Udaipur, 22.05 m against an extreme danger level of 22.00 m on 21 August 2024 (State gauge), the Gumti at Amarpur, 32.74 m (22 July 1993), and the Gumti at Sonamura, danger level 12.5 m and 14.43 m (23 July 1993) (as reported), as boundaries, and the largest recorded release, or the spillway capacity of 481.38 m³/s until the operator gives one, as the release case (Clause 5.8.5(d)); at Udaipur, the pukurs and dighis of the town, among them Kalyan Sagar at Matabari, kept as storage, not drawn down;
- **Dharmanagar on the Juri:** the town on the Juri, with the Juri at Nutan Bazar, 20.66 m on 22 August 2024 against the 20.435 m of 15 May 1984 (as reported), as the boundary;
- **Khowai and Teliamura on the Khowai:** the towns on the Khowai, with the Khowai at Khowai, 28.005 m (24 June 2004, as reported), as the boundary, and the governing cell of sub-area TR-B, since NIH-DHAARA's cell at Khowai town is empty (Clause 2.3.6(c));
- **Kamalpur on the Dhalai:** with the Dhalai at Kamalpur, 33.85 m (15 May 1984, as reported), as the boundary, and the governing cell of sub-area TR-B1;
- **Santirbazar, Bagafa and Sabroom:** the towns of the Muhuri–Feni south, with the landslides of August 2024 at Gardang near Santirbazar (as reported) mapped, the Feni a border river whose CWC site at Sabroom was not reporting in 2024 (as reported), and the 490 mm record floor of sub-area TR-D1;
- **Hill-range corridors:** the drains and culverts of NH-8 through the Atharamura and Longtharai ranges and of NH-108B and NH-208, whose blocked culverts the High Court recorded (WP(C)(PIL) No. 06 of 2026), with the tilla cuts and landslide ground above them mapped and the hazard-first rule below; and
- **Rudrasagar:** the catchment of the Rudrasagar lake at Neermahal, a Ramsar site, 6,052 ha as cited by the Forest Department, with no new storm drain into it without the interception of Clause 8.9 and the lake's level as the High Court has watched it (WP(C)(PIL) No. 05 of 2017, as reported) as the boundary.

Hazard first (set by this Manual). On the landslide ground of the tilla cuts and the hill ranges, in the breach path or leakage path of an embankment, on the Gomati below the Dumbur reservoir, on the active flood plains, "the present-day flood-prone belts fringing the rivers" (CGWB), on filled ponds and lunga fills (TBR 2017, r.32) and on the border reaches with no downstream control, the BSMP begins with a hazard screening (Clause 2.3.6(i)), made with TDMA's hazard pages and the State Disaster Management Plan [TBC], PWD (WR)'s flood-plain localities on the Haora and its records of its embankments, sluices and breaches, GSI's landslide maps where they exist [TBC] and the Natural Hazard Prone Areas of r.2(44) of the TBR 2017 once a Development Plan maps them, and states whether each part of the basin lies in the path of the hazard. The scale is large: the rains of August 2024 were reported to have opened 2,032 landslip locations, and landslides killed seven members of two families at Gardang near Santirbazar and three at Debipur, the Dumbur reservoir released water on 21 August 2024 for the first time "since 1993" by the district's account, which the power minister denied (all as reported, a conflict), and the Haora embankment at Agartala needed 6 km of leakage repairs (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 carry a breach, a debris flow or a landslide. The other ULBs define their basins in the first BSMP that covers them. Where CWC, PWD (WR), a master plan, the operator of the Dumbur reservoir 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.

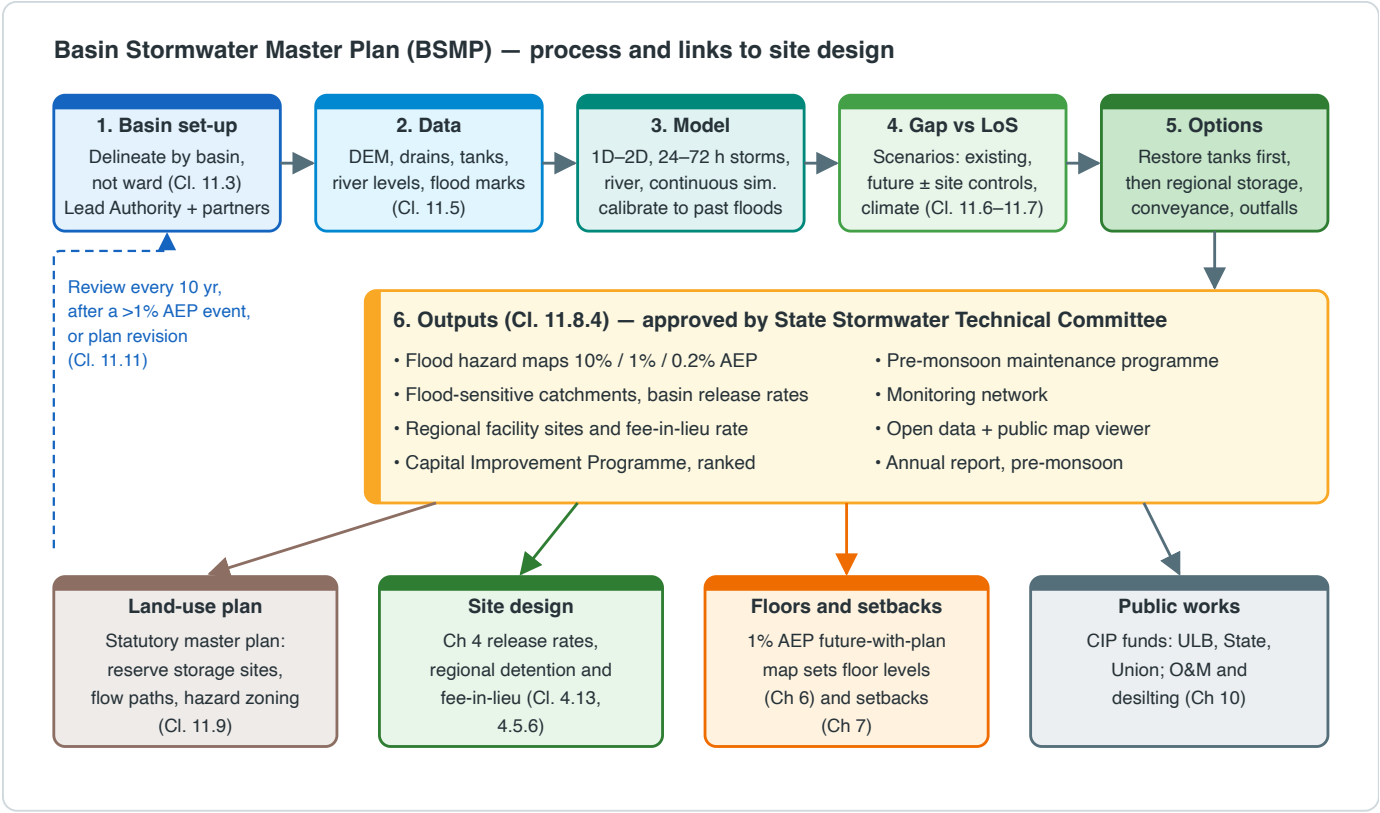

Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

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 Tripura a single channel passes through many hands, and every river crosses the international border on its way to the sea. The Haora rises in the Baramura range and runs 46 km through the Agartala–Sonamura valley into Bangladesh, draining 414 km² (CGWB, aquifer mapping report for West Tripura); in Agartala the city is divided by it and the Katakhal into a North zone, north of the Katakhal, a Central zone between the Haora embankment and the Katakhal, and a South zone, south of the Haora, and the Haora and the Katakhal are the city's "two major drainage channels draining flood water to Bangladesh" (ADB, initial environmental examination, 2020), with the Akhaura canal serving the centre and flowing on to Bangladesh as well. The planning boundaries do not follow the water: the Master Plan for the Agartala Planning Area 2045 covers 238.57 km², the Corporation and 49 gram panchayats (as reported), wider than the Corporation's own area, given as 76.5 km² or 92 km² (as reported, a conflict), and the Agartala–Ranibazar–Jirania Local Planning Area of 2019 lies outside the ULB areas, bounded on the west by the international border (TUDA notification). No order assigns the Haora, the Katakhal or the Akhaura canal to one owner (this Manual's reading of the record): the channels and drains vest in the Municipality "unless the State Government otherwise directs by a notification" (Tripura Municipal Act, 1994, s.91); PWD (WR) holds the embankments and the Katakhal sluice and has mapped the Haora's flood-plain localities; Agartala Smart City Ltd has built storm drains, flood pumps and works on the Akhaura canal and the Katakhal; PWD (R&B) holds the road drains and PWD (DWS) the pump houses and, with the UDD, the treatment plants (CAG; State affidavits to the National Green Tribunal); and the State has reported the Haora's polluted stretch as "Agartala to Champaknagar" while CPCB lists it as "Agartala to Bishramganj", a conflict over one river. Upstream, about 68% of the State lies in the area of the TTAADC (as reported), where the Municipal Act and the TBR 2017 do not apply (s.1(2)); which reaches of each basin lie in it has not been mapped [TBC]. This clause makes the basin the planning unit, so that one model carries each channel from its head in the hills, across the boundaries of the Corporation, the Planning Area and the council area, to the river and the border, 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 Agartala Planning Area (the area of the Master Plan for the Agartala Planning Area 2045, 238.57 km², as reported): the **Agartala Municipal Corporation**, in which the public drains, tanks and water courses vest and which must provide "a safe and sufficient out-fall" (Tripura Municipal Act, 1994, ss.91 and 156(1)), jointly with **TUDA**, which prepares the Master Plan, gives building permission in the Local Planning Areas and for large projects (TBR 2017, r.13(3)) and whose functions include the "development of water bodies or open spaces" (Tripura Urban Planning and Development Act, 2018); the BSMP is taken into the Master Plan and its zoning regulations (Clause 11.9). For the other towns: the **Municipal Council or Nagar Panchayat**, jointly with **TUDA** in the town's Local Planning Area. Each role is the one the body would have if the Manual were adopted. Where a basin extends beyond the ULB's limits or the Planning Area, the other local bodies and Gram Panchayats in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the drains and channels among the Corporation, Agartala Smart City Ltd and the departments 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: **PWD (WR)** for the rivers, the embankments and the sluices in them, among them the Katakhal double-barrel sluice, and the flood-plain mapping of the Haora; the **Agartala Municipal Corporation** and the other **ULBs** for the municipal drains, the channels and the flood pumps they run; **Agartala Smart City Ltd** for the works it builds until they are handed over; **PWD (R&B)** for the road drains, and **NHIDCL** for those of the national highways in its charge; **PWD (DWS)**, with the UDD, for the pump houses and treatment plants in its charge; and the **Wetland Authority of Tripura** for a notified wetland and Rudrasagar. Each town keeps the drain register of Chapters 1 and 6, which gives every reach its owner.
- **TDMA**, with the District Disaster Management Authority, for the flood, embankment-breach, release-reach and landslide hazards that a BSMP must show (Clause 11.3.3).
- In the other ULBs and Tier B bodies, the Lead Authority is named by the UDD. In the area of the TTAADC, the Lead Authority is the District Council or the authority it designates, only where the Council has made a regulation or resolved that this Manual applies (none has). Basins draining to a common river reach or sluice may be grouped into one district-level plan.

PWD (WR) shall also be a partner in every BSMP whose outfall passes through one of its embankments or sluices; TDMA and the District Magistrate and Collector shall be consulted on every BSMP; the Revenue Department on every BSMP that proposes works on land recorded as a pukur, dighi, beel or other water body; the Department of Science, Technology and Environment and TSPCB on every BSMP that proposes works on a drain that carries sewage, among them the drains intercepted for the treatment plants on the Haora and the Katakhal; the Forest Department and the Wetland Authority of Tripura on every BSMP whose basin drains to Rudrasagar or another wetland; the operator of the Gumti hydel project at Dumbur on every BSMP whose outfall lies on the Gomati below it; and CWC, for the levels at its sites, on every BSMP whose boundary is a river it gauges. Because every river leaves the State for Bangladesh, no downstream authority can be a partner, and the BSMP states that the level across the border is unknown (Clause 5.8.5(c)).

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

11.4.2 **When a BSMP is required.**

- (a) Every Tier A body shall approve BSMPs covering its whole area within **3 years** of this Manual taking effect.
- (b) A BSMP is required before:
  - any regional detention or fee-in-lieu is accepted under Clause 4.13;
  - a fee held under Clause 4.5.6.3 is spent; and
  - a basin-specific release rate is applied under Clause 11.8.3.

- (c) A Tier B body shall prepare a BSMP where its Lead Authority, or the State Stormwater Technical Committee, finds recurrent flooding of buildings or arterial roads.

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

11.5 Data and surveys

11.5.1 Each BSMP shall assemble and publish (Clause 11.10) the data in Table 11.1:

Table 11.1 — Minimum data and surveys for a BSMP

Data	Minimum requirement
Terrain	Digital elevation model from LiDAR or photogrammetry, with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum
Drain network	Inventory of all public drains, culverts and outfalls with invert levels, sizes, condition and silt depth; private drains above 600 mm
Waterbodies	Survey of every tank, pukur, 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 Haora at Agartala, danger level 10.70 m and high flood level 12.42 m, and the Manu at Kailashahar, 25.34 m and 25.95 m; CWC levels as transcribed by SANDRP or reported in the press, with the datum not stated) and its recorded peaks, with any State gauge, such as the Haora at Jahar Bridge (danger level 10.50 m, as reported), kept as a separate series and any conflict between published values stated; embankment crest levels and the location of every sluice and flap gate in the embankments of PWD (WR), among them the Katakhal double-barrel sluice, with its sill, gate type, closing level and operating rule; the flood pumps and pumping stations on the outfalls, with their installed and working capacities, discharge pipelines, sump volumes and standby power (the design capacity of none was found [TBC]); the levels of the Katakhal and the Akhaura canal, which have no gauge, by survey; the stage–storage of every pukur, dighi and lunga storage that receives the outfall, starting full to its outlet; past breaches and leaks of the embankments and the land they flooded; the release records of the Dumbur reservoir where it sets the receiving level; and, at every border reach, the statement that no downstream level is known
Rainfall and levels	All available rain gauges (IMD, through its Meteorological Centre Agartala, with its two stations in *Extremes*, Agartala (A) (42724) and Kailashahar (A) (42618), and the stations named in its press releases of August 2024, among them Agartala Aero, Met Agartala (ARG/AWS), Teliamura ARG, Bagafa and Bagafa AWS, Belonia and Belonia ARG, KVK South, KVK Dhalai and Gandacherra AWS; the rain gauges at CWC's river sites, among them Sonamura Mohanbhog, Gajaria, Amarpur, Belonia, Manughat, Kailashahar, Kumarghat, Nutanbazar and Kadamtala; the State's automatic rain gauges, among them the DM Office and Secretariat gauges in Agartala (owners, logging intervals and archives [TBC]); the rain and level sensors of the Agartala Municipal Corporation's Integrated Command and Control Centre (as reported); and the ten automatic rain gauges that IMD is to add in Agartala and other urban areas (TDMA's monsoon checklist of 2026, as quoted) [TBC]) and water-level records, including those for the 22 August 2024 (Agartala Aero 23 cm in the 24 hours to 08:30 IST on 22 August, IMD, with the Haora at the CWC Haora site at 12.42 m the same day, as reported, in the State's flood of record, whose largest measured day was 49 cm at Bagafa, IMD), 17–19 June 2022 (the Agartala urban flood, with about 200 mm in 3 hours by the Mayor's account and 145 mm or 155 mm in 24 hours in other reports, a conflict, all as reported, no IMD hourly value found, and the Haora at 10.82–10.85 m at Jahar Bridge against a danger level of 10.50 m and at 10.72 m at the CWC site against 10.70 m, as reported), 31 May 2025 (about 200 mm in 3 hours at Agartala by the account of the Mayor and officials, with one death in a manhole, as reported; no IMD hourly value found), 13 June 2018 at Kailashahar (the Manu at 25.95 m at the CWC site, 0.16 m above its high flood level of 1993, and about 21,000 people homeless in the town, as reported; no hourly town rainfall found) and 22–24 August 2026 (Chandrapur, Baldakhal and Aralia in Agartala flooded, and the Haora at 10.72 m at 08:00 on 24 August against a danger level of 10.70 m, as reported; no rainfall value found) events
Flood evidence	Surveyed flood marks and mapped flood extents from past events, including public reports

Data	Minimum requirement
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 lungas and flood plains of the valley floors, in Agartala's central saucer between the Haora embankment and the Katakhal, where the ground falls from 25–30 m to about 8 m (ADB, initial environmental examination, 2020), behind the embankments of Kailashahar, Belonia and the other embanked towns and on the pukur, dighi and beel margins, 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 filled pond 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 22 August 2024 (Agartala Aero 23 cm in the 24 hours to 08:30 IST on 22 August, IMD, with the Haora at the CWC Haora site at 12.42 m the same day, as reported, in the State's flood of record, whose largest measured day was 49 cm at Bagafa, IMD), 17–19 June 2022 (the Agartala urban flood, with about 200 mm in 3 hours by the Mayor's account and 145 mm or 155 mm in 24 hours in other reports, a conflict, all as reported, no IMD hourly value found, and the Haora at 10.82–10.85 m at Jahar Bridge against a danger level of 10.50 m and at 10.72 m at the CWC site against 10.70 m, as reported), 31 May 2025 (about 200 mm in 3 hours at Agartala by the account of the Mayor and officials, with one death in a manhole, as reported; no IMD hourly value found), 13 June 2018 at Kailashahar (the Manu at 25.95 m at the CWC site, 0.16 m above its high flood level of 1993, and about 21,000 people homeless in the town, as reported; no hourly town rainfall found) and 22–24 August 2026 (Chandrapur, Baldakhal and Aralia in Agartala flooded, and the Haora at 10.72 m at 08:00 on 24 August against a danger level of 10.70 m, as reported; no rainfall value found) events are the best calibration data Tripura 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 pukur 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. Tripura has no irrigation tank cascades; its storage is in the pukurs and dighis of its towns and villages, the palace and temple tanks, the beels of the valley floors and the Dumbur reservoir. The land records already count them: the Revenue Department's classes of land include পুকুর "Tank/Pond", পুকুরপাড় "Bank of tank", দীঘি "Large tank", দীঘিরপাড় "Bank of large tank", ডোবা "Ditch", বিল "Watery land" and হাওর "Big watery land" (Diversion of Land Rules, 2025, Appendix-I), so the pukurs, dighis and their banks can be counted plot by plot. The losses are reported, not surveyed: ponds filled for housing at Barjala and Lanka Basti in Agartala (as reported), ponds filled and banks walled at Kalyan Sagar, Matabari, where the High Court ordered 110 m of cement embankment demolished (WP(C)(PIL) No. 2 of 2014, as cited), the encroachment of Agartala's water bodies that the High Court took up in 2017 (as cited), and a water body at Gol Bazar filled, which the Tripura Human Rights Commission took up in 2025 (as reported). Against them, the Mayor reported about 65 water bodies cleaned and developed under city schemes, the State told the National Green Tribunal in 2020 that 180 urban water bodies on government land had been identified and 30 prioritised (as reported), and Agartala Smart City Ltd has projects at the Ujjayanta palace lakes and the MBB College lake (as cited). Rudrasagar at Neermahal is the State's Ramsar site, no. 1572, of 240 ha, designated on 8 November 2005 by the Ramsar listing or "officially designated" on 29 February 2007 by the Forest Department, a conflict, with a catchment of 6,052 ha (as cited); the CAG found ring roads built there without the Wetland Authority's permission, which "reduced the water level" (Audit Report for the year 2021-22). The Wetland Authority of Tripura was constituted by notification No. F.17(54)/For-Dev/WATIL/2017/24661-686 of 5 September 2018 and reconstituted in 2022 (as cited). The Dumbur reservoir is not a Ramsar site, and its water spread is given as 4,500 ha originally and 3,049.3 ha by 2012 (ICAR study) or about 41 km² (as reported). No inventory of Agartala's pukurs and dighis, and no survey of the stage–storage of any pukur, dighi or beel in a town, was found [TBC]; the palace-era and temple tanks are counted as existing storage with heritage and fisheries constraints, not as detention to be drawn down.

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 Tripura has been adopted with a design factor; the State Action Plan on Climate Change (2017) and its second version for 2021–2030 were not read [TBC], and are reported to have "only a few sentences on floods and landslides" (as quoted by SANDRP); the block-level vulnerability assessment of 2022 by the Climate Change Cell of the Department of Science, Technology and Environment was not read [TBC]; a study at NIT Agartala with CMIP6 models finds days of 100 mm or more becoming "more frequent" in 2025–2054 (EGU abstract, 2026), and CSTEP (2022) projects more heavy-rainfall events in almost all districts of the North East (as reported); and Bagafa's 49 cm in 24 hours on 22 August 2024 (IMD) exceeds every NIH-DHAARA 100-year cell in the State, which is a reason to keep the factors, not to reduce them; and on the tilla slopes and hill ranges, on the Gomati below the Dumbur reservoir and behind the embankments 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 22 August 2024 (Agartala Aero 23 cm in the 24 hours to 08:30 IST on 22 August, IMD, with the Haora at the CWC Haora site at 12.42 m the same day, as reported, in the State's flood of record, whose largest measured day was 49 cm at Bagafa, IMD), 17–19 June 2022 (the Agartala urban flood, with about 200 mm in 3 hours by the Mayor's account and 145 mm or 155 mm in 24 hours in other reports, a conflict, all as reported, no IMD hourly value found, and the Haora at 10.82–10.85 m at Jahar Bridge against a danger level of 10.50 m and at 10.72 m at the CWC site against 10.70 m, as reported), 31 May 2025 (about 200 mm in 3 hours at Agartala by the account of the Mayor and officials, with one death in a manhole, as reported; no IMD hourly value found), 13 June 2018 at Kailashahar (the Manu at 25.95 m at the CWC site, 0.16 m above its high flood level of 1993, and about 21,000 people homeless in the town, as reported; no hourly town rainfall found) and 22–24 August 2026 (Chandrapur, Baldakhal and Aralia in Agartala flooded, and the Haora at 10.72 m at 08:00 on 24 August against a danger level of 10.70 m, as reported; no rainfall value found) events where data exist.

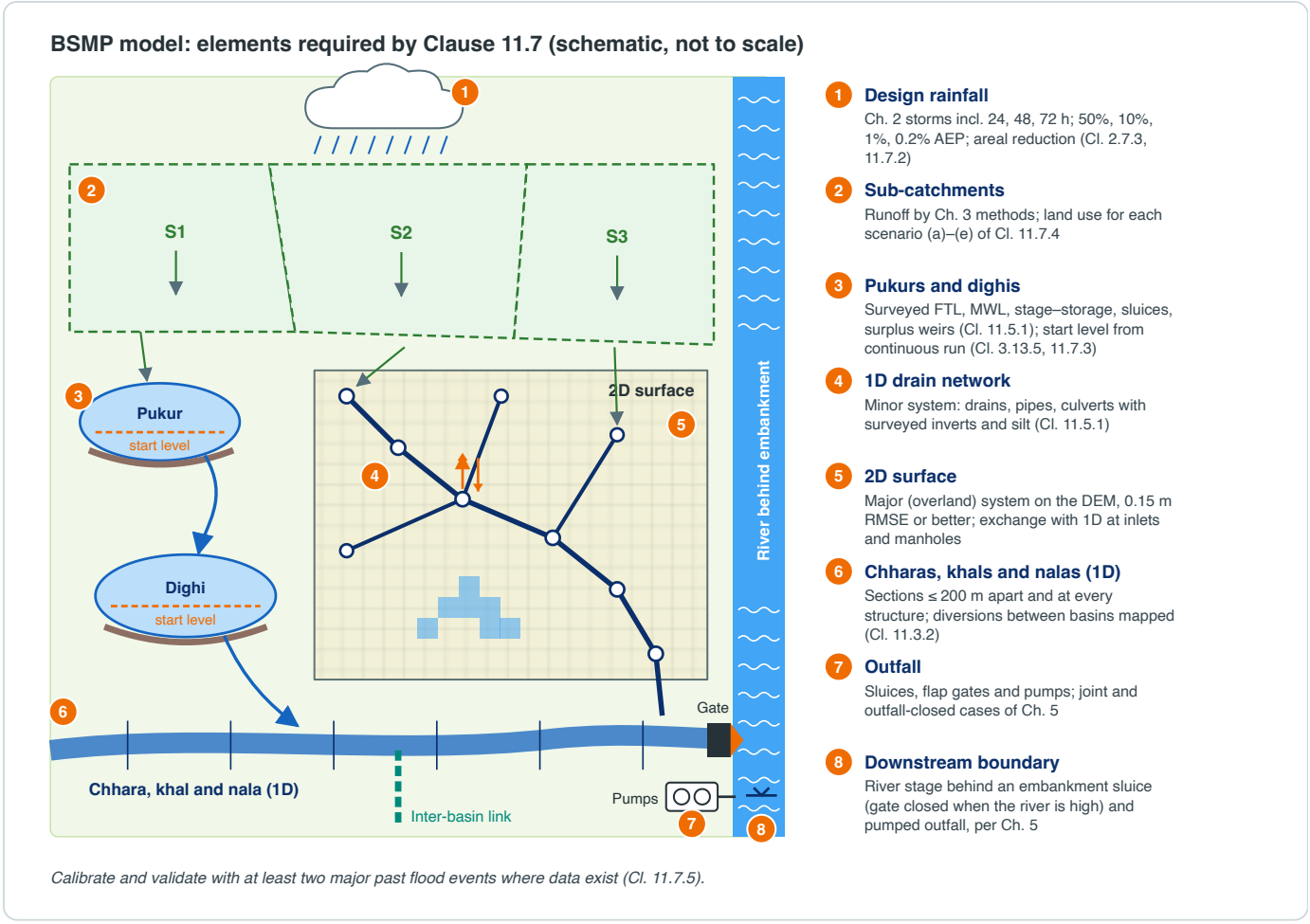

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and pukurs with starting levels from continuous simulation, and the tidal or river boundary at the outfall (schematic, not to scale). Original drawing for this Manual, 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:** pukurs, 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 Haora, the Manu, the Muhuri, the Gomati and the other rivers, with the storage and pumping behind them sized for the outfall-closed durations of Chapter 5, among them the Katakhal double-barrel sluice, the flood pumps that lift Agartala's water by pipeline to the Haora and the Katakhal, and the three pumping stations proposed for Agartala

in July 2026 (as reported); standby power and fuel for the whole closure; screens and silt traps where drains that carry sewage, plastic and garbage enter a pump sump, a gate or a pukur; silt traps and debris racks at the tilla foot and the hill–lunga break, where chharas enter the towns; the interception and screening of dry-weather flow before every outfall to a pukur, a dighi, the Haora, the Katakhal or the Akhaura canal (Chapter 8, Clause 8.9); and the operating rules of the sluices of PWD (WR), agreed with PWD (WR);

5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example IMD district rainfall warnings and nowcasts issued by the Meteorological Centre Agartala, CWC level forecasts for the Manu at Kailashahar and the Gumti at Sonamura and its monitoring of the Haora and the other rivers against their warning and danger levels (as reported; the Kailashahar site was reported inactive in 2024), the alerts of TDMA and the District Disaster Management Authorities, the rain and level sensors of the Agartala Municipal Corporation's Integrated Command and Control Centre (as reported), level gauges with alarms at the Katakhal sluice, on the Akhaura canal and at the flood pumps of Agartala, where none was found, and warnings before releases from the Dumbur reservoir, 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 not a design objective in Tripura, where the stage of extraction is 9.48% and every assessment unit Safe (CGWB, State compilation of 2025, as quoted), and which is credited only on tested, flat tilla tops (Clause 4.11, tilla rule), waterlogging where the water table lies within 2 m of the surface, as it does across much of the valley floors after the monsoon (0.22–6.64 m below ground in West Tripura in November 2017; CGWB), the stability of tilla slopes, cuts and the hill ranges, where water put into fill or weathered rock raises the pore pressure, and the iron-rich shallow groundwater, with up to 4.99 ppm of iron, which clogs infiltration media (Chapter 8);
- effect on downstream basins and the receiving river, khal or chhara; 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 Tripura's town outfalls are closed for days when the rivers are high, and the storage left is in pukurs, dighis and lungas that the towns are filling. When the Haora and the Katakhal run higher than Agartala, "Several pumps have been provided to lift the water out of the city" (ADB, initial environmental examination, 2020), and the city can then drain only as fast as its 18 flood pumps of up to 900,000

L/h each, about 4.5 m³/s together by this Manual's arithmetic, and 6 diesel pumps run (as reported; their working capacity was not found [TBC]); every cubic metre that cannot be pumped must be stored. The storm of 19–24 August 2024 ran for six days, with the Haora's peak on 22 August (as reported), so Chapter 5 keeps the gates shut for the 72-hour storm and, where no stage record exists, a further 72 hours, with the receiving pukurs, dighis and lunga storage full to their outlets at the start (Clause 5.8.5). The lungas are the natural flow paths of the valley floors and the places where the towns are built and the ponds filled, and the TBR 2017 already bar the filling of any "pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts" except by the Local Body with the State's prior approval (r.9(3)), and treat a site on a "recently filled up … pond, lake, marshy" soil with caution (r.32). On the valley floors, where the water table is near the surface in the monsoon, storage means a lined pond or a pukur kept at its outlet level, never a pond that soaks into the ground (Clause 4.11, lunga rule); the storage that r.110 of the TBR 2017 asks for on every plinth of 200 m² or more, credited as Clause 4.11 allows, and the detention of Chapter 4 are the first of it. Conveyance upgrades on their own move water faster to an outfall that the Haora, the Katakhal or another river in flood closes at its sluice for days, to a pukur or lunga storage that a closed sluice holds full, or to an outfall limited by the capacity of its pumps, as in Agartala's central saucer, where 18 flood pumps of up to 900,000 L/h each, about 4.5 m³/s together by this Manual's arithmetic, and 6 diesel pumps were reported in 2024 to lift the city's water to the Haora and the Katakhal (as reported; their working capacity and the flow the drains bring to them were not found [TBC]). Groundwater in Tripura calls for storage and restraint, not recharge. It is not short: the stage of extraction was 9.48% in the assessment of 2024, with every assessment unit Safe, and 9.92% in 2023 (CGWB and RBI tables, as quoted). It is shallow: in West Tripura the dug wells stood 1.63–10.30 m below ground in March 2017 and 0.22–6.64 m in November 2017 (CGWB, aquifer mapping report for West Tripura), and in South and North Tripura 0.90–5.10 m and 1.20–4.37 m after the monsoon in 2008 data (CGWB district profiles, as quoted); in Agartala "The ground water table being very high" (ADB, initial environmental examination, 2020), and "Within a few hours most of the rainwater goes as run off and finally enters Bangladesh" (CGWB). Its quality limits what can be put into it: shallow groundwater carries iron of 0.00–4.99 ppm, "due to the ferruginous nature of Tipam sandstones" (CGWB), which clogs infiltration media. The TBR 2017 nonetheless make groundwater recharge mandatory on plots of more than 500 m² and list recharge pits, trenches, wells and shafts among the techniques (r.110(5)), and no State groundwater Act or authority was found [TBC]. The recharge structures of r.110 therefore sit in saturated ground on the lungas for much of the season they are meant to serve, and Clause 4.11 replaces them there with storage. This is why waterlogging, recharge only on the ground that can take it (Clause 4.11, tilla rule), the stability of tilla slopes and cuts 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 the Agartala Planning Area 2045 and its zoning and development control regulations under the Tripura Urban Planning and Development Act, 2018 (s.53), and the plans of the other Local Planning Areas notified under s.52 once they are made; the Natural Hazard Prone Areas that r.2(44) of the TBR 2017 asks the Development Plans to identify "through local surveys"; in the area of the TTAADC, the plans and rules of the District Council, if the 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. Tripura draws its water lines in its Building Rules, and has no flood-plain zoning law. The TBR 2017 bar the filling of any "canal, pond, water body, wetland, river lets, jhora, water source, natural spring, streams, drains, culverts", except where the Local Body, with the State's prior approval and for reasons recorded in writing, allows a canal, pond, stream, river or "flood plain area to be filled up" (r.9(3)); regulate, but do not forbid, building "in the zone of river (within 15 metres from river bank) or other water fronts of large water bodies (more than 1000 acres)", with a height of 5.00 m (6.50 m on stilts), a length of 20.00 m along the water, a gap of 50.00 m between buildings and a covered area of 200.00 m² (r.9(4)); require the owner of a site within 5.00 m of a tank to keep the building's drainage out of it (r.4(1)(e)); and in the ULBs of the hill areas forbid a site "within five meters in any direction of the outside edge of such water courses" (r.90(1)(i)), the only no-build distance from a watercourse in the rules, and ask for protective works within 5.0 m of a tank, reservoir, jhora, spring, water source or natural drain and where a site is within 30 m of a jhora (r.90(1)(m)). The rules define neither "river bank" nor "outside edge" (this Manual's reading). The "Natural Hazard Prone Areas" of r.2(44) include the "flood prone areas in river plains" of CWC's Flood Atlas of India and areas flooded by "heavy intensity rains, inadequate drainage, etc. as identified through local surveys in the Development Plan of the area"; the plinth is to be at least 60 cm above the crest of the road (r.55); and a site on a "recently filled up … pond, lake, marshy" soil may be restricted or refused (r.32). PWD (WR) has mapped flood-plain localities on the Haora at Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat) for the National Green Tribunal, with the map, return period and status not known [TBC]. The DST&E's guidelines for the protection of lakes, ponds and water bodies, notified after the High Court's order in WP(C)(PIL) No. 2 of 2014 (as cited), were not read, a direction against construction "within 75 Mtrs. of the end of the lake" is of unverified source and scope, and the zoning regulations of the Master Plan 2045 were not read [TBC]; none of them is treated here as a rule. No flood-plain zoning Act or Bill of Tripura was found, and a Union press report says only four States have one (as reported). Where a rule of the TBR 2017 or a Master Plan line 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, rivers, chharas, khals and lunga flow paths alike, and round every pukur, dighi and beel, 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. Zone 1 is a no-build zone, so it is stricter than r.9(4) everywhere and than the 5 m of r.90(1)(i), and it adds a corridor round tanks and along chharas and lungas where the rules set only a drainage duty or protective works (Chapter 7); it applies to new development and redevelopment, and Zone 1 land that is private is reserved in the Master Plan or secured by agreement, not taken. A BSMP gives the Master Plan the 1% AEP drainage-flood map and the buffer widths of Chapter 7 as an input to the hazard surveys of r.2(44), 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 TBR 2017 already exclude water bodies from the area counted as park (r.9(2)), require public open spaces above 500 m² to have "arrangements for complete utilization and capture of storm water" (r.110(4)), ask for permeable materials on all open parking in group housing (r.110) and set landscaping of 1.0–7.5% of plots above 150 m² (r.113, 2022), but allow a ground coverage of 70% for every use and 100% on some industrial and commercial plots (r.46(1) and r.51(2), 2025) and set no 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 lungas and flood plains, 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, lunga rule). 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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- Government of Tripura, Revenue Department. *Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025* (Gazette Extraordinary No. 1072, 3 June 2025), as amended on 6 March 2026 (Gazette Extraordinary No. 2026350): Appendix-I, classification of land.
- Ramsar Convention. Rudrasagar Lake, site no. 1572, information sheet (as cited); and Forest Department, Government of Tripura, Rudrasagar page and the constitution of the Wetland Authority of Tripura, No. F.17(54)/For-Dev/WATIL/2017/24661-686 of 5 September 2018 (as cited).
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- Indian Masterminds, India Today NE, NewKerala, NE Now, Construction World, The NewsMill, Northeast Today, EastMojo, Tripuranet, Deccan Herald and other sources (2014–2026). Reports of the Master Plan 2045, the ADB loans and the drainage programme, the flood pumps, the ₹1,000 crore proposal, the Katakhal cleaning, the

embankment programme, the filling of ponds, the Rudrasagar case and the floods and landslides of 2024 and 2026 (secondary sources).

Annexes and forms

Annex / Form	Content
11A	BSMP terms of reference template
11B	Basin lists and boundaries for Tier A bodies
11C	Depth–damage curves for Tripura 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 Agartala Municipal Corporation, of the Agartala Planning Area of the Master Plan 2045 and of the Agartala-Ranibazar-Jirania Local Planning Area

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

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

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

Item	Tier A authority	Clause
(a)	The Agartala Municipal Corporation	1.6.1(a)
(b)	TUDA, within the Agartala Planning Area of the Master Plan 2045 (238.57 km², as reported) and the Agartala-Ranibazar-Jirania Local Planning Area, wherever it has jurisdiction over a site	1.6.1(b)
—	A Tier B authority that opts into Tier A by council resolution, or that the Government notifies as Tier A	1.6.4

1A.2 Whatever the tier, the design-aid route and the alternatives of Clause 1.7 are not available in a flood-sensitive catchment (Clause 1.6.5; Annex 1B).

To be prepared. This annex will contain the full list, by name, of every Approving Authority within the Agartala Planning Area and the Agartala-Ranibazar-Jirania Local Planning Area, with the date from which each is Tier A, and the boundaries of those areas and of the Agartala Municipal Corporation as a map and as a GIS layer. It needs the notification of the Master Plan for the Agartala Planning Area 2045, declared final on 24 February 2026, with the list of the 49 gram panchayats it takes in (TUDA, UDD) [TBC: notification number and text not read]; TUDA's notification of November 2019 declaring the Local Planning Areas under section 52(1) of the Tripura Urban Planning and Development Act, 2018, with their boundaries (TUDA); the limits and wards of the Agartala Municipal Corporation, given as 49 or 51 wards and as about 76.5 km² or 92 km² (as reported; conflict) [TBC]; the parts of the TTAADC area, if any, that touch these areas [TBC]; and the district, sub-division, revenue circle and mouza boundaries (Revenue Department, Survey of India). Until it is published, the tier is decided by the classes in Clause 1.6.1 and recorded on Form 1-1, and the Authority confirms it at the pre-application stage (Clause 1.5.9).

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

No.	Authority	Class (Municipal Corporation / Municipal Council / Nagar Panchayat / TUDA / Gram 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 Agartala Municipal Corporation, Agartala Planning Area and Local Planning 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)	Agartala's central saucer between the Haora embankment and the Katakhal, with the Akhaura canal	The central part of the city, "at a lower level than other areas giving it the appearance of a saucer", between the Haora embankment on the south and the Katakhal on the north, the erstwhile area of the Corporation, where "During normal rainfall of about 3 to 4 hours, the central part of Agartala gets flooded" (ADB, IEE, 2020); drained by the Akhaura canal, which flows to Bangladesh, and lifted over the embankments by 18 flood pumps of up to 900,000 litres an hour each and 6 diesel pumps when the rivers are high (2024, as reported). No design capacity of the pumping stations was found [TBC]
(b)	The Katakhal basin and its sluice	The land that drains to the Katakhal, Agartala's northern drainage channel to Bangladesh, through its double-barrel sluice near Bhuturia (PWD (WR), as quoted), with the three sewage treatment plants being built on its banks at Ranjit Nagar, Abhaynagar Bridge and Astabal Bridge to take intercepted drain flow (State affidavit to the NGT, 2026). The Katakhal has no gauge, and its flood levels are to be surveyed [TBC]
(c)	The Haora flood-plain-zone localities and Chandrapur	The localities that PWD (WR) has mapped in the flood-plain zone of the Haora, Khayerpur, Kashipur, Baldakhal, Aralia, Jogendranagar and Joynagar (Dashamighat) (State affidavit to the NGT; map, return period and status not known [TBC]), and Chandrapur, flooded on 22–24 August 2026 with Baldakhal and Aralia (as reported). The Haora at Agartala reached 12.42 m on 22 August 2024 (CWC data as transcribed by SANDRP; datum not stated)
(d)	Kailashahar on the Manu	The town on the Manu behind its embankment, raised over 16.8 km in the 2025 programme (as reported); the Manu at Kailashahar has warning, danger and highest levels of 24.34, 25.34 and 25.79 m (7 June 1993) and reached 25.95 m on 13 June 2018, when about 21,000 people were left homeless in Kailashahar (CWC data as transcribed by SANDRP; as reported)
(e)	Belonia on the Muhuri	The town on the Muhuri, where the river reached 18.81 m on 22 August 2024 against a highest level of 16.98 m that had stood since 4 August 1983, and Belonia recorded 32 cm in the 24 hours to 0830 IST on 20 August 2024 (CWC data as transcribed by SANDRP; IMD); 7.47 km of the Muhuri embankment are in the 2025 programme (as reported)
(f)	Udaipur, Amarpur and Sonamura on the Gomati below the Dumbur reservoir	The towns on the release reach of the Dumbur reservoir, whose gates were opened on 21 August 2024 (as reported; conflict); the Gomati at Udaipur reached 22.05 m against its "extreme danger" level of 22.00 m on 21 August 2024 (State gauge), and the Gumti at Sonamura has a highest level of 14.43 m (23 July 1993) (as reported; CWC data as transcribed by SANDRP)

Item	Catchment	Extent as described in Chapter 4
(g)	Dharmanagar on the Juri	The town on the Juri, which reached a new highest level of 20.66 m at Nutan Bazar on 22 August 2024 against 20.435 m of 15 May 1984 (CWC data as transcribed by SANDRP)
(h)	Khowai and Teliamura on the Khowai	The towns of the Khowai valley; the Khowai at Khowai has a highest level of 28.005 m (24 June 2004) (CWC data as transcribed by SANDRP), and 11 of the 17 landslide locations of June 2018 were in Khowai district (as reported)
(i)	Kamalpur on the Dhalai	The town on the Dhalai, whose highest level at Kamalpur, 33.85 m, was set before the monsoon, on 15 May 1984 (CWC data as transcribed by SANDRP), and where NIH-DHAARA returns no data (Clause 2.3.6(c))
(j)	Santirbazar, Bagafa and Sabroom in the south	The towns of sub-area TR-D1, where Bagafa recorded 49 cm in the 24 hours to 0830 IST on 22 August 2024 (IMD) and landslides killed 7 people at Gardang near Santirbazar (as reported); the 1% AEP 24-hour depth there is not less than 490 mm (Clause 2.3.6(h))
(k)	The hill-range corridors	NH-8 through the Atharamura and Longtharai ranges, and NH-108B and NH-208, where the High Court of Tripura recorded "No proper drainage system … water logging everywhere" and culverts blocked "by silt, vegetation, debris" (WP(C)(PIL) No. 06 of 2026, judgment of 08.09.2026); 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 Agartala Municipal Corporation, Agartala Smart City Ltd, PWD (R&B), TUDA, the Municipal Councils and Nagar Panchayats, Survey of India); the drains with their outfalls, the Katakhal sluice, the flap gates and the flood pumps with their sills, closing levels and capacities, and the dry-weather interceptions on them, with levels on a stated datum (PWD (WR), PWD (DWS), the Agartala Municipal Corporation); the flood marks of 17–19 June 2022, 31 May–1 June 2025 and 22–24 August 2026 in Agartala and of August 2024 in every basin (TDMA, the District Magistrates and Collectors, the Agartala Municipal Corporation); the stage records of the CWC sites on the Haora, the Manu, the Gumti, the Muhuri, the Juri, the Dhalai, the Khowai and the Burima, with their datum (CWC), and of the State gauges at Udaipur, Amarpur and the Jahar Bridge (the State); the reservoir levels and release records of the Dumbur reservoir (its operator, reported as TSECL [TBC]); the map of PWD (WR)'s flood-plain zone of the Haora, with its return period [TBC]; and the landslide inventory of August 2024 [TBC]. Other towns of the twenty with Local Planning Areas are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The lines of the TBR 2017 along rivers, ponds and jhoras, 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

Field	Content	Unit or format
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 Tripura 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) ≤ 0.9 × 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 × Q_pre rule (Table 1.2).

S-2.3 *Eligibility:* any site outside a flood-sensitive catchment.

S-2.4 *Conditions:* storage is then sized to hold every duration of Clause 2.5.2 at the PSD; drawdown, minimum orifice and spillway rules of Chapter 4 apply unchanged.

S-3 — Fixed-width waterbody setback

S-3.1 *Replaces:* the waterbody setback extended to the mapped 1% AEP flood extent plus margin (Chapter 7).

S-3.2 *Alternative:* where no 1% AEP extent is mapped, the setback shall be the fixed width for the class of waterbody in the table of Clause 7.4.6 (and Annex 7B), measured as in Clause 7.4.3.

S-3.3 *Eligibility:* waterbodies with no mapped 1% AEP extent.

S-3.4 *Conditions:* no setback under this alternative is less than the Zone 1 minimum of Clause 7.4.7 (Clause 1.10.3(c)); the no-fill zone of Chapter 7 applies; where a 1% AEP extent is later mapped and adopted, the mapped setback applies to new applications.

S-4 — Downstream screening checklist

S-4.1 *Replaces:* downstream analysis by hydraulic model under Chapter 5.

S-4.2 *Alternative:* the Applicant completes a screening checklist of downstream capacity and known flooding, covering at least the conditions of Clause 5.3.4: that the receiving public drain has documented capacity for its minor-system design flow (Chapter 6), and that no flood-prone location is recorded within 500 m downstream. A hydraulic model under Chapter 5 is required only where the screen fails.

S-4.3 *Eligibility:* sites of less than 1 ha, outside flood-sensitive catchments, not discharging to a tidal outfall.

S-4.4 *Conditions:* the checklist is signed by the registered professional who signs the drainage report (Clause 10.6); flood-prone locations are those recorded by the local body, the District Magistrate and Collector and the District Disaster Management Authority, TDMA, PWD (WR) or TUDA (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 pukur or tank storage identified in the basin plan (Clause 4.13.1).

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

S-5.4 *Conditions:*

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

Part 3 — Model council resolution

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

Resolution No. _____ of _____ (name of Municipal Corporation / Municipal Council / Nagar Panchayat), dated _____

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

The Council, having considered the report of the Municipal Commissioner / chief executive officer dated _____, and noting that:

- (i) the Tripura Stormwater Design Manual and its Policy Supplement have been given effect by _____ (instrument and date);
- (ii) this local body is a Tier B / Tier A authority under Clause 1.6 of the Manual; and
- (iii) for a Tier A authority, the State Stormwater Technical Committee concurred on _____ (reference _____),

resolves:

1. to adopt the following alternatives of the Policy Supplement within its area, under the conditions of Clause 1.7.3 of the Manual:

Table 1C.1 — Alternatives adopted by this resolution

Alternative	Adopted (Yes / No)	Area to which it applies (whole area, or wards / zones)	Applies from (date)
S-1 Design-aid route			
S-2 Permissible site discharge			
S-3 Fixed-width setback			
S-4 Downstream screening checklist			
S-5 Fee-in-lieu			

2. that no adopted alternative shall apply within a flood-sensitive catchment except as the Manual allows (Clause 1.6.5);
3. that a copy of this resolution be sent to the State Stormwater Technical Committee within 30 days;
4. that the adopted alternatives be published on the local body's website and entered in the register of Clause 10.17; and
5. that this resolution be reviewed when the tables of Clause 1.7.3(e) are revised.

Mayor / Chairperson: _____ Municipal Commissioner / chief executive officer: _____ Date: _____

Annex 1D — Model TBR 2017 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 Tripura Building Rules 2017 at which the new rule and the conditions would be inserted, and the enabling sections of the Tripura Urban Planning and Development Act, 2018 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 Tripura Building Rules 2017

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

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

A.2 **Insertion of a new rule.** After rule [_____] of the building rules made by the Urban Development Department under section 274 read with section 118 of the Tripura Municipal Act, 1994, the following rule shall be inserted:

Rule [_____]. Stormwater management.

(1) *Definitions.* In this rule, "the Manual" means the Tripura 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 Tripura Stormwater Design Manual, as notified by the Government, applies to:

- (a) every development approved by the local body; and
- (b) every drainage, road, culvert, waterbody and flood-mitigation work executed by the local body, including its own drains and roads (Clause 1.3.1(b)).

B.3 **Public works.** Every detailed project report and contract for a work under B.2(b) shall require compliance with the Manual, from the dates in Clause 1.11 (Clause 1.3.4).

B.4 **Tier and alternatives.** The local body is a Tier _____ authority under Clause 1.6 of the Manual. The alternatives of the Policy Supplement adopted by the local body are listed in the Schedule, with the resolution under which each was adopted.

B.5 **Submittals and review.** Submittals shall be made in the stages of Clause 10.3 of the Manual and reviewed within the periods of Clause 10.7.

B.6 **Maintenance, inspection and enforcement.** Maintenance declarations, inspections, handover of public assets and enforcement shall follow Clauses 10.10 to 10.15 of the Manual.

B.7 **Publication.** The local body shall publish the registers and reports of Clause 10.17 of the Manual.

B.8 **Review.** These bye-laws shall be reviewed whenever the Manual is amended under Clause 1.12.

Table 1D.1 — Schedule: alternatives adopted (layout)

Alternative	Resolution number and date	Committee concurrence (Tier A only)	Applies from	Area

Form 1-1 — Applicability Determination

Supports Clauses 1.5.1 to 1.5.9 and 1.6 of Chapter 1, and Clause 10.3 of Chapter 10.

Draft form — Tripura 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 Tripura Building Rules 2017 — 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 (TBR 2017, r.110: buildings of plinth area 200 m² or more, group housing, public, semi-public and industrial buildings of all sizes, commercial and mixed-use buildings of 50 m² or more; groundwater recharge on plots of more than 500 m² (r.110(5))) — 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 — Tripura 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 automatic rain gauges named in IMD's station tables of August 2024, among them DM Office, Secretariat, Budhjongnagar, HRC Nagicherra, Khumluwang, Teliamura, Belonia and Kadamtala, the rain gauges at CWC's river sites (Sonamura Mohanbhog, Gajaria, Amarpur, Belonia, Manughat, Kailashahar, Kumarghat, Nutanbazar and Kadamtala), the AWS and KVK gauges, and the rain and level sensors of the Agartala Municipal Corporation's Integrated Command and Control Centre, whose owners, logging intervals and archives are to be confirmed [TBC]), and district and basin boundaries (Survey of India, PWD (WR)). 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
TR-Z1 Western valley	The Agartala–Sonamura valley west of the Baramura range, draining west to Bangladesh by the Haora, the Katakhal, the Akhaura canal, the Burima (Bijoy) and the lower Gomati; in CWC subzone 2(c) by elimination, no CWC report (Clause 2.3.6(b)); catchments that cross a zone line take the higher zone value	Agartala (A) (42724, rainfall data 1953–2012); IMD press-release gauges Agartala Aero, Met Agartala, DM Office, Secretariat, Bishalgarh, Sonamura, Sonamura Mohanbhog CWC and Gajaria CWC	Governing cell Agartala (Clause 2.3.6(c)); NIH-DHAARA's own durations, not below the 2(a) ratios, with the short-storm floors (Clause 2.3.6(f), (g)). Saucer and pumped outfalls of central Agartala; the Haora's highest level 12.42 m (22 August 2024; CWC data as transcribed by SANDRP)
TR-Z1 Western valley: TR-A Agartala–Sonamura valley (Agartala–Jirania–Mohanpur–Bishalgarh–Sonamura)	Also Ranirbazar, Melaghar and Boxanagar; the Haora, Katakhal, Akhaura canal, Burima (Bijoy) and lower Gomati plains; the Agartala Planning Area; CGWB's own name for the valley; boundaries [TBC]	Agartala (A) (42724); Agartala Aero; Bishalgarh; Sonamura	NIH-DHAARA governing cell Agartala (23.88° N, 91.32° E): 24 h 225.4 / 320.5 / 360.7 mm and 1 h 67.1 / 92.8 / 103.6 mm at 10 / 50 / 100 years; Bishalgarh 314.6 mm and Sonamura 312.7 mm at 50 years. Records: Agartala (A) 257.2 mm (22 July 1993), below the cell; Agartala Aero 23 cm and Sonamura 20 cm (24 h to 0830 IST, 22 August 2024, IMD). Annual means 1,505–2,020 mm at the CGWB stations (Agartala 1,851 mm; five-year averages), against "around 220 centimeters" in the ADB's report (conflict; IMD normals not obtained [TBC]). Water table 0.22–6.64 m below ground in November 2017 (CGWB, West Tripura)
TR-Z2 Central valleys	The Khowai valley between the Atharamura and Baramura ranges and the Dhalai valley to its east; in subzone 2(c) by elimination	No IMD station in *Extremes*; press-release gauges Teliamura ARG, Khowai, Kamalpur, KVK Dhalai, Gandacherra AWS and Chhamonu	One governing cell for the zone, the cell 6 km south of Khowai, because the Khowai town cell and both Kamalpur cells return no data (Clause 2.3.6(c), (m))
TR-Z2 Central valleys: TR-B Khowai valley (Khowai–Teliamura)	The Khowai between the Atharamura and Baramura ranges (NEER reading, to be confirmed); boundaries [TBC]	Teliamura ARG; Khowai	Governing cell south of Khowai (24.00° N, 91.56° E): 24 h 208.0 / 293.6 / 329.8 mm and 1 h 70.4 / 97.9 / 109.5 mm at 10 / 50 / 100 years; Teliamura cell 240.3 mm at 50 years, 22% lower about 18 km away (NEER reading). Records: Teliamura 23 cm (to 0830 IST, 22 August 2024, IMD). Khowai at Khowai highest level 28.005 m (24 June 2004) (CWC data as transcribed by SANDRP)
TR-Z2 Central valleys: TR-B1 Dhalai valley (Ambassa–Kamalpur)	The Dhalai; boundaries [TBC]	Kamalpur; KVK Dhalai	Both Kamalpur cells of NIH-DHAARA return no data; the one returning cell, Ambassa, gives 258.3 mm at 50 years, and the zone's governing cell applies (Clause 2.3.6(c)). Dhalai at Kamalpur highest level 33.85 m (15 May 1984), before the monsoon (CWC data as transcribed by SANDRP)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
TR-Z3 Northern valleys	The valleys of the Manu, the Juri, the Deo and the Longai, which run north to the Kushiyara plain in Bangladesh; in subzone 2(c) by elimination	Kailashahar (A) (42618, rainfall data 1958–2012); press-release gauges Kailashahar Aero, Kailashahar CWC, Kumarghat CWC, Manughat CWC, Dharmanagar/Panisagar, Nutanbazar CWC, Kadamtala and Kanchanpur	Governing cell Kailashahar; the Kailashahar record of 377.2 mm bounds the 1% AEP depth within 25 km (Clause 2.3.6(h)). The earliest pre-monsoon floods of the State
TR-Z3 Northern valleys: TR-C Manu–Juri–Deo valleys (Kailashahar–Kumarghat–Dharmanagar–Panisagar–Kanchanpur)	Also Fatikroy and Kadamtala; the Longai; boundaries [TBC]	Kailashahar (A) (42618)	Governing cell Kailashahar (24.36° N, 92.04° E): 24 h 239.8 / 337.9 / 379.4 mm and 1 h 59.3 / 81.6 / 91.0 mm at 10 / 50 / 100 years; Dharmanagar 336.9 mm and Kumarghat 274.9 mm at 50 years. Records: Kailashahar (A) 377.2 mm (6 June 1993), 257.1 mm in April (19 April 2004) and 231.2 mm in May (3 May 1993); wettest months May 1991 (1,175.0 mm) and April 1977 (1,012.8 mm) (IMD, *Extremes*). Manu at Kailashahar highest level 25.79 m (7 June 1993), passed at 25.95 m on 13 June 2018; Juri at Nutan Bazar 20.66 m (22 August 2024) (CWC data as transcribed by SANDRP)
TR-Z4 Southern valleys	The Gomati valley below the Dumbur reservoir and the Muhuri and Feni valleys of the south; in subzone 2(c) by elimination	No IMD station in *Extremes*; press-release gauges Udaipur, Amarpur, Amarpur CWC, Bagafa, Bagafa AWS, Belonia, Belonia ARG, Belonia CWC, KVK South and Sabroom	The State's largest measured day and the release reach of the Dumbur reservoir; the Bagafa record bounds the 1% AEP depth in TR-D1 (Clause 2.3.6(h))
TR-Z4 Southern valleys: TR-D Gomati valley (Udaipur–Amarpur–Karbook)	The Gomati below the Dumbur reservoir, a release reach; boundaries [TBC]	Udaipur; Amarpur; Amarpur CWC	Governing cell Udaipur (23.52° N, 91.44° E): 24 h 216.0 / 306.8 / 345.2 mm and 1 h 60.6 / 85.3 / 95.7 mm at 10 / 50 / 100 years; Amarpur 291.1 mm at 50 years. Records: Amarpur 31 cm (to 0830 IST, 20 August 2024, IMD), above the Amarpur cell's 50-year depth and below TR-D's 1% AEP depth. Gomati at Udaipur 22.05 m against an "extreme danger" level of 22.00 m (21 August 2024, State gauge, as reported); the Dumbur release of 21 August 2024 (as reported; conflict)
TR-Z4 Southern valleys: TR-D1 Muhuri–Feni south (Belonia–Santirbazar–Jolaibari–Bagafa–Sabroom)	The Muhuri and the Feni; boundaries [TBC]	Bagafa; Belonia; Sabroom; KVK South	Governing cell Sabroom (23.04° N, 91.68° E): 24 h 267.6 / 385.3 / 435.1 mm and 1 h 63.1 / 88.9 / 99.8 mm at 10 / 50 / 100 years; Belonia 311.9 mm at 50 years. **1% AEP 24-hour depth not less than 490 mm throughout the sub-area** (Bagafa, 49 cm in the 24 hours to 0830 IST on 22 August 2024, IMD; Clause 2.3.6(h)); Belonia 32 cm and Bagafa 38 cm (to 0830 IST, 20 August 2024, IMD). Muhuri at Belonia 18.81 m (22 August 2024) against a highest level of 16.98 m (4 August 1983) (CWC data as transcribed by SANDRP). Landslides at Gardang near Santirbazar, August 2024 (as reported)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
TR-Z5 Hill ranges	The north–south sandstone and shale ranges between the valleys: the Baramura and Atharamura, 150–445 m above mean sea level in West Tripura (CGWB), the Longtharai and Sakhan, and the Jampui, the highest; the record-check domain is either adjoining valley within 25 km (Clause 2.3.6(h)); the hill rule of Clause 4.11 applies	No gauge with a record in the State's hills [TBC]; Gandacherra AWS and Chhamonu are hill-side gauges named by IMD	No cell of its own: the higher of the governing cells of the valley sub-areas on either side of the range, at each duration and AEP (Clause 2.3.6(c)). Landslides, debris and cut slopes govern (Clause 2.3.6(i))
TR-Z5 Hill ranges: TR-E Hill ranges (Baramura–Atharamura–Longtharai–Sakhan–Jampui)	Hill settlements and road corridors: NH-8 through the Atharamura and Longtharai ranges, the Jampui hills (Vangmun), Gandacherra, Chhamanu, the catchment of the Dumbur reservoir, and the hill faces above the valley towns; boundaries follow the crests and slopes [TBC]	None	Landslip locations 2,032 in August 2024 and 17 in June 2018 (as reported); the High Court's findings on the drains and culverts of NH-108B and NH-208 (WP(C)(PIL) No. 06 of 2026). Area with more than 20% slope is excluded from CGWB's recharge computation (CGWB, West Tripura), and is under the hill rule of Clause 4.11

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 Tripura are those of Clause 2.3.6(f) in every sub-area: NIH-DHAARA's own depth for the duration under the governing-cell rule of Clause 2.3.6(c), never below the 2(a) ratios of Table 2B.1 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; the 2(b) ratios are not used (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
All sub-areas (TR-A, TR-B, TR-B1, TR-C, TR-D, TR-D1, TR-E)	CWC FER 2(a), NB/18/1991, §3.1.2 and Fig. 10, 50-yr basis, partial-duration analysis of 12 IMD recording gauges: the lower bound of Clause 2.3.6(f), applied to the 24-h depth before the record check of Clause 2.3.6(h)	0.260	0.370	0.457	0.615	0.805	1.000
All sub-areas	NIH-DHAARA's own t-hour depths under the governing-cell rule of Clause 2.3.6(c) govern wherever they are higher (Clause 2.3.6(f)); 3 h and 6 h interpolated on logarithmic axes between its 2-, 4- and 12-h depths						
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						
TR-Z1 (TR-A): Agartala governing cell	NIH-DHAARA, IMDAA, 50-yr, queried 14 Nov 2026 (3 and 6 h interpolated; ratios a NEER reading; comparison)	0.29	0.46	0.53	0.64	0.77	1.00
TR-Z2 (TR-B, TR-B1): the cell 6 km south of Khowai	As above	0.33	0.50	0.57	0.70	0.82	1.00
TR-Z3 (TR-C): Kailashahar governing cell	As above	0.24	0.40	0.49	0.64	0.79	1.00
TR-Z4 (TR-D): Udaipur governing cell	As above	0.28	0.44	0.54	0.68	0.79	1.00
TR-Z4 (TR-D1): Sabroom governing cell	As above	0.23	0.36	0.45	0.62	0.80	1.00
TR-Z2 (TR-B): Teliamura cell	As above; the highest 1-h ratio of the Tripura cells	0.36	0.56	0.63	0.74	0.83	1.00
Not used in Tripura (reference only)	CWC FER 2(b), Table 4.1, 10-yr basis, six recording gauges in other basins; the report does not extend to the State (Clause 2.3.6(f))	0.48		0.62	0.74	0.87	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 automatic rain gauges of the State, among them those at the District Magistrate's Office and the Secretariat in Agartala, the rain gauges at CWC's river sites, the AWS and KVK gauges, and the rain sensors of the Agartala Municipal Corporation's command centre, whose owners, logging intervals and archives are to be confirmed [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 Tripura NIH-DHAARA was queried at 15 points for this Manual, and its reanalysis cells give 24-hour depths of the right order but below the largest point falls: the Sabroom cell, the highest in the State, gives 435.1 mm at 100 years against the 49 cm that the Bagafa gauge recorded in the 24 hours to 0830 IST on 22 August 2024 (IMD), and the Kailashahar cell 379.4 mm at 100 years against the station's record of 377.2 mm (6 June 1993) in 55 years of data (NIH-DHAARA, queried 14 Nov 2026; IMD, *Extremes*). Two cells, at Khowai town and Kamalpur, return no data. The gauges show the size of the point-to-point gap: on 20 August 2024 Belonia read 32 cm, Belonia ARG 25 cm and Belonia CWC 15 cm, and Bagafa 38 cm against 13 cm at Bagafa AWS (IMD). Values of this kind are grid- or area-average values and need these factors before use as point depths. Until this annex and Annex 2A are published, Clause 2.3.6 takes the higher of the site's cell and the sub-area's governing cell, and raises the result by the short-storm floors and the record check, which keep the design depths at or above the recorded points (Clause 2.3.6(c), (g) and (h)).

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 — Tripura 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 Tripura storms, in the form introduced by Huff (1967), by zone, storm-duration class and quartile, at stated probability levels. It needs storm hyetographs from recording gauges and automatic weather stations (IMD, its automatic weather stations and automatic rain gauges in the State, under the Meteorological Centre Agartala, including the 10 automatic rain gauges it is to add in Agartala and the urban areas (TDMA, as quoted), and any recording gauges of the State, CWC, the KVKs and the Agartala Municipal Corporation [TBC]), separated into independent storms by a stated rule, and the storms that set the IMD records at Kailashahar on 6 June 1993 and Agartala on 22 July 1993, Cyclone Remal of 27–28 May 2024, the storm of 19–24 August 2024 with Bagafa's 49 cm, and the Agartala storms of 17–19 June 2022, 31 May–1 June 2025 and 22–24 August 2026 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 automatic rain gauges of the State, among them those at the District Magistrate's Office and the Secretariat in Agartala, the rain gauges at CWC's river sites, the AWS and KVK gauges, and the rain sensors of the Agartala Municipal Corporation's command centre, whose owners, logging intervals and archives are to be confirmed [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
TR-Z1 Western valley					
TR-Z2 Central valleys					
TR-Z3 Northern valleys					
TR-Z4 Southern valleys					
TR-Z5 Hill ranges					

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 — Tripura 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(c) (no report, so none applies in Tripura) 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 TR-A, TR-B, TR-D, TR-D1 and TR-E and of 1 May–31 October in TR-B1 and TR-C, whatever its duration; III for every design storm of 1 April–31 October on lunga floors and flood plains below the 1% AEP level, pukur, dighi and beel margins and in catchments behind a closed sluice or pumped outfall; III at any time in catchments draining to the Dumbur reservoir or the Gomati release reach; at any other site or time, III for a storm that follows or contains a 5-day total of more than 53 mm; II otherwise (Clause 2.11.4)	_____
G6	Pre-development condition: greenfield, open land in good condition for the mapped HSG (Clause 2.11.5)	_____
G7	Release criterion: standard, Q_post ≤ 0.9 × Q_pre (Clause 2.11.2) / flood-sensitive, mixed-frequency rule (Clause 2.11.3)	_____
G8	Tailwater joint cases run (Clause 2.12): case (a) MHWS + sea-level allowance; case (b) 10% AEP 48 h storm with 1% AEP still-water level + sea-level allowance; governing case	_____
	H. Prepared by	
H1	I confirm that the values above are those extracted and used in the submittal. Name, registration number, signature, date	_____

Design depth = source depth × fixed-interval factor × grid-to-point factor × ARF × climate factor. Where the design depth is lower than the CWC floor for the same AEP, the floor is adopted (Clause 2.3.3).

Table 2F.2 — Form 2-1: depth table (Clause 2.13, item 3)

AEP (T-yr)	Duration	Source depth (mm)	Fixed-interval factor	Grid-to-point factor	ARF	Climate factor	Design depth (mm)	IMD Das et al. (2022) (mm)	CWC floor (mm)	Adopted depth (mm)

Table 2F.3 — Form 2-1: 48- and 72-hour storm construction (Clause 2.9.2)

AEP (T-yr)	Duration (h)	Total design depth (mm)	24 h design depth, final 24 h (mm)	Remainder (mm)	Hours before the final 24 h	Uniform intensity before the final 24 h (mm/h)
	48				24	
	72				48	

ANNEXES TO CHAPTER 3

Hydrologic Methods

These annexes support Chapter 3. Annex 3C sets out benchmark test problems for software acceptance, and Forms 3-1 and 3-2 are the submittal forms required by Clause 3.17. Annexes 3A, 3B, 3D and 3E need survey, gauging or published report data that this draft does not yet contain; each gives the intended layout and the interim rule of Chapter 3 that applies until it is published. The forms are draft forms and have no statutory status.

Annex 3A — Tripura 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 Tripura 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, Tripura (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 PWD (WR), supplemented by piezometers in the recent flood plains and lunga floors (lunga, Bengali লুঙ্গা: the land records' "Flat lands between tillas"; tilla, Bengali টিলা: "Hillock") of every valley, where the CGWB's dug wells in West Tripura stood 0.22–6.64 m below ground in November 2017, central Agartala between the Haora embankment and the Katakhal and the other land behind embankments, the margins of the pukurs, dighis and beels, filled ponds and lunga fills, and the tilla tops and benches where the tilla rule of Clause 4.11 may allow infiltration. 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

Annex 3B — Tripura CN calibration and supplementary land covers (forest of the hill ranges and tillas, lunga land, beel and haor beds, cut tilla slopes and fills, filled ponds and lunga fills)

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 Tripura 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 of the hill ranges and tillas ("Nearly seventy-three per cent of the council's geographical area falls under forest classification", of the Tripura Tribal Areas Autonomous District Council's area, as reported); lunga land, the flat land between tillas that the land records class as "Flat lands between tillas" in their classification of land for agricultural purposes (Diversion of Land Rules, 2025, Appendix-I); the beds and margins of beels (বিল, "Watery land") and haors (হাওর, "Big watery land"), with the marshy and swampy land that the same list calls dhepa (ঢেপা, "Marshy land") and utla (উতলা, "Swampy land"), dry or shrunken at the start of the season; the cut slopes and fills of the tillas, bare or newly vegetated; and filled ponds and lunga fills, the "recently filled up … pond, lake, marshy" land of rule 32 of the Tripura Building Rules, 2017. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from PWD (WR) 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 hill ranges and tillas, with the litter recorded						
Lunga land (the flat land between tillas), cultivated or fallow, ponded or dry at the start of the storm						
Beel or haor bed or margin, or dhepa or utla marsh, dry or shrunken at the start of the storm						
Cut tilla slope or fill, bare or newly vegetated						
Filled pond or lunga fill (rule 32 of the Tripura Building Rules, 2017), with the depth and age of the fill recorded						
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

Segment	Calculation	Travel time
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**
(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
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			

Problem	Result	Benchmark	Software result	Difference (%)	Within ±5%?
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 Tripura.** Tripura 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 Feni and the Muhuri reach the sea only in Bangladesh (NEER's reading). The lunga floors, the recent flood plains 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

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Annex 3E — CWC SUH parameters for Tripura (subzone 2(c): no CWC report; the subzone 2(b) relationships as a cross-check only), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzone 2(b) (South Brahmaputra), whose relationships this Manual uses in Tripura only as a cross-check on the site study, because CWC has published no report for subzone 2(c) (Barak and others), in which the State lies, 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 a CWC Flood Estimation Report for subzone 2(c) (Barak and others), which CWC has never published, with written confirmation from CWC that Tripura lies in subzone 2(c) and that no report for it, or for the rivers of the State that flow to the Meghna in Bangladesh, exists or is in preparation [TBC]; until then, the South Brahmaputra subzone 2(b) report (Revised; Design Office Report No. SB-2(b)/R-4/44/99, March 2000), whose plates stop at about 25° N and whose corrigendum strikes out its one mention of Tripura, for its areal reduction curves (Annex 4.3, read by optical character recognition only [TBC]) and its unit hydrograph relationships, used only as a cross-check (see the References of Chapter 3); the stage records, rating curves, gauge zeros and datums of the CWC sites on the Manu, the Dhalai, the Khowai, the Gumti, the Haora, the Muhuri, the Juri and the Burima, of which only highest and danger levels transcribed by others were read [TBC]; and bridge-catchment data held by the Northeast Frontier Railway and RDSO for the railway to Agartala and Sabroom [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(b) (South Brahmaputra) relationship, computed in Tripura only as a cross-check	In Tripura (subzone 2(c), no CWC report): the site study
Peak discharge of the 1-hour unit hydrograph	Qp	m³/s	Qp = 0.905 A^0.758 (Eq. 3.4.3.2); the peak depends on the catchment area alone	From the calibrated SCS, Clark or Snyder unit hydrograph of the site study (Clause 3.11.1)
Peak discharge per unit area	qp	m³/s per km²	qp = Qp / A	As above
Time from centre of unit rainfall to peak	tp	h	tp = 2.87 qp^−0.839	From the segment Tc of Clause 3.6.2, split at the break of slope between tilla or hill and lunga (Commentary to Clause 3.7, rules (a) and (c))
Width of UH at 50% of peak	W50	h	W50 = 2.304 qp^−1.035	Not used
Width of UH at 75% of peak	W75	h	W75 = 1.339 qp^−0.978	Not used
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.814 qp^−1.018	Not used
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.494 qp^−0.966	Not used
Base width of UH	TB	h	TB = 2.447 tp^1.157	From the site study

Parameter	Symbol	Unit	Subzone 2(b) (South Brahmaputra) relationship, computed in Tripura only as a cross-check	In Tripura (subzone 2(c), no CWC report): the site study
Time to peak from start of rise	Tm	h	Tm = tp + tr/2	From the site study
Unit duration	tr	h	1	The model time step (Clause 2.9.1)
Design storm duration	TD	h	TD = 1.1 tp	Every duration of Clause 2.5.2, up to 72 hours
Design loss rate	—	mm/h	3.5 (printed "0.35 cm/hr", the modal value of 100 flood events, as in the report of 1984); for the cross-check only	SCS-CN with the interim HSG of Clause 3.7.2 and the AMC of Clause 3.8.4; the 2(b) loss rate is not used
Design base flow	—	m³/s per km²	0.05 (68 of 100 events in the range 0.01–0.09); for the cross-check only	From the calibration gauge's record, or 0.05 m³/s per km² until one is analysed (set by this Manual)
Ratio of t-hour to 24-hour rainfall	—	—	10-yr, partial duration, mean of 6 self-recording gauges outside Tripura: 1 h 0.48; 3 h 0.62; 6 h 0.74; 12 h 0.87; 24 h 1.00 (Table 4.1). **Not used in Tripura**, not even for the cross-check	The t-hour depths of Clause 2.3.6(f): NIH-DHAARA's own depths under the governing-cell rule, not below the subzone 2(a) ratios (1 h 0.260; 3 h 0.457; 6 h 0.615; 12 h 0.805) × the 24-hour depth, and not below the short-storm floors of Clause 2.3.6(g); the cross-check uses the same depths
Time distribution of rainfall	—	cumulative fraction by hour	1,040 storms in five duration groups; the tables of Annex 4.4 not read [TBC]	The design hyetographs of Clause 2.9
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	Applies to any IMD daily value used under Clause 2.3.6(d) (Clause 2.6.3)
Areal reduction factor	ARF	% of point rainfall	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 same curves, until a Tripura study replaces them (Clause 2.7.3; set by this Manual); none is applied to a single development site (Clause 2.7.4)
Calibration	—	—	None in Tripura: the 14 catchments are bridge sites in Assam, two of them on rivers that rise in Meghalaya	Required (Clause 3.15) against the CWC and State river gauges of the Commentary to Clause 3.7, rule (d), or surveyed flood marks
Catchment area for which the relationships apply	A	km²	more than 50 to 1,500; up to 5,000 "judiciously"	25–5,000 km²; the cross-check is computed only within 50–1,500 km²
Report reference	—	—	SB-2(b)/R-4/44/99: §§3.4–3.7, Table 3.3, Table 4.1, Annex 4.3, the errata and the worked example	This Manual, Clauses 2.3.6, 2.7.3, 3.11.4 and 3.15

Note: relationships as printed in the CWC subzone 2(b) report (References of Chapter 3), read from a scanned copy; Table 3.3, its ratio table and its errata were checked against the page images by the neighbouring editions of this series, and its Annex 4.3 was read by optical character recognition only [TBC]. A is the catchment area in km². **No CWC report**

covers Tripura. The 2(b) report states its extent as "latitude 25° 15' to 28° North approximately" and says the subzone is bounded "on the south by Barak Subzone 2 (c)"; its §2.4.2.1 mentioned "some parts of Tripura", and its corrigendum orders "omit 'and some parts of Tripura' from this line"; its Plate 9 stops at about 25° N, while Tripura lies between 22°56' and 24°32' N. Its Annexure 1.1 lists "2(c) | Barak and others | Barak | Barak, Kalden and Manipur rivers" (as printed), and no report for 2(c) was ever published: CWC's list has 21 reports for 24 of the 26 subzones. Every river of Tripura, the Haora, the Gomati, the Khowai, the Burima, the Muhuri and the Feni to the west and south, and the Manu, the Dhalai, the Juri, the Deo and the Longai to the north, leaves the State into Bangladesh and reaches the Meghna system, so the State falls in subzone 2(c) by elimination (NEER's reading, to be confirmed with CWC's subzone map [TBC]). **Tripura is the first edition of this series whose whole area lies outside every published CWC report.** No CWC, CDO, RDSO or railway small-catchment study for Tripura was found [TBC]. **Why the 2(b) unit hydrograph is only a cross-check.** It rests on 14 catchments with 100 bridge-years of record, gauged at railway bridges from 1961 to 1983 and at national-highway bridges from 1981; every one is a bridge site in Assam, two of them on rivers that rise in Meghalaya; none lies in Tripura and none drains to the Meghna; and its peak depends on area alone, so it gives the same unit hydrograph to a tilla catchment and to a flat lunga catchment of the same area. Its 50-yr peaks err by "+40.72% to −57.84%" on its own catchments. Carried across the border into a different basin it is a yardstick, not a design method. In Tripura, therefore, every catchment of 25–5,000 km² is designed by the site study of Clause 3.11.4 (Commentary to Clause 3.7, rule (d)); the 2(b) unit hydrograph is computed beside it for the natural condition, within its range of 50–1,500 km², with the depths of Clause 2.3.6 and the ARF above, and reported under Clause 3.11.4(c) and the reasonableness check of Clause 3.15.6. It is never the floor of Clause 3.11.4(d): where the calibrated site study gives a lower 1% AEP peak than the cross-check, the submittal shows the calibration that supports it (Clause 3.15), and where the site study cannot be calibrated, the higher of the two peaks is adopted (set by this Manual). The ARF curves are used in Tripura (Clause 2.7.3) because an areal reduction depends on storm size more than on the basin, because no Tripura ARF exists, and because they are the nearest published curves; they were read by optical character recognition only and are to be checked against the page images [TBC] (set by this Manual). The 2(b) ratios and isopluvials are not used in Tripura (Clause 2.3.6(b) and (f)). **Gauges for calibration.** CWC lists 12 sites in Tripura, two of them level-forecasting (the Manu at Kailashahar and the Gumti at Sonamura) and ten monitoring (SANDRP's transcription of CWC, 2018, as reported); State gauges include the Gomati at Udaipur and Amarpur and the Haora at Jahar Bridge (as reported). Only highest, danger and warning levels were read, from transcriptions, with no gauge zero, datum or rating curve [TBC]. **Use in the State.** Below 25 km² the Rational Method (single elements up to 16 ha) and SWMM or HEC-HMS apply under Clause 3.4, with the design rainfall of Clause 2.3.6, which needs no station; the towns behind embankments are routed with their storage, pumps and sluices against the river level (Commentary to Clause 3.7, rule (e)); and below the Dumbur reservoir the flood is set by the reservoir's releases (Chapter 5).

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 — Tripura 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 Tripura 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 — Tripura 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 — Tripura 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 recent flood plains and lunga floors of the Haora, Gomati, Khowai, Dhalai, Manu, Juri, Deo, Muhuri and Feni valleys, where the CGWB's dug wells in West Tripura stood 0.22–6.64 m below ground in November 2017, central Agartala between the Haora embankment and the Katakhal and the other land behind embankments, the pukur, dighi and beel margins, and filled ponds and lunga fills, 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 (PWD (WR), NRSC, Survey of India), the embankments, sluices and pumping stations of PWD (WR) and the flood pumps of central Agartala, with their closing levels where they exist [TBC], the warning, danger and highest flood levels of the CWC sites, with their gauge zero and datum [TBC], the Haora flood-plain-zone localities mapped by PWD (WR) for the National Green Tribunal (map, return period and status not known [TBC]), the Natural Hazard Prone Areas of rule 2(44) of the Tripura Building Rules, 2017 once the Development Plans identify them [TBC], the boundary of the Rudrasagar Ramsar site, the urban water bodies geo-tagged for the National Green Tribunal in 2020 (as reported), and the levels and release records of the operator of the Dumbur reservoir [TBC], town boundaries (UDD and TUDA for the Agartala Planning Area and the Local Planning Areas, the Agartala Municipal Corporation, the Municipal Councils and Nagar Panchayats, the Revenue Department's land records, and the Tripura Tribal Areas Autonomous District Council [TBC]), flood maps held by TDMA, observation-well records of the CGWB and the PWD (WR), and the extent of the recent flood plains and lunga floors, the Holocene terraces, the tilla uplands of Dupitila sandy clay and laterite, the weathered Tipam sandstone and the sandstone and shale of the hill ranges, with the land to which the lunga rule of Clause 4.11 applies, the tilla tops and benches to which its tilla rule applies, and the slopes of more than 20% to which its hill rule applies from soil survey maps (NBSS&LUP, the Agriculture Department, Tripura (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, chhara, khal, pukur, dighi or beel, or of the water ponded behind any embankment or closed sluice that encloses the site (Clause 4.12.1(b)). For the flotation check in the recent flood plains and lungas of the Haora, Gomati, Khowai, Dhalai, Manu, Juri and Muhuri valleys, the pukur, dighi and beel margins, filled ponds 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	recent flood plain; lunga floor; Holocene terrace or higher flood plain; land behind an embankment (central Agartala between the Haora embankment and the Katakhal, or other); pukur, dighi or beel margin; filled pond or lunga fill; tilla top or bench; other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, monsoon season	m
shgw_basis	Wells or piezometers used, and period of record	text
tidal_influence	Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b))	yes / no
source	Source agency and date of the data	text
geometry	Zone boundary	polygon

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

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

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

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

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

4B.2 PSD and SSR (Table 4.3)

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m^3/ha), standard	SSR (m^3/ha), flood-sensitive
TR-Z1 Western valley: TR-A Agartala–Sonamura valley (Agartala–Jirania–Mohanpur–Bishalgarh–Sonamura); from the Agartala governing cell and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	—	—	—	—	—
TR-Z2 Central valleys: TR-B Khowai valley (Khowai–Teliamura); from the governing cell 6 km south of Khowai and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	—	—	—	—	—
TR-Z2 Central valleys: TR-B1 Dhalai valley (Ambassa–Kamalpur); from the governing cell of TR-B and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	—	—	—	—	—

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
TR-Z3 Northern valleys: TR-C Manu–Juri–Deo valleys (Kailashahar–Kumarghat–Dharmanagar–Panisagar–Kanchanpur); from the Kailashahar governing cell, not below 377.2 mm in 24 hours at 1% AEP within 25 km of Kailashahar (Clause 2.3.6(h)), and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	—	—	—	—	—
TR-Z4 Southern valleys: TR-D Gomati valley (Udaipur–Amarpur–Karbook); from the Udaipur governing cell and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	—	—	—	—	—
TR-Z4 Southern valleys: TR-D1 Muhuri–Feni south (Belonia–Santirbazar–Jolaibari–Bagafa–Sabroom); from the Sabroom governing cell, with the 1% AEP 24-hour depth not below 490 mm (Bagafa, Clause 2.3.6(h)), and the floors of Clause 2.3.6(g)	B / C / D	50% / 70% / 90%	—	—	—	—	—
TR-Z5 Hill ranges: TR-E Hill ranges (Baramura–Atharamura–Longtharai–Sakhan–Jampui); the higher of the rows of the valley sub-areas on either side of the range (Clause 2.3.6(c))	C / D	50% / 70% / 90%	—	—	—	—	—

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 lunga between tillas on the edge of Agartala; they are not NIH-DHAARA values and must not be used for design. Part 1 sets out the inputs, hydrographs and routing step by step, for a trial outlet. Part 2 finds that the trial outlet fails the drawdown check with the blockage of Clause 4.8.3, and revises it to the outlet reported in Table 4.2. Part 3 completes the spillway, outlet, safety and retention checks. The outfall-closed check of Chapter 5 for the same facility on an outfall to a khal on the edge of Agartala that leaves through a gated outfall in a river embankment 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

Item	Value	Basis
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

Duration (h)	AMC	2-yr pre	2-yr post	10-yr pre	10-yr post	100-yr post
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

Stage h (m)	Storage (m³)	Stage 1, 120 mm (L/s)	Stage 2, 470 mm (L/s)	Total (L/s)
0.80	2,000	25.9	83.0	108.9
0.90	2,250	27.5	167.8	195.3
1.00	2,500	29.1	222.3	251.4
1.10	2,750	30.7	265.8	296.5
1.20	3,000	32.1	303.2	335.3
1.30	3,250	33.5	336.4	369.9
1.40	3,500	34.8	366.7	401.5

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

4C.8 **Routing.** Each storm is routed by level-pool continuity (Clause 4.6.1): over each 5-minute step, the change in storage equals inflow volume minus outflow volume. The computation used six 50-second sub-steps per 5-minute step. Each row of Table 4C.7 can be checked by hand as $\Delta S \approx (I - \bar{O}) \times 300$ s, where I is the mean inflow over the 5-minute step ending at the time shown and $\bar{O}$ is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: 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

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
24	70.0	15	12	0.215	536
36	105.0	16	14	0.264	660
48	140.0	16	15	0.294	736
54	181.7	47	19	0.469	1,172
57	213.5	69	23	0.623	1,559
59	248.5	120	91	0.789	1,971
60	293.3	286	170	0.866	2,164
61	378.0	187	332	1.187	2,967
62	399.3	106	237	0.968	2,421
63	414.5	80	142	0.829	2,072
66	446.9	51	52	0.771	1,927
72	489.5	33	33	0.768	1,920
84	489.5	0	18	0.405	1,012
96	489.5	0	10	0.167	418
108	489.5	0	4	0.058	146

The routed outflow volume equals the inflow volume (about 9,470 m³): detention delays the volume but does not remove it.

4C.9 **Results, trial outlet.** Table 4C.9 gives the peaks, maximum stages and drawdown times for the trial outlet.

Table 4C.9 — Results for the trial outlet (120 mm and 470 mm orifices) (Illustrative — not design values)

Duration (h)	2-yr detained (L/s)	2-yr max stage (m)	10-yr detained (L/s)	10-yr max stage (m)	100-yr detained (L/s)	100-yr max stage (m)	100-yr storage (m³)	10-yr 90% drawdown, clean (h)	10-yr 90% drawdown, 50% blocked (h)
1	9	0.15	15	0.30	22	0.59	1,468	27.2	54.2
2	11	0.20	18	0.42	89	0.79	1,966	28.3	57.0
3	13	0.24	20	0.50	135	0.82	2,058	29.3	59.1
6	15	0.31	23	0.64	190	0.89	2,229	31.1	63.4
12	17	0.40	49	0.77	279	1.06	2,647	36.2	69.2
24	19	0.45	87	0.79	334	1.20	2,991	42.8	75.4
48	20	0.51	144	0.83	353	1.25	3,129	42.5	72.7
72	20	0.52	147	0.84	354	1.25	**3,133**	42.5	71.9

The drawdown time is measured from the time of maximum 10-yr storage until 90% of that storage has been released (Clause 4.7.1).

Part 2 — Checks and revision of the outlet (Clauses 4.5, 4.7 and 4.8)

4C.10 **Release caps.** Every 100-yr detained peak is at or below 356 L/s, and every 2-yr detained peak is far below the 2-yr cap of 180 L/s. Both caps are met. The 2-yr peaks are not compared duration by duration with the pre-development peaks: for a flood-sensitive site the 2-yr cap is the single largest pre-development 2-yr peak (Clause 4.5.3.1).

4C.11 **Drawdown.** Clause 4.8.3 requires the low-flow orifice to be assumed **50% blocked** when drawdown is checked. With the 120 mm orifice at half its area, 90% of the 10-yr storage takes 54 to 75 h to drain (Table 4C.9), against the 48-hour limit of Clause 4.7.1. **The trial outlet fails.** With a clean orifice it would drain in about 42 h.

4C.12 **Revised outlet.** The low-flow orifice was increased in 10 mm steps until the blocked drawdown met 48 h for every duration, and Stage 2 was then re-sized so that the 100-yr cap was still met. The result:

- Stage 1: **170 mm** orifice at the floor;
- Stage 2: **460 mm** orifice, invert 0.53 m above the floor (centre at 0.76 m);
- no Stage 3.

The larger low-flow orifice releases more in frequent storms. That is acceptable here because the 2-yr cap of a flood-sensitive site is the largest pre-development 2-yr peak (Clause 4.5.3.1). The WQv is assumed to be treated in a separate practice upstream (Chapter 8), so Stage 1 is not required to hold the WQv for 24–48 h (Clause 4.6.5.1); where Stage 1 also releases the WQv, Clause 4.7.2 must be checked as well.

Table 4C.10 — Stage–storage–discharge, revised outlet (Illustrative — not design values)

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
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)

Item	Value
2-yr peak release	34 L/s (cap 180 L/s)
10-yr drawdown, 50% blocked	45.3 h (limit 48 h)
Retention	RRV 552 m³ provided in addition; credit 7 m³
Still to be checked	Outfall-closed check on an outfall to a khal on the edge of Agartala that leaves through a gated outfall in a river embankment (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 — Tripura 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 Tripura 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 — Tripura 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 — Tripura 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 — Tripura 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 — Tripura 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 — Tripura 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 Tripura. Tripura has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Tripura 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 or State gauge and its datum (or "datum not stated (TBC)"), the lock and the pump-down of Clause 5.8.5(a), for a border reach the level and lock of Clause 5.8.5(c), and for an outfall to a pukur, dighi, beel, lunga 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
Haora at the CWC Haora site	Agartala (TR-A)	Riverine outfall reach behind the Haora embankment, river-locked and pumped; 46 km, 414 km² (CGWB NAQUIM); design level 12.42 m (22 August 2024), the highest of 11.08, 12.14, 12.4 and 12.42 m; danger level 10.70 m, the highest of 10.48, 10.50 (Jahar Bridge) and 10.70 m; all as reported, datum not stated (TBC); lock the 72-hour storm and a further 72 hours without an analysed stage record; border reach	5.8.1, 5.8.5
Katakhal and its double-barrel sluice (PWD (WR), near Bhuturia)	Agartala (TR-A)	Major drain and river-locked outfall of the north of the city; flood pumps discharge to it; no gauge or hydraulics [TBC], surveyed and modelled level required, the Haora design level until then; three interception-fed STPs under construction on its banks; border reach	5.2, 5.8.1, 5.8.5
Akhaura canal	Agartala (TR-A)	Major drain of the central area along the Akhaura road, flowing to Bangladesh; no level or hydraulics [TBC]; border reach; carries sewage (Clause 8.9)	5.2, 5.8.5
Bangeshwar Gang, Debta Gang, Nagichara, Kalapani Charra and Kalapania Khal	Agartala (TR-A)	Major drains and chharas of the city (ADB IEE, 2020); routed as storage behind their outfalls; chhara rule where they leave the tillas; the 5 MLD Joypur STP on the Kalapania Khal	5.2, 5.8.5
Manu at Kailashahar and Kumarghat; Manu at Manughat	Northern valleys (TR-C)	Riverine outfall reaches; Kailashahar 25.95 m (13 June 2018) above the 1993 level of 25.79 m, danger level 25.34 m (CWC) against the State's 24.00 m and 23.05 m (conflict; the higher applies); Kumarghat 32.97 m (7 June 1993); Manughat 46.6, 46.97, 48.04 or 18.04 m (unresolved, not used; modelled or surveyed level); as reported, datum not stated (TBC)	5.8.1, 5.8.5
Juri at Nutan Bazar; Deo; Longai	Northern valleys (TR-C)	Riverine outfall reaches; Nutan Bazar 20.66 m (22 August 2024) above 20.435 m (15 May 1984), as reported, datum not stated (TBC); Deo and Longai no gauge level, modelled or surveyed level required	5.8.1, 5.8.5
Dhalai at Kamalpur	Central valleys (TR-B1)	Riverine outfall reach; 33.85 m (15 May 1984), as reported, datum not stated (TBC)	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Khowai at Khowai and Teliamura	Central valleys (TR-B)	Riverine outfall reach; 140 km and 1,100 km² in old West Tripura district (CGWB NAQUIM); Khowai 28.005 m (24 June 2004), as reported, datum not stated (TBC); enters Bangladesh 1 km north of Khowai town	5.8.1, 5.8.5
Gomati (CWC: Gumti) at Amarpur, Udaipur and Sonamura	Southern and western valleys (TR-D, TR-A)	Riverine outfall reaches and the Dumbur release reach; Amarpur 32.74 m (22 July 1993), State gauge extreme danger 32.00 m; Udaipur State gauge 22.05 m (21 August 2024), extreme danger 22.00 m; Sonamura 14.43 m (23 July 1993), danger level 12.5 m; as reported, datum not stated (TBC); lock not less than 72 hours after the storm with the release	5.8.1, 5.8.3, 5.8.5
Dumbur reservoir (Gumti hydel project, Tirthamukh)	Gomati basin (TR-E)	Reservoir above the release reach; full reservoir level 93.55 m against a "danger level" of 94 m (94 m used); spillway capacity 481.38 m³/s (release until the operator gives a recorded one); operator TSECL (as reported); operator's levels in writing; no credit for warnings, drawdown or attenuation; not a Ramsar site	5.8.3, 5.8.5
Muhuri at Belonia	Southern valleys (TR-D1)	Riverine outfall reach; 18.81 m (22 August 2024) above 18.12 m (20 August 2024), 17.32 m (2 August 2024) and 16.98 m (4 August 1983), as reported, datum not stated (TBC); border reach	5.8.1, 5.8.5
Feni at Sabroom	Southern valleys (TR-D1)	Border reach; CWC site named in 2024 but not working (as reported); modelled or surveyed level required	5.8.1, 5.8.5
Burima (Bijoy) at Gajaria	Western valley (TR-A)	Riverine outfall reach; 11.25 m against 11.15 m (24 June 2004) (conflict; 11.25 m applies), 10.77 m on 22 August 2024; as reported, datum not stated (TBC); border reach near Boxanagar	5.8.1, 5.8.5
Pukurs, dighis, beels, haors and unfilled lungas that receive town drains, among them the Ujjayanta palace lakes, the MBB College lake, the College Tilla lake, Banamalipur Dighi and Kalyan Sagar	Statewide	Receiving storage; full to the outlet at the start; surveyed stage–storage [TBC]; storage belongs to the system; palace-era and temple tanks not drawn down; interception and screens before any outfall that carries sewage	5.8.5
Rudrasagar	Sepahijala (TR-A)	Ramsar site No. 1572 (240 ha; 2005 or 2007, conflict); catchment 6,052 ha (as cited); no storage credited; interception and screens; Wetland Authority of Tripura's permission	5.8.5
Chharas of the tilla uplands and of the Baramura, Atharamura, Longtharai, Sakhan and Jampui ranges	Every valley; hill ranges (TR-E)	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 tilla foot; lock not less than 24 hours	5.2, 5.8.1, 5.8.5
Drains of the Municipalities, Agartala Smart City Ltd, TUDA, PWD (R&B) and NHIDCL 1.0 m wide or more; PWD (WR) channels and sluices	Tripura	Major drains; PWD (WR)'s consent through an embankment or sluice; owner's consent (TMA s.161), design water level and flap gate	5.2, 5.8.5
River mouths subject to sand-bar closure	None in Tripura	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 PWD (WR) mouth-maintenance programme. It needs PWD (WR) river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (PWD (WR)), the drain inventories of AMC 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, PWD (WR) canal, the Haora, the Katakhal, the Akhaura canal, the Bangeshwar Gang, the Debta Gang, the Nagichara, the Kalapani Charra and the Kalapania Khal in Agartala, every channel that discharges through a sluice in an embankment or to a drainage pumping station, any drain built or held by a Municipality, Agartala Smart City Ltd, TUDA, PWD (R&B) or NHIDCL with an internal width of 1.0 m or more, and every chhara, khal and lunga flow path 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 Tripura) are assumed closed at the start of the monsoon unless PWD (WR) 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	PWD (WR) 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	PWD (WR) 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 a lunga between tillas on the edge of Agartala draining to a khal

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 a lunga between tillas on the edge of Agartala. It discharges through its own outlet chamber and a flap gate to a public storm drain that runs along the lunga to a khal, which leaves through a gated outfall in a river embankment; when the river beyond the embankment is high the gate is shut, and the khal rises behind it and stays up, 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 Tripura an outfall to a khal behind an embankment sluice, as this one is, is closed for the whole 72-hour storm and for as long after it as the river stays above the sill, and for not less than a further 72 hours where no stage record has been analysed, and its stored volume is pumped down within 48 hours with the gate still shut; an outfall below the design level of a full pukur, dighi, beel or lunga is closed for the whole storm; an outfall to the Dumbur release reach is closed for not less than 72 hours after the storm; and an outfall to a chhara whose invert is below its design level is closed for the storm and the stream's recession, and for not less than 24 hours, 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. On the lunga floor the facility is a lined detention pond or tank, not an infiltrating basin, and the seasonal high water table sets its flotation check (Clause 4.11 (lunga rule); Clause 4.12); where the drain receives runoff from the tilla slopes above the site, it also needs the debris rack, the bulking factor and the silt trap at the tilla foot of Clause 6.3.6.

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 recent flood plains and lungas of the Haora, Gomati, Khowai, Dhalai, Manu, Juri and Muhuri valleys, the pukur, dighi and beel margins, filled ponds 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 — Tripura 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 pukur, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or pukur: 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, Agartala, border reaches, rivers with CWC sites and the Dumbur release reach, pukurs, dighis and lungas, chharas, and drains of other bodies: for a river-locked outfall, the operator of each sluice, gate and pumping station identified (PWD (WR), the Municipality, Agartala Smart City Ltd or another body), gate sills, embankment or wall crest, installed capacity, operating levels and sluice-closing level obtained, with every level tied to the datum of a named CWC or State gauge, or entered as "datum not stated (TBC)", 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 or State gauge transferred to the outfall (the Haora at the CWC Haora site 12.42 m, Kailashahar 25.95 m, Kumarghat 32.97 m, Sonamura 14.43 m, Amarpur 32.74 m, Udaipur State gauge 22.05 m, Kamalpur 33.85 m, Nutan Bazar 20.66 m, Belonia 18.81 m, Gajaria 11.25 m, Khowai 28.005 m; never a Manughat value), with the profile or interpolation used; 10% AEP river level, not below the danger level transferred (Haora 10.70 m, Kailashahar 25.34 m, Sonamura 12.5 m) or, at a monitoring site, the design river level; drain, khal, pukur or lunga behind the gate routed with its whole catchment and present storage, starting full to its outlet, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump, from certified curves), pumps operable at the design river level; the lock (the whole 72-hour storm and, after it, the longer of the time the river stays above the sill from the stage record used and a further 72 hours where no stage record has been analysed) and the pump-down to the starting level within 48 hours with the gate shut; gate-failure, leakage and breach checks; for Agartala, the zone (North, Central or South), the outfall (Haora, Katakhal, Akhaura canal or another channel), the pumps serving it confirmed in writing by their owner, the surveyed and modelled Katakhal or Akhaura canal level (the Haora design level until then), and any ADB, Smart City or PWD (WR) works counted only once built; for a border reach, the gauge level or 2024 peak used, the modelled or surveyed level where no site works, and the last analysis point in India; for the Dumbur release reach, the operator's consent, levels in writing (feet converted at 1 ft = 0.3048 m, datum stated), the reservoir level at release (94 m until the operator confirms), the largest recorded release or the spillway capacity of 481.38 m³/s, placed before, during and after the storm, and a lock of not less than 72 hours after the storm, with no warning, drawdown or attenuation credited; for a pukur, dighi, beel, lunga or pond, its outlet level, surveyed monsoon water line, surveyed stage–storage relation, starting level and design level, whether it is a palace-era, temple or fisheries tank or Rudrasagar, the custodian's consent, and the interception and screens before it; for a chhara, the 1% AEP study with the rainfall of its sub-area, 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 tilla foot, landslide ground on its path, and a lock of not less than 24 hours; PWD (WR)'s written consent for any work through an embankment or sluice; owner's consent (the Municipality under s.161 of the Tripura Municipal Act, 1994; PWD (R&B), NHIDCL, Agartala Smart City Ltd or another body; the District Council in the TTAADC area), permitted rate, design water level or computed channel level, and flap gate; and TBR 2017 r.9(3), r.9(4), r.4(1)(e) and, in the hill ULBs, r.90(1)(i) and (m), the status of any water body under the Diversion of Land Rules, and the Haora flood-plain-zone localities 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				

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
R1				
R2				

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

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

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

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

Period	Inflow (m³)	Gravity outflow (m³)	Pumped (m³)	Storage at start (m³)	Storage at end (m³)
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 PWD (WR) 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 Tripura 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 — Tripura Stormwater Design Manual, Draft v1.0.

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — Tripura 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, AMC, TDMA, PWD (WR) (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 — Tripura 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 Tripura 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 Tripura 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: PWD (R&B), NHIDCL and Agartala Municipal Corporation standard details, NIT Agartala, which the sources name only for its rainfall research and whose hydraulic testing capability was not confirmed during research [TBC], or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

Table 6A.1 — Interim requirements for inlets until Annex 6A is published (from Chapters 6 and 9)

Item	Requirement	Clause
Inlet type on public streets	Kerb-opening or combination inlets, unless the Approving Authority accepts grate-only inlets for a location	6.6.1(a)
Inlet level	Openings at road level; gutter depression where practicable	6.6.1(b)
Clean capacity	FHWA HEC-22 (4th ed., 2024) or the manufacturer's tested rating for the exact geometry; CPHEEO §5.6.2 equations as a cross-check only	6.6.2
Clogging, on grade	Grate 50%; kerb opening 10%	6.6.3, Table 6.5
Clogging, in a sag	Grate 50%; kerb opening 20%	6.6.3, Table 6.5
Spacing	By sequential calculation from the top of each gutter run; not more than 30 m on kerbed roads	6.6.4
Kerb opening size	Clear height at least 100 mm; length at least 1.0 m	9.11.4
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 Tripura, 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 Agartala Municipal Corporation and other urban local bodies, PWD (WR) records for channels, land cover from NRSC, soils from the Tripura 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.

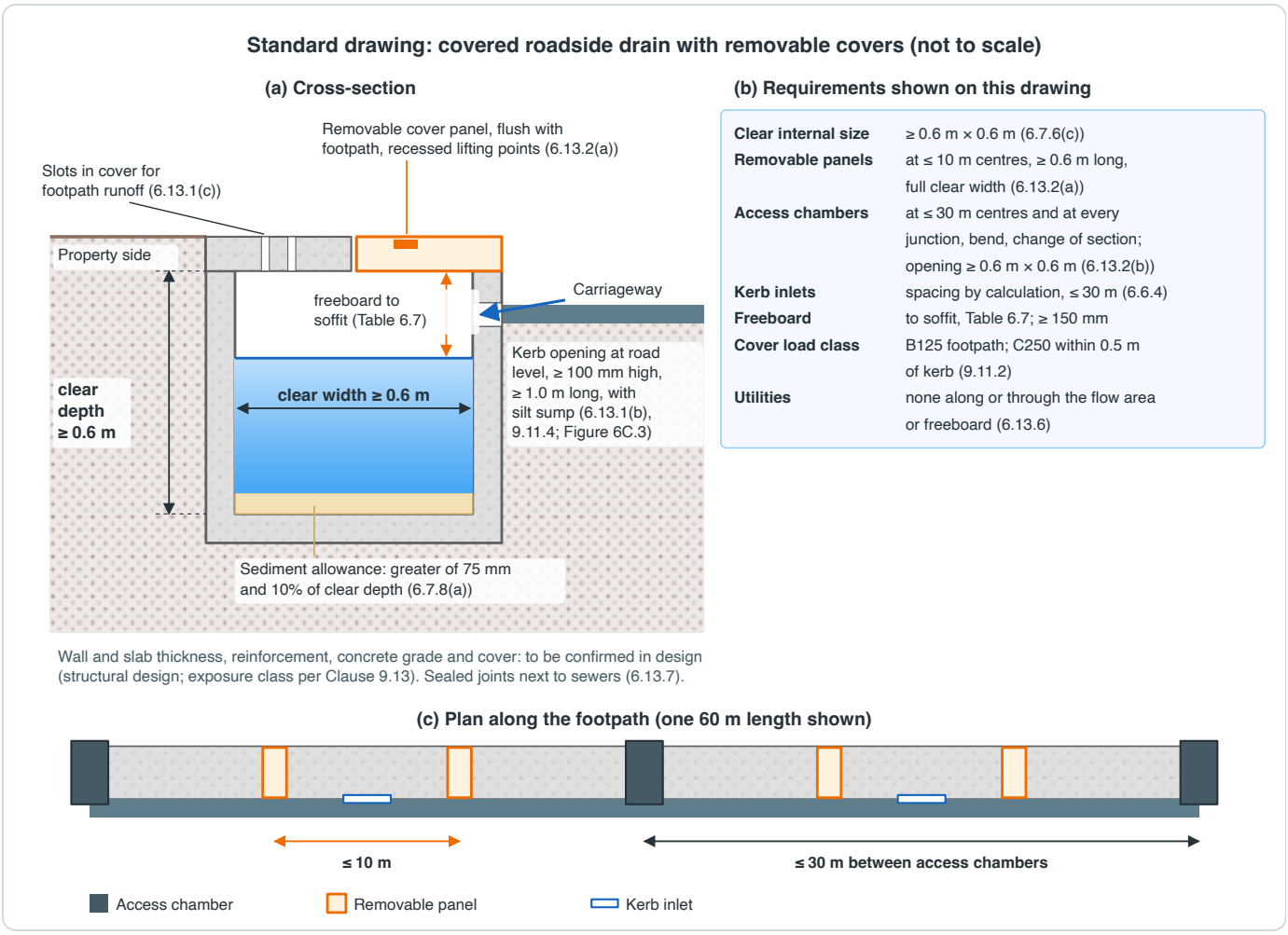


Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

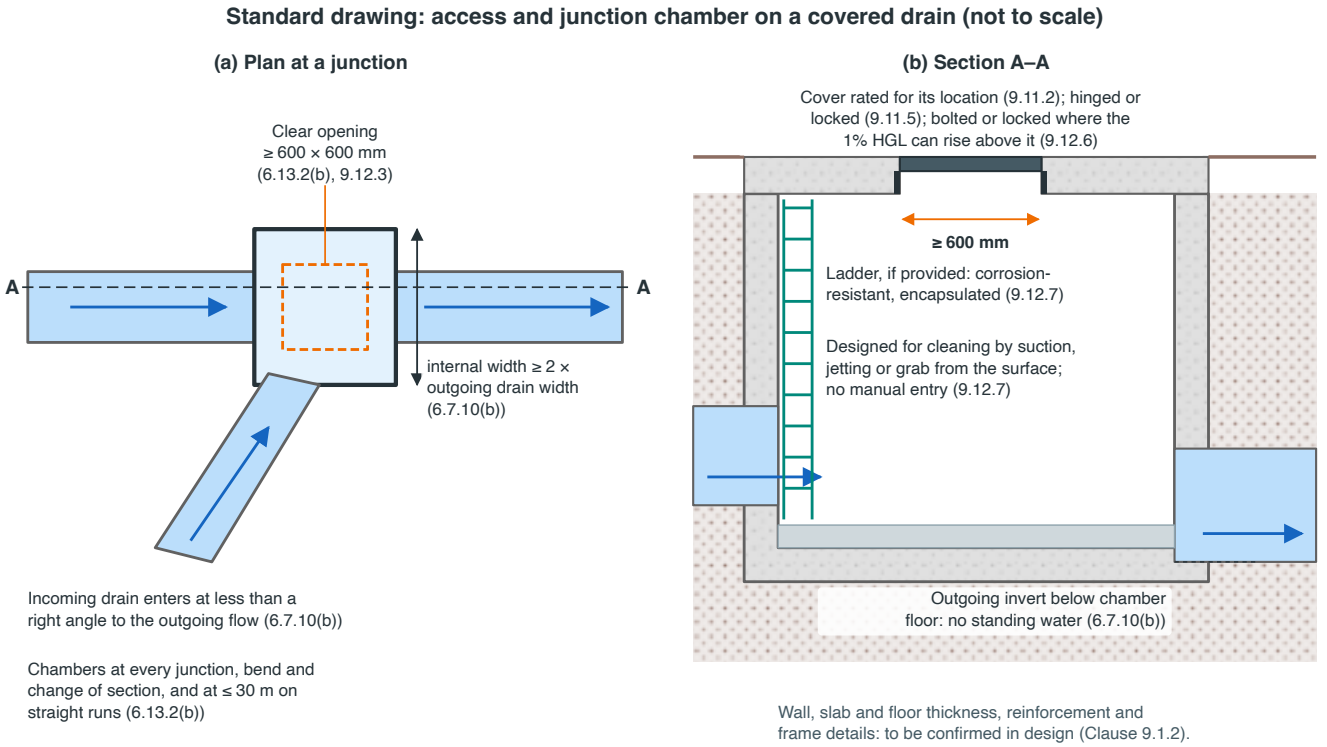


Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

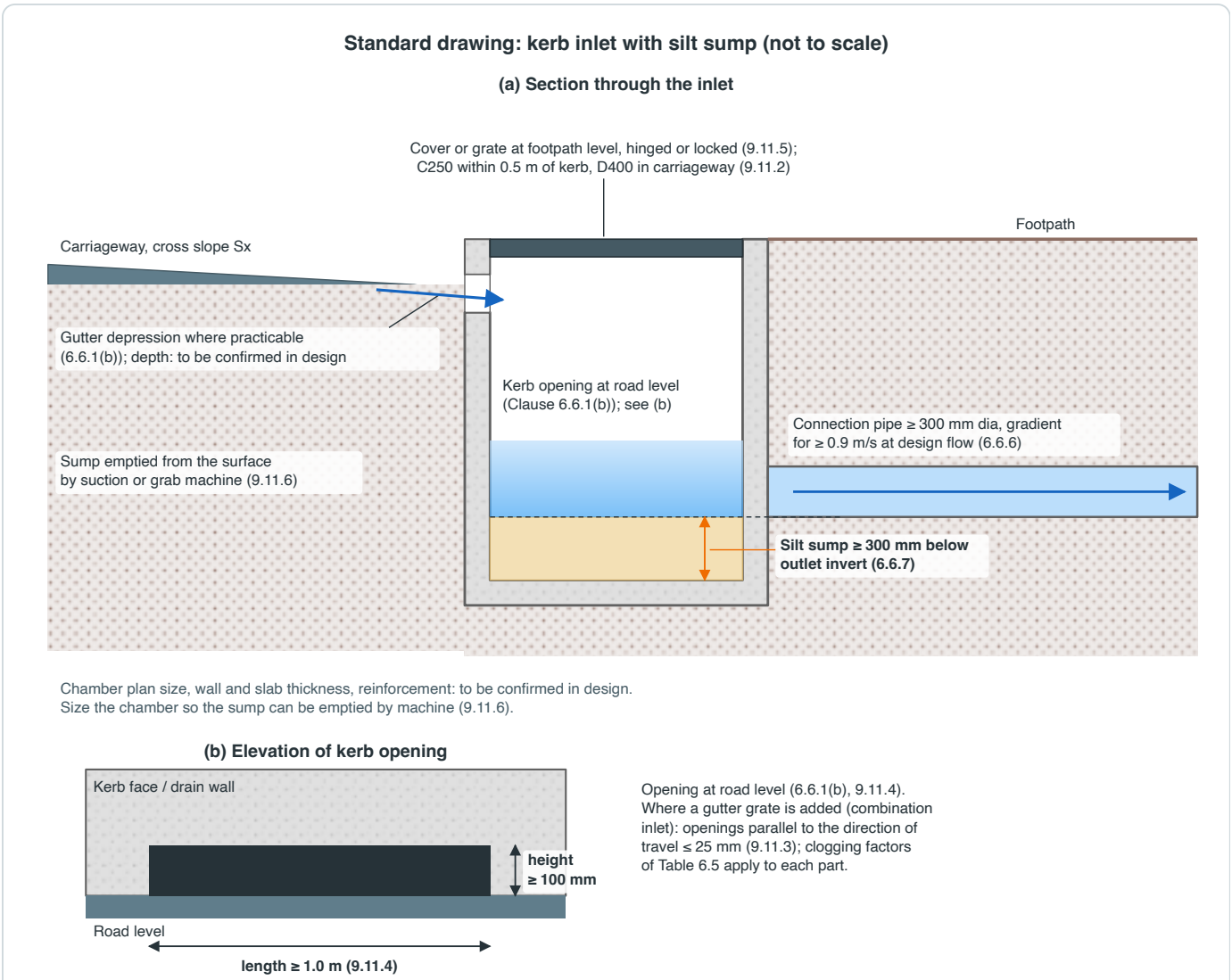


Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th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

ANNEXES TO CHAPTER 7

Waterbodies, Ponds (Pukurs) 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 Bengali 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 PWD (WR) and the Revenue Department. It needs the land records of the Revenue Department, kept by district, sub-division, revenue circle and mouza (the plot numbering was not confirmed [TBC]), with each plot's land class under Appendix-I of the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025, among them pukur ("Tank/Pond"), pukurpar ("Bank of tank"), dighi ("Large tank"), dighirpar ("Bank of large tank"), doba ("Ditch"), beel ("Watery land"), haor ("Big watery land"), chhara ("Streams"), lunga ("Flat lands between tillas"), khal ("Khal"), nala ("Water channel") and bandh ("Embankment"), including government (khas) land recorded as water; the list of 180 urban water bodies on government land that the ULBs geo-tagged for the National Green Tribunal in 2020, of which 30 were prioritised (as reported); the Agartala Municipal Corporation's zone-wise affidavit on the encroachment of water bodies before the High Court of Tripura (2017, as cited); PWD (WR)'s records of its embankments, sluices and anti-erosion works and its mapping of the Haora flood-plain zones; the land-use maps of the Master Plan for the Agartala Planning Area 2045 (text not read [TBC]) and the layouts of the Local Planning Areas; the records of the Wetland Authority of Tripura for Rudrasagar; in the TTAADC area, the land records of the District Council (not researched [TBC]); and each town's drain register (Chapter 6); the PWD (WR) and Gram Panchayat or Village Committee 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 PWD (WR) records, with local name	7.3.1(a)
WB_NAME_BN	Text	Bengali script	Yes	Name in Bengali	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, revenue circle 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	PWD (WR) record / 1% AEP computed	Tanks	Which value governs MWL	7.2
TBL	Number	m (datum)	Tanks	Top bund level, lowest point	7.3.1(d)
WEIR_CREST	Number	m (datum)	Tanks	Surplus weir crest level	7.3.1(d)
WEIR_LEN	Number	m	Tanks	Surplus weir crest length	7.3.1(d)
WEIR_TYPE	Text	—	Tanks	Surplus weir type (for example fixed crest, with shutters or falling boards)	7.3.1(d)
SLUICE_N	Integer	—	Tanks	Number of sluices; details in WB_STRUCT	7.3.1(d)
SUPPLY_CH	Text	WB_ID(s)	Tanks	Supply channel(s) feeding the tank	7.3.1(d)
SURPLUS_CS	Text	WB_ID(s)	Tanks	Surplus course(s) leaving the tank	7.3.1(d)
UPSTR_WB	Text	WB_ID(s)	Cascades	Upstream tank(s) in the cascade	7.3.1(e)
DNSTR_WB	Text	WB_ID	Cascades	Downstream tank, river, drain or sea outfall	7.3.1(e)
CATCH_AREA	Number	ha	Channels	Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1)	7.4.1

Field	Type	Unit / domain	Required	Content	Clause
DATUM	Text	—	Yes	Datum of all levels; conversion from any older PWD (WR) datum	7.3.5
LEVEL_DATE	Date	—	Tanks	Date of the level survey	7.7.1(a)
SSC_DATE	Date	—	Tanks	Date of the latest stage–storage survey	7.7.1(b)
FLOOD_SRC	Code	Adopted map / site study / none	Yes	Source of the 1% AEP extent	7.3.4
FLOODWAY	Code	Delineated / whole 1% extent / below MWL	Yes	Basis of the floodway	7.6.1
ENCR_KNOWN	Code	Yes / No	Yes	Known encroachment; details in WB_ENCR	7.3.1(g)
CREDITED	Code	Yes / No	Tanks	Storage counted under Clause 7.7, with the scheme reference	7.7.1
WETLAND	Code	Notified / listed / other	Wetlands	Status under Clause 7.12.1	7.12.1
SOURCES	Text	—	Yes	Sources used, from the list in Clause 7.3.3(a) to (e)	7.3.3
UPDATED	Date	—	Yes	Date of the last edit, and by whom	7.3.1

Table 7A.2 — Code lists

Code list	Values	Clause
WB_TYPE	River (nadi); khal (canal or channel); chhara (stream); nala, doba (ditch) or drain; lunga flow path; pukur (tank or pond); dighi (large tank); beel or haor (natural wetland); marsh or swamp (dhepa, utla); ponded area behind an embankment (with its sluice); reservoir; retention pond or basin; brick-field pit kept as a water body (TBR 2017, r.9(5)); supply channel; surplus course	7.2
CUSTODIAN	Agartala Municipal Corporation (TMA 1994, s.91); other Municipal Council or Nagar Panchayat (s.91); Agartala Smart City Ltd (works not handed over); TUDA (LPA layouts); PWD (WR) (embankment, sluice, anti-erosion work, minor-irrigation dam); PWD (R&B) or NHIDCL (road drains and culverts); PWD (DWS) (pump house, STP); Dumbur reservoir operator; Forest Department or Fisheries Department (Rudrasagar); Revenue Department (khas land); Gram Panchayat or Village Committee; religious institution; private owner; District Council, TTAADC area [TBC]; Wetland Authority of Tripura (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 PWD (WR) control, the operating rule is PWD (WR)'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, revenue circle, district].
2. Custodian: [PWD (WR) division / ULB / Gram Panchayat or Village Committee / other].
3. Cascade position: upstream tank(s) [ ]; downstream tank, river or drain [ ].
4. Datum: [ ]. Surveyed levels (Clause 7.7.1(a)), date of survey [ ]: FTL [ ] m; MWL [ ] m; TBL (lowest point) [ ] m; surplus weir crest [ ] m, length [ ] m; sluice sills [ ] m.
5. Stage–storage curve (Clause 7.7.1(b)): survey date [ ]; attached as Schedule 1.
6. Controllable outlets (Clause 7.8.2(a)): [gated sluice / regulator / none]; capacity at FTL [ ] m³/s.

7C.2 Purposes and priority

7. The tank serves [irrigation of a command area of [ ] ha / drinking water supply / recharge / flood storage]. Irrigation and water supply remain primary unless the custodian records otherwise (Clause 7.8.2(d)).

7C.3 Levels and dates through the year (Clause 7.8.1(a))

8. The tank shall be operated to the levels in Table 7C.1.

Table 7C.1 — Rule levels by period (to be completed for each tank)

Period	Target level (m)	Upper limit (m)	Lower limit (m)	Purpose
[1 Jan – date]	[ ]	FTL	[ ]	Holding for irrigation / supply
[date – start of cushion period]	[ ]	FTL	[ ]	Holding
[Flood-cushion period, if any]	Cushion level [ ]	Cushion level [ ]	[ ]	Flood cushion (Clause 7.8.2)
[End of cushion period – 31 Dec]	[ ]	FTL	[ ]	Refilling

9. Where no flood cushion is adopted, the starting level for design is FTL (Clause 7.7.3) and the row for the cushion period is deleted.

7C.4 Flood cushion (Clause 7.8.2)

10. Cushion level: [ ] m, which is [ ] m below FTL, giving a cushion volume of [ ] m³ from Schedule 1.
11. Dates: the cushion applies from [ ] to [ ].
12. Drawdown: the tank can be drawn down from FTL to the cushion level through [outlet] in [ ] hours, with a release not exceeding the maximum release rate of paragraph 18.
13. Reliability: continuous simulation (Clause 3.13) over the record [years] shows that the cushion is available at the start of a design storm in [ ]% of monsoon seasons, which shall be at least 90%. The simulation report is Schedule 2.
14. Yield: the custodian accepts the loss of irrigation or supply yield stated in Schedule 3 [and the compensation recorded there].
15. Where the tank has no controllable outlet, this section does not apply and no flood cushion is assumed (Clause 7.8.3).

7C.5 Releases (Clause 7.8.1(b) to (d))

16. Sluice and regulator settings at each level: Table 7C.2.
17. Operator: the sluices and regulators are operated by [post]. A release above [ ] m³/s may be ordered only by [post], or, in an emergency, by [post].
18. Maximum release rate: [ ] m³/s. This rate, added to the flow from the downstream catchment, does not flood buildings downstream (Schedule 4 gives the downstream check).
19. No person shall cut, lower or breach the bund or surplus weir except under the custodian's emergency procedure (Clause 7.14.5).

Table 7C.2 — Outlet settings by level (to be completed for each tank)

Tank level (m)	Sluice 1	Sluice 2	Regulator	Expected outflow (m³/s)	Notes
Below cushion level	[ ]	[ ]	[ ]	[ ]	
Cushion level to FTL	[ ]	[ ]	[ ]	[ ]	
FTL (weir begins to spill)	[ ]	[ ]	[ ]	[ ]	
Above FTL to MWL	[ ]	[ ]	[ ]	[ ]	Check freeboard to TBL (Clause 7.7.4(b))

7C.6 Forecasts, warnings and communication (Clause 7.8.1(e) and (f))

20. The triggers and actions are in Table 7C.3.
21. Before any release under this rule, the operator shall inform the ULBs and the district administration downstream, and residents by the means stated in Schedule 5, at least [ ] hours before the release where the forecast allows.

Table 7C.3 — Triggers and actions (to be completed for each tank)

Trigger	Source	Action	By whom
IMD district heavy-rainfall warning for the catchment	IMD	Read gauges [ ] hourly; check outlets are free; confirm the tank is at or below its rule level	[ ]
IMD or TDMA red alert	IMD, TDMA	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 Tripura State Pollution Control Board (TSPCB) 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 Tripura State Pollution Control Board (TSPCB) 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 Bengali waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are the Bengali words for waterbodies, channels, embankments and land that Tripura's land records use, with a few that appear in place names, the Building Rules and the dictionary. Their primary source is the State's own gazette: Appendix-I, "Classification of land for Agricultural purpose", of the Tripura Land Revenue and Land Reforms (Diversion of Land) Rules, 2025 (Tripura Gazette Extraordinary No. 1072, 3 June 2025; "App-I", with its item number), which gives each Bengali class with an official English gloss. Meanings are also given, where found, from S. Biswas, *Samsad Bengali-English Dictionary*, as served by the Digital South Asia Library (edition not confirmed; "Biswas", with its print page). The Bengali script is the gazette's. The name used in the land records, a municipal record or PWD (WR)'s records for each waterbody should be recorded in the inventory (Annex 7A) alongside the Manual's term. **Two cautions apply.** Roman spellings vary (for example beel and bil, lunga and loonga, Katakhal and Kathakhal), and modern usage may be narrower or wider than the gazette's and the dictionary's 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, PWD (WR) and municipal usage and the terms of Kokborok and the other languages in use in the State.

The Manual's term for a dug tank or pond is **pukur**, written on first use as "**pukur (Bengali পুকুর: a tank or pond — the land records' 'Tank/Pond'; plural pukurs)**", and its term for a large tank is **dighi**, written on first use as "**dighi (Bengali দীঘি: a large tank)**". *Pukur* is the gazetted land class "Tank/Pond" in the rules that control the diversion of water bodies, and the dictionary gives it the engineering verbs of the tank (পুকুর কাটা, "to excavate a pond"; পুকুর ঝালানো, "to dredge a tank"); *dighi* has its own class, "Large tank". Bengali marks the plural with *-gulo* or *-guli*, not with an ending of this kind, so the English plural **pukurs** is a convention of this Manual. Engineered storage built under this Manual is a **detention pond**, never a pukur, and a natural wetland is never called a pukur. A **doba** is recorded in Tripura as a "Ditch", never as a pond. The Building Rules call a hill stream a **jhora**; this Manual keeps that word when it quotes the rules and writes **chhara** elsewhere.

Table 7E.1 — Waterbodies and wet land

Bengali term	Meaning (source)	Manual term (Clause 7.2)
পুকুর (pukur)	"Tank/Pond" (App-I, 9); "n. a pond, a tank, a pool"; পুকুর কাটা "v. to excavate a pond"; পুকুর ঝালানো "v. to dredge a tank" (Biswas, p. 653)	Pukur (tank or pond), see the definitions after Clause 7.2
পুকুরপাড় (pukurpar)	"Bank of tank" (App-I, 10)	Bank of a pukur; in Zone 1 (definitions after Clause 7.2)
দীঘি, দিঘি (dighi)	"Large tank" (App-I, 14); "n. a large and deep tank or pond" (Biswas, pp. 499, 501)	Dighi (large tank)
দীঘিরপাড় (dighirpar)	"Bank of large tank" (App-I, 31)	Bank of a dighi; in Zone 1
ডোবা (doba)	"Ditch" (App-I, 11); "n. a pit full of water; a small pool of water" (Biswas, p. 436)	Doba (ditch); never a pukur

Bengali term	Meaning (source)	Manual term (Clause 7.2)
বিল (bil; beel)	"Watery land" (App-I, 13); "… a fen; a marsh" (Biswas, p. 770)	Beel (natural wetland), see the definitions after Clause 7.2
হাওর (haor)	"Big watery land" (App-I, 12); "n. an extensive marsh or quagmire or fen" (Biswas, p. 1050, as হাওড়)	Haor (large natural wetland)
ঢেপা (dhepa)	"Marshy land" (App-I, 21)	Marsh (Clause 7.12)
উতলা (utla)	"Swampy land" (App-I, 23)	Marsh or swamp (Clause 7.12)
জলা (jala)	"n. a marsh, a bog"; ~জমি, "wetlands" (Biswas, p. 395)	Marsh; not a land class in App-I
বালুরচর (balurchar)	"Sandy land bed" (App-I, 22)	Sand bar within a river (part of the waterbody)

Table 7E.2 — Streams, channels, drains and wells

Bengali term	Meaning (source)	Manual term (Clause 7.2)
নদী (nadi)	"River" (App-I, 33)	River
ছড়া (chhara)	"Streams" (App-I, 35); the dictionary gives the word no stream sense (Biswas, p. 374)	Chhara (stream), see the definitions after Clause 7.2; cite the gazette
খাল (khal)	"Khal" (App-I, 34); "n. a canal; a strait; a channel …" (Biswas, p. 281)	Khal (canal or channel), as in the Katakhal and the Kalapania Khal
নালা (nala)	"Water channel" (App-I, 7); "n. a duct; a drain; a canal; a wayside gutter" (Biswas, p. 567)	Nala (water channel)
ড্রেন (drain)	"Drain in Municipal area" (App-I, 8)	Drain (the gazette uses the English loan)
নর্দমা (nardama)	"n. a drain; a gutter; a sewer" (Biswas, p. 558)	Drain (minor system); colloquial
ঝোরা (jhora)	The Building Rules' word for a hill stream ("natural drainage channel/jhora", "streams/jhoras", rr.5, 90 and 99); "n. a cascade, a waterfall, a fountain" (Biswas, p. 418)	Used only when quoting the rules; otherwise chhara
ইন্দারা (indara); কুয়া (kua)	"Pucca well"; "Kachha well" (App-I, 19 and 20)	Well (Clause 8.11)

Table 7E.3 — Land and embankments

Bengali term	Meaning (source)	Use in this Manual
লুঙ্গা (lunga)	"Flat lands between tillas" (App-I, 5); not in Biswas; the CGWB writes "loonga"	Lunga (valley floor between tillas) and its flow path, see the definitions after Clause 7.2
টিলা (tilla)	"Hillock" (App-I, 15); "n. a mound, a hillock, a knoll, a hummock" (Biswas, p. 424)	Tilla (low hill or terrace upland)
বাঁধ (bandh)	"Embankment" (App-I, 30); "n. a dam; a breakwater … (geog.) a dyke" (Biswas, p. 735)	Bandh: the term for a river or pond embankment

Kokborok. Kokborok is an official language of the State with Bengali (Tripura Official Language Act, 1964, as amended in 1979; in force for official purposes from 1 May 1999). Its script is disputed between Roman and Bengali (as reported), and this Manual takes no side: it gives the Kokborok words it found only in the phonetic (IPA) forms of a linguistic study of the Debbarma dialect (Brahma, 2022, *Himalayan Linguistics* 21(2), Tables 9–10, citing B. Debbarma's *Concise Kokborok-English-Bengali Dictionary*, 2001, which was not read). **Their Roman and Bengali spellings were not**

confirmed [TBC], so they are given for reference only and are not used as defined terms: tɯi "water"; tɯɪma "river"; tɯɪsluŋ "canal"; tɯɪsuŋ "riverbank"; tɯɪtɔr "flood"; **tɯɪwar "large pond, lake"**, the nearest Kokborok word to pukur and dighi; and tɯɪmuk "fountain". Kokborok names such as *Saidra* for the Haora and *Twijilikma* for Rudrasagar (both as reported) are recorded in the WB_NAME field of Annex 7A with a note.

Table 7E.4 — Terms avoided or not yet verified

These terms or senses are in use or have been proposed but were not confirmed 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 (doba) as "pond"	In some Bengali usage a small pool, grouped with tanks	**Avoided** in that sense: Tripura's land records class it as "Ditch"
ছড়া (chhara) from the dictionary	Biswas gives "rhyme; string; bunch" and no stream sense	**Not cited**; the gazette's "Streams" is the source
Katakhal as "cut canal"	A reading of the name	**Not used**: the etymology is not verified
hachuk	Kokborok "hill", from Wiktionary only	**Not used**
Kokborok words in Roman or Bengali script	Spellings of the IPA forms above	Not confirmed [TBC]
Terms in 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 Tripura 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 — Tripura 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 Bengali) and inventory ID (Annex 7A), if any	_____	7.3.1
A3	Waterbody type (Clause 7.2)	_____	7.2
A4	Position: within the site / within 100 m of the site boundary / downstream within the Chapter 5 extent	_____	7.3.2
A5	Survey numbers and village	_____	7.3.1(a)
A6	Custodian	_____	7.3.1(b)
A7	Sources checked (tick): Revenue Department land records (district, sub-division, revenue circle, mouza; Appendix-I land class), the 2020 list of 180 urban water bodies, Master Plan 2045 and LPA maps, PWD (WR) embankment and sluice records and Haora flood-plain-zone map, TTAADC records [TBC], drain register □; PWD (WR) / Gram Panchayat or Village Committee 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 PWD (WR) 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 (PWD (WR) 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 r.9(4) "zone of river" of the TBR 2017 (15 m from the river bank; a regulated zone, not a no-build line, stated and never governing alone); in a hill ULB, the 5 m of r.90(1)(i) and the protective works of r.90(1)(m) (narrower than Zone 1, stated, never governing alone); a zoning or development control line of the Master Plan for the Agartala Planning Area 2045 or another Master Plan (not read [TBC]); a condition of the Local Body's approval under r.9(3) or of a decision under the Diversion of Land Rules; a PWD (WR) condition at an embankment or sluice; the boundary of Rudrasagar or of a wetland notified under the 2017 Rules; 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 — Tripura 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; PWD (WR) 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 — Tripura 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 Tripura 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 Tripura 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 — Tripura 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 Tripura, 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 Tripura 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 Building Rules ask for landscaping of 1.0% to 7.5% of the plot by plot size, with one evergreen tree for every 100 or 200 m² and compensatory planting (r.113, inserted in 2022), without naming any species for drainage. This annex therefore lists **no species** for Tripura, and gives no Bengali or Kokborok plant names, rather than carry over lists drawn up for other States or invent local names. Until the State Stormwater Technical Committee issues lists, the species for each BMP shall be chosen, and recorded on the BMP design sheet, by a horticulturist or the Forest 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 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 lunga floors and flood plains, 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.** On tilla slopes and cut faces and in the hill ranges (sub-area TR-E), species chosen first to bind soil on banks, cut slopes and the margins of chharas; 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, chhara or khal, or on an embankment (bandh), without the consent of its custodian (PWD (WR), the ULB or another body); and none that would obstruct the flow of a channel or the outlet of a pukur, dighi or beel.
- (e) **Not in the pukurs and wetlands.** No planting under this annex in a pukur, dighi, beel, haor, Rudrasagar or a notified wetland, or on a recorded pukurpar or dighirpar, 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 Tripura 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 Tripura 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 Forest Department lists as invasive in Tripura	—	No list of invasive species for Tripura 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

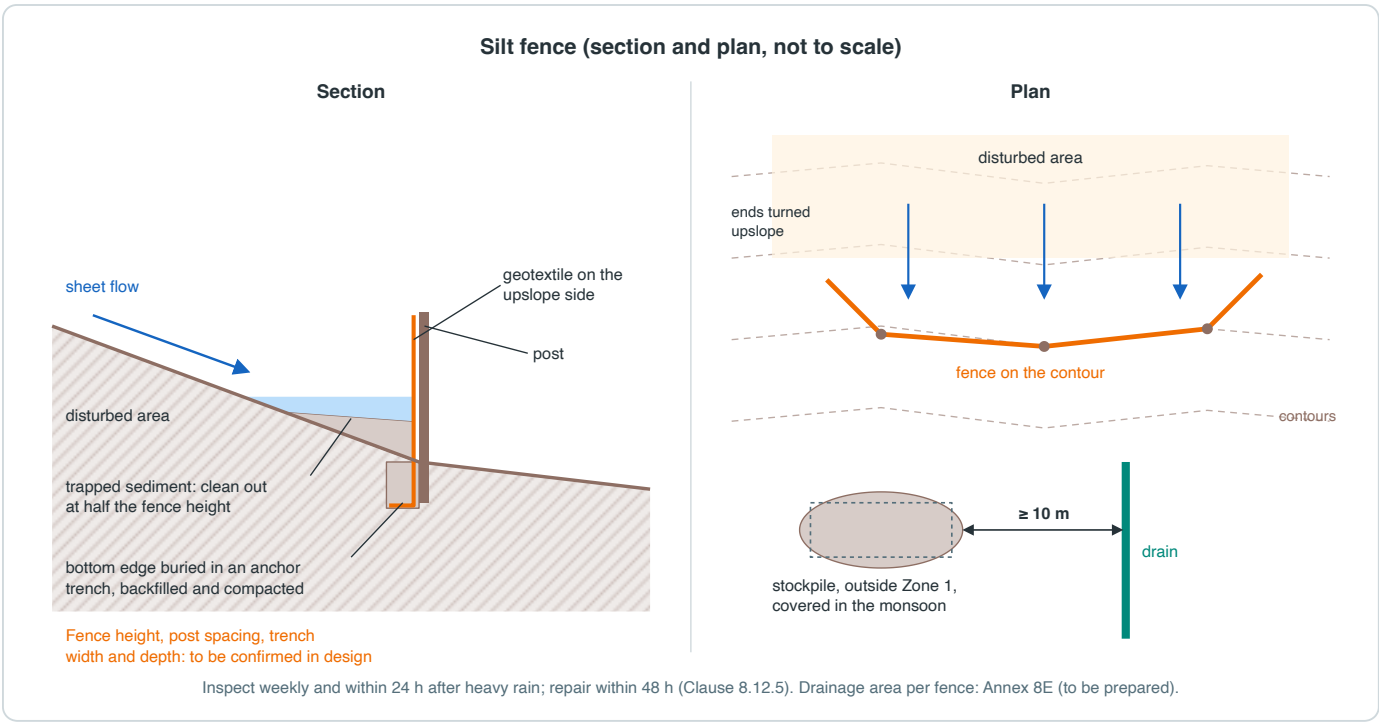


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted 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 Tripura rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

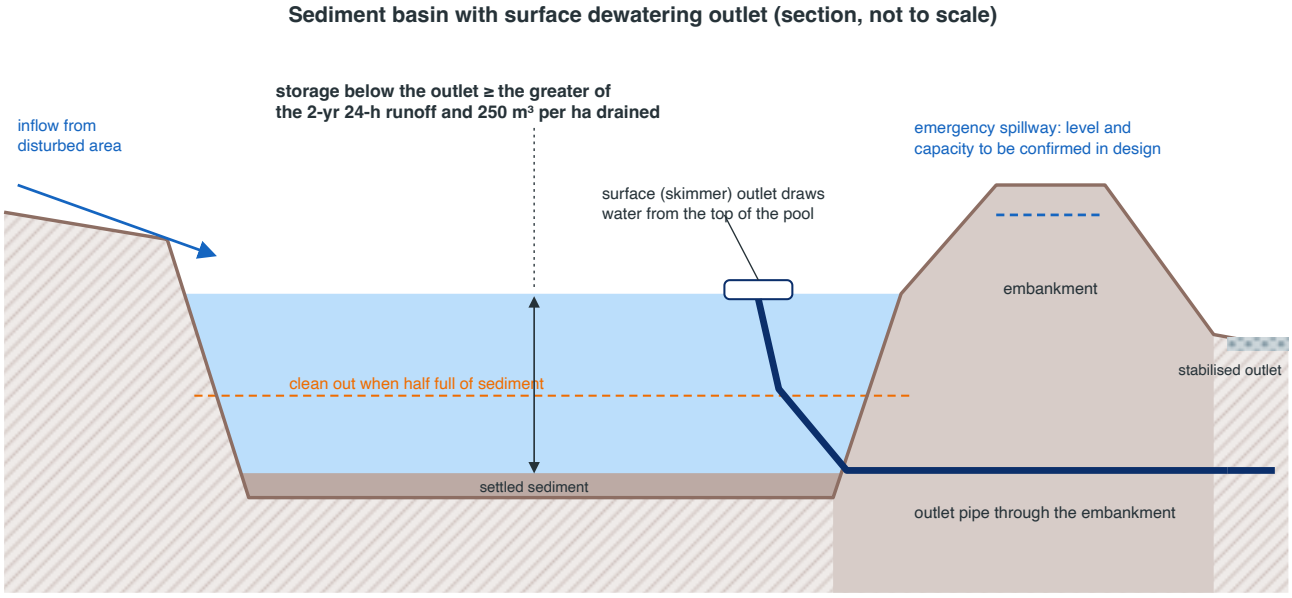
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used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

The designer shall show the drainage area and slope length served by each fence on the ESC plan.

Notes:

1. Place along the contour at the downslope edge of the disturbed area, never across a concentrated flow path.
2. Turn the ends upslope so that water cannot run round them.
3. Inspect weekly and within 24 hours after every heavy-rainfall event; repair within 48 hours; remove sediment when the deposit reaches half the fence height (Clause 8.12.5).
4. Remove only after the area draining to it is stabilised (Clause 8.12.6).
5. Stockpiles: outside Zone 1, at least 10 m from any drain, and covered during the monsoon (Clause 8.12.3(f)).

8E.2 Sediment trap and sediment basin



Sediment trap: disturbed area up to 2 ha. Sediment basin: more than 2 ha (Clause 8.12.3(b), (c)).
Design rainfall from Chapter 2 with climate factor 1.0 (Clause 8.12.4). Dewatering of excavations passes through the basin, a settling tank or a filter bag.

Figure 8E.2 — Sediment trap or basin in section: inflow, storage volume below the outlet, surface dewatering outlet (skimmer) drawing water from the top of the pool, emergency spillway, and sediment cleanout level at half the storage. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).

Notes:

1. **Sediment trap:** for concentrated flow from disturbed areas of up to 2 ha (Clause 8.12.3(b)). Storage volume, depth and outlet: to be confirmed in design.

2. **Sediment basin:** for disturbed areas of more than 2 ha. Storage below the outlet ≥ the greater of (a) the runoff from the 50% AEP (2-yr) 24-hour storm and (b) 250 m³ per hectare of drainage area (Clause 8.12.3(c)).
3. The dewatering outlet draws water from the surface (Clause 8.12.3(c)).
4. An emergency spillway and its capacity: to be confirmed in design. Where the basin is also a permanent detention facility, the Chapter 4 spillway rules apply.
5. Clean out when half full of sediment (Clause 8.12.5). Remove sediment from any permanent facility before its as-built survey (Clause 8.12.6).
6. Dewatering of excavations shall pass through a sediment basin, settling tank or filter bag (Clause 8.12.3(g)).

Illustrative — not design values. A sediment basin serves 3.0 ha of disturbed land. Assume a 2-yr 24-hour rainfall of 100 mm (climate factor 1.0, Clause 8.12.4) and a curve number of 86 for bare compacted ground under the antecedent moisture condition of Chapter 2.

- $S = 25{,}400 / 86 - 254 = 41.35$ mm; $I_a = 0.2S = 8.27$ mm
- $Q = (P - I_a)^2 / (P - I_a + S) = (100 - 8.27)^2 / (100 - 8.27 + 41.35) = 8{,}414 / 133.08 = 63.2$ mm
- (a) Runoff volume = $10 \times Q \times A = 10 \times 63.2 \times 3.0 = 1{,}896$ m³
- (b) 250 m³/ha × 3.0 ha = 750 m³
- Required storage below the outlet = max (1,896, 750) = 1,896 m³. Here the 2-yr runoff governs.

8E.3 Stabilised construction exit and concrete washout

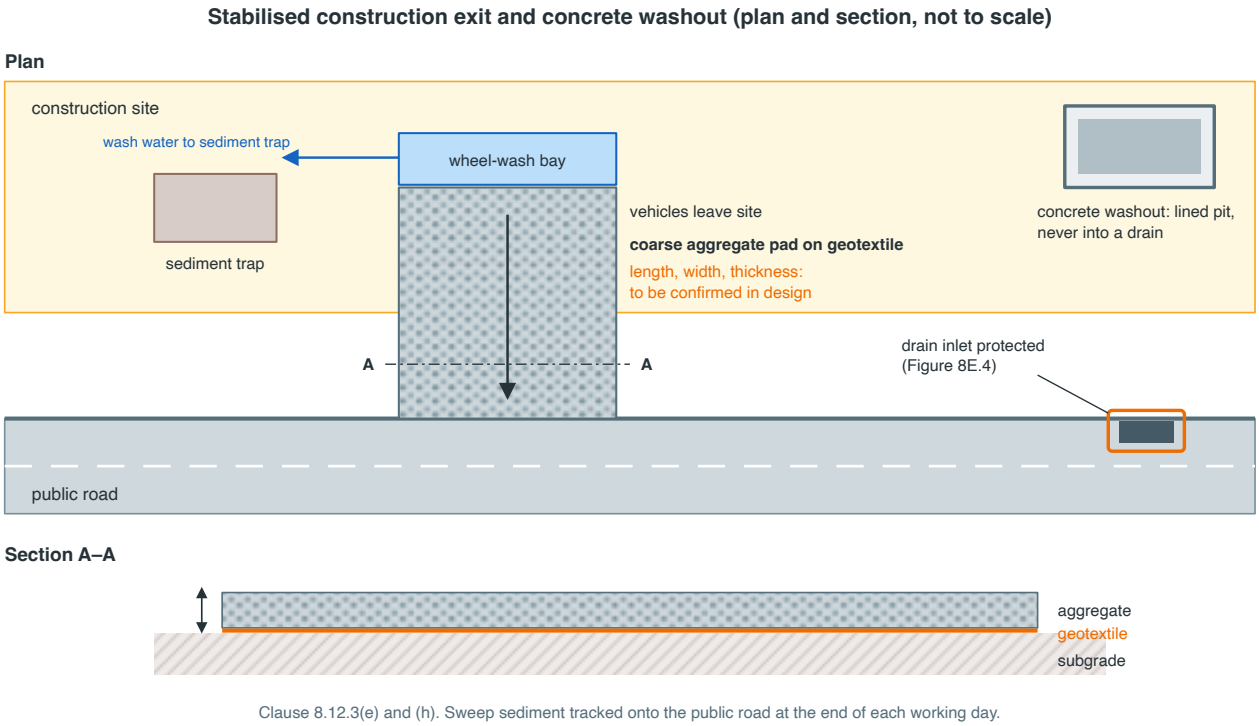


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).

Notes:

1. Provide at every point where vehicles leave the site onto a public road, with wheel washing (Clause 8.12.3(e)).
2. Pad length, width, thickness and aggregate size: to be confirmed in design.
3. Wash water drains to a sediment trap or basin, never to a drain.
4. Concrete washout in a lined pit, never into a drain (Clause 8.12.3(h)).

5. Sweep any sediment tracked onto the public road at the end of each working day.

8E.4 Inlet protection

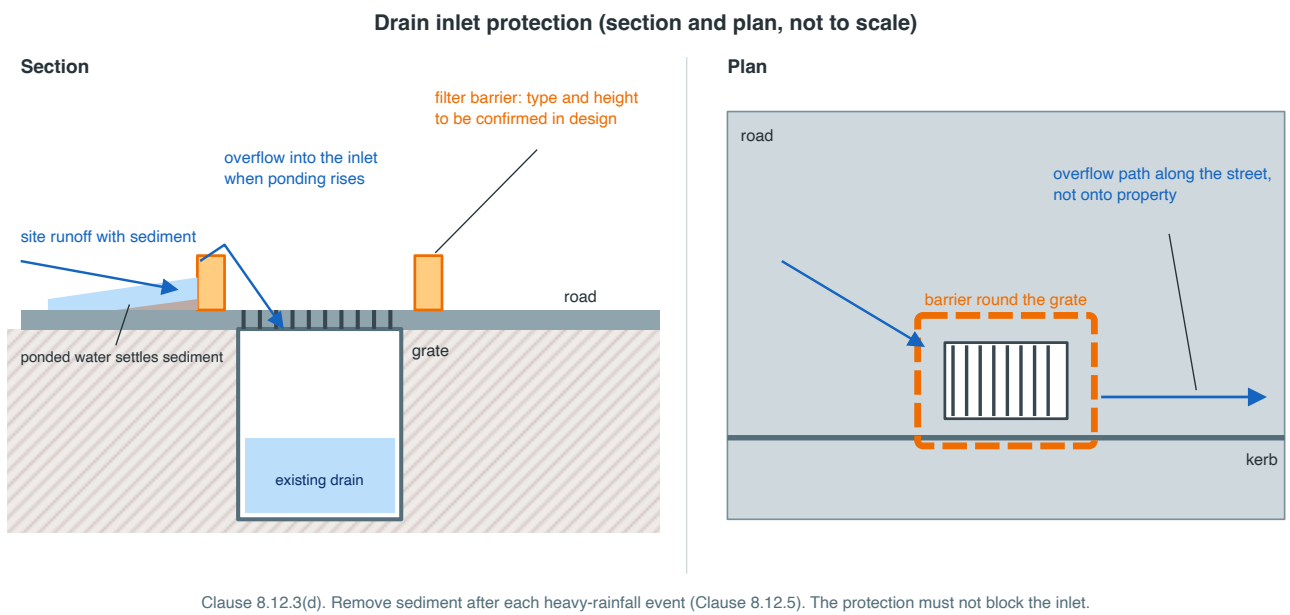


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

Notes:

1. At every existing drain inlet that receives runoff from the site (Clause 8.12.3(d)).
2. The protection must not block the inlet: water ponding behind it must be able to overflow into the inlet or along the street.
3. Barrier type and height: to be confirmed in design.
4. Remove sediment after each heavy-rainfall event (Clause 8.12.5).

8E.5 Timing and inspection

Table 8E.2 — ESC timing and inspection (Clauses 8.12.2 and 8.12.5)

Item	Requirement
Completed earthworks	Stabilised by vegetation, mulch, matting or paving by 31 March
Area cleared between 1 April and 31 October	Sediment controls in place before clearing
Area exposed in the monsoon	As small as practicable
Inspection	Weekly, and within 24 h after every heavy-rainfall event (Chapter 10)
Repair	Within 48 h
Cleaning	When half full of sediment
Removal	Only after the area draining to the measure is stabilised

Form 8-1 — Water Quality Sheet

Supports Clauses 8.4, 8.6 and 8.14 of Chapter 8.

Draft form — Tripura 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 — Tripura 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.

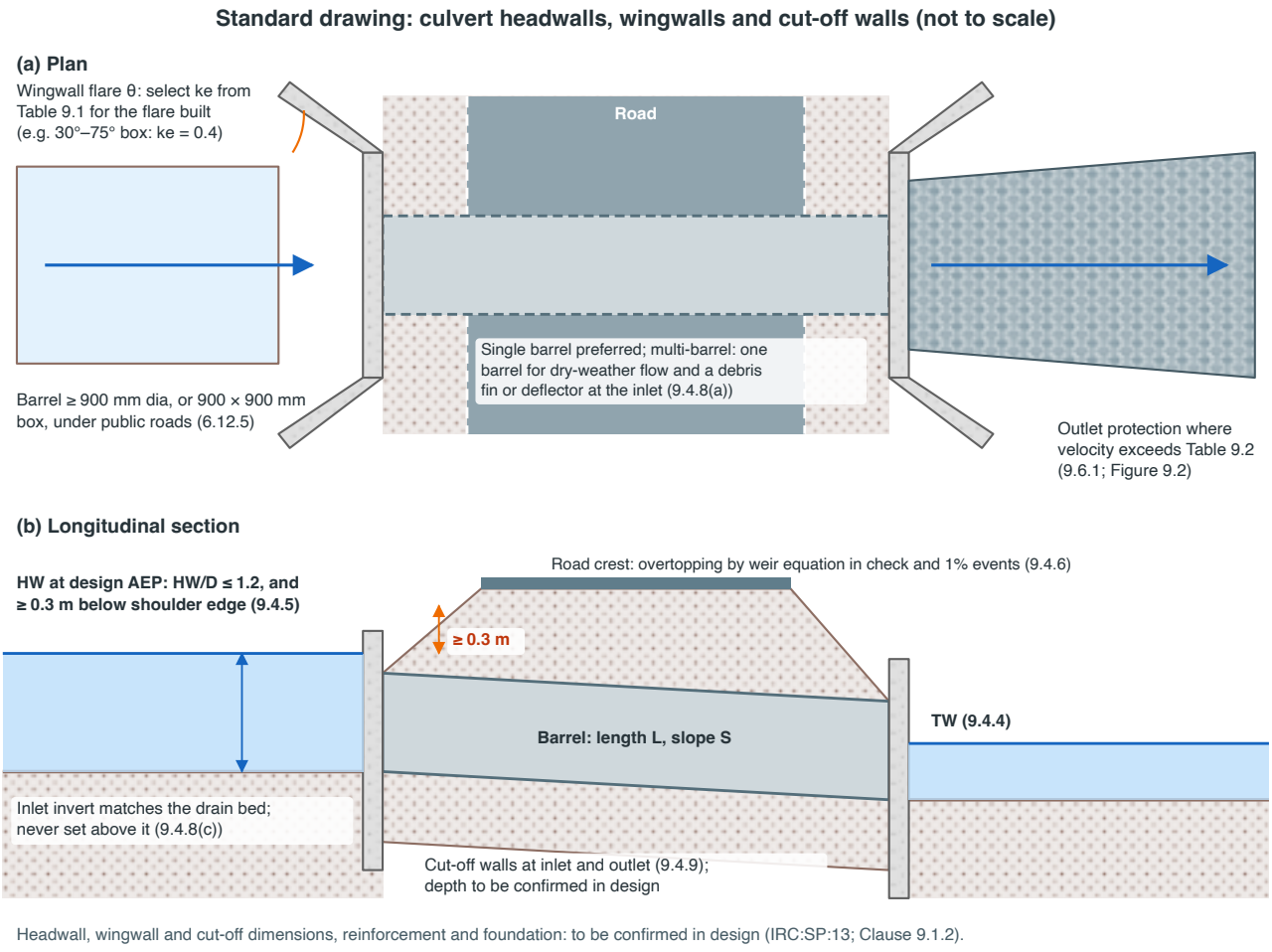


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

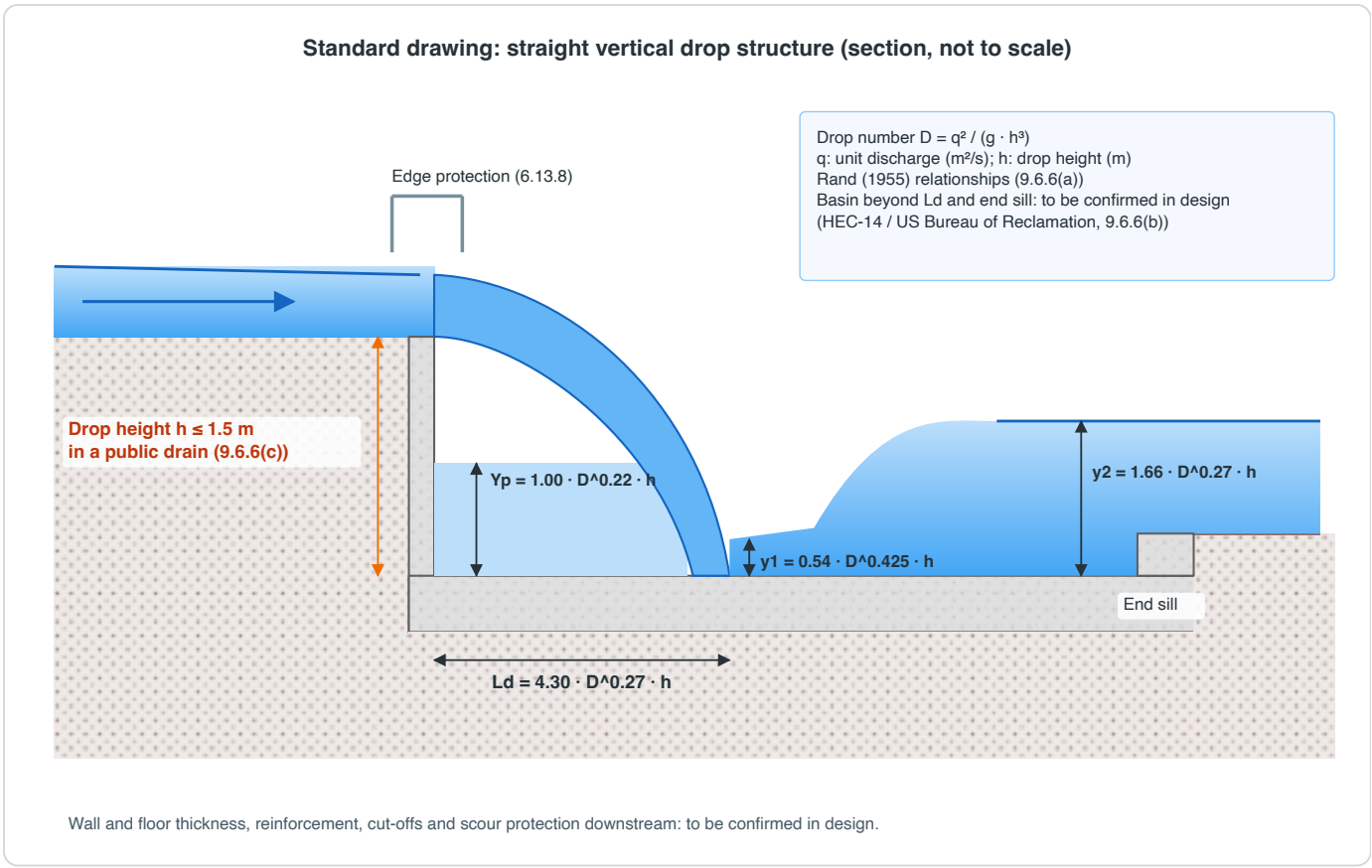


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

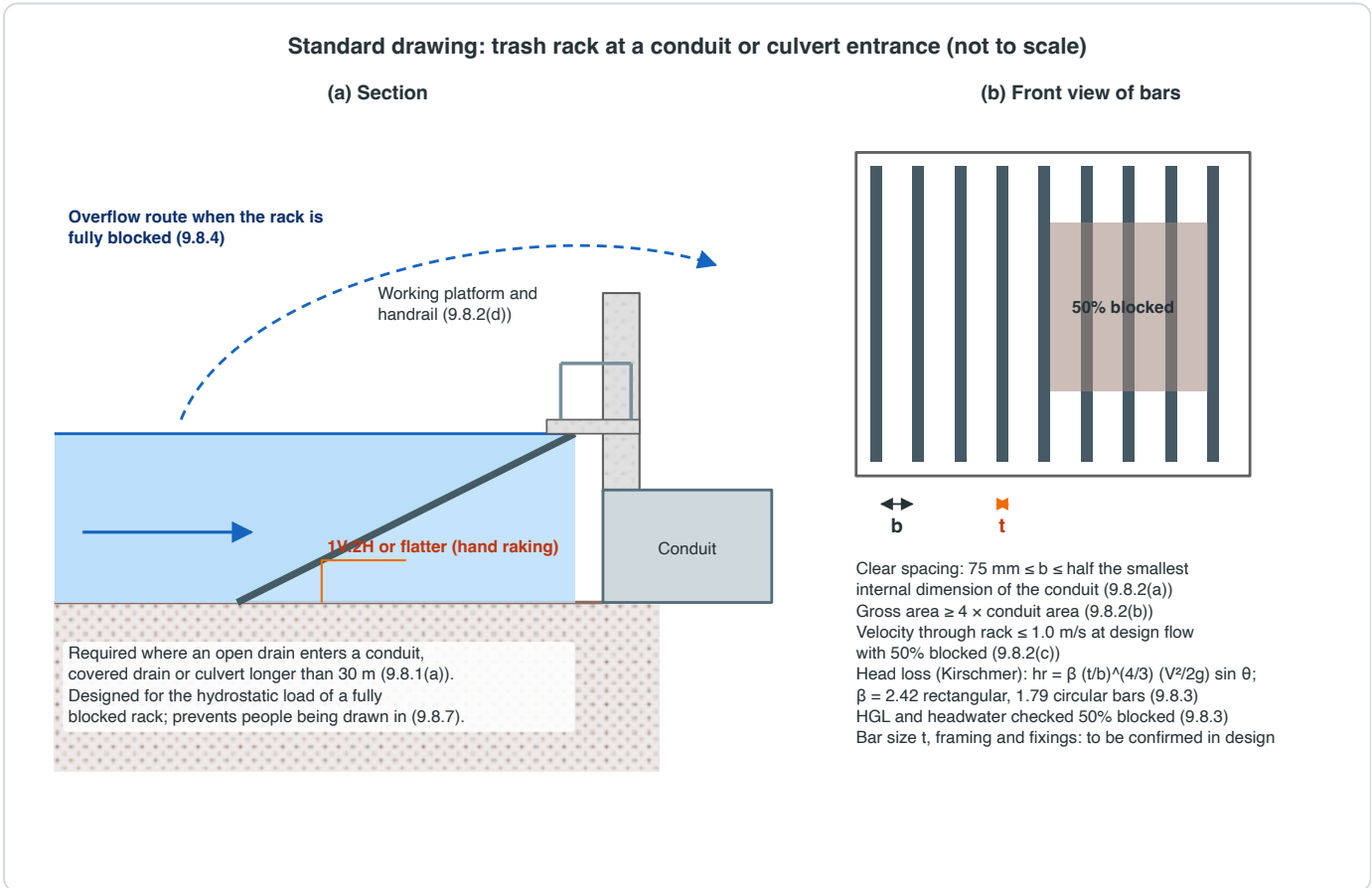


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

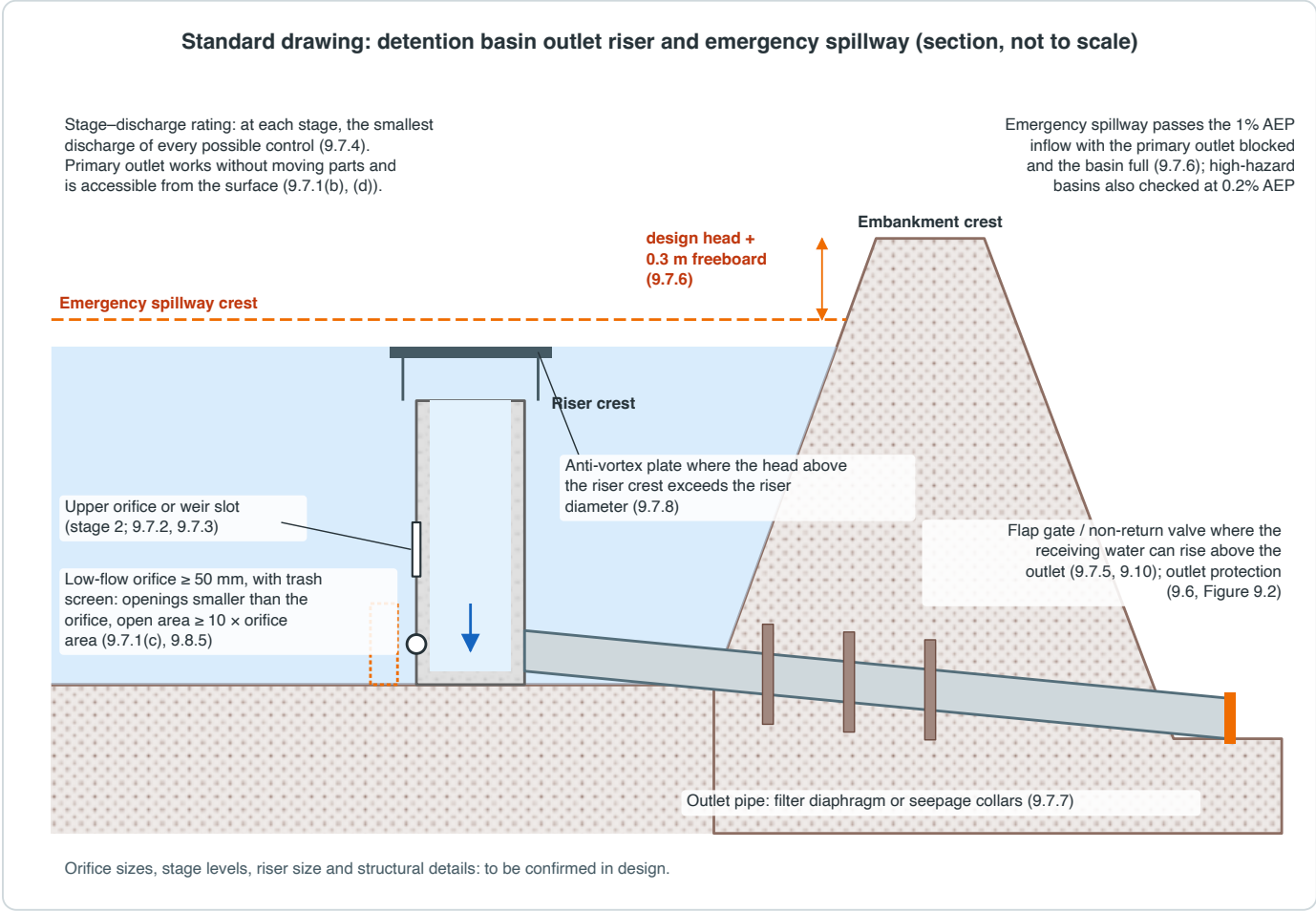


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — Tripura 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)	_____	_____	_____	_____

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ANNEXES TO CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

These annexes support Chapter 10. They give the specification and user-guide outline of the compliance calculator, the GIS data specification, the maintenance access dimensions that the Manual sets, model O&M plans for each facility type, model empanelment criteria, and the eight forms that Chapter 10 requires. The Design Rainfall Sheet (Form 2-1) is in the annexes to Chapter 2. The forms are draft forms. The model texts are for consideration by a competent authority and are not in force.

Annex 10A — Compliance calculator and user guide

Supports Clauses 10.4.1(g), 10.5 and 10.9.1(b) of Chapter 10.

> **Status.** The compliance calculator does not exist yet. Clause 10.5.1 requires the State Stormwater Technical Committee to issue and maintain it. This annex is the specification the calculator shall meet and the outline of its user guide. Until the calculator is issued, the designer completes Form 10-2 by hand from the calculations of Chapters 4, 5 and 8, enters "not issued" as the calculator version, and attaches the calculations.

10A.1 General requirements

The calculator shall:

- (a) be a spreadsheet or web tool, published free of charge with its user guide and the source of every table in it (Clause 10.5.4);
- (b) print its version number and release date on every output page and every exported file (Clause 10.5.3);
- (c) keep a public version log. A new version applies to new submittals 6 months after release; a submittal keeps one version from Stage 1 to Stage 4 unless the Applicant elects a later one (Clause 10.5.3);
- (d) work for one site at a time, with one or more drainage areas, each draining to its own outfall (Clause 4.5.1.3);
- (e) never apply a value that the Manual has not published. Where a table it needs has not been issued (for example Table 4.3 of Annex 4B, or the S-2 discharge tables of Annex 1C), the calculator shall show that route as "not available" rather than estimate the value; and
- (f) export its inputs and results as a machine-readable file (CSV or JSON) as well as Form 10-2, so that the Authority can load them into the facility register (Clause 10.17.1(b)).

10A.2 Inputs

Table 10A.1 — Calculator inputs

No.	Input	Unit	Source
I1	Authority, tier (A or B) and file number	—	Clause 1.6

No.	Input	Unit	Source
I2	Site area; land disturbance area	ha	Clause 1.5.2
I3	New impervious area; replaced impervious area; existing impervious area before demolition	m²	Clauses 1.5.2, 1.5.6, 4.5.6.1
I4	Development type: new, redevelopment, linear public work, single dwelling	—	Clauses 1.5.6–1.5.8
I5	Flood-sensitive catchment (yes / no), and basin with an approved BSMP (yes / no)	—	Clauses 4.5.3, 4.13, 11.12
I6	Rainfall zone	—	Annex 2A
I7	Retention depth P_R; 3-month ARI 24-hour depth P_3m	mm	Annexes 2E, 8A
I8	Design rainfall depths by duration (1–72 h) and AEP, with the climate factor, as recorded on Form 2-1	mm	Clauses 2.5, 2.8, 2.13
I9	15-minute intensities i_10 and i_2, with the climate factor (fixed-coefficient route only)	mm/h	Clause 4.14.4
I10	Drainage areas: for each, area, land cover, impervious percentage, HSG and curve number, pre- and post-development	ha, %, —	Clauses 3.3, 3.7, 3.9
I11	Areas preserved under a registered covenant	ha	Clause 4.4.7
I12	Seasonal high groundwater depth below the base of each retention practice	m	Clauses 4.4.3(c), 8.8
I13	Measured infiltration rate at each practice	mm/h	Clause 4.4.3
I14	Retention volume provided, by practice; reuse demand where retention is by reuse	m³, m³/d	Clauses 4.4.3, 4.4.5
I15	Route: full hydrograph method (Clause 4.6); design-aid S-1 (Clause 4.14.2); PSD S-2 (Clause 1.7); fixed-coefficient (Clause 4.14.3); constrained redevelopment (Clause 4.5.6)	—	Clauses 1.7, 4.5.6, 4.6, 4.14
I16	For the full method: model results for each AEP and duration — pre- and post-development peaks, storage used, retention credit found by routing	m³/s, m³	Clauses 4.4.6.2, 4.6
I17	Outlet: low-flow orifice diameter or least slot dimension; drawdown times from routing	mm, h	Clauses 4.7, 4.8.2
I18	Outfall: tidal or non-tidal; outfall-closed check result	—	Chapter 5
I19	Fee-in-lieu unit rate notified for the basin, where the route applies	₹/m³	Clause 4.13.3
I20	Stage of submittal (1, 2 or 4) and, at Stage 4, the as-built values of I14, I16 and I17	—	Clauses 10.5.2, 10.9.1(b)

10A.3 Calculations, by clause

Table 10A.2 — Calculations the calculator shall perform

Step	Calculation	Clause
C1	**Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies under r.110 of the TBR 2017 to every building with a plinth area of 200 m² or more, to group housing, public and semi-public and industrial buildings of all sizes and to commercial and mixed-use buildings of 50 m² or more, with groundwater recharge on plots of more than 500 m² (r.110(5)); r.110 sets no volume, so the volume is provided as storage of at least 25 litres per m² of roof (Clause 4.11, set by this Manual) and credited only as Clause 4.11 allows and reuse and never as detention; no recharge pit, trench, well or shaft is built or credited on the recent flood plains and lungas, below the 1% AEP flood level, behind an embankment that ponds when its sluices close or its pumps stop, on pukur, dighi and beel margins, on filled ponds and lunga fills or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, lunga rule), or in sub-area TR-E, on natural slopes steeper than 20%, on tilla slopes, cut faces, fill or slide debris (Clause 4.11, hill rule), and there the r.110 recharge structures are replaced by storage and the applicant seeks the ULB's relaxation; recharge is credited only on tested, flat tilla tops (Clause 4.11, tilla rule).	1.5.2–1.5.8
C2	**Process flags.** Stage 0 mandatory (≥ 2 ha, flood-sensitive, variance or regional route, tidal outfall or waterbody); Stages 1 and 2 may be combined (< 1 ha, not flood-sensitive); empanelled signatory required; independent check required.	10.3.2, 10.3.3, 10.6.1, 10.6.4
C3	**Route eligibility.** Tier B simplified method: ≤ 2 ha, or ≤ 0.5 ha in a flood-sensitive catchment, and only once Table 4.3 is published. Fixed-coefficient route: ≤ 1 ha and none of the exclusions of Clause 4.14.3. Constrained redevelopment: existing ≥ 60% impervious and ≤ 1 ha. Regional detention or fee-in-lieu: only in a basin with an approved BSMP.	4.5.6.1, 4.13.1, 4.14.1, 4.14.3, 11.12.1(b)
C4	**Retention volume.** RRV = 10 × Q_R × A, with Q_R the SCS-CN runoff from P_R for each sub-area at AMC II, summed over sub-areas. The larger of the Ia = 0.2S and Ia = 0.05S results governs. The Rv form (RRV = 10 × P_R × Rv × A, Rv = 0.05 + 0.009 × I) is offered only for sites < 0.5 ha and the Tier B method. No climate factor.	4.4.2, 3.8.5(c), 2.8.3
C5	**Preservation credit.** Preserved areas are modelled at their pre-development CN in the post-development condition.	4.4.7
C6	**Retention checks.** Design infiltration rate ≤ half the measured rate; groundwater ≥ 1.0 m below the base; drawdown of the retained volume within 72 h at the design rate (or by the stated reuse demand). A practice that fails any check gets no credit; any shortfall is reported and treated as WQv.	4.4.3–4.4.5, 4.4.6.4
C7	**Water quality volume.** P_wq = max(P_ret, P_3m); WQv = 10 × Q_wq × A by SCS-CN, or (P_wq / 1000) × Rv × A (A in m²) for sites < 0.5 ha and the Tier B method. The retained volume counts toward the WQv in full. No climate factor.	8.4.1–8.4.4, 3.8.5(c)
C8	**Retention credit.** Tier A: the credit found by routing is entered (I16); the calculator does not compute it. Tier B: V_credit = C_R × RRV provided, with C_R = 0 until Annex 4B is published.	4.4.6
C9	**Design-aid route (S-1).** V = SSR × A − V_credit; Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages, from Table 4.3. Shown as "not available" until Table 4.3 is published.	1.7.2, 4.14.2
C10	**Permissible site discharge (S-2).** Q = PSD (m³/s/ha) × A for each AEP, from the S-2 tables. Shown as "not available" until they are issued.	1.7.2, 1.7.3(e)
C11	**Fixed-coefficient route.** Q_cap,10 = 2.78 × C_10 × i_10 × A and Q_cap,2 = 2.78 × C_2 × i_2 × A (L/s); V_100 and V_2 = max over d of [10 × C_v × P(d) × A − 1.8 × Q_cap × d] for d = 1 to 72 h, with pervious C ≥ 0.50 for d ≥ 12 h; V = max(V_100, V_2); retention added without credit. Coefficients from Table 4.3A (provisional).	4.14.4–4.14.7
C12	**Release-rate screen (full method).** For each AEP and duration: Q_post ≤ 0.9 × Q_pre (standard), or the two mixed-frequency caps (flood-sensitive). Report the governing duration and margin.	4.5.2, 4.5.3
C13	**Constrained redevelopment.** Q_post ≤ 0.5 × Q_existing for 2-, 10- and 100-yr at each duration; shortfall volume = greenfield storage − storage provided; fee = shortfall × unit rate.	4.5.6.2, 4.5.6.3
C14	**Minimum orifice.** Flag any orifice < 50 mm. Where a cap is below the discharge of a 50 mm orifice at the corresponding stage, report "50 mm orifice deemed to comply".	4.5.5.1, 4.8.2
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

Step	Calculation	Clause
C16	**Fee-in-lieu.** Fee = detention volume required on site × notified unit rate.	4.13.3
C17	**Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide.	10.5.2(c)
C18	**As-built re-run.** At Stage 4, repeat C4 to C17 with the as-built values and report each change from Stage 2.	10.9.1(b), 10.9.2

10A.4 Outputs

The calculator produces:

- (a) **Form 10-2**, filled in, with the calculator version and release date on every page;
- (b) a machine-readable export of every input and result of Tables 10A.1 and 10A.2; and
- (c) a list of the flags raised (C1 to C3, C6, C14, C17), each with the clause on which it is based (Clause 10.7.7).

10A.5 Testing before release

Before each release the State Stormwater Technical Committee shall check that the calculator reproduces, within rounding, the worked examples of the Manual that use the same method, including the illustrative examples of Clauses 4.6.7 and 4.14, and the benchmark problems of Annex 3C where they apply. The test results shall be published with the version log.

10A.6 Outline of the user guide

The user guide shall contain at least:

1. Purpose, status and limits of the calculator: a summary and screening check outside the design-aid route (Clause 10.5.2(c)).
2. How to obtain the current version, and the version rule of Clause 10.5.3.
3. Each input of Table 10A.1, with where to find it in the Manual and its annexes.
4. Each calculation of Table 10A.2, with its equation and clause.
5. The tolerance used in step C17, and what the drainage report must explain where it is exceeded (Clause 10.5.2(c)).
6. How to read and sign Form 10-2, and what to attach.
7. At least one worked example for each route, labelled "Illustrative — not design values".
8. The sources of every table in the calculator (Clause 10.5.4), and the version log.

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) for the whole State, whichever contains the site (Clause 10.4.4(c)). One system shall be used for all layers.

- (c) **Vertical reference.** All levels shall be in metres relative to a named vertical datum, stated in the metadata. The metadata shall also state the relationship between that datum and the river datums of the CWC level-forecasting and level-monitoring sites on the Haora, the Gumti (Gomati), the Manu, the Khowai, the Dhalai, the Juri, the Muhuri and the Burima (not stated in any source found [TBC]), of the State gauges, such as the gauge at Jahar Bridge on the Haora and those at Udaipur and Amarpur on the Gomati, of the embankment crests, sluice sills and gate-closing levels of PWD (WR), of the levels of the Dumbur reservoir (full reservoir level given as 93.55 m, as reported, on a datum not stated), and of the flood marks surveyed on the Katakhal, the Akhaura canal and the other ungauged channels, streams, ponds and tanks 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 `AMC-BP-2026-0123_S2_20261015.gpkg`.
- (f) **Identifiers.** Every feature has an identifier unique within the submittal (FAC_ID, OUT_ID, CAT_ID, FLP_ID). The Authority replaces them with register identifiers on acceptance and returns the mapping to the Applicant.

10B.2 Layers

Table 10B.1 — Layers

Layer	Geometry	Content	Required at
SW_SITE	Polygon	Site boundary	Stages 1, 2, 4
SW_CATCH	Polygon	Catchment boundaries draining to and through the site, pre- and post-development (Clause 10.4.1(b))	Stages 1, 2, 4
SW_FAC	Polygon (point for buried items smaller than 5 m across)	Every stormwater facility: retention, detention, water quality, pumping, gate, conveyance element designed under this Manual	Stages 2, 4; handover
SW_OUTF	Point	Every outfall from the site, and every public outfall	Stages 1, 2, 4; handover
SW_FLOW	Line	Major-system flow paths through and from the site, and natural drainage paths (Clause 10.15.1(g))	Stages 1, 2, 4
SW_CONV	Line	Drains and pipes designed under Chapter 6	Stage 4 for public works; handover
SW_META	Table (no geometry)	Metadata of Table 10B.6	Every stage

10B.3 Attribute schema

Types: T = text, I = integer, R = real, D = date (ISO 8601, yyyy-mm-dd). "Req." marks fields that shall not be empty; other fields are filled where they apply.

Table 10B.2 — Attributes of SW_FAC (facilities)

Field	Type	Unit	Req.	Content	Source
FAC_ID	T	—	Yes	Facility identifier	10B.1(f)
FAC_TYPE	T	—	Yes	Code from Table 10B.7	Clause 4.10, Table 10.3
FAC_NAME	T	—		Name on the drawings	—
OWNER_TYP	T	—	Yes	PRIVATE / ASSOC / DEVELOPER / ULB / DEPT	Clauses 10.10, 10.14

Field	Type	Unit	Req.	Content	Source
OWNER_NM	T	—	Yes	Name of a corporate owner or association only; for an individual, "private individual" (Clause 10.17.3)	Clause 10.17.3
CTRL_AREA	R	ha	Yes	Area draining to the facility	Clause 4.5.1.3
V_RET	R	m³		Retention volume provided	Clause 4.4
V_WQ	R	m³		Water quality volume provided	Clause 8.4
V_DET	R	m³		Detention volume at the top design level	Clause 4.6
Q_2	R	L/s		Release at the 50% AEP (2-yr) design level	Clause 4.5
Q_10	R	L/s		Release at the 10% AEP (10-yr) design level	Clause 4.5
Q_100	R	L/s		Release at the 1% AEP (100-yr) design level	Clause 4.5
ORIF_MM	R	mm		Low-flow orifice diameter or least slot dimension	Clause 4.8.2
INV_OUT	R	m		Outlet invert level	Clause 10.9.1(a)
TWL_DES	R	m		Top design water level	Clause 10.9.2(a)
SPILL_LV	R	m		Spillway or overflow crest level	Clause 4.9
PUMPED	T	—	Yes	Y / N	Clause 10.10.3
REGIONAL	T	—	Yes	Y / N	Clause 4.13
EMPANEL	T	—	Yes	Y / N: facility under Clause 10.6.1(c) or (d)	Clause 10.6.1
STATUS	T	—	Yes	Code from Table 10B.8	Clause 10.17.1(a)
APPR_DATE	D	—		Date of Stage 2 approval	Clause 10.3
ASB_DATE	D	—		Date the as-built certificate was accepted	Clause 10.9
DECL_REF	T	—		Registration reference of the Maintenance Declaration (Form 10-6)	Clause 10.10.1(e)
HAND_DATE	D	—		Date of the Asset Handover Certificate (Form 10-8)	Clause 10.14
LAST_INSP	D	—		Date of the latest inspection	Clause 10.12
INSP_RES	T	—		Code from Table 10B.9	Clause 10.17.1(a)
OUT_ID	T	—	Yes	Outfall to which the facility discharges	—

Table 10B.3 — Attributes of SW_OUTF (outfalls)

Field	Type	Unit	Req.	Content	Source
OUT_ID	T	—	Yes	Outfall identifier	10B.1(f)
RECEIVER	T	—	Yes	Receiving drain, channel, waterbody or sea, by name	Clause 4.5.1.3
RECV_TYPE	T	—	Yes	PUBLIC_DRAIN / CANAL / RIVER / TANK / SEA / OTHER	Chapter 5
INV_LEVEL	R	m	Yes	Outfall invert level	Clause 10.9.1(a)
SIZE_MM	R	mm	Yes	Diameter, or width × height written in the drawing	Chapter 6
TIDAL	T	—	Yes	Y / N	Chapter 5
GATE_TYPE	T	—		NONE / FLAP / TIDE / DUCKBILL / PENSTOCK / NRV	Clauses 5.11, 9.10
GATE_REQ	T	—	Yes	Y / N: invert below the 1% AEP still-water level	Clause 5.11.1

Field	Type	Unit	Req.	Content	Source
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1
Q_100	R	L/s		Design 1% AEP discharge	Chapter 5

Table 10B.4 — Attributes of SW_CATCH (catchments)

Field	Type	Unit	Req.	Content	Source
CAT_ID	T	—	Yes	Catchment identifier	10B.1(f)
CONDITION	T	—	Yes	PRE / POST / EXTERNAL (land outside the site draining through it)	Clause 10.4.1(b)
AREA_HA	R	ha	Yes	Area	—
IMPERV_PC	R	%	Yes	Impervious percentage	Clause 3.9
HSG	T	—	Yes	A / B / C / D, or mixed with area shares in NOTES	Clause 3.7
CN	R	—		Curve number, AMC II	Chapter 3
OUT_ID	T	—	Yes	Outfall to which it drains	Clause 4.5.1.3
FLOODSENS	T	—	Yes	Y / N	Clause 4.5.3
NOTES	T	—		Free text	—

Table 10B.5 — Attributes of SW_FLOW and SW_CONV (flow paths and conveyance)

Field	Type	Unit	Req.	Content	Source
FLP_ID	T	—	Yes	Line identifier	10B.1(f)
LINE_TYPE	T	—	Yes	OVERLAND / NATURAL / OPEN_DRAIN / COVERED_DRAIN / PIPE / CULVERT	Chapter 6
US_LEVEL	R	m		Upstream invert or ground level	Chapter 6
DS_LEVEL	R	m		Downstream invert or ground level	Chapter 6
SIZE_MM	R	mm		Pipe diameter, or drain width (depth in NOTES)	Clause 6.7.6
Q_DES	R	L/s		Design discharge	Chapter 6
AEP_DES	T	—		Design AEP, for example "10%" or "1%"	Clause 6.4
RESERVE_M	R	m		Drainage reserve width, where one applies	Clause 6.9.7
NOTES	T	—		Free text	—

Table 10B.6 — Metadata (SW_META)

Field	Content
FILE_NO	Authority file number
STAGE	1, 2, 4 or HANDOVER
H_CRS	EPSG code of the horizontal reference system
V_DATUM	Name of the vertical datum

Field	Content
TIDE_REL	Relationship of the vertical datum to the Chapter 5 river datums of the CWC level-forecasting and level-monitoring sites on the Haora, the Gumti (Gomati), the Manu, the Khowai, the Dhalai, the Juri, the Muhuri and the Burima (not stated in any source found [TBC]), of the State gauges, such as the gauge at Jahar Bridge on the Haora and those at Udaipur and Amarpur on the Gomati, of the embankment crests, sluice sills and gate-closing levels of PWD (WR), of the levels of the Dumbur reservoir (full reservoir level given as 93.55 m, as reported, on a datum not stated), and of the flood marks surveyed on the Katakhal, the Akhaura canal and the other ungauged channels, streams, ponds and tanks (for example, MSL = x.xx m on the site datum)
SURVEYOR	Name and licence number of the surveyor
SURV_DATE	Date of the survey
PREP_BY	Name and registration number of the certifying professional
CALC_VER	Compliance calculator version (Annex 10A), or "not issued"
DATE	Date the file was prepared

10B.4 Code lists

Table 10B.7 — Facility type codes (FAC_TYPE)

Code	Facility	Inspection row of Table 10.3
RET_SOAK	Soakaway, recharge pit or shaft	Retention / infiltration
RET_TRENCH	Infiltration trench or basin	Retention / infiltration
RET_BIO	Bioretention or rain garden	Retention / infiltration
RET_PERM	Permeable pavement	Retention / infiltration
RET_REUSE	Retention by reuse (tank with demand)	Underground or podium detention tank, gravity outlet
DET_BASIN	Surface detention basin	Surface detention basin or multi-use open space area
DET_OSR	Multi-use detention in open space, park or playfield	Surface detention basin or multi-use open space area
DET_ROOF	Rooftop detention	Underground or podium detention tank, gravity outlet
DET_PODIUM	Podium or landscape-deck detention	Underground or podium detention tank, gravity outlet
DET_PARK	Parking-lot detention	Surface detention basin or multi-use open space area
DET_TANK	Underground tank or vault, gravity outlet	Underground or podium detention tank, gravity outlet
DET_PUMP	Pumped detention or pump station	Pumped detention, pumps and controls
WQ_POND	Wet pond or constructed wetland	Surface detention basin or multi-use open space area
WQ_SWALE	Swale or filter strip	Private drains and inlets
WQ_GPT	Gross pollutant trap, first-flush device or oil-grit separator	Gross pollutant trap / first-flush device
GATE	Flap or tide gate, non-return valve	Flap / tide gate, non-return valve
CONV	Private drain, inlet or culvert	Private drains and inlets

Table 10B.8 — Status codes (STATUS)

Code	Meaning
PROPOSED	In a Stage 1 or Stage 2 submittal

Code	Meaning
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)

Element	Requirement	Clause
Manholes and access chambers on public drains	Clear access opening at least 600 mm	9.12.3
Inlet chambers on public roads	Silt sump at least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7
Underground tanks and vaults	Access openings over the outlet chamber and over every inlet; in tanks over 500 m², not more than 30 m apart; floor falling at least 1% to a sump at the outlet	4.10.2(b), (c)
Detention outlets serving more than 1 ha	A means of isolating the outlet (stop-log slot or penstock)	4.8.6
Outfall gates	Stop-log slot or penstock upstream on outfalls larger than 600 mm (Chapter 5) and on outfalls of 900 mm or more or serving a pumped or storage system (Chapter 9); the gate chamber accessible at all tides, with its access above HAT + surge + sea-level allowance	5.11.3(d), (e); 9.10.3
Pump stations	Maintenance vehicle access usable in the 1% AEP event; hard standing and a quick-coupling connection for mobile pumps; clear space between adjacent pumps or motors of 0.6 m (small and medium units) or 1.0 m (large units)	9.9.6, 9.9.10, 9.9.12
Pretreatment devices	Cleanable without entering or disturbing the main BMP	8.5.4
Screens at outfalls, culvert inlets and pump sumps	Cleanable from a safe platform, with vehicle access	8.10.3(d)
Infiltration trenches	Observation well to the base of each trench	8.7.6(c)
Publicly accessible storage	Side slopes no steeper than 4H:1V, with at least a quarter of the perimeter at 6H:1V or flatter	4.15.1(c)
Wet basins	Safety bench at least 3 m wide, no more than 0.3 m below normal water level	4.15.2
Fencing	At least 1.2 m high, non-climbable, with a lockable gate, where Clause 4.15.3 requires it	4.15.3

Table 10C.2 — Access dimensions not set by the Manual (to be confirmed in design)

Element	What the designer shall state	Clause setting the function
Vehicle access route to the inlet, outlet and base of a basin, pond or open channel	Width, gradient, turning space and design load for the plant in the O&M plan	10.13.2
Maintenance strip beside a basin or pond	Width along at least one side	10.13.2
Ramp into a basin	Width, gradient and surface for the sediment-removal plant	10.13.2
Access openings of private tanks	Clear size of each opening over the inlet, outlet and each chamber	10.13.3(a)
Ladders and steps	Type and spacing; ventilation for confined-space entry	10.13.3(b)
Headroom in underground tanks	Clear height for manual cleaning	10.13.3(d)
Reach to orifices and screens	How the outlet is cleaned without entering a full facility	10.13.4

> **Commentary.** APWA 5600 (2006, §5608) required a maintenance access strip of 15 ft (about 4.5 m) for detention facilities. The Manual did not adopt a fixed width for private sites, because plot sizes in Tripura 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

Task	Frequency	Standard or trigger	Clause
Bioretention: mulch, plants, ponding	Every 6 months	Ponding drains within 48 h; dead plants replaced; mulch 50–75 mm	8.7.2
Permeable paving: surface	Every 6 months	Sweep or vacuum; no resurfacing with impermeable material	8.7.5(e)
Keep the contributing area stable	Each inspection	Bare soil stabilised; no sediment washing in	10.8.3(b)
Keep the facility in place and in use	Each inspection	Not filled, covered, paved or built over without approval	10.10.1(d)

Table 10D.3 — Surface detention basin or multi-use open space area

Task	Frequency	Standard or trigger	Clause
Inspect inlets, outlet, orifice, trash rack and spillway	Every 6 months; before 31 March; after each heavy-rainfall day	Orifice and rack clear; spillway unobstructed	Table 10.3, 4.8, 4.9
Remove debris and sediment	When the sediment trigger is reached, and after events	Design volume restored	10.11.1(c)
Check that the basin drains	After rain	No low point ponds for more than 72 h	4.15.7
Vegetation	As set in the plan	Grass cut; no woody growth on embankments or in the outlet zone	10.11.1(b)
Safety features	Every 6 months	Signs in Bengali and English and a depth marker in place; fences and gates sound where required	4.15.3, 4.15.5
Embankment (if any)	Every 6 months and after events	No cracks, slips, seepage or animal burrows	4.9.6

Table 10D.4 — Underground or podium detention tank, gravity outlet

Task	Frequency	Standard or trigger	Clause
Inspect from the access openings: inlets, outlet, orifice, screen, sump, vents	Every 6 months; before 31 March; after each heavy-rainfall day	Clear; vents open	Table 10.3, 4.10.2
Clean the sump and floor	When the sediment trigger is reached	Floor falls freely to the sump	4.10.2(c)
Inlet silt trap or GPT	Every 3 months (Table 10.3 row for GPTs)	Cleaned	4.10.2(e)
Overflow route	Each inspection	Operates when the outlet is blocked; route to the overland path unobstructed	4.9.5
Confined-space entry	Each entry	Entry procedure stated in the maintenance declaration followed; covers locked after	4.15.6
Use of the space	Each inspection	Not used for parking or storage; volume not reduced	10.10.1(d)

Table 10D.5 — Pumped detention, pumps and controls

Task	Frequency	Standard or trigger	Clause
Test run of each pump, duty and standby	Monthly	Each pump starts on level control; roles alternate	Table 10.3, 9.9.4(c)

Task	Frequency	Standard or trigger	Clause
Full duty test	Before 31 March	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 31 March	Automatic changeover works; fuel for at least 72 h of all duty pumps on site	9.9.9
Level sensors, float back-up, alarms, telemetry	Monthly	High-level and fault alarms reach the control room	9.9.8
Screens and silt trap	Every 3 months and after events	Clean	9.9.7
Records	Continuous	Sump levels, run hours and power status logged; kept at least 5 years	9.9.8(c)
Warning actions	On an IMD heavy-rainfall or cyclone warning	Actions written in the plan: _____ (for example staff on site, fuel topped up, mobile pump connection checked)	10.11.1(e), 9.9.12

Table 10D.6 — Flap or tide gate, non-return valve

Task	Frequency	Standard or trigger	Clause
Inspect and operate	Every 3 months; after each heavy-rainfall day	Opens at a small head; no debris, sand or growth holding it	Table 10.3, 9.10.4
Seal test	Before 31 March	Seals against the receiving water	Table 10.3, 10.9.3
Beach, estuary and creek outfalls	After every high-tide or surge event in the monsoon season	Sand and debris cleared	9.10.5(b)
Isolation	Before 31 March	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 31 March	No corrosion that would stop the gate working	9.10.6
Property non-return valves	Every 3 months	Cleaning eye accessible; valve seals	5.11.4

Table 10D.7 — Gross pollutant trap or first-flush device

Task	Frequency	Standard or trigger	Clause
Inspect and empty	Every 3 months; before 31 March; after each heavy-rainfall day	Emptied before the capture chamber is full; bypass clear	Table 10.3, 8.4.6
Screens	Each inspection	Clean; overflow path clear	8.10.3(b)
Disposal	Each cleaning	Material taken to an authorised solid-waste facility	—

Table 10D.8 — Private drains and inlets

Task	Frequency	Standard or trigger	Clause
Inspect and clean drains, inlets and silt sumps	Every 6 months; before 31 March	Free of silt and debris	Table 10.3
Check for sewage connections	Each inspection	None; any cross-connection removed	1.5.4, 8.9

Task	Frequency	Standard or trigger	Clause
Overland flow paths	Each inspection	Not obstructed by walls, fill or stored material	6.9.2, 10.15.1(g)

Annex 10E — Empanelment criteria for Stormwater Design Professionals and reviewers

Supports Clauses 10.6, 10.7.4 and 11.4.3 of Chapter 10.

> *Model text for consideration by a competent authority. Not in force.* Clause 10.6.2 assigns the issue of empanelment criteria to UDD. The text below is a model. Values shown as "[ ]" are for the competent authority to set; the Manual does not set them.

10E.1 Model criteria

1. **Lists.** The competent authority shall keep three public lists:
    - (a) **Stormwater Design Professionals**, who may sign designs under Clause 10.6.1 and act as independent checkers under Clause 10.6.4;
    - (b) **Empanelled Reviewers**, who may review submittals for an Authority under Clause 10.7.4; and
    - (c) a **basin modelling endorsement**, held by a Stormwater Design Professional who may prepare or direct a BSMP under Clause 11.4.3.
2. **Eligibility for list (a).** An applicant shall:
    - (a) hold a degree in civil engineering, or an equivalent qualification recognised by the competent authority (Clause 10.6.2);
    - (b) be registered as a professional under the Tripura Building Rules 2017 (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 — Tripura Stormwater Design Manual, Draft v1.0. Lodge with every Stage 1 and Stage 2 submittal. For each item give the page or sheet where it is addressed, or the reason it does not apply. The Authority does not start technical review without a completed Form 10-1 (Clause 10.4.3).

Table 10F.1 — Form 10-1, Section A: Submittal

No.	Field	Entry
A1	Authority and file number	_____
A2	Site name and address; survey numbers	_____
A3	Stage: 1 / 2 / combined 1 and 2 (Clause 10.3.3) / public work DPR or tender (Clause 10.3.4)	_____
A4	Applicant	_____
A5	Certifying professional (name, registration and empanelment number)	_____

Table 10F.2 — Form 10-1, Section B: Stage 1 contents (Clause 10.4.1)

No.	Item	Clause	Page / sheet	Not applicable: reason
B1	Form 1-1; Form 1-2 where a variance or waiver is sought	10.4.1(a)	_____	_____
B2	Site plan: existing and proposed levels, impervious areas, catchment boundaries to and through the site	10.4.1(b)	_____	_____
B3	Soils (HSG), seasonal high groundwater, infiltration tests or test plan	10.4.1(c)	_____	_____
B4	Design Rainfall Sheet (Form 2-1)	10.4.1(d)	_____	_____
B5	Pre-development condition and hydrologic method	10.4.1(e)	_____	_____
B6	Order of measures: areas preserved, retention method, detention concept, conveyance	10.4.1(f)	_____	_____
B7	Preliminary retention, WQ and detention volumes and release rates, with Form 10-2	10.4.1(g)	_____	_____
B8	Downstream extent and tailwater case	10.4.1(h)	_____	_____
B9	Waterbodies, setbacks and the 1% AEP level	10.4.1(i)	_____	_____
B10	Land reserved for facilities and maintenance access	10.4.1(j)	_____	_____
B11	Professional Design Certificate (Form 10-3)	10.4.5	_____	_____

Table 10F.3 — Form 10-1, Section C: Stage 2 contents (Clause 10.4.2)

No.	Item	Clause	Page / sheet	Not applicable: reason
C1	Updated Stage 1 contents (Section B)	10.4.2	_____	_____
C2	Final calculations for every storage duration and AEP, with the outfall-closed check	10.4.2(a)	_____	_____

No.	Item	Clause	Page / sheet	Not applicable: reason
C3	Stage–storage–discharge tables; emergency spillway design	10.4.2(b)	_____	_____
C4	Hydraulic design of conveyance, inlets and structures	10.4.2(c)	_____	_____
C5	Water quality design; first-flush device or GPT where required	10.4.2(d)	_____	_____
C6	Construction drawings, details and specifications of every facility	10.4.2(e)	_____	_____
C7	Construction sequence, with protection of retention and infiltration areas	10.4.2(f)	_____	_____
C8	Hold-point schedule (Form 10-4, Section A)	10.4.2(g)	_____	_____
C9	Draft O&M plan and draft Maintenance Declaration (Form 10-6)	10.4.2(h)	_____	_____
C10	Model input files and GIS data	10.4.2(i)	_____	_____
C11	Certificates (Form 10-3, signed by designer and, where required, checker)	10.4.2(j)	_____	_____

Table 10F.4 — Form 10-1, Section D: Digital submittal (Clause 10.4.4)

No.	Item	Clause	Provided (yes / no)	Detail
D1	Reports and drawings as searchable PDF	10.4.4(a)	_____	_____
D2	Models in native, runnable format; software name and version	10.4.4(b)	_____	_____
D3	GIS data to Annex 10B; horizontal reference system (EPSG code)	10.4.4(c)	_____	_____
D4	Vertical datum named; relationship to the Chapter 5 river datums of the CWC level-forecasting and level-monitoring sites on the Haora, the Gumti (Gomati), the Manu, the Khowai, the Dhalai, the Juri, the Muhuri and the Burima (not stated in any source found [TBC]), of the State gauges, such as the gauge at Jahar Bridge on the Haora and those at Udaipur and Amarpur on the Gomati, of the embankment crests, sluice sills and gate-closing levels of PWD (WR), of the levels of the Dumbur reservoir (full reservoir level given as 93.55 m, as reported, on a datum not stated), and of the flood marks surveyed on the Katakhal, the Akhaura canal and the other ungauged channels, streams, ponds and tanks	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 — Tripura 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 — Tripura 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, TBR 2017 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 Tripura 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 — Tripura 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 — Tripura 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 — Tripura 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, revenue circle, 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 — Tripura 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 — Tripura 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 Tripura 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, pukur 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:** PWD (WR), wherever the basin includes a river, canal or tank under its control, and [other local bodies, TUDA or UDD, TDMA] (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, khal or chhara 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, pukur, 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 State gauge kept as a separate series and any conflict between published values stated; embankment crest levels; the sluices and flap gates in the embankments, among them the Katakhal double-barrel sluice, with their sills, gate types, closing levels and operating rules; the flood pumps and pumping stations on the outfalls, with their installed and working capacities, discharge pipelines, sump volumes and standby power; the levels of the ungauged Katakhal and Akhaura canal by survey; the stage–storage of the receiving pukurs, dighis and lunga storage; past breaches and leaks of the embankments; the release records of the Dumbur reservoir; and, at every border reach, the statement that no downstream level is known;
- (f) rainfall and water levels: all available records (IMD, through its Meteorological Centre Agartala, with its two stations in *Extremes*, Agartala (A) (42724) and Kailashahar (A) (42618), and the stations named in its press releases of August 2024, among them Agartala Aero, Met Agartala (ARG/AWS), Teliamura ARG, Bagafa and Bagafa AWS, Belonia and Belonia ARG, KVK South, KVK Dhalai and Gandacherra AWS; the rain gauges at CWC's river sites, among them Sonamura Mohanbhog, Gajaria, Amarpur, Belonia, Manughat, Kailashahar, Kumarghat, Nutanbazar and Kadamtala; the State's automatic rain gauges, among them the DM Office and Secretariat gauges in Agartala (owners, logging intervals and archives [TBC]); the rain and level sensors of the Agartala Municipal Corporation's Integrated Command and Control Centre (as reported); and the ten automatic rain gauges that IMD is to add in Agartala and other urban areas (TDMA's monsoon checklist of 2026, as quoted) [TBC]), including the 22 August 2024 (Agartala Aero 23 cm in the 24 hours to 08:30 IST on 22 August, IMD, with the Haora at the CWC Haora site at 12.42 m the same day, as reported, in the State's flood of record, whose largest measured day was 49 cm at Bagafa, IMD), 17–19 June 2022 (the Agartala urban flood, with about 200 mm in 3 hours by the Mayor's account and 145 mm or 155 mm in 24 hours in other reports, a conflict, all as reported, no IMD hourly value found, and the Haora at 10.82–10.85 m at Jahar Bridge against a danger level of 10.50 m and at 10.72 m at the CWC site against 10.70 m, as reported), 31 May 2025 (about 200 mm in 3 hours at Agartala by the account of the Mayor and officials, with one death in a manhole, as reported; no IMD hourly value found), 13 June 2018 at Kailashahar (the Manu at 25.95 m at the CWC site, 0.16 m above its high flood level of

1993, and about 21,000 people homeless in the town, as reported; no hourly town rainfall found) and 22–24 August 2026 (Chandrapur, Baldakhal and Aralia in Agartala flooded, and the Haora at 10.72 m at 08:00 on 24 August against a danger level of 10.70 m, as reported; 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 22 August 2024 (Agartala Aero 23 cm in the 24 hours to 08:30 IST on 22 August, IMD, with the Haora at the CWC Haora site at 12.42 m the same day, as reported, in the State's flood of record, whose largest measured day was 49 cm at Bagafa, IMD), 17–19 June 2022 (the Agartala urban flood, with about 200 mm in 3 hours by the Mayor's account and 145 mm or 155 mm in 24 hours in other reports, a conflict, all as reported, no IMD hourly value found, and the Haora at 10.82–10.85 m at Jahar Bridge against a danger level of 10.50 m and at 10.72 m at the CWC site against 10.70 m, as reported), 31 May 2025 (about 200 mm in 3 hours at Agartala by the account of the Mayor and officials, with one death in a manhole, as reported; no IMD hourly value found), 13 June 2018 at Kailashahar (the Manu at 25.95 m at the CWC site, 0.16 m above its high flood level of 1993, and about 21,000 people homeless in the town, as reported; no hourly town rainfall found) and 22–24 August 2026 (Chandrapur, Baldakhal and Aralia in Agartala flooded, and the Haora at 10.72 m at 08:00 on 24 August against a danger level of 10.70 m, as reported; 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 not a design objective in Tripura, where the stage of extraction is 9.48% and every assessment unit Safe (CGWB, State compilation of 2025, as quoted), and which is credited only on tested, flat tilla tops (Clause 4.11, tilla rule), waterlogging where the water table lies within 2 m of the surface, as it does across much of the valley floors after the monsoon (0.22–6.64 m below ground in West Tripura in November 2017; CGWB), the stability of tilla slopes, cuts and

the hill ranges, where water put into fill or weathered rock raises the pore pressure, and the iron-rich shallow groundwater, with up to 4.99 ppm of iron, which clogs infiltration media; effect on downstream basins and the receiving river, khal or chhara; 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 lungas, flood plains and tilla cuts after any large flood or landslide, the drain network of every drain-owning body (the Agartala Municipal Corporation and the other ULBs, Agartala Smart City Ltd, PWD (R&B), NHIDCL, PWD (WR) and PWD (DWS)), the drain register of each town giving every reach its owner, its land status (khas or government, private or Council land) and whether it is a vested municipal drain, an embankment drain or sluice, or a natural chhara or lunga, the embankments of PWD (WR) with every sluice, its sill, closing level and operating rule, the flood pumps and pumping stations on the outfalls with their working capacities, the pukurs, dighis and beels with their stage–storage and outlet levels and their land classes in the Revenue Department's records, the interception points of the drains that feed the treatment plants, the release reach below the Dumbur reservoir, the embankment breach and leakage paths, and the landslide and flood hazards mapped by TDMA, GSI and PWD (WR) (other likely sources: Survey of India, CWC, CGWB, the Master Plan 2045 maps, the land records by district, sub-division, revenue circle and mouza, and the TTAADC's land records [TBC]). No basin map of any Tripura town was found. Until the annex is published, the basins of Agartala (the central saucer and the Akhaura canal; the Katakhal; the Haora), Kailashahar, Belonia, Udaipur, Amarpur and Sonamura, Dharmanagar, Khowai and Teliamura, Kamalpur, Santirbazar, Bagafa and Sabroom, the hill-range corridors and Rudrasagar 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 landslide ground, in breach paths, on the release reach and on the active flood plains 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
Agartala Planning Area (Agartala Municipal Corporation, TUDA)	Central saucer between the Haora embankment and the Katakhal, with the Akhaura canal	Sub-area TR-A (Clause 2.3.6(c)); local rain with the outfalls shut a design case (Clause 5.8.5(b)); flood pumps and pipelines; drains that carry sewage in the 1D network
Agartala Planning Area (as above)	Katakhal to the double-barrel sluice, with the Kalapania Khal	No gauge: surveyed flood marks, the Haora level until surveyed [TBC]; interception points of the treatment plants on its banks
Agartala Planning Area (as above)	Haora, 414 km², from the Baramura range to the border	Upper catchment in TR-E; PWD (WR) flood-plain localities and Chandrapur; Haora at the CWC Haora site, 12.42 m, as boundary (datum not stated)
Kailashahar	Town behind the Manu embankment	Outfalls once surveyed [TBC]; Manu at Kailashahar (CWC) as boundary, with the conflicting danger levels stated; record check of Clause 2.3.6(h)
Belonia	Town behind the Muhuri embankment	Muhuri at Belonia, 18.81 m (2024), as boundary; TR-D1 record floor of 490 mm
Udaipur, Amarpur, Sonamura	Towns on the Gomati below the Dumbur reservoir	Largest recorded release, or spillway capacity, as boundary (Clause 5.8.5(d)); State and CWC gauges stated separately; tanks kept as storage
Dharmanagar	Town on the Juri	Juri at Nutan Bazar, 20.66 m (2024), as boundary
Khowai, Teliamura	Towns on the Khowai	Khowai at Khowai, 28.005 m (2004), as boundary; governing cell of TR-B

Tier A body or area	Basin	Note from Chapter 11
Kamalpur	Town on the Dhalai	Dhalai at Kamalpur, 33.85 m (1984), as boundary; governing cell of TR-B1
Santirbazar, Bagafa, Sabroom	Towns of the Muhuri–Feni south	Landslide ground mapped; Feni a border river with no working gauge reported; TR-D1 record floor
Hill-range corridors	NH-8, NH-108B and NH-208 through the ranges	Hazard screening first; culverts and silt traps (Clause 6.3.6(k) and (m))
Rudrasagar	Catchment of the Ramsar lake at Neermahal	No new storm drain into it without interception (Clause 8.9); lake level as boundary
Other Tier A bodies and ULBs	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_BN	Text	Basin name in English and Bengali
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 PWD (WR) 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 Tripura 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 Tripura 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 22 August 2024 (Agartala Aero 23 cm in the 24 hours to 08:30 IST on 22 August, IMD, with the Haora at the CWC Haora site at 12.42 m the same day, as reported, in the State's flood of record, whose largest measured day was 49 cm at Bagafa, IMD), 17–19 June 2022 (the Agartala urban flood, with about 200 mm in 3 hours by the Mayor's account and 145 mm or 155 mm in 24 hours in other reports, a conflict, all as reported, no IMD hourly value found, and the Haora at 10.82–10.85 m at Jahar Bridge against a danger level of 10.50 m and at 10.72 m at the CWC site against 10.70 m, as reported), 31 May 2025 (about 200 mm in 3 hours at Agartala by the account of the Mayor and officials, with one death in a manhole, as reported; no IMD hourly value found), 13 June 2018 at Kailashahar (the Manu at 25.95 m at the CWC site, 0.16 m above its high flood level of 1993, and about 21,000 people homeless in the town, as reported; no hourly town rainfall found) and 22–24 August 2026 (Chandrapur, Baldakhal and Aralia in Agartala flooded, and the Haora at 10.72 m at 08:00 on 24 August against a danger level of 10.70 m, as reported; no rainfall value found) floods (Revenue Department and TDMA 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 $D_1, D_2, \ldots$ at annual exceedance probabilities $P_1 > P_2 > \ldots$, 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, khal, pukur 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 level-forecasting and level-monitoring sites on the Haora, the Gumti (Gomati), the Manu, the Khowai, the Dhalai, the Juri, the Muhuri and the Burima (not stated in any source found [TBC]), of the State gauges, such as the gauge at Jahar Bridge on the Haora and those at Udaipur and Amarpur on the Gomati, of the embankment crests, sluice sills and gate-closing levels of PWD (WR), of the levels of the Dumbur reservoir (full reservoir level given as 93.55 m, as reported, on a datum not stated), and of the flood marks surveyed on the Katakhal, the Akhaura canal and the other ungauged channels, streams, ponds and tanks 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 `haora_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 — Tripura 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 pukur 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	_____