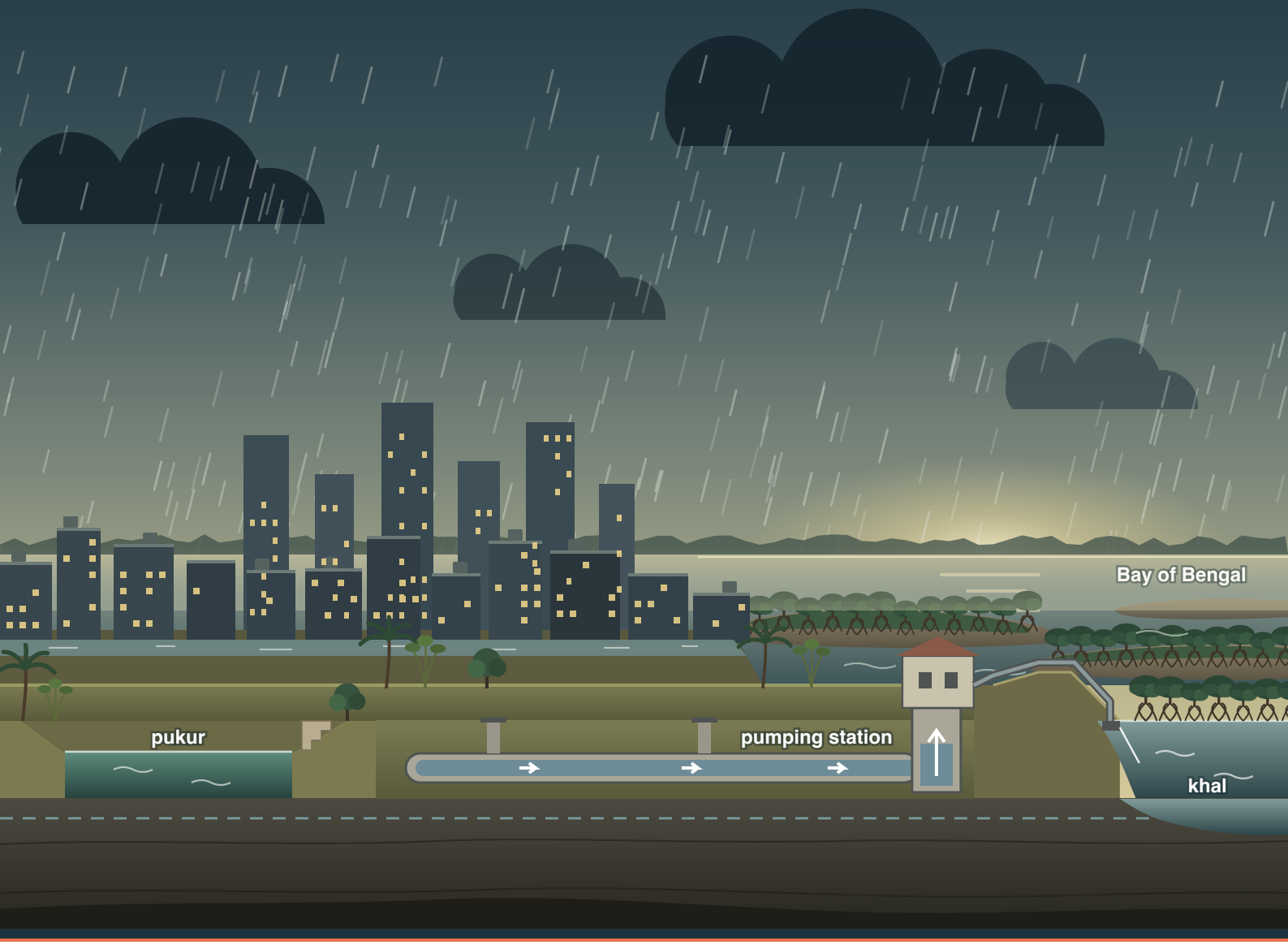
WEST BENGAL

Stormwater Design Manual

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



Preserve | Retain | Detain | Convey | Maintain

Draft v1.0

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Prepared by

Neer.

About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of West Bengal or by any of its departments, local bodies or agencies, including the Kolkata Municipal Corporation (KMC), the Kolkata Metropolitan Development Authority (KMDA), the New Town Kolkata Development Authority (NKDA) and the other Municipal Corporations, Municipalities and development authorities of the State. Where it names a body, such as the Urban Development and Municipal Affairs Department (UD&MA), the Irrigation and Waterways Department (I&WD), WBSDMA, the West Bengal State Coastal Zone Management Authority, the East Kolkata Wetlands Management Authority, KMC, KMDA, NKDA, a Municipality or the Damodar Valley Corporation, it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role.

Supplements. The Manual carries one supplement, for a place that lies outside the State's jurisdiction. Supplement S01 covers the Union Territory of the Andaman and Nicobar Islands, in the Bay of Bengal. The islands fall within the jurisdiction of the Calcutta High Court, whose Circuit Bench sits at Sri Vijaya Puram, and Bengali is widely spoken there. No West Bengal Act, rule or authority applies in the islands; the supplement works through the instruments of the Union Territory. It has not been adopted, notified or endorsed by the Andaman and Nicobar Administration or by any of its departments, local bodies, Tribal Councils or agencies. What this notice says of the Manual applies to the supplement.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. The development rules, drainage standards and approval conditions in force continue to apply.

Names. Older sources and some IMD and tide-gauge stations keep the old names Calcutta (Kolkata), Burdwan (Bardhaman), Midnapore (Medinipur), Contai (Kanthi) and Saugor (Sagar); this Manual uses the present names and keeps the old ones where a source or a station uses them. In the islands, Port Blair was renamed Sri Vijaya Puram in 2024, Havelock Island is Swaraj Dweep and Neil Island is Shaheed Dweep; the IMD station and the 1999 building bye-laws keep the name Port Blair. Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2 and 3; this Manual does not use it for any Municipal Corporation, and names the Asansol Municipal Corporation in full;
- CD is chart datum; the community development blocks of the islands are written in full;
- SWD is a storm water drain, and SWF the storm-water flow of a combined system (Chapter 5); and
- KMC is the Kolkata Municipal Corporation, and KMCBR its Building Rules, 2009.

The sense is clear from the context. Bengali terms used in the text, such as *pukur* (pond), *dighi* (large tank), *khal* (canal), *bheri* (embanked fishery) and *bandh* (embankment), are explained where they first appear.

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

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

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

Preface

West Bengal's cities and towns flood for three reasons. Kolkata showed the first on 23 September 2025, when its drains could not take a storm of the kind they were never designed for; the lower Damodar and Ghatal showed the second in September 2024, when dam releases and swollen rivers held the land under water; and the delta showed the third when Cyclones Aila and Amphan drove the sea over its embankments.

1. **Drains built for frequent storms, discharging against the tide.** Kolkata drains away from its river. The city stands on the levee of the Hooghly and its land slopes east, so most of its storm water is pumped: the large Kolkata Municipal Corporation stations at Ballygunge (1,233 cusec) and Palmer Bazar (1,184 cusec) lift it into outfall channels that run about 27 km from Bantala to the Kultigang, a tidal arm of the Raimangal estuary, through the East Kolkata Wetlands. The core system is a combined one: the Kolkata Municipal Corporation Act, 1980 requires KMC to provide one outfall "for the effectual drainage and proper discharge of storm-water and sewage", and the pumping stations designed for KMC since 2015 still pump storm flow mixed with sewage to the canals. The system was sized for small storms. Kolkata's first brick sewer, commissioned in 1876, was designed to carry 6.35 mm of rain an hour, and an attempt in the 1970s to raise this to 12.7 mm/h is reported not to have succeeded. The drainage master plan of the metropolitan area was based on a storm that comes "once in two months (6 times in a year)", with 70% of the land impervious, and its intensity–frequency curve was adopted by KMDA and the local bodies. On the night of 22–23 September 2025 IMD's Alipore observatory recorded 251.4 mm in 24 hours, 185.6 mm of it in three hours and 98 mm in a single hour, fifteen times the design rate of the old sewers; a KMC gauge at Garia was reported to have recorded 332 mm. Kolkata went under water, and about ten people died, most of them by electrocution in flooded streets. A project report for the KMC pumping stations records that "discharge through the outfall is partially achieved due to high water levels in the canal, particularly during tidal period". Roofs, roads and paving now send more water to the drains, and faster.
2. **Rivers that rise from upstream.** Much of south Bengal drains to rivers whose level is set by rain and dams far upstream. On 17 September 2024 the combined release from the Maithon and Panchet dams of the Damodar Valley Corporation, in Jharkhand, was stated to have peaked at 2.5 lakh cusec, about 7,080 m³/s; parts of Howrah, Hooghly, Paschim and Purba Medinipur, Bankura and Purulia flooded, and the Shilabati rose above its danger level at Ghatal, a low basin that drains slowly to the Rupnarayan and floods repeatedly. In July 2017 floods across the State affected 8.7 million people, killed 217 and caused damage of ₹17,727.94 crore, and the Comptroller and Auditor General (CAG) found that flood works had been "taken up at different locations depending on priority and availability of funds without being linked to a comprehensive plan". In the north, the Teesta flood of October 1968 and the outburst of South Lhonak lake in Sikkim on 4 October 2023, which left silt in the Teesta and in the Teesta–Mahananda link canal, show the same: a town drain is only as good as the river it empties into.
3. **The sea, the cyclones and sinking land.** The Hooghly is tidal well above Kolkata, with a range of about 17 ft at its mouth; in the 1960s a tidal bore was reported on practically every spring tide. INCOIS puts the 100-year extreme sea level at Diamond Harbour at 3.79 m above mean sea level now, rising to 4.34–4.46 m by 2100. Cyclones bring the sea inland. Aila, on 25 May 2009, breached about 177 km of the 3,122 km of embankments that protect the Sundarbans and badly damaged another 601 km; Amphan, on 20 May 2020, brought "tidal waves of 15 feet height" into the 24 Parganas and Purba Medinipur, and 240 mm of rain at Alipore in 24 hours. Yaas (May 2021) and Remal (May 2024) followed. The land is also going down. Satellite measurements show parts of Kolkata subsiding by 2.8–5.5 mm a year, as fast as the sea is rising at Diamond Harbour (3.73 mm a year), and the two add: a gravity outfall built today loses both together.

Behind all three lies lost storage. Kolkata's ponds, the *pukurs* and *dighis*, and the wetlands to its east once held much of its rain. An estimate by the National Atlas and Thematic Mapping Organisation (NATMO) put the city's water bodies at about 8,700; a later satellite count found about 4,900. Salt Lake and New Town stand on reclaimed wetland. The

Calcutta High Court froze reclamation of the East Kolkata Wetlands in 1992, and the wetlands were listed under the Ramsar Convention in 2002, but ponds are still filled across the city; KMC has filed hundreds of police complaints over it.

Design for West Bengal therefore has to cover more than the monsoon. Four of the last five damaging cyclones struck in late May, near spring tides, and the all-time daily record at Diamond Harbour (290.7 mm, 27 May 1993) is a May storm; Dum Dum's largest pre-monsoon day, 220 mm on 8 May 1949, came from a nor'wester. October and November bring cyclones and depressions as well.

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;
- 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 tide, the khal or the river is high, or when the pumps that serve it are running at full capacity.

The Manual also sets how public drains, roads, khals, pukurs, pumped outfalls and basin-wide master plans are designed, 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 West Bengal's south-west monsoon and the nor'westers and cyclones that bracket it; the very wet sub-Himalayan north, where Jalpaiguri receives about 3,700 mm a year, and the delta, where the State average is about 1,850 mm; the deltaic clays and high water table of the south, the laterite of the western plateau and the sandy terai of the north; the pukurs, the East Kolkata Wetlands and the Sundarbans; combined sewers and pumped, tide-locked outfalls; rivers regulated by dams; and the macro-tidal Hooghly estuary.

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 and the NDMA urban flood guidelines are also used.
2. **Overall structure.** Kansas City Metro APWA Section 5600 (Version 2025.01), the most recent comprehensive regional standard. It supplies the preserve, retain, detain, convey and maintain sequence and the required retention volume.
3. **Design rainfall.** The CWC *Flood Estimation Reports* for the three subzones that cover West Bengal, 1(g) Lower Ganga Plains, 2(a) North Brahmaputra and 1(f) Middle Ganga Plains, as the interim source, and frequency analysis of hourly rainfall by the National Institute of Hydrology (NIH), Roorkee, for climate-change ratios.
4. **Tropical and coastal practice.** The PUB Singapore *Code of Practice on Surface Water Drainage* (7th ed., 2025), for the fixed-coefficient route for small sites, drainage reserves and coastal platform levels. 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 Kolkata Municipal Corporation Act, 1980 and the KMC Building Rules, 2009; the West Bengal Municipal (Building) Rules, 2007; the New Town Kolkata (Building) Rules, 2009, as amended in 2021; the West Bengal Town and Country (Planning and Development) Act, 1979; the West Bengal Inland Fisheries Act, 1984 (s.17A) and the East Kolkata Wetlands (Conservation and Management) Act, 2006; the Calcutta High Court's judgment of 1992 on the East Kolkata Wetlands; and the CRZ Notification 2019 as it will be applied in West Bengal through its Coastal Zone Management Plan. This Manual follows them or, where disclosed, makes them stricter.

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 25 years. An engineer designing a drain in West Bengal can cite 1, 2, 5 or 25 years, depending on the code chosen.
- **Detention.** CPHEEO describes limiting peak outflow to pre-development rates as general practice. It uses no "shall" and names no storm frequencies.
- **Climate.** The NDMA Urban Flooding Guidelines (2010) call for detention and retention facilities and for rainfall curves adjusted for climate change, but give no sizing rule or return period.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. IMD's 2022 national set of rainfall intensity curves has no curve for any West Bengal station. The reanalysis grids of NIH-DHAARA come close to the CWC values near Kolkata (50-year 24-hour depth 294 mm), but give two to three times the CWC values in the north and on the coast: 677 mm against about 320 mm at Siliguri, 790 mm against about 360–400 mm at Cooch Behar, and 631 mm against about 360 mm at Digha.

West Bengal has no drainage design standard of its own. Research for this Manual found no West Bengal design standard, State IDF relationship or circular of UD&MA or I&WD that fixes return periods or design rainfall for urban drains, and no published IDF relationship for Kolkata or any other city in the State. In particular:

- current practice designs for very frequent storms. The metropolitan drainage master plan used a storm that comes six times a year, and the old sewers of central Kolkata carry 6.35 mm/h. The project reports for KMC's sewerage and drainage works since 2015 state no design rainfall intensity or return period;
- core Kolkata is a combined system by law. KMC must provide one outfall for storm water and sewage (KMC Act, s.277), all public drains vest in KMC (s.280), and the Commissioner may, but need not, require a separate drain for rain water (s.292). New works keep the combined system, separating the dry-weather flow at the pumping stations and pumping the combined storm flow to the outfall canals. This Manual states how its rules apply where the receiving system is combined;
- the building rules do not require on-site detention or limit peak runoff. The KMC Building Rules, 2009 make rainwater harvesting part of the plan only "as per Environmental Impact Assessment Guideline", require a plinth of at least 60 cm, and allow a site to be raised by up to 600 mm in areas prone to waterlogging; the Commissioner may impose conditions where a building would put an additional burden on the drainage system, but no rule says what they should be. The West Bengal Municipal (Building) Rules, 2007 are reported to mandate rainwater harvesting, though the threshold could not be read for this Manual; the New Town rules, since 2021, require it for every new building;
- there are almost no setbacks in metres from khals, ponds or rivers. The KMC Building Rules reward keeping a pond, counting it in plot area and relaxing setbacks where water bodies and heritage buildings cover a quarter of the plot, but set no distance from a khal. The West Bengal Municipal (Building) Rules, 2007 limit the height and length of buildings within 15 m of a river bank, and bar the filling of ponds, canals, wetlands and drains without the State's approval, as reported; they do not keep the bank clear;
- pond protection depends on the West Bengal Inland Fisheries Act, 1984 (s.17A), whose size threshold of 5 cottah was removed in 2008, as reported, on restoration notices under s.53 of the West Bengal Town and Country (Planning and Development) Act, 1979, and on police complaints. In *Anuradha Sen v. Kolkata Municipal*

Corporation (January 2024) the Calcutta High Court held that KMC must first establish that a site is a "water area" before acting;
- there are no flood lines and no floodplain zoning law. The CAG asked I&WD in 2019 to enact the Model Flood Plain Zoning Bill; no Act has followed; and
- West Bengal's Coastal Zone Management Plan under the CRZ Notification 2019 had not been approved by December 2025. Revised plans were sent for Purba Medinipur in September 2025 and North 24 Parganas in October 2025, and the plan for South 24 Parganas, which covers the Sundarbans, was promised for January 2026. The State has told the National Green Tribunal that the High Tide Line of 2011 "no longer exists" on its eroding coast, while the Ministry's committee asked that it be kept. Until a plan under the 2019 Notification is approved, this Manual uses the plans prepared under the CRZ Notification 2011.

So each region and each local body interprets the central manual its own way. KMC, the other Municipal Corporations, the Municipalities, KMDA, NKDA, the development authorities, I&WD, consultants and funding agencies fill the gaps differently. Two drains on the same street, built by different agencies, can be sized for different storms from different rainfall sources. A KMC drain can discharge into an I&WD canal designed to another standard, with no agreed level at which the canal is full or the tide shuts the outfall. 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 (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites (Chapter 4);
- a required tailwater and pumped-outfall check (Chapter 5); and
- basin-wide master plans, so that neighbouring local bodies plan together (Chapter 11).

It uses the route the CPHEEO manual itself provides: a State may adopt standards higher than the national values (CPHEEO 2019, Table 4.1, Note 2). A Municipal Corporation, a Municipality or a development authority 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 §6; NDMA (2010) Urban Flooding Guidelines; MoHUA Model Building Bye-Laws (2016); Kolkata Municipal Corporation Act, 1980, ss.277, 280 and 292; KMC Building Rules, 2009, rr.2(27), 65A, 76, 105, 117 and 144; West Bengal Municipal (Building) Rules, 2007, r.8 (as reported); New Town Kolkata (Building) Rules, 2009, as amended by UD&MA notification No. 2282-T&CP/C-2/2C-17/2020 of 8 September 2021, r.28(4); West Bengal Inland Fisheries Act, 1984, s.17A, and its amendments of 1993 and 2008 (as reported); Calcutta High Court, Anuradha Sen v. Kolkata Municipal Corporation (9 January 2024) and People United for Better Living in Calcutta v. State of West Bengal (24 September 1992), as reported; NGT, OA 258/2024 (compliance report of the District Magistrate, South 24 Parganas) and MA 03/2024/EZ in OA 06/2021/EZ (affidavits of the West Bengal State Coastal Zone Management Authority, March and December 2025); CAG, Report No. 2 of 2019 (Government of West Bengal), Implementation of Flood Control Measures, Chapter 6; Gupta, K. (2005), Waterlines 23(4); CPHEEO, appraisal note on drainage of Howrah city under JNNURM; KMC/ADB, Initial Environmental Examination, KEIIP Tranche 1, Sewerage and Drainage (2015), and Periodic Financing Request Report, Tranche 2 (2016); I&WD, Kolkata Metropolis Drainage and AILA pages (archived 1 May 2026); IMD, press release on extremely heavy rainfall over Kolkata (23 September 2025); IMD, report on Super Cyclonic Storm Amphan (14 June 2020); IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); IMD, Observed Rainfall Variability and Changes over West Bengal State (2020); Das et al. (2022), MAUSAM 73(4); NIH-DHAARA (accessed 6 November 2026); CWC, Flood Estimation Reports for Subzones 1(g), 2(a) and 1(f); INCOIS (2025), extreme sea levels (TR-04); PSMSL, relative sea-level trends (January 2026); Gole and Vaidyaraman, Salinity distribution and effect of fresh water flows in the Hooghly River (CWPRS, ICCE); Thakur et al. (2026), ISPRS Annals XI-3-2026; Ray, M., on Kolkata's missing water bodies (India Water Portal); government statement on DVC releases, 17–19 September 2024, and reports of the September 2025 Kolkata floods (press).

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.

Supplements. The supplement follows the annexes. It applies the Manual to the Union Territory of the Andaman and Nicobar Islands, and states where its rules differ.

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

Where to start.

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

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Abbreviations

Abbreviation	Meaning
A&N	Andaman and Nicobar Islands
ADB	Asian Development Bank
AEP	Annual exceedance probability
AMC	Antecedent moisture condition
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
APWD	Andaman Public Works Department
ARF	Areal reduction factor
BSMP	Basin Stormwater Master Plan
CAG	Comptroller and Auditor General of India
CD	Chart datum
CGWB	Central Ground Water Board
CMPO	Calcutta Metropolitan Planning Organisation
CN	Curve number (SCS/NRCS method)
CPHEEO	Central Public Health and Environmental Engineering Organisation
CRZ / CZMP	Coastal Regulation Zone / Coastal Zone Management Plan
CSE	Centre for Science and Environment
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
DDMA	District Disaster Management Authority
DVC	Damodar Valley Corporation
DWF	Dry-weather flow (of a combined system)

Abbreviation	Meaning
EIA	Environmental impact assessment
EKW / EKWMA	East Kolkata Wetlands / East Kolkata Wetlands Management Authority
ESC	Erosion and sediment control
ESL	Extreme sea level
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FRL	Full reservoir level
FTL / MWL	Full tank level / maximum water level
GLOF	Glacial lake outburst flood
HAT / MHWS	Highest astronomical tide / mean high water springs
HFL	High flood level
HGL	Hydraulic grade line
HMC	Howrah Municipal Corporation
HSG	Hydrologic soil group
HTL	High tide line
I&WD	Irrigation and Waterways Department, West Bengal
ICRZ / IIMP	Island Coastal Regulation Zone / Integrated Island Management Plan (Andaman and Nicobar Islands)
IDF	Intensity–duration–frequency
IMD	India Meteorological Department
INCOIS	Indian National Centre for Ocean Information Services
IRC	Indian Roads Congress
KEIIP	Kolkata Environmental Improvement Investment Program (ADB-assisted)
KMC	Kolkata Municipal Corporation
KMCBR	Kolkata Municipal Corporation Building Rules, 2009
KMDA	Kolkata Metropolitan Development Authority
KOD	Kidderpore Old Datum
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MSL	Mean sea level
NCSCM	National Centre for Sustainable Coastal Management
NDMA	National Disaster Management Authority
NDZ	No Development Zone (CRZ and ICRZ Notifications)
NGT	National Green Tribunal
NHO	National Hydrographic Office

Abbreviation	Meaning
NIH	National Institute of Hydrology, Roorkee
NKDA	New Town Kolkata Development Authority
PAT Regulation	Andaman and Nicobar Islands (Protection of Aboriginal Tribes) Regulation, 1956
PSD	Permissible site discharge
PSMSL	Permanent Service for Mean Sea Level
RRV	Required retention volume
RWH	Rainwater harvesting
SLA	Sea-level allowance
SoI	Survey of India
SUH	Synthetic unit hydrograph (CWC)
SVPMC	Sri Vijaya Puram Municipal Council (formerly Port Blair Municipal Council)
SW monsoon / JJAS	South-west monsoon, June–September
SWD	Storm water drain
SWF	Storm-water flow (of a combined system)
SWID	State Water Investigation Directorate, West Bengal
T&CP Act	West Bengal Town and Country (Planning and Development) Act, 1979
TCP Regulation	Andaman and Nicobar Islands Town and Country Planning Regulation, 1994
UD&MA	Urban Development and Municipal Affairs Department, West Bengal
ULB	Urban local body (a Municipal Corporation, a Municipality or a Notified Area Authority)
UT	Union Territory
UTM	Universal Transverse Mercator
WBMBR	West Bengal Municipal (Building) Rules, 2007
WBPCB	West Bengal Pollution Control Board
WBSCZMA	West Bengal State Coastal Zone Management Authority
WBSDMA	West Bengal State Disaster Management Authority
WQv	Water quality volume

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 West Bengal. 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 multi-day south-west monsoon storms of June–September and the cyclonic storms of May and October–November, as well as for short-duration intensities;
- (d) to design outfalls for tidal tailwater on the Hooghly, in the outfall channels that carry Kolkata's storm water east to the Kulti, and in the creeks of the Sundarbans and the Medinipur coast, and river tailwater raised by Damodar Valley Corporation (DVC) releases on the Damodar and by floods on the Teesta and the Mahananda, 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 for Kolkata and for the municipal areas of the State (the KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> Commentary. West Bengal's floods come from four mechanisms, often together. The first is the short, intense storm on a city whose drains were never built for it. Kolkata's first brick sewer, commissioned in 1876, was designed for 6.35 mm of rain an hour with full runoff, and an attempt in the 1970s to raise the capacity to 12.7 mm an hour was not achieved (Gupta, 2005); the later metropolitan drainage master plan was based on a storm of "once in two months" with 70% imperviousness (CPHEEO). On 22–23 September 2025 the IMD gauge at Alipore recorded 251.4 mm in 24 hours, 185.6 mm of it in three hours and 98 mm in the peak hour (IMD, 2025), and some ten people died, most of them by electrocution in flooded streets (as reported). The second is the long monsoon depression: on 26–29 September 1978, 369.6 mm fell at Alipore in a day, 409.3 mm at Uluberia, 400.0 mm at Suri and 387.7 mm at Durgapur (IMD). The third is the river below a dam. In September 2024 the combined release from the DVC dams at Maithon and Panchet peaked at about 2.5 lakh cusecs (about 7,080 m³/s), and Howrah, Hooghly, the two Medinipurs, Bankura and Purulia were flooded, with the Shilabati above danger level at Ghatal (as reported); in July 2017 floods across the State affected 8.7 million people, killed 217 and caused damage of ₹17,727.94 crore (CAG, 2019, citing CWC). In the north, the Teesta flooded in October 1968, when Kalimpong recorded 419.2 mm and Bagdogra 345.2 mm in a day (IMD), and again after the South Lhonak glacial lake burst on 4 October 2023 and sent silt down the Teesta and into the Teesta–Mahananda link canal (as

reported). The fourth is the cyclone on a macro-tidal coast: Aila on 25 May 2009 breached about 177 km of the Sundarbans embankments and badly damaged a further 601 km (I&WD), and Amphan on 20 May 2020 brought 24 cm of rain to Alipore in a day and tidal waves of 15 ft to the 24 Parganas and Purba Medinipur (IMD, 2020); Yaas (2021) and Remal (2024) also struck in late May.

Lost storage makes all four worse. Kolkata drains east, away from the Hooghly, through outfall channels that pass the East Kolkata Wetlands to the Kulti, and most of its storm water has to be pumped (I&WD). Its ponds are its de facto detention, and they are being filled: a satellite count found about 4,889 where an earlier survey had found some 8,731 (as reported). The CAG found that flood works in the State were "taken up at different locations depending on priority and availability of funds without being linked to a comprehensive plan", and asked I&WD to adopt the model flood plain zoning Bill (CAG, 2019). No city in the State has published a stormwater design storm in research for this Manual. Objectives (b) to (e) address the storage and tailwater failures, which a drain-sizing manual alone cannot fix.

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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 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.

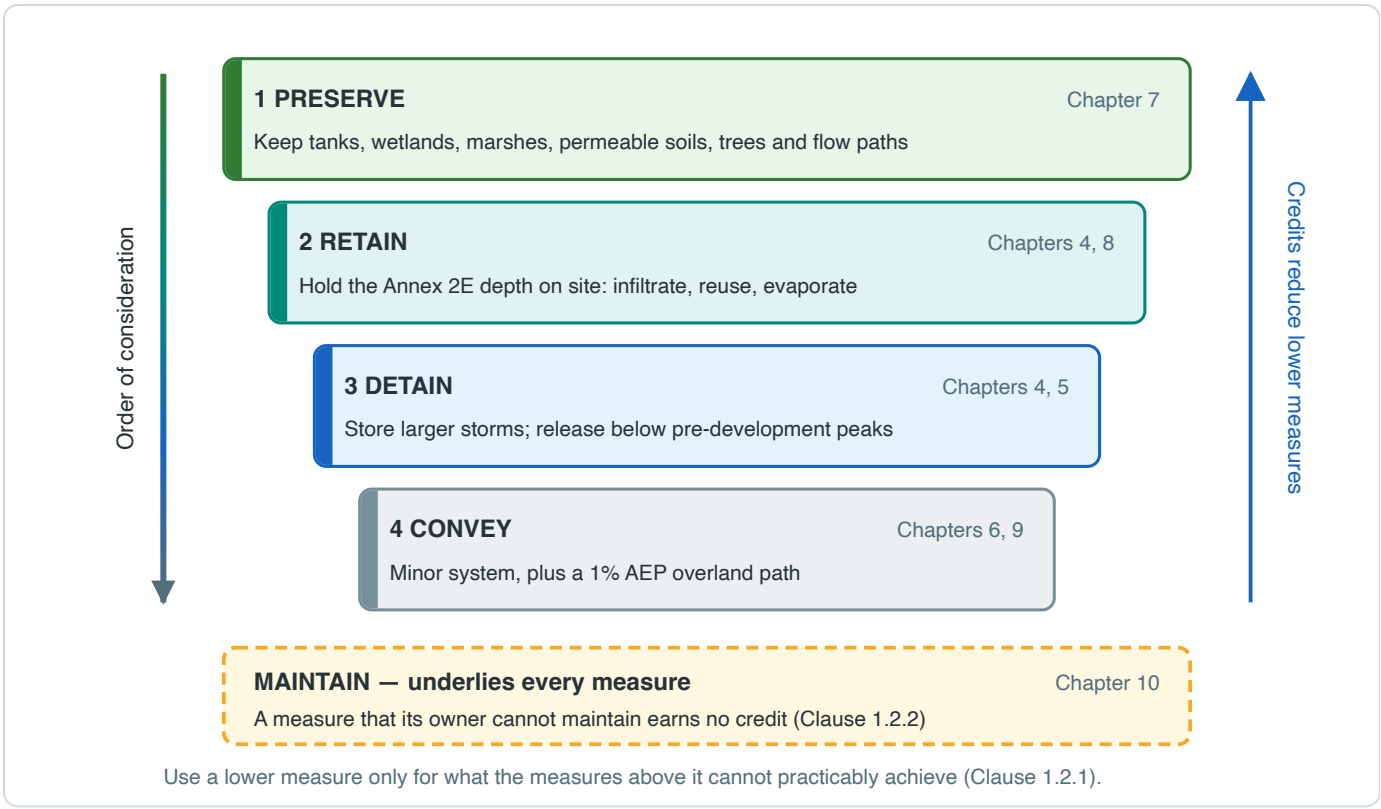

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

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 West Bengal, the top layer has a particular meaning: much of the State's flood storage sits in its pukurs and dighis, in the khals and outfall channels of Kolkata, in the East Kolkata Wetlands (a Ramsar site of 12,500 ha since 2002), in the mangroves and tidal creeks of the Sundarbans (a Ramsar site of 423,000 ha since 2019), and in the beels and floodplains of the rivers. The ponds and wetlands have the strongest protection: section 17A of the West Bengal Inland Fisheries Act, 1984 bars the filling of a water area, with no minimum size since an amendment of 2008 (as reported); rule 8 of the West Bengal Municipal (Building) Rules 2007 bars the filling of any canal, pond, wetland or drain without the prior approval of the State Government (as reported); and the East Kolkata Wetlands (Conservation and Management) Act, 2006, and the Calcutta High Court's judgment of 1992 before it, restrict any change in the character of the wetlands (as reported). The khals and floodplains have no comparable protection: West Bengal has no flood lines and no flood plain zoning law (CAG, 2019). Losing that storage cannot be offset economically by pipes and pumps.

1.3 Legal basis and status

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

- (a) an amendment to the KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 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. West Bengal has no single building code. Kolkata has the KMC Building Rules 2009, in force from 15 September 2009 under the KMC Act 1980; the municipal areas, notified areas and industrial townships have the West Bengal Municipal (Building) Rules 2007 (Notification No. 67/MA/O/C-4/3R-8/2002 of 14 February 2007, amended by No. 446-MA of 22 June 2018, as reported), with a separate chapter for Salt Lake in Bidhannagar; and New Town has the New Town Kolkata (Building) Rules 2009 under the New Town Kolkata Development Authority Act, 2007, last amended by UD&MA Notification No. 2282-T&CP/C-2/2C-17/2020 of 8 September 2021. The building rules of the other Municipal Corporations were not read for this Manual [TBC]. The KMC copy read appears to include later amendments, whose notification numbers were not seen. None of these instruments sets a design storm, return period, runoff coefficient, release rate or detention volume. The KMC rules make rainwater harvesting part of the plan only "as per" the Environmental Impact Assessment guideline (rule 144), keep the plinth at least 60 cm (rule 105), allow a site in a waterlogging-prone area to be raised by up to 600 mm (rule 76(i)), require basements to keep out surface drainage (rule 118(6)(b)), and reward keeping a pond: water bodies count in the plot area for FAR, and setbacks, height and internal roads are relaxed where a water body or heritage building covers at least 25% of the plot (rules 2(27), 65A, 74(4) and 81(9)). They have no setback from a khal. Their one opening for a runoff condition is the Commissioner's power to sanction, "subject to such restrictions or conditions … as he may deem fit", a building that "will put additional burden on the existing … sewerage and drainage system". An amendment of the KMC rules and of the 2007 Rules by UD&MA, which makes both, is the natural route for a statewide condition of approval, which is why Clause 1.3.1(a) names them. 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 Municipal Commissioner of KMC under the KMC Building Rules 2009 in Kolkata; NKDA under the New Town Kolkata (Building) Rules 2009 in New Town; elsewhere in urban areas, the Municipality or Municipal Corporation concerned, under the West Bengal Municipal (Building) Rules 2007 or the building rules that apply to that Corporation; or a development authority under the West Bengal Town and Country (Planning and Development) Act, 1979 (such as KMDA, SJDA or ADDA) where it grants permission in its planning area, 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 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 the drainage pumping stations and outfalls of low-lying Kolkata and of the canals and outfall channels that carry its storm water to the Kulti, low-lying Howrah, the lower Damodar, Mundeswari, Rupnarayan and Shilabati below the DVC dams including the Ghatal basin, the embanked islands of the Sundarbans, and Siliguri on the Mahananda and the Teesta towns below the Gajoldoba barrage, 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.
Drainage report	The preliminary or final report required by Chapter 10.
Registered professional	A person registered under the KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 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).

Term	Meaning in this Manual
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 Kolkata Gazette.

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

1.5 Applicability

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

- (a) all development requiring planning permission, building permit or layout approval under the KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007;
- (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 West Bengal, 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 as set by rule 144(1) of the KMC Building Rules 2009 in Kolkata (rooftop rainwater harvesting, for direct use or recharge, in the plan of a new or expanded building or housing complex "as per" the Environmental Impact Assessment guideline of the State or Union government), by rule 28(4) of the New Town Kolkata (Building) Rules 2009, as amended in 2021, in New Town (every new building or housing complex, and every expansion), and by the West Bengal Municipal (Building) Rules 2007 in the municipal areas (whose threshold was not read for this Manual [TBC]), 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.

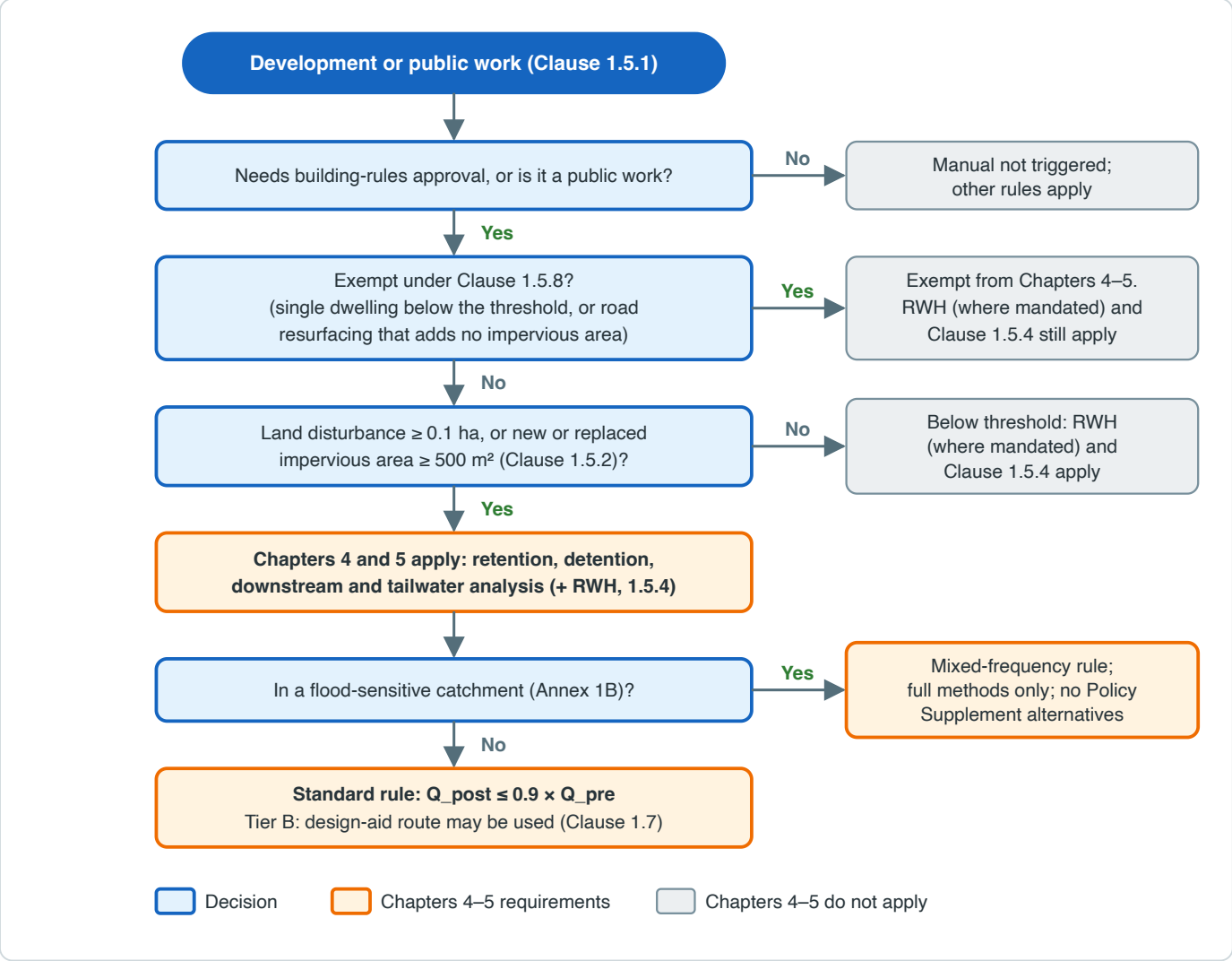

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 West Bengal plots are small and the cumulative effect of many small plots is what fills Kolkata's drains. For small buildings, the KMC Building Rules 2009 set the plinth at not less than 60 cm and so located with respect to the crest of the road that "adequate drainage of the site is assured" (rule 105), and allow the whole site to be raised by up to 600 mm in an area prone to waterlogging, with the Commissioner's permission (rule 76(i)); the West Bengal Municipal (Building) Rules 2007 set the same 60 cm plinth (rule 57(1), as reported).

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 Kolkata Municipal Corporation (KMC);
- (b) every Approving Authority within the Kolkata Metropolitan Area (KMA), for which KMDA is the development authority, or within the planning area of the Siliguri Jalpaiguri Development Authority (SJDA) or the Asansol Durgapur Development Authority (ADDA), as those areas are notified from time to time, including the Howrah and Bidhannagar Municipal Corporations, NKDA in New Town, the Siliguri, Asansol and Durgapur Municipal Corporations, KMDA, SJDA and ADDA where they are the Approving Authority, and the Municipalities in those areas; and
- (c) every other Municipal Corporation constituted under any Act of the State, as constituted from time to time.

1.6.2 **Tier B authorities.** All other Municipalities and Notified Area Authorities 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

Item	Tier A	Tier B
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 UD&MA 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 Kolkata Metropolitan Area (KMA) or the planning area of the Siliguri Jalpaiguri or Asansol Durgapur Development Authority (SJDA, ADDA), 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. Kolkata Municipal Corporation, with its own Sewerage and Drainage Department and drainage pumping stations, and a small Municipality 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 Kolkata.

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 $Q_{post(T)} \le 0.9 \times Q_{pre(T)}$, computed for the site	**Permissible site discharge (PSD):** a tabulated unit-area release rate (m³/s/ha) by zone and AEP, derived from the $0.9 \times Q_{pre}$ 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

No.	Main-text requirement	Adoptable alternative	Eligibility
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
RWH mandates (KMC Building Rules 2009, rule 144; New Town Kolkata (Building) Rules 2009, rule 28(4); West Bengal Municipal (Building) Rules 2007)	Continue unchanged. In Kolkata, rooftop rainwater harvesting is part of the plan of a new or expanded building or housing complex "as per" the State or Union EIA guideline, and tree cover of at least 15% of the land is required on projects of 6,000 m² of floor area or more (rule 144); in New Town it is required in every new building or housing complex and every expansion, with a 15% fee rebate for retrofits (rule 28(4), 2021); the 2007 Rules also require it, but their rule number and threshold were not read for this Manual [TBC]. None gives a storage volume per m² or an outlet rule. RWH storage is not detention unless it is a dedicated empty-on-arrival volume with an outlet, and tanks are assumed full at the start of SW monsoon storms (Chapter 4). Recharge pits may count toward retention where they meet Chapters 4 and 8.
Plinth, site level, roof drainage and basements (KMC Building Rules 2009, rules 76(i), 105, 117 and 118; West Bengal Municipal (Building) Rules 2007, rules 57 and 59)	Continue. The plinth of at least 60 cm and the floor level of Clause 1.5.4(b) both apply; the higher governs. Raising a site by up to 600 mm in a waterlogging-prone area (rule 76(i)) is fill, and is assessed for its effect on storage and flow paths under Chapters 4 and 6. Where the Commissioner requires rain-water pipes to connect to a drain or sewer (rule 117(2)), the connection is made under Chapters 4 and 6, after the retention and detention of Chapter 4. Basements keep out surface drainage and are pumped (rule 118(6)(b)); their pumping is not counted as outlet capacity.

Instrument	Relationship
Drainage-capacity condition (KMC Building Rules 2009, procedure for sanction)	Continues. Where the Commissioner considers that a building "will put additional burden on the existing … sewerage and drainage system", sanction may be subject to conditions; Chapters 4 and 5 give the technical content of such a condition and apply to every development above the thresholds of Clause 1.5.2 whether or not it is invoked.
Kolkata Municipal Corporation Act, 1980 (West Bengal Act LIX of 1980), ss.277, 280, 292, 293, 296 and 400; West Bengal Municipal Act, 1993	Drains vest in KMC (s.280), which must provide a safe and sufficient outfall for storm water and sewage together without flooding Kolkata or the country round the outfall (s.277). No premises may be built or occupied without a drain to the Commissioner's specification (s.293), and blocks within 30 m of a municipal drain may be drained in combination (s.296). The Commissioner may require separate drains for rain water and for sewage (s.292); this Manual's rules for sites that discharge to a combined sewer are in Chapters 5, 6 and 8. Section 400(1) notices are used against unauthorised work, including pond filling. The sections were read from a scanned copy, and quotations are as reconstructed. The drainage sections of the West Bengal Municipal Act, 1993 were not reviewed for this Manual [TBC].
Water bodies and rivers in the municipal areas (West Bengal Municipal (Building) Rules 2007, rule 8)	No canal, pond, water body, wetland, rivulet, jhora, spring, stream, drain or culvert may be filled except for reasons recorded in writing and with the prior approval of the State Government; within 15 m of a river bank, buildings are limited to 5.00 m in height, 20 m in length and 200 m² in covered area, with clear gaps of 15–30 m between them according to the width of the river (as reported). These limits are not a setback: building is not barred within 15 m of the bank. The setback of Chapter 7 (Clause 7.4.7) applies its no-fill zone to all development and is wider where the hydraulic corridor or the mapped 1% AEP extent requires; it is stricter than the statute and is set by this Manual.
West Bengal Town and Country (Planning and Development) Act, 1979 (West Bengal Act XIII of 1979)	Development authorities such as KMDA, SJDA and ADDA prepare land-use and development plans and grant permission in their areas; section 53 restoration notices, followed by police complaints, are KMC's working tool against the filling of ponds (as filed before the National Green Tribunal). Flood-sensitive catchments, drainage corridors and regional facility sites should be shown in the plans. This Manual does not decide zoning. The Act was read only in extracts [TBC].
Ponds: West Bengal Inland Fisheries Act, 1984, s.17A	No person may fill a water area, or depressed land that holds water for six months of the year, to convert it to solid land, or put it to a non-fishery use, without the permission of the Fisheries Department; restoration is at the owner's cost, and the offence carries up to two years' imprisonment, a fine of up to ₹2 lakh, or both. The 1993 threshold of 5 cottahs (0.035 ha) was omitted by the amendment of 2008 (as reported). The Calcutta High Court has held that the authority must first establish that the site is a "water area" (*Anuradha Sen v. Kolkata Municipal Corporation*, 9 January 2024, as reported). Works under this Manual that drain to a pukur shall meet the water-quality rules of Chapter 8, and no work shall reduce its area or storage (Chapter 7).
East Kolkata Wetlands (Conservation and Management) Act, 2006 (West Bengal Act VII of 2006)	The wetlands (the Ramsar site of 12,500 ha) must keep their area and character; a change of use needs EKWMA's sanction and may be only for the improvement or upkeep of the local environment, and a water body filled must be replaced by one of no less area within the wetlands (ss.9 and 10, as reported). Kolkata's outfall channels pass through the wetlands to the Kulti. Works under this Manual that drain into or through them need EKWMA's consent, and no work shall reduce their storage.
West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005 (West Bengal Act XVIII of 2005)	New wells need a permit from the authorities under the Act, administered by SWID (as reported). No recharge or RWH obligation in the Act was found. Recharge wells and deep infiltration under Chapters 4 and 8 are subject to its permits and to the arsenic and salinity limits of Chapter 8.
Flood-prone land	West Bengal has no flood plain zoning law and no flood lines: the CAG recommended that I&WD adopt the model flood plain zoning Bill and found flood works "taken up at different locations … without being linked to a comprehensive plan" (CAG Report No. 2 of 2019). This Manual does not create flood lines. Where the 1% AEP extent of Chapter 7 is mapped, it governs the setback; where a plan zone is wider, the zone governs (Clause 1.3.3).
Wetlands (Conservation and Management) Rules, 2017	Apply to notified wetlands and the Ramsar sites (the East Kolkata Wetlands, Ramsar site from 19 August 2002, 12,500 ha; and the Sunderbans Wetland, from 30 January 2019, 423,000 ha). Where their restrictions are wider than the setback of Chapter 7, they govern (Clause 1.3.3). A State Wetland Authority is reported to be active before the National Green Tribunal; its notification was not read [TBC].

Instrument	Relationship
CRZ Notification 2019, through the Coastal Zone Management Plan in force	The State's plan under CRZ 2019 had not been approved by December 2025: the draft went to the Union Ministry on 4 October 2024, revised plans for Purba Medinipur and North 24 Parganas were sent on 10 September and 29 October 2025, and the South 24 Parganas plan was promised for January 2026, with the 2011 High Tide Line still in dispute on an eroding coast (WBCZMA affidavits before the National Green Tribunal). Until it is approved, the plans prepared under CRZ 2011 apply [TBC]. WBCZMA recommends CRZ clearance for outfalls, drains, sluices and pumping stations in the CRZ. CRZ categories and lines are taken from the approved maps, and govern where wider than Chapter 7 (Clause 1.3.3).
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 West Bengal is framed as a water supply and recharge measure. It works well for that purpose. It cannot, however, be relied on for flood control in the SW monsoon, because RWH sumps are usually full or the ground saturated by the time a July to September monsoon depression or a May or October–November cyclone 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.

Kolkata is spending heavily on drainage. The Kolkata Environmental Improvement Investment Program (KEIIP), financed by ADB from 2013, built sewer-drains, pumping stations and pumping mains and a flood early-warning system, and its unfinished works passed in 2025 to the ADB-financed KMC Sustainability, Hygiene and Resilience project, which plans some 84 km of combined trunk and secondary sewers (ADB, 2016; as reported). These works are **combined**: each pumping station separates the dry-weather flow, but in a storm the storm-water flow, "mixed with sewage", is pumped to the outfall canals (KMC, 2015). That is the system the law describes. The KMC Act 1980 makes the Corporation provide "a safe and sufficient outfall … for the effectual drainage and proper discharge of storm-water and sewage" without flooding the city or the country round the outfall (s.277(1)), vests every public drain in the Corporation (s.280), and lets the Commissioner require "an entirely distinct drain for rain water and unpolluted sub-soil water" (s.292), a power and not a duty (as read from a scanned copy). Where a site discharges to a combined sewer, the requirements of this Manual apply as Chapters 5 and 6 set out. No development-control condition stops new plots in the same catchments from using up the capacity such works create. Linking Chapters 4–5 to approvals closes that gap.

West Bengal's law already holds many of the tools. The KMC plan sanction asks whether the site is a "filled up tank or part tank" and requires the house drains and the "means of communication with any municipal drain" to be shown; KMC enforces against pond filling through notices under section 53 of the West Bengal Town and Country (Planning and Development) Act, 1979 and section 400(1) of the KMC Act, followed by police complaints (as filed before the National Green Tribunal); and the Calcutta High Court has held that KMC must first establish that a site is a "water area" before it acts under section 17A of the Inland Fisheries Act (*Anuradha Sen v. Kolkata Municipal Corporation*, 9 January 2024, as reported). Storm water from Kolkata, Bidhannagar and New Town also reaches

the outfall through canals of I&WD; an outfall to such a canal is designed for the canal's own water level, as for a river (Clause 5.8), and needs the consent of I&WD. None of these instruments says how high a flood reaches or how much storage a filled pond removes; this Manual supplies that technical test.

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 and Municipal Affairs Department (UD&MA)	Would own the Manual. Makes the building rules for Kolkata, for the municipal areas and for New Town, and would issue their amendment (Clause 1.3.1(a)). Would constitute and service the State Stormwater Technical Committee. Oversees KMDA and the other development authorities under the West Bengal Town and Country (Planning and Development) Act, 1979, whose land-use plans should show flood-sensitive catchments, drainage corridors and regional facility sites. Technical support to Tier B authorities, including through the Municipal Engineering Directorate. Maintains the empanelled reviewer list (Clause 10.7).
State Stormwater Technical Committee (Clause 1.3.2)	Adopts higher standards. Issues Annexes, tables and the compliance calculator. Concurs with Tier A alternatives. Decides variances referred to it. Reviews the Manual (Clause 1.12).
Kolkata Municipal Corporation (KMC)	Approving Authority under the KMC Building Rules 2009 in Kolkata. Owner of the public drains and sewage disposal works vested in it (KMC Act, s.280), with the duty to provide a safe and sufficient outfall for storm water and sewage (s.277); runs the combined sewer-drains and the drainage pumping stations through its Sewerage and Drainage Department, and protects ponds through its Environment and Heritage and Building Departments. Would apply this Manual to its own works, including those of KEIIP's successor projects, and decide where separate rain-water drains are required (s.292). Inspects and enforces (Clauses 10.12–10.15).
Kolkata Metropolitan Development Authority (KMDA)	Development authority for the Kolkata Metropolitan Area under the 1979 Act. Its land-use notifications bar a change in the use of land, including ponds, without permission (as cited in KMC's notices). Should reserve drainage corridors and regional facility sites in its plans; applies this Manual to the drains and canals it builds. Member of EKWMA.
Howrah Municipal Corporation and Bidhannagar Municipal Corporation	Approving Authorities in their areas (Bidhannagar under the Salt Lake chapter of the 2007 Rules; Howrah under the rules that apply to it [TBC]). Owners of the municipal drains and pumping in their areas. Would provide outfall levels and pump operating rules for tailwater (Chapter 5). Receive handed-over assets (Clause 10.14). Inspect and enforce (Clauses 10.12–10.15).
New Town Kolkata Development Authority (NKDA) and West Bengal Housing Infrastructure Development Corporation (WBHIDCO)	NKDA is the Approving Authority in New Town under the New Town Kolkata (Building) Rules 2009, and would apply this Manual to its drains. WBHIDCO develops New Town and its infrastructure, and would apply this Manual to its works and hand drains over to NKDA (Clause 10.14).
Siliguri Jalpaiguri Development Authority (SJDA) and Siliguri Municipal Corporation	SJDA plans its area; Siliguri Municipal Corporation approves buildings and owns the drains within the city, for which it sought a drainage master plan covering all 47 wards in 2022 (as reported). Their roles were not researched further for this Manual [TBC].
Asansol Durgapur Development Authority (ADDA) and Asansol Municipal Corporation	ADDA plans its area; Asansol Municipal Corporation approves buildings and owns the drains within the city. Their roles were not researched for this Manual [TBC].
Municipalities and Notified Area Authorities	Approving Authorities under the West Bengal Municipal (Building) Rules 2007, through the Board of Councillors (as reported). Owners of the public drains vested in them. Inspect and enforce (Clauses 10.12–10.15).

Agency	Role under this Manual
Irrigation and Waterways Department (I&WD)	Rivers, embankments (about 3,122 km in the Sundarbans), sluices, the outfall channels and canals of the Kolkata area and the pumping at Kulti and on the I&WD channels; flood schemes such as the Ghatal Master Plan. Provides design water levels and tailwater (Chapters 5 and 7). Consents to outfalls into its canals and drainage works. Holds rain-gauge and river-gauge records (Annex 2A).
Damodar Valley Corporation (DVC)	A statutory body of the Union, not of the State. Operates the dams at Maithon and Panchet, whose releases set the tailwater on the lower Damodar, the Mundeswari and the Rupnarayan. Would be asked for release scenarios for Chapter 5; this Manual places no duty on it.
West Bengal State Disaster Management Authority (WBSDMA), the Department of Disaster Management and Civil Defence and the District Disaster Management Authorities	Hazard and flood mapping. Notify or recommend flood-sensitive catchments. Pre-monsoon preparedness. Lead the post-event review (Clause 10.16), using their flood records.
State Water Investigation Directorate (SWID)	Administers the West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005. Advises on groundwater levels, recharge, infiltration, arsenic and coastal salinity (Chapters 3, 4 and 8).
West Bengal Pollution Control Board (WBPCB)	Consents to establish and operate for local-authority drainage and sewerage works. Regulates discharges of sewage into canals, rivers and storm drains. Supports the removal of sewage connections to storm drains and the treatment of combined flows (Chapter 8).
Syama Prasad Mookerjee Port, Kolkata	A major port of the Union. Holds land and docks on the Hooghly front; the Hooghly tide tables are published for the port (as reported). Would be consulted where an outfall, river-front work or tide gate lies within port limits; its role at urban outfalls was not researched for this Manual [TBC].
West Bengal State Coastal Zone Management Authority (WBCZMA)	Recommends CRZ clearance for outfalls, drains, sluices and pumping stations in the CRZ of Purba Medinipur and the two 24 Parganas. Advises on CRZ categories and the HTL from the Coastal Zone Management Plan in force.
East Kolkata Wetlands Management Authority (EKWMA)	Manages the East Kolkata Wetlands under the 2006 Act. Its sanction is needed for any change of use in the wetlands. Consulted on any outfall or channel work that passes through them (Chapters 5 and 7).
Land and Land Reforms Department, the Fisheries Department and the District Magistrates	Maintain the land records of ponds, khals and government land used for setbacks and storage, which are the starting point for the waterbody inventory of Chapter 7. The Fisheries Department grants the permission needed under section 17A of the Inland Fisheries Act before a water area is filled or converted.

Commentary. Ownership of West Bengal's drainage is split. Inside Kolkata the drains vest in KMC, but the outfall channels and canals that carry the city's storm water to the Kulti, and the pumps at their tail, belong to I&WD, and the exact boundary between the two on the khals was not found in research for this Manual. The channels pass through the East Kolkata Wetlands, which EKWMA manages. On the lower Damodar the river that receives the drains is set by the releases of DVC, a Union body, from dams in Jharkhand, and in September 2024 the State publicly disputed those releases (as reported). Sundarbans towns drain through sluices in embankments maintained by I&WD. Recent reports indicate a change of State government after the 2026 Assembly election; this Manual names departments and authorities as the statutes 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. A site that drains to the Hooghly or to the outfall channels east of Kolkata through a lock gate or sluice, as at Chitpur and Dhapa, or to a Sundarbans creek through a sluice in an embankment, does not discharge to a tidal reach for this clause, because the gate is closed whenever the water outside is higher than the water behind it; nor does a site whose drainage reaches the outfall only by pumping.

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 Kolkata a count from satellite imagery found about 4,889 ponds where an earlier NATMO survey had found some 8,731, a loss of about 44% (as reported), although section 17A of the West Bengal Inland Fisheries Act, 1984 has barred the filling of water areas since 1994.

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 Kolkata Metropolitan Area and of the Siliguri Jalpaiguri and Asansol Durgapur planning areas
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model KMCBR/WBMBR 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 West Bengal. Where a Municipal Corporation, a Municipality, NKDA or a development authority has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in West Bengal trace to the rainfall input, not the hydraulics. West Bengal shows how. No design-intensity table or IDF relationship was found for any city in the State in research for this Manual. Kolkata's first brick sewer (1876) was designed for 6.35 mm of rain an hour, and the attempt in the 1970s to raise it to 12.7 mm an hour was not achieved (Gupta, 2005), while single hours of the city's storms reach about 100 mm (Dum Dum, 24 August 1987; Alipore, 23 September 2025). The metropolitan drainage master plan was based on a storm of "once in two months", six times a year, with 70% imperviousness, and the curve drawn for it "has been adopted by KMDA / ULBs" (CPHEEO); the curve itself was not found. The KEIIP environmental reports state no design intensity, return period or runoff coefficient (KMC, 2015). The two published sources that seem to fill the gap do not. IMD Das et al. (2022) has no panel for any West Bengal station. NIH-DHAARA's reanalysis-based 24-hour depths agree with the CWC plates near Kolkata but are about twice the plate values and the gauge records at Siliguri and Cooch Behar (Clause 2.3.6). Fixing one transparent source and method for the whole state is the main purpose of this chapter.

2.2 Definitions

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

Term	Meaning in this Manual
Design storm	A hyetograph (rainfall depth versus time) of stated AEP, duration and temporal pattern.
Critical duration	The storm duration that produces the largest peak flow, water level or storage requirement for the element being designed.
Areal reduction factor (ARF)	Ratio of catchment-average rainfall to point rainfall for the same AEP and duration.
SW monsoon season (JJAS)	June–September, when the State receives about three-quarters of its annual rainfall: a State mean of 1,418.7 mm in June–September out of 1,851.4 mm a year, for 1989–2018 (IMD, 2020). Annual means range from about 1,259 mm in Nadia and 1,852 mm in Kolkata to 3,334 mm in Darjeeling and 3,721 mm in Jalpaiguri (IMD, 2020). Onset is in the first week of June in most districts and in the third week in Purulia, and withdrawal in the fourth week of September (ICAR-CRIDA). The antecedent moisture rule of Clause 2.11.4 refers to this season; the pre-monsoon deadline of 15 May is set ahead of both this season and the May cyclones.
Pre-monsoon and cyclone months (May, October and November)	Months outside the season in which nor'westers, and cyclones and depressions from the Bay of Bengal, bring some of the State's largest storms. With the SW monsoon season they form the design season of this Manual: no design storm, works deadline or operating rule shall assume that heavy rain is confined to June–September. In the delta, rain in May is "of the same order as that in the month of October" (CWC, 1994). May records include 220.0 mm in 24 hours at Dum Dum on 8 May 1949, 295.1 mm at Contai on 28 May 1960, 353.2 mm at Cooch Behar on 28 May 1989, 312.8 mm at Jalpaiguri on 24 May 1999 and 290.7 mm at Diamond Harbour on 27 May 1993, the last that station's all-time 24-hour record; October and November records include 419.2 mm at Kalimpong on 5 October 1968, 325.1 mm at Midnapore on 17 October 1942 and 286.3 mm at Berhampore on 31 October 1917, each the station's 24-hour record (IMD). Cyclones Aila (25 May 2009), Amphan (20 May 2020), Yaas (26 May 2021) and Remal (26 May 2024) all struck in late May. Design statistics use annual maxima from all seasons, and Clause 2.11.4 applies AMC III to the design storms of these months in the Coastal belt and Sundarbans zone.
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 West Bengal this clause is suspended until Annex 2A is published: Clause 2.3.6 sets the interim source.

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

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

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

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

- (a) the IMD isopluvial / IDF values of Das et al. (2022), *MAUSAM* 73(4), for durations of 1–24 h;
- (b) for catchments of 25–5,000 km², the 24-hour point rainfall from the CWC Flood Estimation Report for subzone 1(f) (Middle Ganga Plains), 1(g) (Lower Ganga Plains) or 2(a) (North Brahmaputra), as applicable.

Where the design value is lower than the CWC 1(f)/1(g)/2(a) 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.

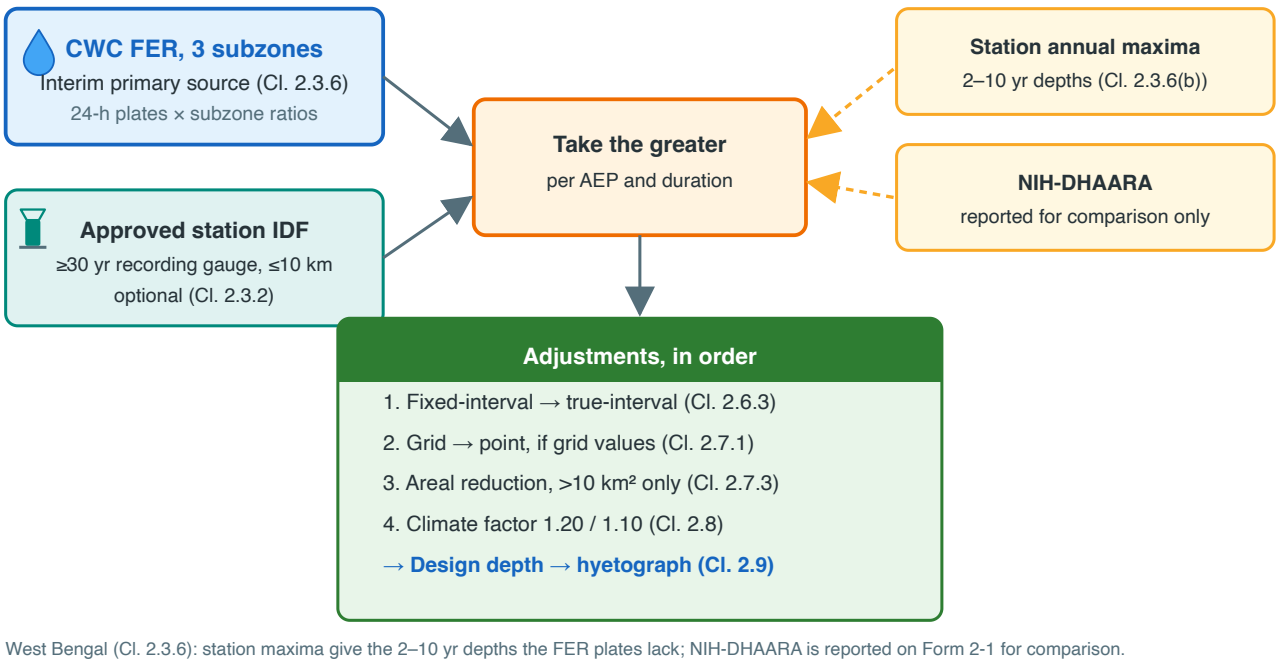

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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

- (a) **24-hour depth, 4%, 2% and 1% AEP (25-, 50- and 100-yr).** The 24-hour point value at the site read from the isopluvial plates of the CWC Flood Estimation Report for the subzone that contains the site, whatever the catchment area: 1(g) (Lower Ganga Plains, revised 1994) in all of south Bengal, from Birbhum and Murshidabad to the coast, in both its hilly region (Purulia, the west of Bankura and the Asansol–Durgapur area) and its plain region (the delta, including the Kolkata Metropolitan Area), which is most of the State; 2(a) (North Brahmaputra) in the Teesta, Jaldhaka and Torsa basins, in Darjeeling, Kalimpong, Jalpaiguri, Alipurduar and Cooch Behar districts; and 1(f) (Middle Ganga Plains) in Malda, Uttar Dinajpur and Dakshin Dinajpur and on the Mahananda side of Siliguri (Annex 2A). Within 5 km of a subzone boundary, and wherever the plates of two reports cover the site, the higher of the two plate values is used; Siliguri lies on the boundary of 1(f) and 2(a), and the higher value is used throughout the area of the Siliguri Municipal Corporation. Where no plate for one of these AEPs can be read for the site, the depth for that AEP is the station estimate of (b), and is recorded as such on Form 2-1. For orientation only, the plates give about 280–320 mm at Kolkata and Howrah, 320–360 mm at Haldia and Diamond Harbour, about 360 mm at Digha and Contai, 200–240 mm at Asansol and Durgapur, 240–280 mm at Purulia, 280–360 mm at Malda, about 320 mm at Siliguri, 360–400 mm at Jalpaiguri and Cooch Behar, and more than 480 mm in the Buxa–Jayanti duars for the 50-year storm.
- (b) **24-hour depth, more frequent AEPs (2-, 5- and 10-yr).** The reports have no plates for these. The depth is the Gumbel (EV1) estimate from the annual maximum daily rainfall series, of all months, of the IMD station agreed with the Authority, multiplied by the fixed-interval factor of Clause 2.6.3. In the Kolkata Metropolitan Area it is the

higher of the estimates for Kolkata (Alipore), 42807, and Kolkata (Dum Dum) (A), 42809; elsewhere the station is, for example, Bagdogra (A), 42398, for Siliguri; Jalpaiguri, 42399; Cooch Behar (A), 42403; Malda, 42503; Bankura, 42707; Haldia, 02206; or Darjeeling, 42295; or else the nearest IMD station with 30 or more years of record, from the candidates in Annex 2A.

- (c) **48- and 72-hour depths.** The Gumbel estimate from the annual maximum 2-day and 3-day rainfall series of the same station or stations, with the fixed-interval factors of Clause 2.6.3, and not less than the 24-hour depth for the same AEP.
- (d) **Durations shorter than 24 hours.** The 24-hour depth multiplied by the ratios of the report for the site's subzone in Table 2B.1, at every AEP. The 1-hour ratio is 0.350 in 1(g), 0.260 in 2(a) and 0.31 in 1(f). Where (a) takes the higher of two subzones, the depth at each duration is the higher of the two products. Between the tabulated durations the ratio is interpolated on logarithmic axes. Below 1 hour, the ratio is agreed with the Authority and recorded on Form 2-1 until Annex 2B gives one.
- (e) **Short storms.** In the Kolkata Metropolitan Area the 1-hour depths given by (d), about 98–112 mm for the 50-year storm, are close to the largest hourly falls on record, 100 mm at Dum Dum on 24 August 1987 and 98 mm at Alipore on 23 September 2025. The recorded 3-hour falls, 207 mm at Dum Dum on 25–26 August 1984 and 185.6 mm at Alipore on 23 September 2025, exceed the 50-year 3-hour depths of (d), about 144–165 mm; and the 24-hour records at Alipore (369.6 mm, 28 September 1978) and Dum Dum (383.2 mm, 6 June 1984) exceed the 100-year plate value, about 320–360 mm (IMD; CWC). Whether the plates understate the extremes of the delta is not resolved; a frequency analysis of the Alipore and Dum Dum recording-gauge series under Annexes 2A and 2B is needed to show it. Until Annex 2B is published, the depths of (d) are used as they stand, and are not reduced towards NIH-DHAARA.
- (f) **NIH-DHAARA.** Its present-day values at the site are reported on Form 2-1 beside the interim values, for comparison only. Its projected depths are not used under Clause 2.8.4; the ratio of its projected to its present-day depths may be reported as a check on the climate factors of Table 2.2, which apply.
- (g) **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 West Bengal the platform does not yet meet that purpose. Its present-day values there come from IMDAA reanalysis (about 12 km) for 2000–2022, not from gauges. Near Kolkata they agree with the CWC report: about 294 mm for the 50-year 24-hour depth against about 280–320 mm on the 1(g) plates, and about 90 mm for the 50-year 1-hour depth, close to the 98 mm Alipore hour of 23 September 2025 and the 100 mm Dum Dum hour of 24 August 1987. In the north and on the coast they are far higher than the plates and than any gauge record: about 677 mm at Siliguri against about 320 mm, 790 mm at Cooch Behar against about 360–400 mm (the IMD station record there is 417.3 mm), 533 mm at Jalpaiguri against about 360–400 mm, and 631 mm at Digha against about 360 mm (Digha's record is 325.3 mm and Contai's 447.1 mm) (NIH-DHAARA, queried 6 Nov 2026; IMD; CWC). A source that matches the gauges in one part of the State and doubles them in another cannot be adopted zone by zone until the benchmark checks of Annex 2A show where it holds. Clause 2.3.6 therefore uses the CWC reports and the long IMD station records until Annex 2A has been done, and uses NIH-DHAARA for comparison and as a check on the climate factors only. The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the subzone boundaries, the Siliguri and Kolkata rules and durations between the tabulated ratios are set by this Manual. Two points in the reports are unresolved: the 1(f) report was read only through an OCR text of the scanned copy, so its ratios and plate values are to be checked against the page images before Annex 2B is issued [TBC]; and the 1(g) ratios were derived for the 10-year storm, the report stating that those for longer return periods are "comparable". IMD Das et al. (2022) has no panel for any West Bengal station, so the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available; its range for the Gangetic Plain as a whole (4–16 cm in 1 hour and 12–42 cm in 24 hours, for 2–100 years) is too wide to serve as a check.

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

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

2.5 Design durations

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

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

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

> Commentary. West Bengal's worst rainfall floods have come from long spells. On 26–29 September 1978 a monsoon depression gave 369.6 mm in a day at Alipore, 409.3 mm at Uluberia, 400.0 mm at Suri and 387.7 mm at Durgapur, and September 1978 is the wettest month on record at Uluberia, Durgapur and Suri (IMD); the gauge

at Durgapur took 388 mm in 24 hours, of which 308 mm fell in 12 hours (CWC, 1994). In September 2024 days of rain over the Damodar basin filled the DVC reservoirs, and their combined release then peaked at about 2.5 lakh cusecs on 17 September (as reported). Monthly totals show the scale: Alipore recorded 1,157.0 mm in September 1900, Uluberia 1,066.6 mm in September 1978 and Bagdogra, by Siliguri, 2,524.1 mm in June 1995 (IMD). 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 West Bengal recording gauges. They shall not be lower than the ratios of the CWC Flood Estimation Report for the subzone. IMD Das et al. (2022) has no West Bengal station panel and is not used as a floor in West Bengal.

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

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

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

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

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

2.7 Point, grid and areal rainfall

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

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

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

- for 25–5,000 km² in subzone 1(f), 1(g) or 2(a): use the ARF curves of the applicable CWC Flood Estimation Report;
- for 10–25 km²: interpolate linearly between ARF = 1.0 at 10 km² and the CWC value at 25 km².

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

> **Commentary.** Gridded and district-average return levels are much lower than point values. For example, NIH-DHAARA's IMDAA cell at Dum Dum gives a 50-year 24-hour depth of about 244 mm, some 15% below the 280–320 mm of the CWC isopluvials, although the Dum Dum gauge has recorded 383.2 mm in a day; and on 23 September 2025 a KMC gauge at Garia was reported to have taken 332 mm while the IMD gauge at Alipore took 251.4 mm (NIH-DHAARA, queried 6 Nov 2026; IMD; CWC; as reported). In West Bengal the reanalysis cells also err the other way: in the north and on the coast they give up to about twice the plate values and the gauge records, as at Siliguri and Cooch Behar (Clause 2.3.6). Neither error can be corrected without the factors of Annex 2C. Using grid values as point values without correction would make site-level design unsafe.

2.8 Climate factor

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

Table 2.2 — Interim climate factors

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

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

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

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

> **Commentary.** CPHEEO (2019) considers a fixed climate factor "not feasible" nationally and recommends trend testing instead. That leaves designers without a usable number. The 1.20 short-duration factor matches the UK value cited by CPHEEO itself. It is at or below published projections for India: Ali and Mishra (2018) project 3-hourly 100-year maxima rising by about 20% at 1.5 °C and 25% at 2.0 °C of warming. No West Bengal or city design uplift factor was found. IMD's monograph for the State found, for 1989–2018, a significant increase in heavy-rainfall days in Alipurduar, Jalpaiguri, Kalimpong, Purulia, Bankura, both Medinipurs and both 24 Parganas, a decrease in Malda, Nadia and Murshidabad, and no significant change in Kolkata district (IMD, 2020). Kolkata's short-duration extremes are not new: the 207 mm that fell at Dum Dum in 3 hours in August 1984 exceeds the 185.6 mm of September 2025 (CWC, 1994; IMD, 2025). Two studies that include Kolkata in non-stationary IDF analyses (Vinnarasi and Dhanya, 2022; Ghate and Timbadiya, 2023) were not read. NIH-DHAARA's bias-corrected CMIP6 runs could give a ratio of future to present depths; none has yet been computed for this Manual, and under Clause 2.3.6(f) it would serve only as a check. The factors of Table 2.2 are therefore interim values, not West Bengal estimates.

2.9 Temporal patterns (design hyetographs)

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

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

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

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

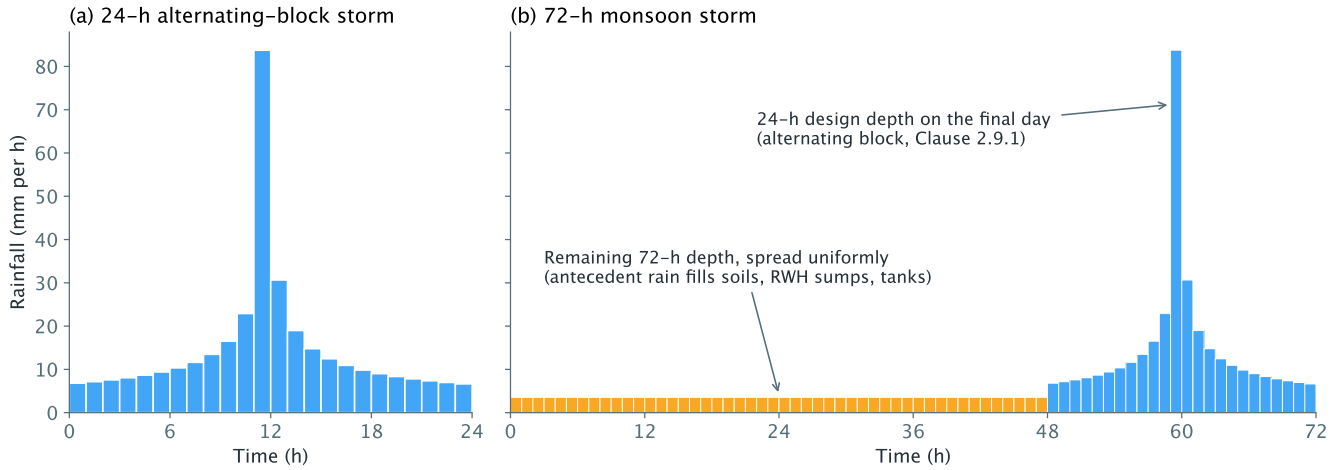

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour SW monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from West Bengal 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 West Bengal sequence: in September 1978 the heaviest falls came on 27–28 September after days of rain, and by the time they arrived the pukurs, khals and fields of the delta were full and its clay soils saturated. The same sequence fills the DVC reservoirs whose releases then govern the river tailwater, as in September 2024, and in Kolkata it fills the outfall channels whose levels limit the pumps. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in West Bengal 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 low-lying wards of Kolkata and its outfall-channel catchments, Howrah, the lower Damodar and Ghatal, the Sundarbans islands, and Siliguri and the Teesta towns, 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 of June–September at a site in zone WB-Z1 (Darjeeling–Kalimpong hills) or WB-Z2 (Terai and Duars) of Annex 2A, and for every design storm of July–September elsewhere in the State, whatever its duration. Use AMC III also for every design storm of the cyclone months, May and October–November, at a site in zone WB-Z6 (Coastal belt and Sundarbans). Use AMC II (average conditions) for every other storm, including those of June outside WB-Z1 and WB-Z2.

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

Commentary. Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that SW monsoon extremes arrive after weeks of rain. In West Bengal this holds for short storms too. The deltaic clays of Kolkata, Howrah and the 24 Parganas have a high water table through the season, and the CWC design loss rates, 2.7 mm/h in subzone 1(g) and 2.4 mm/h in 2(a) (CWC, 1994; CWC, 1991), are low, as they would be on saturated clays. North Bengal is wetter and its season longer: Jalpaiguri's annual mean is 3,721 mm and Cooch Behar's 3,050 mm (IMD, 2020), and its monsoon begins in early June. The cyclones of May and October–November come with days of rain from the same system and the surge that closes the outfalls. This Manual therefore uses AMC III for every design storm of June–September in the north (zones WB-Z1 and WB-Z2), of July–September elsewhere, and of the cyclone months on the coast (zone WB-Z6), and AMC II otherwise (Clause 2.11.4). These are interim choices set by this Manual; no West Bengal study 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 the Gangetic delta near Kolkata 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.

Kolkata drains away from the Hooghly: the bank of the river is a natural levee and the land slopes east, so most of the city's storm water is pumped into outfall channels that run through the East Kolkata Wetlands to the Kulti outfall on the Kultigang, a channel of the tidal Raimangal estuary (I&WD). Cases (a) and (b) are therefore run at every pumping station and lock that discharges to those channels or to the Hooghly, with the tailwater of Chapter 5: the tidal level in the Kultigang plus the hydraulic gradient of the channel for the eastern outfalls, and the Hooghly level for the river outfalls. KEIIP records that one Kolkata pumping basin stays flooded because "discharge through the outfall is partially achieved due to high water levels in the canal, particularly during tidal period" (KMC, 2015). Howrah lies lower than the Hooghly (CPHEEO), and in Howrah, Hooghly and Purba Bardhaman districts the tailwater is the Damodar, Mundeswari or Rupnarayan level under DVC release scenarios as well as the tide. At Haldia, Diamond Harbour, Digha and the

Sundarbans towns the tailwater is the estuary or the sea, where the tide range reaches about 17 ft (5.2 m) at the mouth of the Hooghly (CWPRS) and the 100-year extreme sea level at Diamond Harbour is 3.79 m above mean sea level (INCOIS, 2025); levels are taken on a stated datum (chart datum, mean sea level or the Kidderpore Old Datum), as Chapter 5 requires. In North Bengal, at Siliguri and Jalpaiguri, the tailwater is the Mahananda or Teesta level, not the sea.

> Commentary. On the Bengal coast the coincidence is on record. During Aila, on 25 May 2009, the surge at Sagar Island was reported as about 3.3 above the predicted level (the unit is not stated), "exacerbated by the occurrence of the new moon the day after" (I&WD); Yaas, on 26 May 2021, came at a perigean spring tide, with a surge reported at more than 2 m above the astronomical tide at Digha and in the Sundarbans (as reported); and in Kolkata the flooding of 23 September 2025 was blamed partly on a high tide in the choked canals (as reported). INCOIS puts the tidal maximum at Diamond Harbour at 2.57 m and the 100-year extreme sea level at 3.79 m above mean sea level, rising to 4.34 m (SSP2-4.5) or 4.46 m (SSP5-8.5) by 2100 (INCOIS, 2025). Mean sea level at Diamond Harbour rose by 3.73 mm a year over 1948–2015 and at Haldia by 2.62 mm a year over 1971–2023 (PSMSL), while parts of Kolkata subsided by 2.8–5.5 mm a year in 2017–2022 (Thakur et al., 2026): relative sea-level rise at a Kolkata outfall adds both. The levels of the sources are on different datums, which is why Chapter 5 requires every level to name its datum. Because rainfall and surge share a weather cause (the cyclones of the Bay of Bengal that bring the heaviest coastal rain also drive the surge, and the recent ones have struck near spring tides: Aila in May 2009, the day before a new moon, and Yaas in May 2021, at a perigean spring tide), 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.

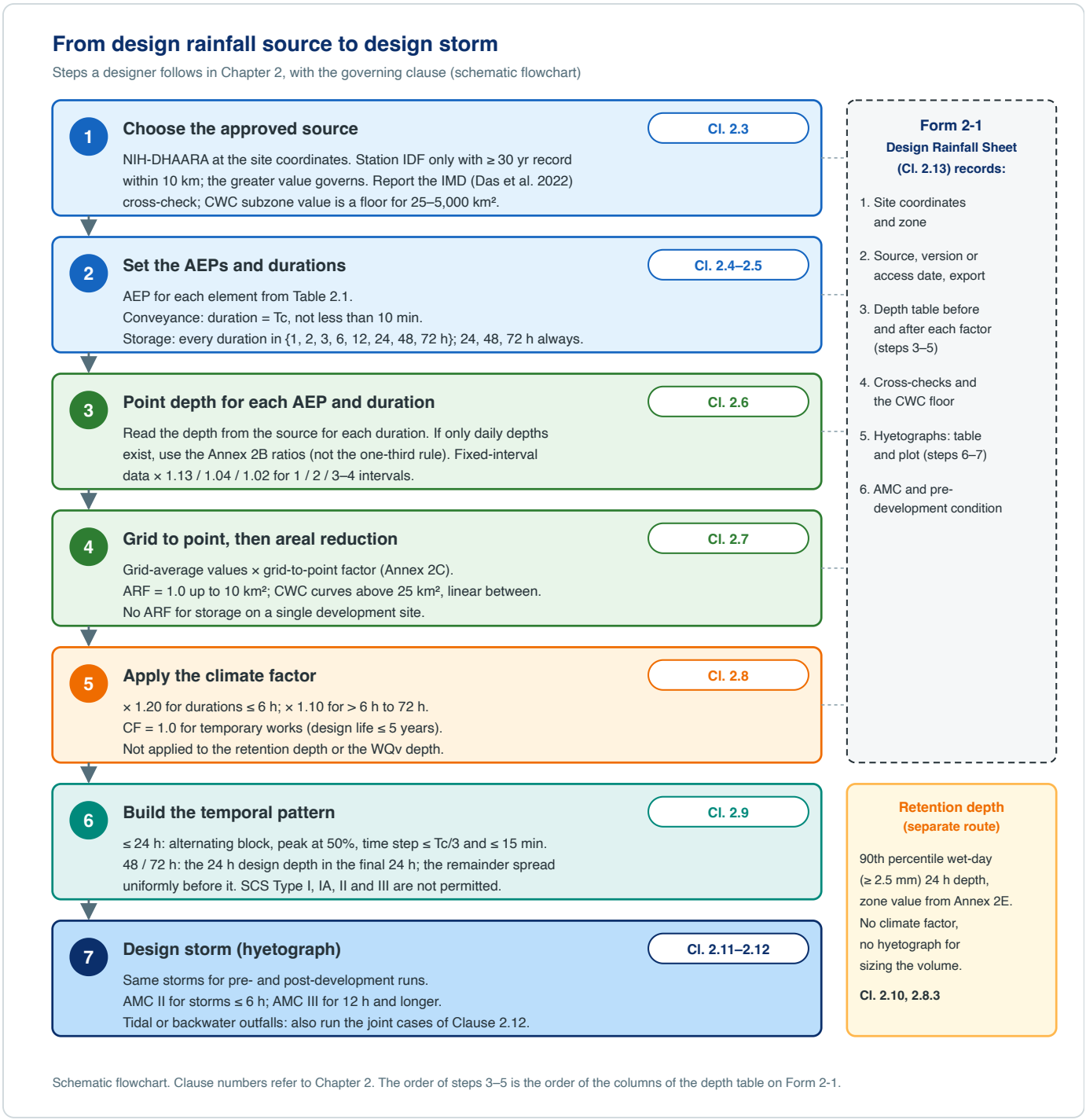

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the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

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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	West Bengal 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 deltaic clays, alluvium and lateritic soils of West Bengal, where an HSG A to C jump would be excessive. The 35% minimum imperviousness for unplanned upstream land in 3.3.5(a) is the APWA value (2011, §5602.3E.2). Using the master-plan land use for conveyance follows CPHEEO, which requires C to reflect "ultimate development of the catchment as per the master plan" (CPHEEO 2019, Part A §4.4.1.5).

3.4 Selection of method

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

Table 3.1 — Permitted hydrologic methods

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

Purpose	Catchment / condition	Permitted method	Clause
Pipe or drain network with backwater, tidal or tank tailwater	Any size	Hydrograph method with dynamic-wave hydraulic routing	3.12.4; Chapter 5
Catchment-scale flows	25–5,000 km² in CWC subzone 1(f), 1(g) or 2(a)	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

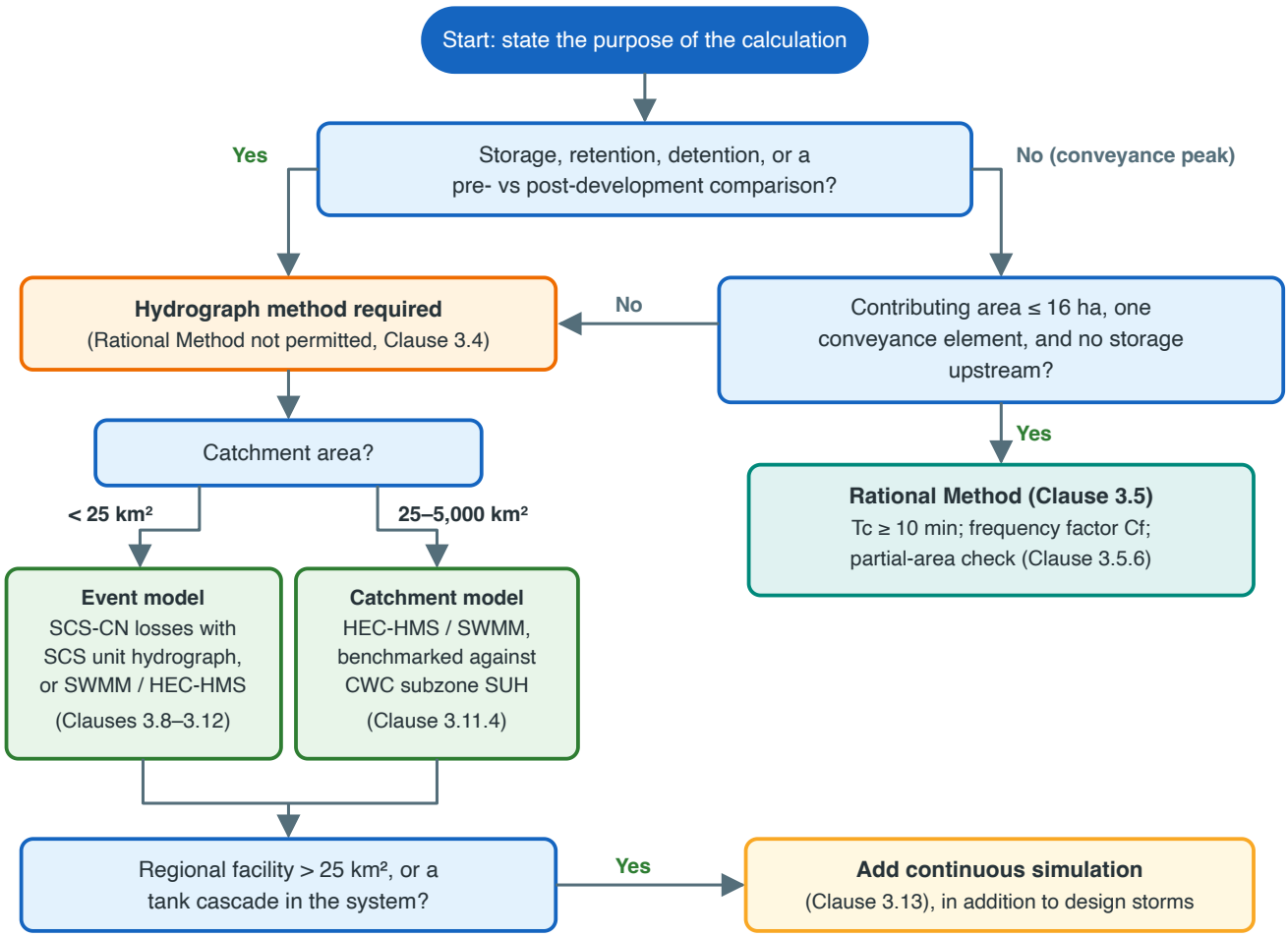

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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 Irrigation and Waterways Department (I&WD).

> **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

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

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

Table 3.3 — Frequency factor Cf

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

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

3.5.5 **Time of concentration and networks.**

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

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

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

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

3.6 Time of concentration

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

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

- (a) **Sheet flow:**

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

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

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

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

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

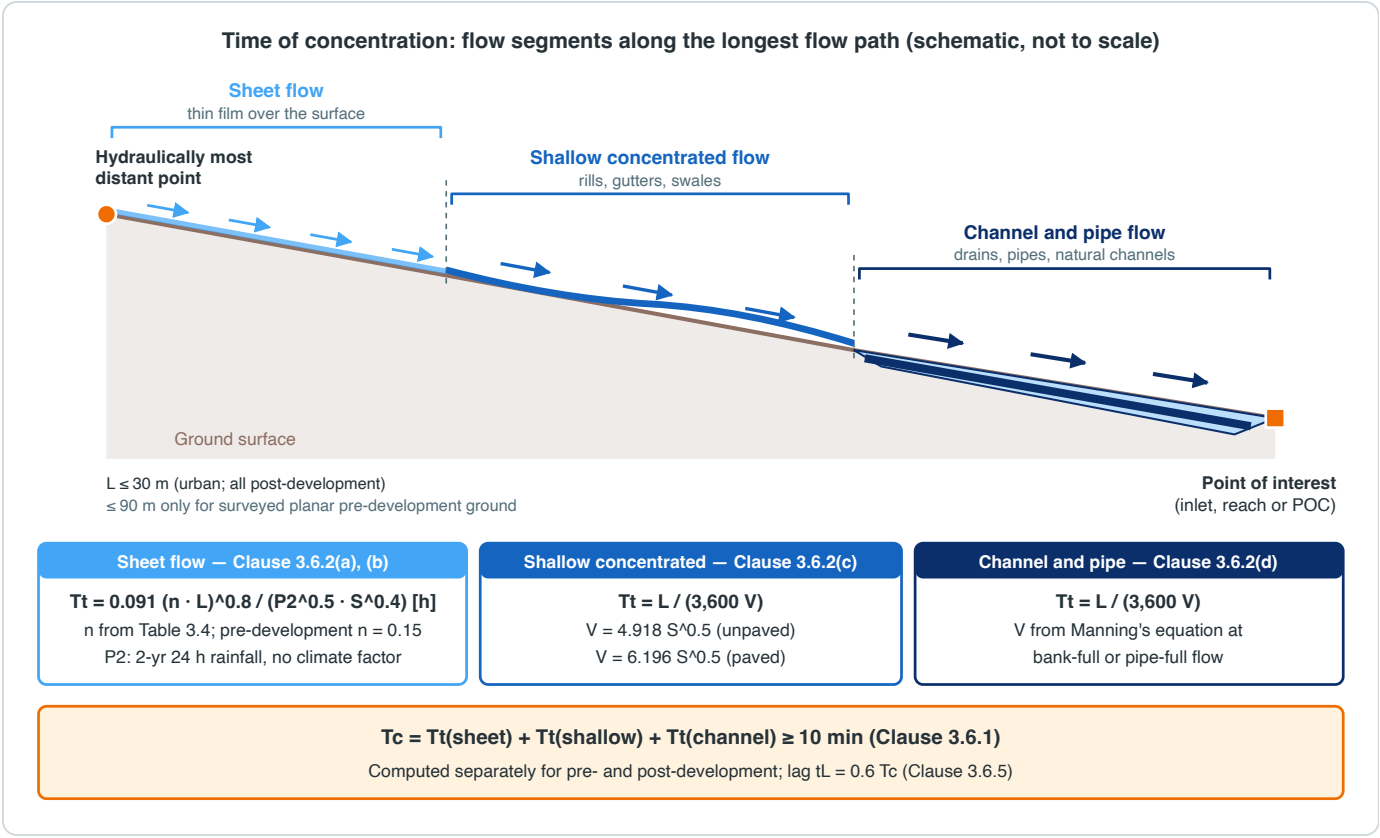

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986),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

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

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

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

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

```
tc = 0.0195 L^0.77 S^−0.385
```

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

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

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

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

3.7 Soils and hydrologic soil groups

3.7.1 **Mapping.** HSG shall be assigned from the soil series mapped by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) or the State agricultural universities of West Bengal, 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 West Bengal: the deltaic clays, including the clays of Kolkata, Howrah and the North and South 24 Parganas, HSG D, because the water table in them stays high through the SW monsoon; the saline soils of the Sundarbans and the coastal belt, HSG D; the deep clays of the Tal lowlands of Malda, HSG D; clay loams of the delta and the plains, HSG C; the clay-loam uplands of the Barind, HSG C; the loamy alluvium of Nadia, Murshidabad and the Malda Diara, HSG B, or HSG C where a field infiltration test gives less than 6 mm/h; the lateritic and red gravelly soils of the western plateau, HSG C, because they crust and are shallow, or HSG D where hard laterite or rock lies within 50 cm of the surface (NEH Part 630, Ch. 7); the sandy loams of the Terai, HSG B; the brown forest soils of the Darjeeling–Kalimpong hills, HSG C, because they are shallow over rock; the coastal dune sands of Digha and Contai, HSG A; and made ground, including the fill on which Salt Lake (Bidhannagar) and New Town were built over former wetland, HSG D unless a field test shows otherwise. A field infiltration test is required on every site larger than the limits of the simplified method of Clause 4.14.1; on smaller sites, loamy alluvium that has not been tested shall be taken as HSG B only where a trial pit shows no clay layer within 1 m of the base of the facility, and otherwise as HSG C. 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 coastal dune sands of Digha and Contai and on the sandy loams of the Terai, where the mapped HSG can be A or B while the seasonal water table makes the soil behave as D during the SW monsoon (Clause 3.10), and on the loamy alluvium of Nadia, Murshidabad and the Malda Diara, where a clay lens can turn a B soil into a C soil. The district soil tables show how much of the State is fine-textured: clayey and clay-loam soils make up 50% of South 24 Parganas, 65% of Howrah and of Hooghly and 98% of Purba Medinipur; deep clay to clay loam in the Tal lowlands is 30% of Malda, with the Barind clay-loam uplands 40% and the sandy loam to loam of the Diara 30%; deep loams are 87% of Nadia and loams 74% of Murshidabad; moderately deep to deep red soils and shallow to moderately deep loams cover Purulia; and in Jalpaiguri and Alipurduar shallow to moderately coarse loams make up 43%, deep clayey soils 31% and deep clay loams 19% (ICAR-CRIDA district contingency plans; some of the tables are internally inconsistent, and there is no table for Kolkata or North 24 Parganas). The CWC reports describe red and yellow soils in the west of subzone 1(g), alluvium in the east, mixed red, black and laterite soils in the south, and deltaic alluvium near the mouth of the Hooghly (CWC 1994), and a belt of terai soil through the middle of subzone 2(a), with brown hill soils above it (CWC 1991). No measured infiltration rates or HSG mapping for West Bengal's soils, and no NBSS&LUP soil-series map of the State, were obtained during research for this Manual, and the CGWB data portal could not be reached [TBC]. The only regional evidence of losses is the design loss rates of the CWC Flood Estimation Reports, which were fitted to monsoon floods on natural catchments: 2.7 mm/h in subzone 1(g), 2.4 mm/h in subzone 2(a) and, as read by optical character recognition, 3.0 mm/h in subzone 1(f) (Annex 3E). These are about half the rates of the reports for western India, and are consistent with HSG C and D soils at monsoon saturation. A test on dry, cracked clay or on crusted laterite misstates its wet-season capacity, so the field test should be a pit or borehole infiltration test at the depth of the proposed facility, made after pre-wetting. The interim groups of Clause 3.7.2, the 6 mm/h threshold, HSG D for the deltaic clays, the saline soils, the Tal lowlands and made ground, and the clay check for untested alluvium are set by this Manual pending a soil-series lookup for West Bengal's districts.

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 of the SW monsoon season, whatever its duration, from June to September at a site in the Darjeeling–Kalimpong hills or the Terai and Duars (Zones WB-Z1 and WB-Z2 of Annex 2A) and from July to September elsewhere; AMC III also for every design storm of the cyclone months, May and October–November, at a site in the Coastal belt and Sundarbans (Zone WB-Z6); and AMC II for other storms, including those of June outside Zones WB-Z1 and WB-Z2. CN for AMC I and III shall be obtained from AMC II by:

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

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.

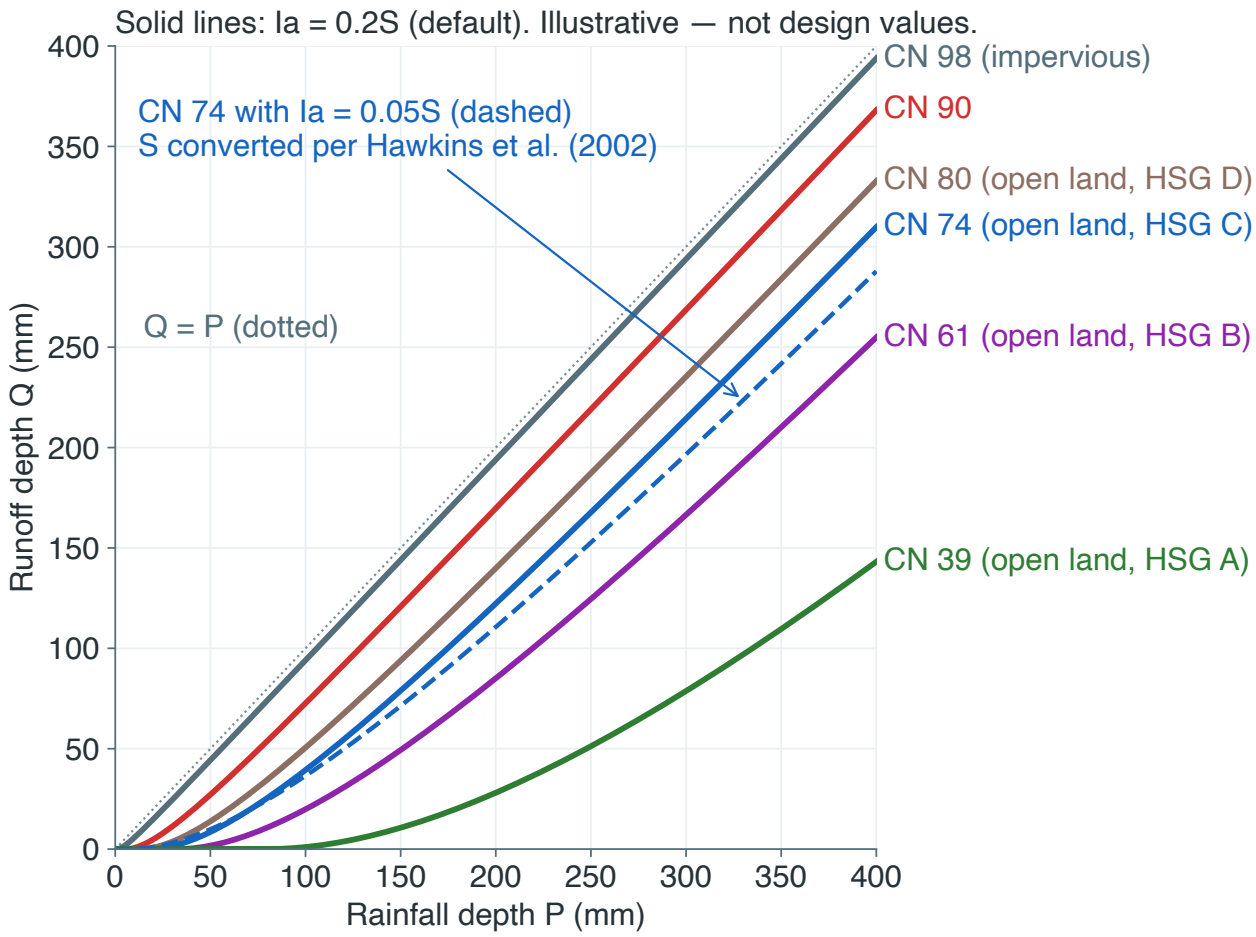

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion 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 West Bengal. The AMC conversion equations are the standard NEH-4 relationships as given by Chow, Maidment and Mays (1988, §5.5). Converting only the pervious component

follows APWA, which states that "direct conversion of composite antecedent moisture conditions is not appropriate" (KC Metro APWA 5600, 2011, §5602.2C). Converting a composite CN would wrongly lower the CN of the impervious part.

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

3.9 Impervious connectivity

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

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

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

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

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

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

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

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

3.10 Groundwater, high water table and tank backwater

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

3.10.2 **Water-table data.** The seasonal high water table shall be taken as the highest level recorded in the SW monsoon season (June–September), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or SWID 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 in the deltaic clays of Kolkata, Howrah and the 24 Parganas, in the Sundarbans and the saline coastal belt, on the margins of the Hooghly and the other tidal rivers and khals, and in the Tal lowlands of Malda, the water table rises close to the surface during the SW monsoon, and whatever infiltration capacity the soil has in the dry season is gone when the design storm arrives. The soil tables describe these areas directly: clayey and clay-loam soils make up 65% of Howrah district and 98% of Purba Medinipur, and deep clay to clay loam lowland 30% of Malda (ICAR-CRIDA district contingency plans). The Ground Water Year Book for West Bengal and the CGWB data portal could not be reached during research for this Manual, and no depth-to-water records for Kolkata were obtained [TBC]. The Hooghly is tidal at Kolkata. Its tidal range reaches about 17 ft (about 5.2 m) at the mouth, and bores run up it on practically every spring tide (CWPRS), and the tidal maximum at Diamond Harbour is 2.57 m above mean sea level (INCOIS 2025), so on the river and khal margins the water table moves with the tide. The land is sinking as well: Kolkata subsided at 2.8 to 5.5 mm a year between 2017 and 2022 (Thakur et al. 2026), as fast as the sea is rising at Diamond Harbour (3.73 mm a year, PSMSL), and the relative rise of the water table against the ground adds both. Clause 3.10.4 reflects the State's receiving waters. Kolkata stands on the natural levee of the Hooghly and its land slopes east, away from the river; its storm water and sewage are pumped, at stations such as Ballygunge (1,233 cusec) and Palmer Bazar (1,184 cusec), into outfall channels that run through the East Kolkata Wetlands to the Kulti, a tidal river (I&WD). At the Behala Flying Club pumping station the basin stays flooded because discharge through the outfall "is partially achieved due to high water levels in the canal, particularly during tidal period" (KEIIP IEE 2015). Howrah lies below the level of the Hooghly (CPHEEO appraisal note). Inland, town drains discharge to rivers fed by reservoirs: in September 2024 the combined release from the Maithon and Panchet dams of DVC reached about 2.5 lakh cusec (as reported), and the Damodar, the Mundeswari and the Rupnarayan then set the level at the outfalls of Howrah, Hooghly and Paschim Medinipur districts.

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 1(f) (Middle Ganga Plains), 1(g) (Lower Ganga Plains) or 2(a) (North Brahmaputra):

- (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 1985, 1991 and 1994; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the reports of 1985 to 1994, 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 tanks at FTL in 3.12.5 because West Bengal's damaging floods arrive after weeks of rain, when the reservoirs and pukurs are already full, and because most urban pukurs and bheris are kept full whatever the rain. A pukur is a fishery as well as a pond: the West Bengal Inland Fisheries Act, 1984 protects any water area or depressed land that holds water for at least six months a year (section 17A, as reported), and the bheris of the East Kolkata Wetlands are kept full for sewage-fed fish culture. In September 2024 the reservoirs of DVC on the Damodar were releasing about 2.5 lakh cusec on 17 September (as reported), so the floods of the lower Damodar and of Ghatal came when every storage upstream was full. Pukurs should therefore be assumed full from June, and should be modelled below

FTL only where a continuous simulation under Clause 3.13 or a notified operating rule supports it. The window of 1 June to 30 November in Clause 3.13.5(a) is set by this Manual to include the post-monsoon depressions and cyclones of October and November, which fall on tanks at their highest: 325.1 mm fell at Midnapore on 17 October 1942, 286.3 mm at Berhampore on 31 October 1917, and on 9 November 1986 Haldia had 212.7 mm, Uluberia 199.8 mm and Dum Dum 184.3 mm (IMD). May, the month of the pre-monsoon cyclones, is left out of the window, because tanks are at their lowest before the monsoon and including it would lower the starting level.

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 June to 30 November 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.

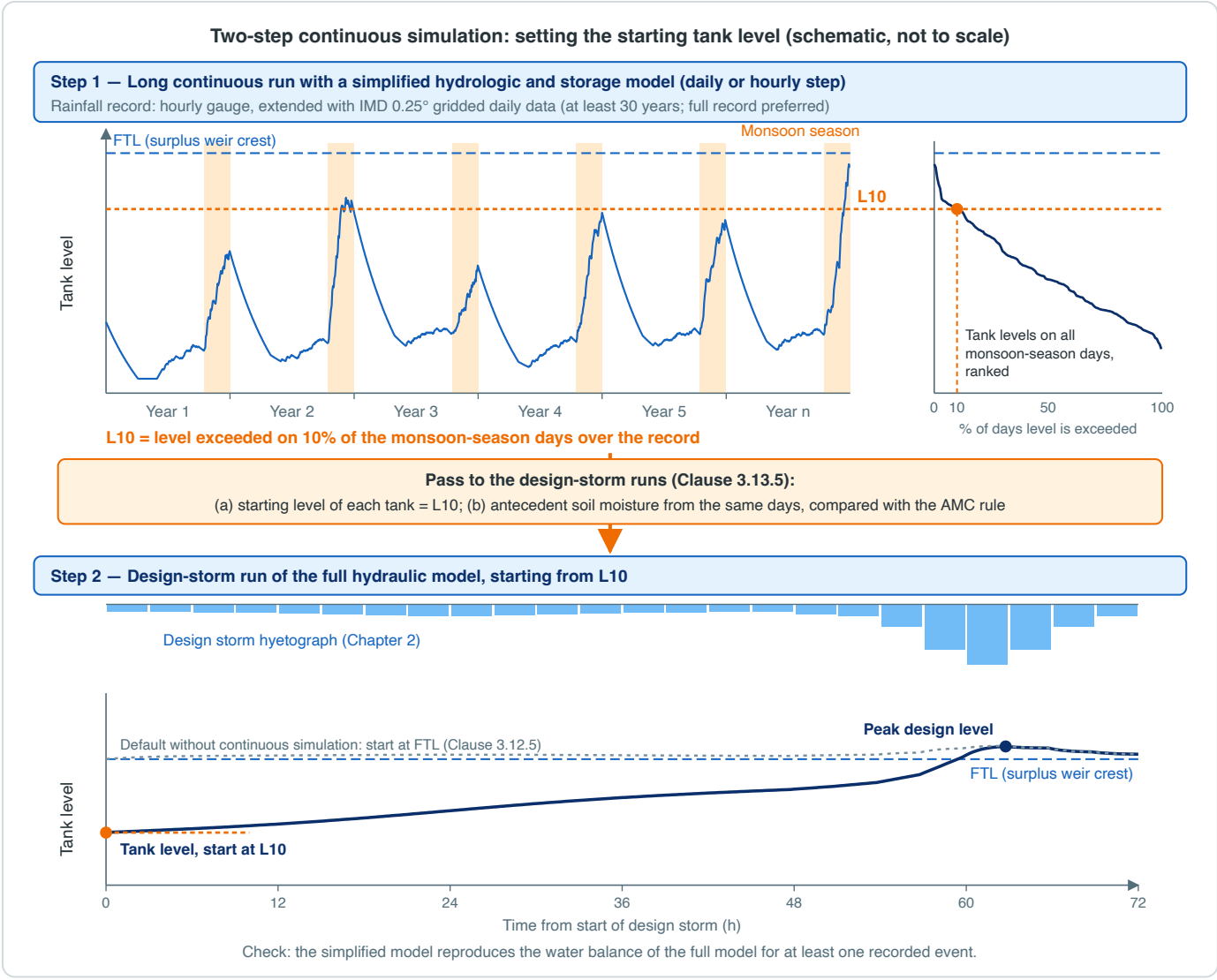

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 June to 30 November (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place 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 West Bengal. The record length matters less than what the simulation is for. Its main purpose here is to find how full the tanks and soils usually are when a south-west monsoon storm arrives, and how often heavy rain coincides with a closed outfall. A design storm cannot answer either question, because it starts from one assumed condition. It is not intended to replace design storms for the peak flow in urban drains. Clause 3.13.5 therefore allows the long run to be made with a simple storage model, which takes minutes, and passes the starting tank levels to the detailed hydraulic model, which is then run only for the design storms. Running a detailed 1D–2D city model continuously for decades is rarely practical and is not required. The 10% exceedance level in 3.13.5(a) is set by this Manual: it

represents a wet but not exceptional monsoon, so that the design storm arrives on tanks that are already well filled, as they were in September 2024, when the DVC reservoirs on the Damodar were releasing about 2.5 lakh cusec.

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.

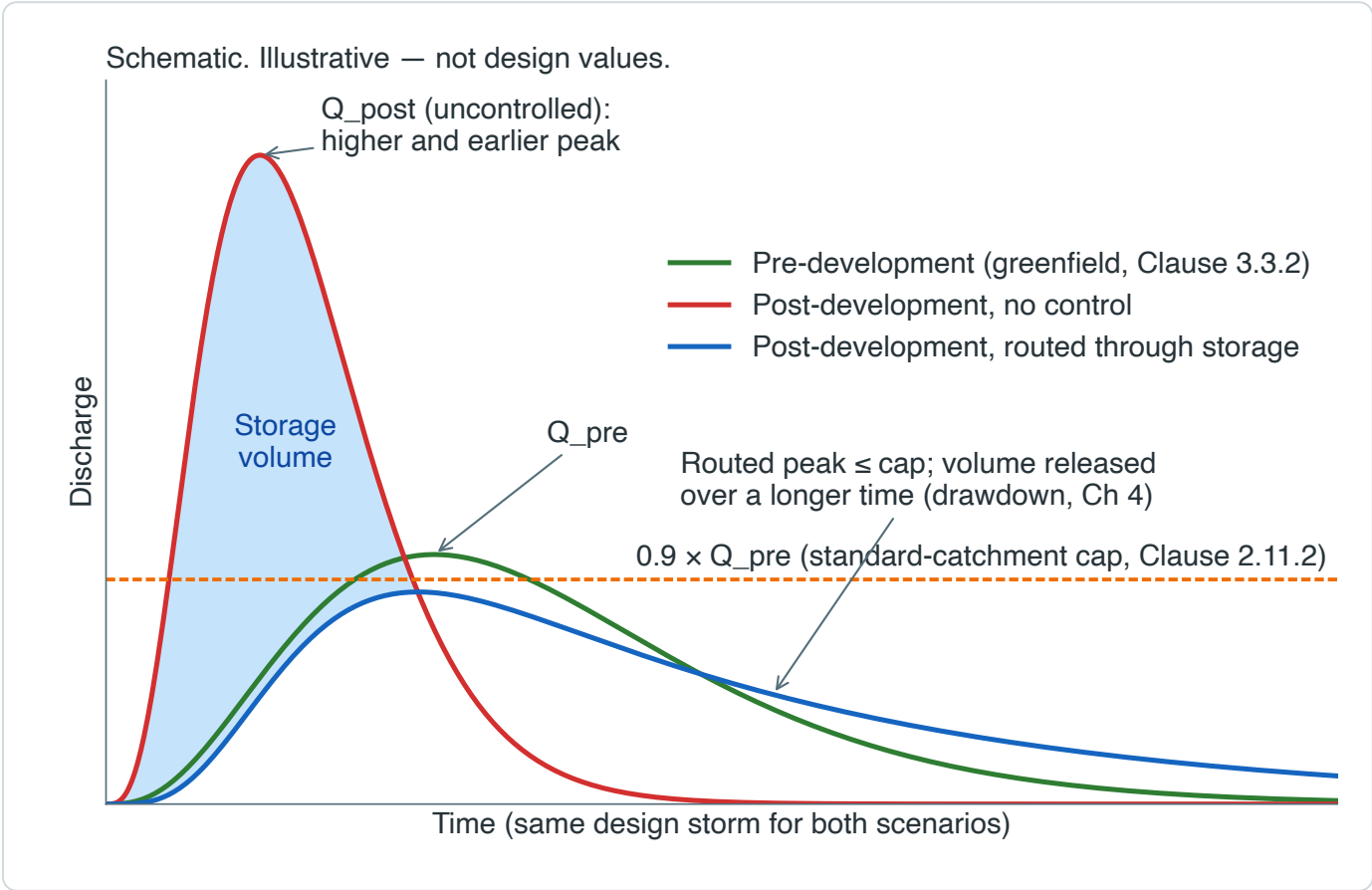

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro 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 West Bengal 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 (I&WD gauging sites, KMC or WBSDMA level sensors, tank gauges, or surveyed flood marks).

3.15.3 **Events.** At least three independent events shall be used for calibration and at least one further event for validation. At least one event shall be a long-duration SW monsoon or cyclone event (for example the Kolkata storm of 22–23 September 2025, the south Bengal rains of 26–29 September 1978 or Cyclone Amphan on 20–21 May 2020, 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	West Bengal soil series to HSG lookup; seasonal high water table map
3B	West Bengal CN calibration and supplementary land covers (paddy, bheris, tea gardens, mangroves)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for subzones 1(f), 1(g) and 2(a), with worked example
Form 3-1	Hydrologic Calculation Summary
Form 3-2	Pre- vs Post-Development Comparison

CHAPTER 4

Site Runoff Control: Retention and Detention

4.1 Purpose and scope

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

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

4.1.2 This chapter applies to land disturbance of **0.1 ha or more**, or new or replaced impervious area of **500 m² or more**, as set in Chapter 1. Single dwellings below that threshold, and road resurfacing that adds no impervious area, are exempt. The existing RWH mandate of the building rules (rainwater harvesting in the plan of a new or expanded building or housing complex "as per" the Environmental Impact Assessment guideline of the State or the Union under Rule 144 of the KMC Building Rules 2009; in every new building or housing complex in New Town under Rule 28(4) of the New Town Kolkata (Building) Rules 2009, as amended in 2021; and in the municipal areas as the West Bengal Municipal (Building) Rules 2007 require, whose threshold was not read for this Manual [TBC]; the rules are discussed in the Commentary to Clause 4.11) continues to apply to every building it covers, whether or not this chapter applies.

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

> **Commentary.** No Indian national rule or West Bengal building rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention. West Bengal has no single building code: the KMC Building Rules 2009 apply in Kolkata, the West Bengal Municipal (Building) Rules 2007 in the municipal areas, notified areas and industrial townships, and the New Town Kolkata (Building) Rules 2009 in New Town. Their drainage provisions protect the building, not the catchment. In Kolkata the plinth must be "so located with respect to the crest of the road level that adequate drainage of the site is assured", and at least 60 cm high (Rule 105); the whole site may be raised by up to 600 mm "to avoid flooding for areas prone to water logging", with the Municipal Commissioner's permission (Rule 76); basements must keep surface drainage out and be able to pump water out (Rule 118(6)); and roofs drain through rain-water pipes that the Commissioner may require to be connected to a drain or sewer "and/or rain water harvesting system" (Rule 117). The municipal rules set the same 60 cm plinth and leave the connection of rain-water pipes to the Board (Rules 57 and 59 of the 2007 Rules, as reported). Rainwater harvesting is required under Rule 144 of the KMC rules only "as per Environmental Impact Assessment Guideline", in every new building in New Town, and in the municipal areas to a threshold that was not read for this Manual [TBC] (Commentary to Clause 4.11). None of these sets a design storm, a release rate or an overflow path. The one hook for a stormwater condition is in Kolkata: where the Municipal Commissioner, having

regard to "the existing water supply, sewerage and drainage system" of a ward, considers that a building "will put additional burden on the existing civic services", he may sanction it "subject to such restrictions or conditions … as he may deem fit to impose", after scrutiny by the Municipal Building Committee and with the prior approval of the Mayor-in-Council (KMC Building Rules 2009, Rule 16(4)). This chapter is written so that it can supply the technical content of such a condition; it has not been adopted for that purpose. Where design standards were found, they are for public drains, and they are far below the rainfall of Chapter 2. Kolkata's first brick sewer, commissioned in 1876, "was designed to cope with 6.35 mm/h of rainfall with 100 per cent of runoff"; attempts in the 1970s to raise the capacity to 12.7 mm/h did not succeed (Gupta 2005). The drainage master plan of the Calcutta Metropolitan Planning Organisation was based on a storm of "once in two months (6 times in a year)" and a "coefficient of imperviousness … 70%", and its intensity–frequency–duration curve "has been adopted by KMDA / ULBs" (CPHEEO appraisal note, Howrah drainage). The environmental examinations of the KEIIP sewerage and drainage works state no design rainfall intensity or return period (KEIIP IEE 2015). In core Kolkata the receiving system is, by law, a combined one. The Corporation must provide "a safe and sufficient outfall … for the effectual drainage and proper discharge of storm-water and sewage" (KMC Act 1980, section 277), all public drains vest in it (section 280), and the Commissioner may, but need not, require "an entirely distinct drain for rain water" (section 292; the Act was read from a poorly scanned copy). The new KEIIP works are combined as well: each pumping station separates the dry-weather flow, but in rain the "SWF mixed with sewage [is] to be disposed off in Churial canal" (KEIIP IEE 2015). Where a site drains to a combined sewer, retention and detention matter more, not less. Every litre a site releases at the peak of a storm takes up capacity that the sewage also needs, and what cannot be pumped away backs up through gullies into the streets or spills, diluted sewage and all, to a canal. Clauses 4.4 and 4.5 therefore apply in full at each connection to a combined sewer, with no relief because the sewer is combined, and Clause 6.3.6 sets the further rules for the connection. The CPHEEO (2019) manual describes limiting outflow to the pre-development peak as typical practice, but it uses no "shall" and names no storm frequencies (CPHEEO Part A §8.5.1). This chapter turns that description into a development-control requirement.

4.2 Definitions

Term	Meaning in this Manual
Retention	Permanent removal of runoff from the surface drainage system by infiltration, evapotranspiration or reuse, so that the water never reaches the outfall.
Retention depth	The 90th percentile wet-day 24-hour rainfall depth for the site's zone (Clause 2.10, Annex 2E).
Required retention volume (RRV)	The runoff volume from the retention depth over the post-development site (Clause 4.4.2).
Detention	Temporary storage of runoff, released through a controlled outlet at a rate set by Clause 4.5.
Retention credit	The reduction in required detention storage that results from retention practices, determined by routing under Clause 4.4.6. It is **not** the same as the retained volume.
Permissible site discharge (PSD)	The maximum rate at which a site may discharge for a stated AEP, in L/s or L/s/ha.
Site storage requirement (SSR)	The detention storage required per hectare of site under the simplified method of Clause 4.14.
Multi-stage outlet	An outlet structure with separate openings at different levels, each controlling a different AEP (Figure 4.2).

Term	Meaning in this Manual
Drawdown time	Time from the peak stored volume until the stated fraction of that volume has been released.
Emergency spillway	A secondary overflow that passes flows above the primary outlet capacity, or all flow when the primary outlet is blocked, without overtopping the embankment.
Freeboard	Vertical distance between the maximum design water level and the embankment crest or other critical level.
Flood-sensitive catchment	A catchment listed in Clause 4.5.3 or notified under Clause 4.5.4.
Authority	The approving authority under Chapter 1 (the Municipal Commissioner of KMC under the KMC Building Rules 2009 in Kolkata; NKDA under the New Town Kolkata (Building) Rules 2009 in New Town; elsewhere in urban areas, the Municipality or Municipal Corporation concerned, under the West Bengal Municipal (Building) Rules 2007 or the building rules that apply to that Corporation; or a development authority under the West Bengal Town and Country (Planning and Development) Act, 1979 (such as KMDA, SJDA or ADDA) where it grants permission in its planning area, as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Kolkata Municipal Corporation, every Approving Authority within the Kolkata Metropolitan Area (KMA) or the planning area of SJDA or ADDA, including the Howrah, Bidhannagar, Siliguri, Asansol and Durgapur Municipal Corporations, NKDA in New Town and the Municipalities of those areas, and every other Municipal Corporation. Tier B: Municipalities and Notified Area Authorities.

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 (m³) = 10 × Q_R × A

where:

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

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

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

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

4.4.3 Verification

Retention by infiltration shall be supported by:

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

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

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

> it does, Chapter 8 governs.

4.4.4 Limits on retention

4.4.4.1 Infiltration practices shall not be used:

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

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

4.4.5 Drawdown of retention

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

4.4.6 Retention credit: definition and computation

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

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

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

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

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

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

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

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

> Commentary. "Credited against detention" (APWA 5600 2025.01) can be read in two ways. One reading subtracts the retained volume from the detention volume, cubic metre for cubic metre. The other routes the storms with retention in place and sees what detention is still needed. The two readings give very different answers in West

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

4.4.7 Preservation credit

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

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

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

4.5 Release-rate criteria

4.5.1 General

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

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

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

4.5.2 Standard catchments

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

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

4.5.3 Flood-sensitive catchments

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

> Q_post(1% AEP, 100-yr) ≤ Q_pre(10% AEP, 10-yr), and Q_post(50% AEP, 2-yr) ≤ Q_pre(50% AEP, 2-yr).

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

4.5.3.2 The flood-sensitive catchments are:

- (a) **low-lying Kolkata and its outfall-channel catchments**: the catchment of every drainage pumping station and outfall of KMC, all of which pump to canals and outfall channels that are held up by the tide, including the South Suburban, Churial and Monikhali basins and the low-lying wards of Behala, Tollygunge and Garden Reach, and, outside KMC, the catchments of Bidhannagar, New Town and South Dum Dum that drain to the Bagjola and Kestopur canals and the Kulti outfall;
- (b) **low-lying Howrah**: the parts of the Howrah Municipal Corporation area, and of the municipalities beside it on the right bank of the Hooghly, that lie below the level of the river at high tide;
- (c) the **lower Damodar and Ghatal**: the catchments that drain to the Damodar, the Mundeswari, the Rupnarayan or the Shilabati below the DVC dams, in Howrah, Hooghly, Purba Bardhaman and Paschim Medinipur districts, including Amta, Udaynarayanpur, Arambagh, Khanakul and the Ghatal basin;
- (d) the **embanked islands of the Sundarbans**: every town and settlement on an island or tract protected by the embankments of I&WD in South and North 24 Parganas, including Canning, Gosaba, Kakdwip, Namkhana and Sagar, whose drainage leaves through sluices in the embankments;
- (e) **Siliguri and the Teesta towns**: the catchments within the Siliguri Municipal Corporation area that drain to the Mahananda, and the towns on the Teesta below the Gajoldoba barrage, including Jalpaiguri and Mekhliganj; and
- (f) 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 tide-locked, closed by a lock gate, sluice or flap gate when the Hooghly or a tidal khal is high, dependent on pumping, or held up by a river raised by dam releases, such as those of DVC on the Damodar, or by backwater, for part of the SW monsoon or of a cyclone storm (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 Kolkata entry follows the way the city drains. Its land slopes east from the levee of the Hooghly, and since the Bidyadhari was abandoned as an outfall in 1928 its storm water and sewage have been pumped into outfall channels that run through the East Kolkata Wetlands to the Kulti, a tidal river; the main KMC stations at Ballygunge, Palmer Bazar and Dhapa Lock together have about 2,900 cusec of installed pumps (I&WD). The drains behind them were sized for far less than the design storms of this Manual: the first brick sewer, of 1876, for 6.35 mm/h (Gupta 2005). On 22–23 September 2025 Alipore recorded 251.4 mm in 24 hours, 185.6 mm of it in the three hours from 02:30 and 98 mm in the single hour from 03:00 (IMD); between 9 and 12 people died, most of them by electrocution in flooded streets, and choked drains and canals and a high tide were blamed (as reported). The added areas of the south are worse: in Behala, Tollygunge and Garden Reach some pockets "remain partially inundated for even 3 to 4 months in a year", the South Suburban catchment experiences "frequent and prolonged waterlogging", and at the Behala Flying Club pumping station discharge through the outfall is only partly achieved "due to high water levels in the canal, particularly during tidal period" (KEIIP IEE 2015). The Bagjola canal is the main outlet for South Dum Dum, New Town and Bidhannagar, and its pump house at Kulti, of 1,650 cusec, has been described as inadequate; an increase to 4,000 cusec has been reported as approved, but its status is not known (as reported) [TBC]. The Howrah entry follows the CPHEEO appraisal of the city's drainage, which found the area "marked by the lower levels as compared to the level of River Hooghly", and only 20% of the pumping stations of the metropolitan drainage master plan built (CPHEEO appraisal note). The lower Damodar entry follows the DVC releases of September 2024, when the combined release from Maithon and Panchet reached about 2.5 lakh cusec on 17 September and Howrah, Hooghly, the two Medinipurs, Bankura and Purulia were flooded, and the Ghatal basin, which floods almost every year (as reported); the floods of July 2017 damaged property worth ₹17,727.94 crore and took 217 lives in the State, and every block of the Kandi Master Plan area was inundated (CAG Report No. 2 of 2019). The Sundarbans entry follows the cyclones: Aila, on 25 May 2009, breached about 177 km of the State's embankments in the Sundarbans and badly damaged a further 601 km, out of about 3,122 km (I&WD, as reported); Amphan, on 20 May 2020, sent "tidal waves of 15 Feet height" over the low-lying areas of the 24 Parganas and Purba Medinipur (IMD); and Yaas, on 26 May 2021, arrived with a perigean spring tide and breached embankments in South 24 Parganas and Purba Medinipur (as reported). The Siliguri and Teesta entry follows the floods of the Mahananda at Siliguri in September 2024 and the glacial lake outburst of 4 October 2023, after which more than 8,000 m³/s passed the Teesta barrage and silt was laid down in the Teesta and in the Teesta–Mahananda link canal (as reported); the Siliguri Municipal Corporation sought a drainage master plan for all its 47 wards in 2022 (as reported). Haldia, Digha and the towns of the Purba Medinipur coast, Malda and English Bazar on the Mahananda, and Asansol and Durgapur are candidates for notification under Clause 4.5.4. The notification triggers in 4.5.4.1 have no direct precedent and are set by this Manual. The 6-month lead time follows the update rule of Clause 2.14.2. Clause 4.16 explains why releases below pre-development are needed at all.

4.5.5 Minimum outlet and short-duration 2-yr checks

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

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

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

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

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

4.5.6 Constrained redevelopment sites

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

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

New development on undeveloped land is never eligible.

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

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

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

- (a) paid into the ring-fenced account of the basin in which the site lies;
- (b) spent only on regional detention or on restoring 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 I&WD 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 old core wards of north and central Kolkata, central Howrah, or the bazaar areas of Siliguri, 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 SW monsoon storms of every duration, June–September in Zones WB-Z1 and WB-Z2 and July–September elsewhere, and for cyclone-month storms in Zone WB-Z6, 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 the Gangetic delta near Kolkata. They are not NIH-DHAARA values and must not be used for design.

Inputs:

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

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

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

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

How to read it:

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

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

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

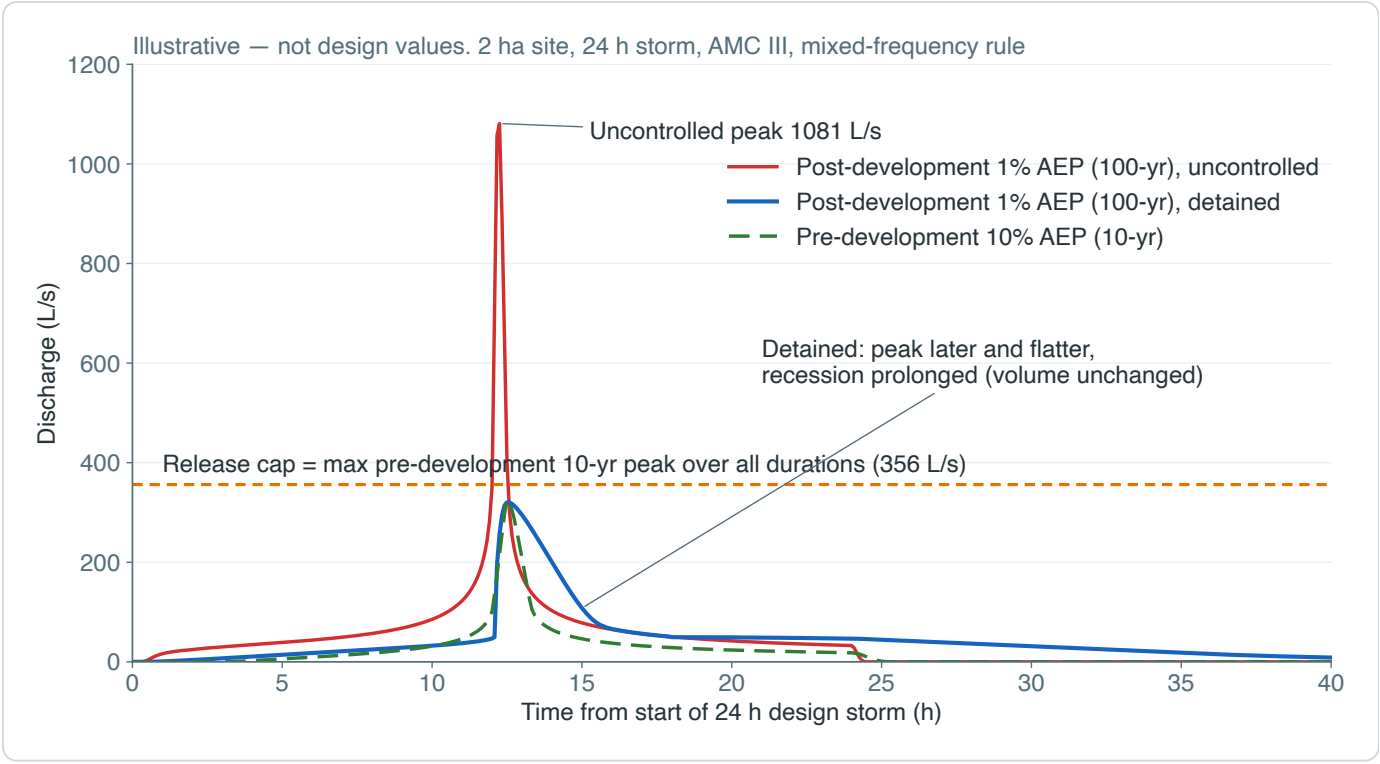


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA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

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

4.7 Drawdown

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

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

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

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

> Commentary. KC APWA 5600 (2006) required dry basins to release at least 80% of storage within 24 hours of the inflow peak and to empty within 72 hours. Singapore PUB requires detention to be restored within 4 hours. The 48-hour, 90% rule is longer than PUB's because West Bengal storage must hold multi-day volumes. It is still short enough that a basin filled by one SW monsoon depression will have most of its volume back before the next, which in late September 1978 in south Bengal [TBC] followed within days.

4.8 Outlet structures

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

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

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

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

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

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

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

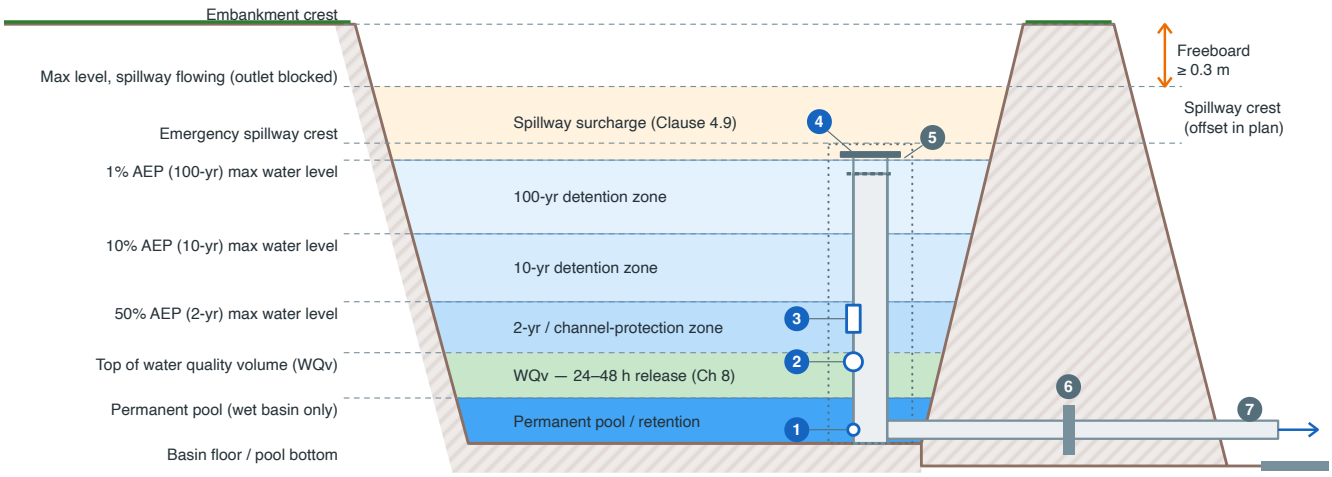
- be at least 300 mm in diameter (Chapter 6);
- have watertight joints;
- have a filter diaphragm or seepage collars over the length within the embankment; and
- have an energy-dissipating outfall (Chapter 9).

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

> Commentary. The 50 mm minimum is smaller than the 75 mm (3 in) of KC APWA 5600 (2006), so the trash-rack requirements are correspondingly stricter. The ratios in 4.8.3 (bar spacing at half the opening, open area 10 times the opening, 50% blockage for the drawdown check) have no direct precedent and are set by this Manual. The blockage factor matches the 50% grate clogging factor for sag inlets in Chapter 6. Indian urban drains carry heavy

loads of solid waste, so a low-flow orifice without an effective rack will block within one season.

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



Key

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

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

4.9 Emergency spillway, freeboard and embankment safety

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

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

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

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

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

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

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

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

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

4.9.6 **Embankments.**

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

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

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

4.10 Facility types

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

4.10.2 **Underground tanks and vaults.**

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

4.10.3 **Rooftop detention.**

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

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

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

4.10.5 **Parking-lot detention.**

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

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

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

4.10.7 **Ponds and wet basins.**

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

> Commentary.
>
> - The rooftop depth (150 mm) and parking depths (200 and 300 mm) have no direct precedent. This Manual sets them so that a blocked outlet is noticed before it becomes dangerous.
> - The 1.2 m pool depth equals the 4 ft minimum permanent pool of KC APWA 5600 (2006). This Manual adopts it mainly for weed and mosquito control.
> - Pumped detention tanks need maintenance declarations in Singapore (PUB Addendum No. 3, April 2025). This Manual adopts the same approach through Chapter 10.
> - Using open space for multi-use detention fits the KMC Building Rules 2009, which allow sewers, underground reservoirs and septic tanks in the mandatory open spaces and leave a "garden covered with permeable material" out of the floor area. A detention area graded into the unpaved part of the open space keeps it permeable and usable, which is what 4.10.6 requires. A pukur on the plot is not open space for this purpose. The KMC rules count a water body within the plot in the plot area for FAR (Rule 2(27)), and relax the setback, height and internal-road rules where a water body, a heritage building or both cover at least

25% of the land (Rules 65A, 74(4) and 81(9)); the pukur is preserved under step 1 of Clause 4.3.1 and modelled as a water surface (Clause 3.3.2(e)) that starts at its full level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows. Land within 15 m of a river bank, where the West Bengal Municipal (Building) Rules 2007 limit buildings to 5 m in height (Rule 8(4), as reported), and land in the hydraulic corridor of a khal or pukur under Chapter 7 is corridor or flood land already: water reaches it first, so it is not counted as detention for the development beside it (Chapter 7). In New Town, the roof gardens that the 2021 amendment requires on plots of more than 300 m² are pervious roof area; they can provide retention or rooftop detention only where they are designed for it under Clauses 4.4.1 and 4.10.3.

4.11 Rainwater harvesting versus detention accounting

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

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

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

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

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

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

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of Rule 144 of the KMC Building Rules 2009, the rainwater harvesting rule of the West Bengal Municipal (Building) Rules 2007, Rule 28(4) of the New Town Kolkata (Building) Rules 2009, or any rainwater harvesting rule of another local authority.

Commentary. RWH in West Bengal is required by three sets of rules, and none of them read for this Manual sets its volume. In Kolkata, Rule 144(1) of the KMC Building Rules 2009 requires that a rainwater harvesting system "shall form a part of the building and shall have to be included in the plan, either for direct use of the rain water or for ground water recharging or both", for a new building or housing complex, or the expansion of an existing one, "as per Environmental Impact Assessment Guideline issued by the State Government/Government of India". Read literally, the rule applies only to projects that those guidelines reach; the scale of building it catches in practice was not found [TBC]. Rule 117(2) lets the Municipal Commissioner require rain-water pipes to be connected to a drain or sewer "and/or rain water harvesting system in conformity with rule 144", and Rule 144(2) requires tree cover on at least 15% of the land of a project with a total floor area of 6,000 m² or more. In New Town the rule is wider: since the 2021 amendment, a rooftop RWH system "shall form a part of the building" for every new building or housing complex and every expansion, and an existing building that adds one may get a 15% reduction in its plan sanction fee (New Town Kolkata (Building) Rules 2009, Rule 28(4)). In the municipal areas the West Bengal

Municipal (Building) Rules 2007 make RWH mandatory (Rule 171, or Rule 168(13), as reported); their thresholds and sizing were not read for this Manual [TBC]. Nothing in any of these rules requires a tank to be empty before a storm. This Manual credits these structures as follows:

- An RWH storage 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 after weeks of SW monsoon rain it is full. A tank may also provide detention only if it is built as a combined tank under Clause 4.11.3, with a detention zone above its RWH overflow level that drains through its own orifice; only that zone counts.
- An RWH tank counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing, demonstrated under Clause 4.4.3; it is then modelled under Clause 4.4.6 like any other retention practice. In the deltaic clays, where recharge is rarely possible, reuse is the practical way to earn retention.
- Recharge pits, trenches and wells count as retention only where they meet Clause 4.11.4. In the deltaic clay zone, the Sundarbans, the river and khal margins and the Tal lowlands the seasonal high water table is too close to the surface for the 1.0 m separation, so a recharge structure there gets no retention credit, though it remains mandatory where the rules require it. Recharge in the districts where groundwater carries arsenic is also subject to Chapter 8. On the lateritic and red soils of the western plateau and the sandy loams of the Terai, a tested pit or trench that ends at least 1.0 m above the seasonal high water table may be credited.
- The tree cover of Rule 144(2) and the roof gardens of New Town are pervious area. They enter the post-development run as pervious land under Clause 3.9.2 and lower the runoff there, so they get no further credit as retention or detention.

Where the site drains to a combined sewer, an RWH tank that overflows to the sewer adds to the combined flow at the peak of the storm; its overflow is routed to the detention facility under Clause 4.11.2, like any other. In the deltaic clays and the coastal belt, a recharge pit drains slowly or not at all in the SW monsoon. Treating RWH as detention would therefore credit storage that does not exist when it is needed. That is why this Manual assumes RWH sumps 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.

4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the deltaic clay zone of Kolkata, Howrah and the 24 Parganas, the Sundarbans and the saline coastal belt, the margins of the Hooghly and the other tidal rivers and khals, the coastal dune sands of Digha and Contai, and the Tal lowlands and other floodplain lowlands, or any area where the groundwater table lies within 3 m of the surface at any time of year shall establish a design groundwater level (DGWL) for the facility. The DGWL is the seasonal high level during or after the SW monsoon, from:

- (a) site piezometer readings over at least one full June–November season; or
- (b) where (a) is not available, the higher of the CGWB or SWID record for the nearest observation well, plus **0.5 m**, and the level of any adjacent tidal water body at MHWS.

For the flotation check of 4.12.3 at sites in the deltaic clay zone, 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. West Bengal's shallowest groundwater is in the deltaic clays of Kolkata, Howrah and the 24 Parganas, in the Sundarbans and the saline coastal belt, on the margins of the Hooghly and the other tidal rivers and khals, in the coastal dune sands of Digha and Contai, and in the Tal lowlands and other floodplain lowlands. No published site-scale seasonal groundwater depths for these areas were found during research for this Manual: the Ground Water Year Book for West Bengal and the CGWB data portal could not be reached [TBC]. The delta has three problems that an infiltration device or a deep tank can make worse. First, the tide reaches far inland: the range at the mouth of the Hooghly is about 17 ft (about 5.2 m) and bores run up the river on practically every spring tide (CWPRS), so on the river and khal margins the water table should be expected to rise and fall with the tide. Second, the ground is sinking. Kolkata subsided at 2.8 to 5.5 mm a year between 2017 and 2022, and earlier studies found rates of up to 12 mm a year (Thakur et al. 2026); subsidence of about 8 mm a year near Salt Lake has been linked to pumping from the confined aquifer (as reported). The sea is rising at 3.73 mm a year at Diamond Harbour (PSMSL), and the relative rise of the water table and of the tide against the ground adds both, so a tank set just clear of the water table today may float within its life. Third, the groundwater of many blocks of the delta carries arsenic: an older CGWB overview counted 79 blocks in eight districts above 0.05 mg/l (as reported), so recharge there is governed by Chapter 8. On the lateritic and red soils of the western plateau and the sandy loams of the Terai the position can differ, and infiltration may suit the ground where tests show it, subject to the 1.0 m separation of Clause 4.4.3 and to Chapter 8. The two sides of a deltaic site remain: where groundwater is deep enough, infiltration is the best retention and should be used; where it is shallow, as over most of the delta, an unlined tank fills with groundwater before the storm begins, and an empty lined tank can float. The June–November monitoring season of 4.12.1(a) is set by this Manual to cover the SW monsoon and the post-monsoon high that the CGWB measures in November. The factor of 1.2, the 0.5 m allowance and the "ground level" default for the deltaic clay zone have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for West Bengal's delta towns 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 SW monsoon. Storage below FTL that is held for irrigation or supply through June to September shall not be credited.
- (d) the tank meets Chapter 7: surveyed FTL, a documented operating rule, and a maintained surplus weir;
- (e) the site still provides **retention** (Clause 4.4) and **WQv** treatment (Chapter 8) on site; and
- (f) in flood-sensitive catchments, the regional facility meets the mixed-frequency rule for its whole contributing area.

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

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

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

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

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

> Commentary. The Malaysian DID (2008) checklist favoured community ponds over on-site detention for sites above 0.1 ha. Studies of on-site detention show that its benefit depends on location and fades with distance downstream (Colorado State University thesis; McEnroe for Kansas City), and that a pond low in the catchment can synchronise with the main-stem peak (*Water* 2016). Regional storage therefore has to be sited by basin modelling, not simply aggregated.
>
> West Bengal has no tank Act, and its regional storage is of three kinds: the pukurs and dighis of the towns, the bheris and wetlands east of Kolkata, and the reservoirs and canals of the river systems. The pukurs are protected by three overlapping laws rather than one. Section 17A of the West Bengal Inland Fisheries Act, 1984 bars the filling of a water area, or of depressed land that holds water for at least six months a year, and an amendment of 2008 removed the minimum size of 5 cottahs (0.035 ha) that the 1993 text had set (as reported); KMC acts against filling by notices under section 53 of the West Bengal Town and Country (Planning and Development) Act, 1979 and section 400(1) of the KMC Act, followed by police complaints (NGT, OA 258/2024, compliance report); and in the municipal areas no pond, canal or wetland may be filled without the prior approval of the State Government (West Bengal Municipal (Building) Rules 2007, Rule 8(3), as reported). The Calcutta High Court has held that KMC must first establish that a site is a "water area" before it acts under section 17A (*Anuradha Sen v. Kolkata Municipal Corporation*, 9 January 2024, as reported). The ponds are still being lost: KMC listed 3,874 water bodies in 2006, against about 8,731 counted earlier by NATMO and about 4,889 in a later satellite count (as reported). East of the city, the East Kolkata Wetlands, a Ramsar site of 12,500 ha since 19 August 2002 (MoEF&CC), receive the city's sewage and storm water through the outfall channels; under the East Kolkata Wetlands (Conservation and Management) Act, 2006 their character may not be changed without the sanction of the Management Authority, and a water body may be filled only if one of no less area is created within the

wetlands (sections 9 and 10, as reported), and the Calcutta High Court froze their reclamation in 1992 (*PUBLiC v. State of West Bengal*, as reported). The Census of Water Bodies sheet for West Bengal was not read for this Manual [TBC]. Three points follow:

- Pukurs and bheris are kept full. A pukur is a fishery, and the bheris are kept full for sewage-fed fish culture, so below FTL they give no flood storage when a SW monsoon storm arrives (Clause 3.12.5).
- The East Kolkata Wetlands are not spare capacity. They are already the route by which the city's storm water reaches the Kulti, and any work that raises their levels or changes their character needs the sanction of the Management Authority; regional detention there is a matter for the basin master plan of Chapter 11, not for a site.
- An I&WD canal is not regional storage. Storm water spilled to the Bagjola, Kestopur or another outfall canal uses capacity that the canal and its outfall pumps at Kulti need for the drainage of the whole basin; it can be relied on only with the written agreement of I&WD, for a stated flow and level.

The first point is the basis of condition 4.13.2(c) in West Bengal. A pukur, a dighi or a bheri gives flood storage only above FTL, unless a notified operating rule commits it to be lowered before the SW monsoon. The 3-year operational limit and the 10-year maintenance allowance have no direct precedent and are set by this Manual.

4.14 Simplified methods for small sites

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

4.14.2 **Method.**

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
WB-Z1 Darjeeling–Kalimpong hills	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
WB-Z2 Terai and Duars	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
WB-Z3 North Bengal Gangetic plains	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
WB-Z4 Western plateau	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
WB-Z5 Central and Gangetic delta	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
WB-Z6 Coastal belt and Sundarbans	A / 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:

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

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

Table 4.3A — Fixed release coefficients (provisional)

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

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

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

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

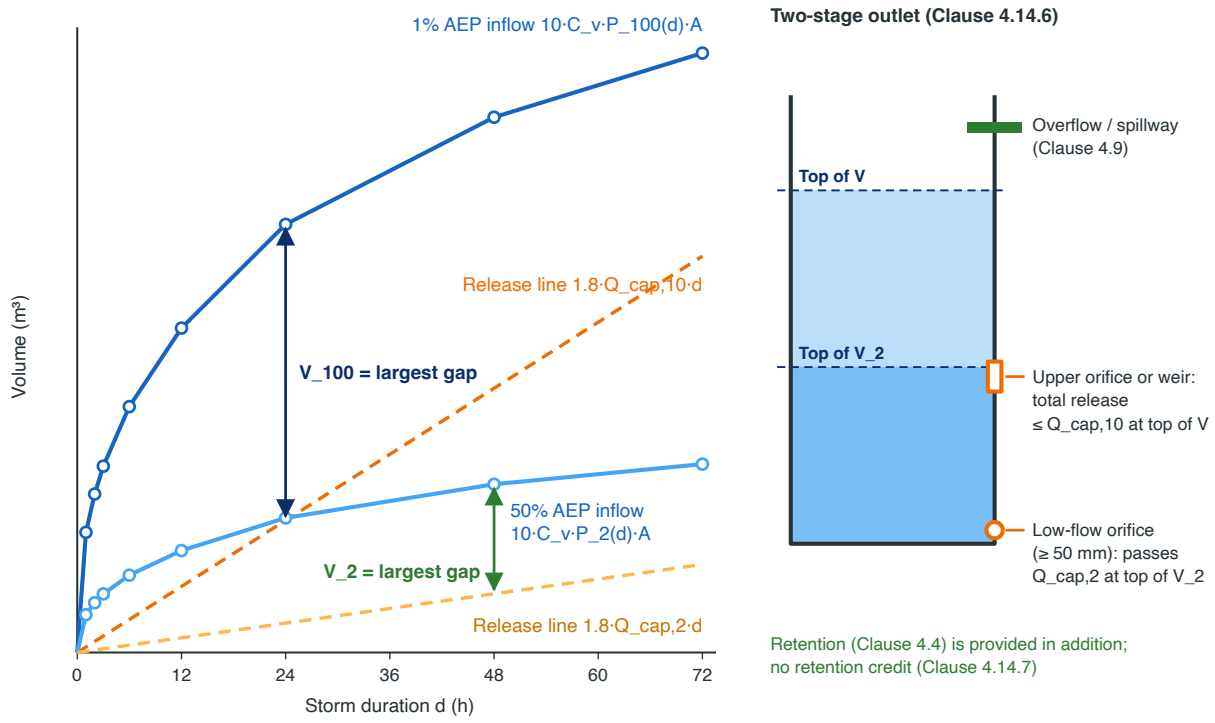
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

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

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

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

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



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

$Q_{cap,10} = 2.78 \times C_{10} \times i_{10} \times A$; $Q_{cap,2} = 2.78 \times C_2 \times i_2 \times A$; (L/s; A in ha; i in mm/h)

C_{10}, C_2 from Table 4.3A by soil group; i_{10}, i_2 for a 15-minute duration with the climate factor (Clause 2.8)

$V = \max(V_{100}, V_2)$; $V_T = \max$ over d of $[\ 10 \times C_v \times P_T(d) \times A - 1.8 \times Q_{cap} \times d\ ]$ (m^3) ; 1.8 = 3.6 × 0.5 (average release of half the cap)

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

Commentary. The fixed-coefficient route follows Singapore, which caps the peak runoff from every development of 0.2 ha or more with one runoff coefficient, C = 0.55, applied to the 10-yr storm (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5, Addendum No. 3, 2025). It is quick to apply and quick to check: the cap needs only the site area, the soil group and two intensities. PUB's 0.55 is not used here, because Singapore's baseline is the existing urban drainage system, while this Manual's baseline is greenfield land (Clause 4.5.1.2). The coefficients of Table 4.3A are set by this Manual from the greenfield curve numbers of Clause 3.3 (CN 39, 61, 74 and 80 for soil groups A to D). They are the ratios of runoff to rainfall that those curve numbers give for 1-hour depths typical of the Gangetic delta, 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 West Bengal, the governing failure is volume with no outlet. Kolkata does not drain to the Hooghly, on whose levee it stands; its land slopes the other way, and it drains east, by pumping, to outfall channels and canals that are themselves held up by the tide, and at the Behala Flying Club pumping station the basin stays flooded because the outfall works only partly "due to high water levels in the canal, particularly during tidal period" (KEIIP IEE 2015). Where the system is combined, as in core Kolkata, what fills behind the closed outfall is storm water mixed with sewage. Howrah lies below the level of the Hooghly (CPHEEO appraisal note). On the coast a cyclone surge closes every outfall it reaches, and the recent ones have struck near spring tides: the surge of Aila in May 2009 came the day before a new moon, and Yaas in May 2021 arrived with a perigean spring tide (I&WD; as reported). Inland, town drains meet the same condition from rivers fed by reservoirs: in September 2024 the lower Damodar, the Mundeswari and the Rupnarayan rose after DVC released about 2.5 lakh cusec from Maithon and Panchet (as reported). A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.

The response in this Manual is layered:

- release below pre-development (Clause 4.5);
- retain the frequent storms (Clause 4.4);
- route long SW monsoon storms (Clause 4.6.3);
- prefer regional storage in the 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.

> Commentary. West Bengal's drains fail in two places that site design does not see. At the outfall, the tide and the pumps decide. Kolkata lies on the natural levee of the Hooghly, about 130 km above its mouth, and the land slopes east, away from the river (I&WD), so most of the city's storm water is lifted by pumping stations into outfall channels that run past the East Kolkata Wetlands to the Kultigang. KMC's three main stations, at Ballygunge, Palmer Bazar and Dhapa Lock, have about 2,900 cusec installed between them (I&WD), and in a storm the KEIIP stations pump storm-water flow mixed with sewage to the canals (KMC, 2015). When the canals stand high at high tide, the basins behind them stay flooded. Downstream, the rivers rise on dam releases: in September 2024 the combined release from Maithon and Panchet on the Damodar reached about 2.5 lakh cusec, and parts of Howrah, Hooghly and the two Medinipurs were flooded (press reports). On the coast, cyclones bring surge and rain together, and the Sundarbans drain through sluices in about 3,122 km of I&WD embankments, of which Cyclone Aila breached about 177 km in May 2009 (I&WD). A detention basin that meets every release rate in Chapter 4 still fails if the drain below it is already full, or if its outfall is shut. This chapter makes both failure modes part of the design.

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).

Term	Meaning in this Manual
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, I&WD canal, the khals and outfall channels of Kolkata and its suburbs (such as Tolly's Nullah, the Circular Canal, the Beleghata, Kestopur and Bagjola canals and the storm-water flow channel from Bantala to the Kultigang), any khal or drainage channel maintained by I&WD or a local body, any irrigation canal that receives storm water, or a tidal creek.
Chart datum (CD)	The datum of the published tide tables and nautical charts, to which tidal heights are referred.
Mean sea level (MSL)	Average sea level over a long period at a tide gauge.
MHWS	Mean high water springs: the average of high waters at spring tides.
HAT	Highest astronomical tide: the highest level predicted under average meteorological conditions over a full tidal cycle (18.6 years).
Storm surge	The rise in sea level above the astronomical tide caused by wind and low pressure, mainly during cyclones.
Still-water level	Astronomical tide plus surge, excluding individual waves.
Sea-level allowance (SLA)	The allowance added to present-day tidal levels for sea-level rise over the design life (Clause 5.7.4).
Tailwater	The water level at the downstream end of a drain, outlet or storage.
Tide-lock	The condition in which the tailwater is at or above the upstream water level, so a gravity outfall cannot discharge.
Lock window	A period during which the outfall-closed check of Clause 5.10 sets gravity discharge to zero.
Sand bar	A bar of beach sand that partly or fully closes a river mouth or creek inlet.
Project datum	The levelling datum used on the project drawings. It must be tied to a Survey of India benchmark (Clause 5.7.2).

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, KMC, WBSDMA or I&WD; 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.

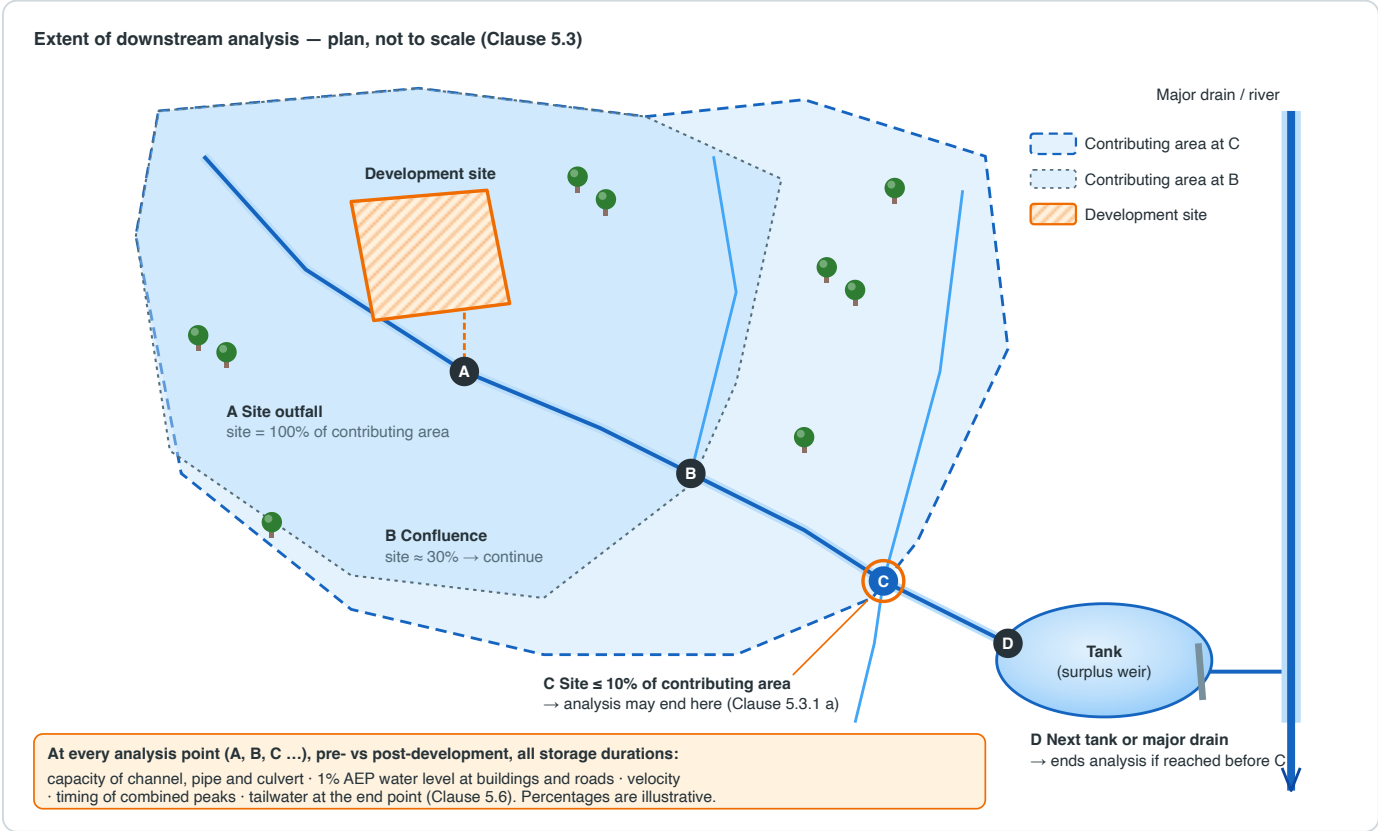

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next pukur or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 West Bengal. In Kolkata, where storm water pumped from the city's eastern basins travels some 27 km along the outfall channels from Bantala, past the East Kolkata Wetlands, before it reaches the tidal Kultigang (I&WD), and in the municipalities of the Kolkata Metropolitan Area, where a drain can pass through a chain of pukurs, bils and khals before it reaches the Hooghly or an I&WD channel, 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 Kolkata's south suburban catchment, which the KEIIP environmental assessment describes as experiencing "frequent and prolonged waterlogging" (KMC, 2015), at Behala, where the basin behind the

pumping station stays flooded while the canal is high at high tide (same source), and in the Ghatal basin of Paschim Medinipur, described as a bowl that cannot drain (press reports). 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 Hooghly from Garden Reach at Kolkata to Diamond Harbour, Haldia and Sagar Island, where a tidal bore runs up the river on spring tides (CWPRS), the Kultigang at the end of Kolkata's outfall channels, which joins the Raimangal estuary, and the tidal rivers and creeks (khanris) of the Sundarbans), 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, KMDA or the Authority adopts a higher projection for the planning area, for example a projection of relative sea-level rise for Kolkata that adds the INCOIS (2025) estimates for Diamond Harbour of about 0.58 m (SSP2-4.5) and 0.80 m (SSP5-8.5) of mean-sea-level rise by 2100 to the land subsidence measured in the city (Clause 5.8.5(f)); 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.

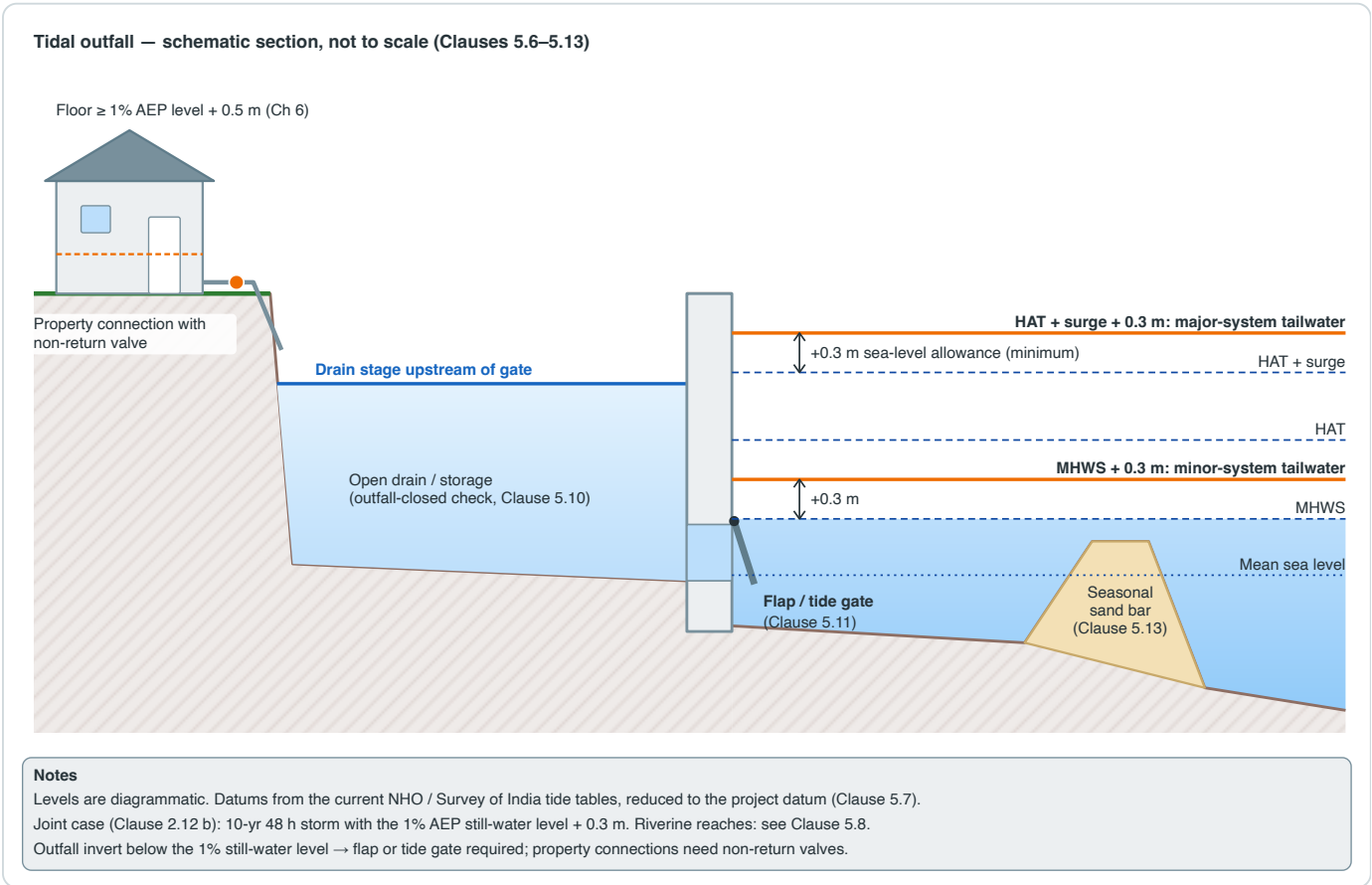

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater 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 Cyclone Aila, whose surge at Sagar Island in May 2009 was observed to be "around 3.3" (the unit is not stated) above the predicted level and which breached about 177 km of the Sundarbans embankments (I&WD), Cyclone Amphan, which IMD reported sent tidal waves of 15 ft over low-lying parts of the 24 Parganas and Purba Medinipur in May 2020, and the INCOIS (2025) estimate that surge and wave set-up add about 1.16 m to the 100-year sea level at Diamond Harbour, showed why it is needed in West Bengal.

Indian tide tables have been published by the Survey of India since the nineteenth century; in West Bengal, PSMSL holds tide-gauge records from Kidderpore for 1881–1931 (station 48), from Garden Reach at Kolkata from 1932 (station 369, which PSMSL flags for quality control and notes is significantly affected by river flow), from Sagar for 1937–1987 (station 417), from Diamond Harbour from 1948 (station 543) and from Haldia from 1971 (station 1270) (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. Its 2025 technical report gives 100-year extreme sea levels for one West Bengal site, Diamond Harbour: 3.79 m above mean sea level at present, made up mainly of a modelled tidal maximum of 2.57 m and 1.16 m of surge and wave set-up, and 4.34 m (SSP2-4.5) or 4.46 m (SSP5-8.5) by 2100, when mean-sea-level rise of 0.58 m or 0.80 m is partly offset by a fall of 3 cm or 12 cm in the tidal maximum. It gives no value for Kolkata, Haldia, Sagar, Digha or the Sundarbans. No surge return-level product for the Hooghly estuary, the Sundarbans or the Purba Medinipur coast suitable for design was found during research, and the values of MHWS and HAT relative to chart datum for Garden Reach, Diamond Harbour, Haldia and Sagar were not seen [TBC], which is why Annex 5A is needed. The sources also mix datums: the INCOIS levels are above mean sea level, the tide tables use chart datum, and older Kolkata levels are given relative to the Kidderpore Old Datum (KOD) (CWPRS). Every level used under this chapter shall therefore name its datum. The tide is large: the maximum range at the mouth of the Hooghly is about 17 ft (about 5.2 m), and a bore of up to about 8 ft runs up the river on practically every spring tide (CWPRS, data of 1963–64). The long-term sea-level trend is 3.73 ± 0.53 mm/yr at Diamond Harbour for 1948–2015 and 2.62 ± 0.47 mm/yr at Haldia for 1971–2023 (PSMSL, which makes no correction for land movement). Kolkata's ground is sinking at 2.8–5.5 mm/yr (2017–2022) over a growing area (Thakur et al., 2026), as fast as the sea is rising, and relative sea-level rise at a Kolkata outfall is the sum of the two; Clause 5.8.5(f) adds it to the sea-level allowance of Clause 5.7.4.

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:

- in Kolkata and Howrah: the **Hooghly**, tidal at the city, with the gravity outfalls through its levee and the locks at its junctions with the city's canals, such as **Chitpur lock** (Clause 5.8.5);
- in Kolkata's eastern and southern basins and the suburbs: **Tolly's Nullah**, the **Circular Canal** and the **Beleghata**, **Kestopur** and **Bagjola** canals, the canals that receive the storm-water flow of the KMC pumping stations (such as the **Churial**, **Begore**, **Rania**, **Western** and **Parnashree** canals), and the **storm-water flow channel** from **Bantala** to the **Kultigang** past the East Kolkata Wetlands, with the pumped and lock-gated outfalls of Clause 5.8.5;
- in Howrah, Hooghly and Purba Bardhaman: the **Damodar**, **Mundeswari** and **Rupnarayan**, with the releases of **Maithon** and **Panchet** (Clause 5.8.3);
- in Paschim Medinipur: the **Shilabati**, **Kangsabati** and **Rupnarayan** of the **Ghatal** basin (Clause 5.8.5);

- in North Bengal: the **Teesta** below the **Gajoldoba** barrage, with its releases (Clause 5.8.3), the **Mahananda** at Siliguri and Malda, and the **Jaldhaka** and **Torsa**;
- on the coast and in the Sundarbans: the Hooghly at **Diamond Harbour**, **Haldia** and **Sagar**, the creeks of the Purba Medinipur coast, and every river or creek reach into which a town drain discharges through a sluice in an embankment (Clause 5.8.5); and
- elsewhere: any river or I&WD channel listed in Annex 5B.

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

- (a) I&WD 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 Maithon and Panchet on the Damodar above Howrah, Hooghly and Purba Bardhaman, or the Teesta barrage at Gajoldoba above Jalpaiguri), 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 **Pumped and lock-gated outfalls, the East Kolkata outfall channels, embankment sluices, dam-release and backwater reaches, I&WD drainage channels and khals, and subsidence.**

- (a) **Pumped and lock-gated outfalls.** For an outfall to a canal, khal or channel that reaches a river only through a pumping station, a lock or a sluice gate (for example the KMC pumping stations at Ballygunge, Palmer Bazar and Dhapa Lock, the I&WD stations at Uttarbhag, Chowbhaga and Keorapukur, the pump house at Kulti at the tail of the Bagjola canal, and Chitpur lock on the Circular Canal), or into a drain that itself discharges to such a canal, the designer shall identify the body that operates each station, lock or gate, and obtain its installed capacity, its operating levels and the sill of each gate. The tailwater at the outfall shall be the higher of:

    - the level of Clause 5.7 or Clause 5.8 in the water body beyond the station, lock or gate; and
    - the maximum level in the canal or khal behind it, computed by routing it as a storage with the inflow of the whole catchment that drains to it, including any part outside the town, its storage as surveyed in its present condition, net of silt, encroachment and vegetation, 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 less the largest pump (set by this Manual), with gravity discharge through a lock or gate only while the level beyond it is lower.

  Where a lock or gate can discharge for only part of each tide, or is closed for the whole of a river flood, the lock windows of Clause 5.10 shall be extended to that period (Clause 5.10.6). A capacity that has been approved but not yet commissioned, such as the reported upgrade of the Kulti pump house from 1,650 to 4,000 cusec, shall not be counted.

- (b) **Outfall channels through the East Kolkata Wetlands.** For an outfall to the storm-water flow channel from Bantala to the Kultigang, or to a canal that discharges to it, the downstream boundary of the model shall be the tidal level of Clause 5.7 in the Kultigang at the outfall, with each pumping station on the route at its capacity

under (a), until I&WD publishes a design water level for the channel [TBC]. No storage in the wetlands or their bheris shall be counted in a project's design. No drain, bund, outfall or pumping station that discharges to the wetlands, or alters a water body in them, shall be designed under this Manual without the sanction required by the East Kolkata Wetlands (Conservation and Management) Act, 2006 (as reported); this Manual authorises none of them.

- (c) **Embankment sluices.** For a drain that discharges through a sluice in an embankment to a tidal river or creek (in the Sundarbans, on the Purba Medinipur coast, or along the Hooghly and its tributaries), the sluice shall be treated as a gate under (a), and the land and drains behind the embankment routed as a closed storage for as long as the level outside stands above the level inside. Floor levels and pumped outfalls behind an embankment shall also be checked for a breach of the embankment, with the land behind it filled to the level beyond it.

- (d) **Dam-release and backwater reaches.** For an outfall to a river reach whose level is set by releases from dams or a barrage upstream (for example the Damodar, the Mundeswari and the Rupnarayan below Maithon and Panchet, for Howrah, Hooghly and Purba Bardhaman; the Shilabati, Kangsabati and Rupnarayan of the Ghatal basin; or the Teesta below the Gajoldoba barrage), or by the tidal Hooghly downstream, the river level of Clause 5.8.2 shall:

    - include the releases of Clause 5.8.3 from every dam and barrage above the reach, combined as they occurred in the largest recorded event, unless an operating rule in force staggers them;
    - be computed with the downstream boundary of the river model at the tidal boundary of Clause 5.9.3 where the reach is tidal, or at the recorded level of the receiving river in the largest recorded event, unless the model is carried far enough downstream that moving the boundary changes the level at the outfall by less than 10 mm;
    - for the major-system cases, be not less than the highest recorded flood level at the outfall, where I&WD or the local body has recorded one; and
    - on the Teesta and the other rivers of North Bengal, use bed levels from a survey made after October 2023, because the South Lhonak outburst of 4 October 2023 sent silt down the Teesta (set by this Manual).

- (e) **I&WD drainage channels, khals and canals.** Town drainage shall not be discharged to an I&WD drainage channel, khal or irrigation canal without the consent of I&WD or of the channel's owner. 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 I&WD states it and its level in the coincident case of Clause 5.8.4, with the channel level computed from all the storm water it receives, including other towns' drains and pumped discharges; and
    - the outfall shall have a flap gate (Clause 5.11) where the design water level is above the outfall invert.

- (f) **Subsidence.** For an outfall in Rainfall Zones WB-Z5 and WB-Z6 (Annex 2A) to a tidal water body, or to a channel whose level is set by one, the SLA of Clause 5.7.4 shall be increased by the land subsidence expected over the design life of the element. The rate shall be the one measured at or near the site by levelling or by satellite radar (PS-InSAR); where no measurement is available, it shall be **5.5 mm/yr**, the upper end of the range measured in Kolkata for 2017–2022 (Thakur et al., 2026) (set by this Manual). The sensitivity run of Clause 5.7.4(c) shall double the sea-level part of the SLA and keep the subsidence part.

No pump, lock, sluice or release operation that helps drainage, such as pumping a canal down before a storm, opening a lock or sluice early or staggering dam releases, 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 canal, khal, river or channel (Clause 5.12.3).

> 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. West Bengal's rivers break that assumption in two ways. Kolkata's khals and outfall channels have small catchments in the city

and its suburbs, so the storm that fills the town drains also fills them, and their outlet is held by the tide or by the pumps. The Damodar is the opposite case: its flood comes from rain on the Chota Nagpur plateau, largely in Jharkhand, and reaches Howrah, Hooghly and Purba Bardhaman through the dams at Maithon and Panchet. But the plains are wet at the same time. In the storm of 26–29 September 1978, 369.6 mm fell at Alipore on 28 September, 409.3 mm at Uluberia on 29 September and 387.7 mm at Durgapur on 27 September (IMD), so the river flood and the town storm came from one system. In the north, the Teesta and the Torsa rise on rain in the hills while the same monsoon falls on Jalpaiguri, the wettest district of the State at about 3,720 mm a year (Guhathakurta et al., 2020). 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 two West Bengal cases. Below the Damodar Valley Corporation's dams, a government statement reported in the press put the combined peak release from Maithon and Panchet at about 2.5 lakh cusec (about 7,080 m³/s) from 08:00 to 18:00 on 17 September 2024, reduced to 80,000 cusec by 06:50 on 19 September; other reports gave more than 3 lakh cusec, DVC's own engineer was quoted at 1.7 lakh cusec, and a letter from the State Government cited about 5 lakh cusec, so the figures conflict. Howrah, Hooghly, Paschim and Purba Medinipur, Bankura and Purulia were flooded, with the Shilabati above danger level at Ghatal (press reports). The releases are decided by a committee on which West Bengal and Jharkhand are represented (as reported), and its operating rule was not found. In the north, more than 8,000 m³/s was reported released from the Teesta barrage when the South Lhonak glacial lake in Sikkim burst on 4 October 2023, and the flood left silt in the Teesta and in the Teesta–Mahananda link canal (secondary sources). No published operating rule or release hydrograph for any of these structures was found, so until one is published the largest recorded release applies, and that record is itself to be obtained from DVC and I&WD.

Clause 5.8.5 is set by this Manual. In West Bengal the tailwater at a town outfall is set less often by the open tide or a free river than by a structure and how it is worked: a pumping station, a lock, an embankment sluice or a dam.

The first is Kolkata's pumped and lock-gated system. The city slopes east from the Hooghly's levee. Tolly's Nullah was opened in 1777, the Circular Canal in 1820 and Chitpur lock in 1833; the Bidyadhari, the old outfall, was abandoned in 1928, and under the Kulti Outfall Scheme two parallel channels now carry the city's storm water and dry-weather flow separately for 27 km from Bantala to the Kultigang, "connected with the live Raimangal estuary" (I&WD). I&WD lists KMC's main pumping stations at Ballygunge (1,233 cusec), Palmer Bazar (1,184 cusec) and Dhapa Lock (480 cusec), its own stations at Uttarbhag, Chowbhaga and Keorapukur, and more than twenty smaller ones. The Bagjola canal, the main outlet for South Dum Dum, Bidhannagar and New Town, ends at a pump house at Kulti of 1,650 cusec that is reported to be inadequate; an upgrade to 4,000 cusec is reported as approved by CWC, but its status was not found (press reports). The KEIIP pumping stations discharge storm-water flow to the Churial, Begore, Rania, Western, Parnashree, Bagjola and other canals and Tolly's Nullah (KMC, 2017). When a lock is shut or a canal stands high, the canal becomes a closed reservoir for its catchment, and its outflow is whatever the pumps can lift. Clause 5.8.5(a) therefore routes the canal behind its station, with the whole catchment that drains to it, its present, silted storage, and only the pumping that is really available. It does not count the largest pump, for the same reason that Clause 5.12.2(b) requires a standby pump on every new station: a station cannot rely on every unit running through a storm. No operating rule for any lock, sluice or pumping station on the outfall channels, and no design water level for them, was found in the public domain.

The second is the East Kolkata Wetlands. The city's storm water and sewage pass east by the wetlands, a Ramsar site of 12,500 ha since 19 August 2002 (MoEF&CC), protected by the East Kolkata Wetlands (Conservation and Management) Act, 2006, under which their area and character are to be kept intact and a change of use needs sanction (as reported), and by the Calcutta High Court's judgment of 1992 that stopped further reclamation (secondary sources). Their storage role in a design storm was not researched, and they are not a detention basin for development. Clause 5.8.5(b) gives them no storage credit and leaves every work in them to the Act.

The third is the embankment. The islands of the Sundarbans, which became a Ramsar site of 423,000 ha on 30 January 2019 (MoEF&CC), and much of the coast and the lower rivers, lie behind I&WD embankments, about 3,122 km in the Sundarbans alone, and drain through sluices at low tide. Cyclone Aila breached about 177 km of

them on 25 May 2009 and severely damaged a further 601 km (I&WD), and in Cyclone Yaas in May 2021, 51 embankment breaches were reported in Purba Medinipur and 24 in South 24 Parganas (press reports). Behind a sluice, the drainage of a town such as Canning, Kakdwip, Namkhana or Gosaba is a polder problem. Clause 5.8.5(c) treats the sluice as a gate and the embankment as one that can breach.

The fourth is the dam-release reach. Howrah, Hooghly and Purba Bardhaman lie below Maithon and Panchet, so their outfalls to the Damodar, the Mundeswari and the Rupnarayan are set by releases decided outside the State as well as inside it (Clause 5.8.3). The Ghatal basin, on the Shilabati, Kangsabati and Rupnarayan, is described as a bowl that cannot drain; the State is reported to be carrying out the Ghatal Master Plan from its own funds from 2025–26 (press reports). In the north, the Teesta at Jalpaiguri flows below the Gajoldoba barrage, and the 2023 outburst raised its bed with silt (secondary sources), which is why Clause 5.8.5(d) asks for a bed survey made after it. West Bengal has no flood lines and no floodplain zoning law: the CAG asked I&WD in 2019 to adopt the model flood plain zoning bill, and found flood works "taken up at different locations depending on priority and availability of funds without being linked to a comprehensive plan" (CAG, 2019). Clause 5.8.5(d) therefore uses the highest recorded flood level as a floor for the major-system cases.

The fifth is subsidence. Kolkata's ground is sinking at 2.8 to 5.5 mm/yr (2017–2022), over a growing area, and earlier studies gave rates of up to 12 mm/yr (Thakur et al., 2026), against a sea-level trend of 3.73 mm/yr at Diamond Harbour (PSMSL). Over a 50-year design life, subsidence at the upper end of the measured range adds about 0.28 m, nearly as much as the minimum SLA of Clause 5.7.4, and relative sea-level rise at a Kolkata outfall is the sum of the two. PSMSL makes no correction for land movement, and a tidal level taken from a tide table and connected to a benchmark that is itself sinking understates the future tailwater. Clause 5.8.5(f) adds the subsidence to the SLA, with the upper end of the measured range as the default because the subsiding area is reported to be growing.

5.9 Joint-probability cases

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

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

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

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

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

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

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

5.10 Outfall-closed (tide-locked) storage check

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

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

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

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

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

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

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

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

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

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

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

> V_inflow ≤ V_storage available + V_pumped + V_gravity (between locks)

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

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

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

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

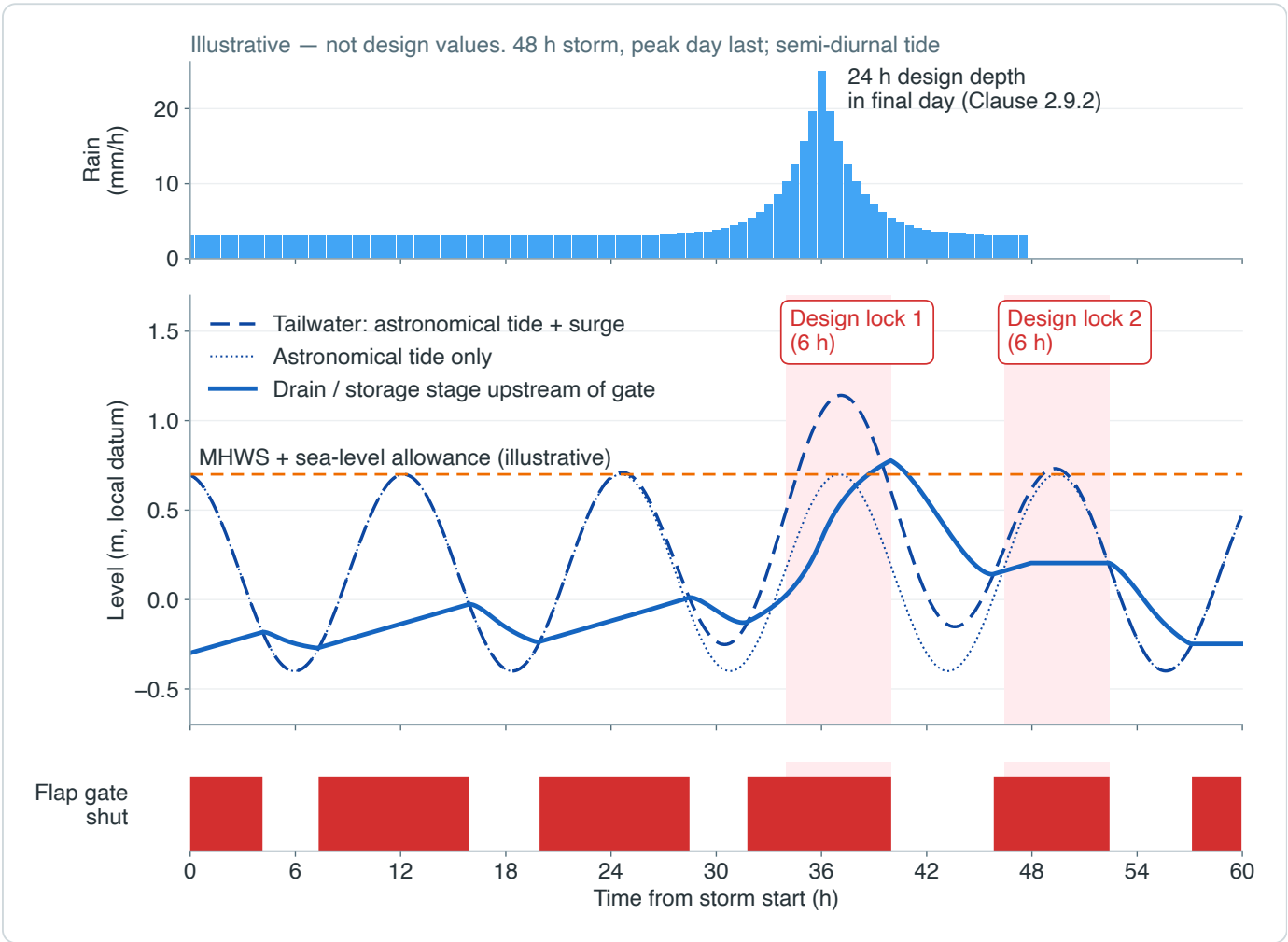

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal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

> **Commentary.** The outfall-closed check is the distinctive West Bengal requirement in this Manual. Kolkata shows why. The city falls away from the Hooghly, so its gravity outfalls to the river work only through locks and gates while the river is low, and its eastern basins depend on pumps that discharge to canals which are themselves tidal. At the KEIIP pumping station at Behala Flying Club the storm-water pumps have to run in parallel, and the basin stays flooded because discharge through the outfall "is partially achieved due to high water levels in the canal, particularly during tidal period" (KMC, 2015). On 23 September 2025, 185.6 mm fell at Alipore in three hours (IMD, 2025), and the waterlogging was blamed on "disfigured drainage and choked canals, coupled with heightened high tide"; nine to twelve people died, most of them electrocuted (press reports). The coast is harder still. The maximum tidal range at the mouth of the Hooghly is about 17 ft, and a tidal bore runs up the river on practically every spring tide (CWPRS), so a gravity outfall above low water but below high water can discharge for only part of each tide, and a sluice through a Sundarbans embankment stays shut for as long as the river outside stands high. A rate rule cannot help when there is no outlet: an orificed basin behind a closed gate simply fills.
>
> The default of two consecutive 6-hour locks has no direct precedent. It represents gravity outfalls failing to discharge for about half of each tidal cycle around the two high tides nearest the storm peak. Figure 5.3 shows why both windows matter. The first lock catches the storm peak. The second arrives before the storage has drained, so the stage rises again.
>
> Placing the first window on the rainfall peak is deliberately unfavourable. Cyclone rainfall and surge share a cause, and Clause 2.12 already treats them as dependent. The check replaces neither the J2 and J3 level checks nor the downstream analysis; it adds a test of timing and volume.

5.11 Flap gates, tide gates and non-return valves

5.11.1 **Where required.** A flap gate, tide gate or equivalent non-return device is required on every outfall whose invert is below the **1% AEP still-water level** (Clause 5.7.3). It is also required on outfalls into irrigation channels under Clause 5.8.5.

5.11.2 **Hydraulics.** The design shall include:

- the gate's head loss and opening head, from the manufacturer's certified head–discharge curve; and
- the reduction in effective outfall capacity when the gate is partly open.

Gates shall not be assumed to seal perfectly in the outfall-closed check unless they are tested.

5.11.3 **Construction.**

- (a) Gates, hinges and seats shall be of corrosion-resistant materials suitable for seawater (Clause 4.12.5).
- (b) The gate shall be set so that sand, silt or debris on the downstream side cannot hold it shut or open. Where the bed is mobile, the gate invert shall be raised above the bed, or the approach shall be protected.
- (c) A trash screen shall be provided upstream where the gate could be jammed by debris.
- (d) A stop-log slot or penstock shall be provided upstream for maintenance isolation on outfalls larger than 600 mm.
- (e) The gate chamber shall be accessible at all tides, with its access above HAT + surge + SLA.

5.11.4 **Non-return valves on property connections.** A non-return valve, or a backwater valve with an accessible cleaning eye, is required on every property drainage connection where the lowest opening served is below:

- the major-system tailwater (J2) at the point of connection; or
- the maximum stage in the outfall-closed check (Clause 5.10).

Basement drainage shall in addition be pumped to a level above both, with its own non-return valve.

5.11.5 **Inspection.** Gates and valves shall be inspected and operated:

- before **15 May** 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. Both failures matter in West Bengal. Kolkata's eastern drainage passes locks and gates such as Chitpur lock, built in 1833 where the Circular Canal meets the Hooghly (I&WD), whose operators have warned of damage at full-moon high tides (press reports). The Sundarbans drain through sluices in about 3,122 km of I&WD embankments, of which about 177 km were breached and a further 601 km severely damaged in Cyclone Aila in May 2009 (I&WD); a sluice jammed open lets the tide behind the embankment, and one held shut by silt keeps the land behind it flooded after the water outside has fallen. The 15 May inspection date is set ahead of the SW monsoon.

5.12 Pumped outfalls

5.12.1 **When required.** Pumping shall be provided where gravity discharge cannot meet:

- the outfall-closed check of Clause 5.10;
- the drawdown requirement of Clause 4.7; or
- the J2 and J3 cases.

Pumping shall not be used where a gravity solution meets these requirements.

5.12.2 **Capacity.**

- (a) The duty pumps together, with the storage provided, shall pass every case of Clause 5.9 (including J4), demonstrated by routing.
- (b) **Standby** capacity at least equal to the largest duty pump shall be installed (duty + 1 standby as a minimum).
- (c) Pump capacity shall be stated at the static head for the **J2** tailwater, not at mean tide.

5.12.3 **Effect on the receiving water.** Pumped discharge to a river, canal or creek shall be included in the river or creek level analysis of Clause 5.8. Pumping that raises the receiving water level above the acceptance criteria of Clause 5.5 elsewhere is not permitted.

5.12.4 **Power supply.** Pumping stations shall have either:

- two independent power supplies; or
- standby generation for 100% of the duty capacity, with on-site fuel for at least **72 hours** of duty operation.

Changeover shall be automatic.

5.12.5 **Flood immunity.** Electrical panels, control equipment, generators and fuel storage shall be set above the higher of:

- the 1% AEP flood level + 0.5 m; and
- HAT + surge + SLA + 0.5 m.

Access to the station shall remain usable in the 1% AEP event.

5.12.6 **Discharge arrangement.** Rising mains shall discharge:

- over a level above the J2 tailwater; or
- through a non-return valve and a flap gate.

The arrangement shall prevent back-siphoning.

5.12.7 **Controls and monitoring.** Each station shall have:

- automatic level control;
- remote alarms for high level, pump failure and power failure, sent to the operator; and
- a level and run-time log kept for at least 5 years.

Wet wells shall be sized to keep pump starts within the manufacturer's limits.

5.12.8 **Screens.** Inlet screens shall be provided with a cleaning method that works during a storm (a mechanical rake, or duplicate screens).

5.12.9 **Testing.** Every pumped outfall shall be test-run at full duty, including on standby power, before **15 May** 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 any river or creek mouth on the Purba Medinipur coast or in the Sundarbans that a pre-monsoon survey shows closed or restricted by sand or silt, and any other mouth listed in Annex 5B.

5.13.2 **Assumption at the start of the SW monsoon.** The mouth shall be assumed **closed** by a bar at the start of the June–September season, at the crest level of the most recent pre-monsoon survey. This applies unless I&WD certifies that:

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

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

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

5.13.4 **No credit for emergency cutting.** Bar cutting or breaching during the storm shall not be assumed in design, unless I&WD 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.** The research for this Manual found no record of seasonal sand-bar closure at the mouths of West Bengal's rivers or creeks, and no I&WD or municipal procedure for clearing them. In the delta the outfalls close with silt rather than sand: the Bidyadhari, once Kolkata's outfall, declined and was finally abandoned by the Government in 1928, which is why the city now drains to the Kulti (I&WD), and silt from the 2023 South Lhonak outburst was reported in the Teesta–Mahananda link canal (secondary sources). Silting of that kind is dealt with by the present-condition storage of Clause 5.8.5(a) and the river bed survey of Clause 5.8.5(d). So Clause 5.13.4 gives no credit for cutting at present, and the mouths to which Clause 5.13.1 applies, on the Purba Medinipur coast and in the Sundarbans, are to be confirmed by pre-monsoon survey and listed in Annex 5B. 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 I&WD 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 beside a khal in Kolkata's eastern suburbs
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) West Bengal 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.** West Bengal's town drains were designed for frequent storms, where a design standard is stated at all. Kolkata's first brick sewer, commissioned in 1876, was designed to carry 6.35 mm of rain an hour (a quarter of an inch) with 100% runoff, and attempts were made in the 1970s to raise the capacity to 12.7 mm an hour (Gupta, 2005); KMC engineers are still quoted as saying that the underground network prevents waterlogging only when it rains up to about 6 mm in an hour (press reports). The metropolitan drainage master plan of the CMPO was based on a storm "of once in two months (6 times in a year)" and a coefficient of imperviousness of 70%, and its intensity–frequency–duration curve "has been adopted by KMDA / ULBs" (CPHEEO appraisal of the Howrah drainage project under JNNURM); that curve was not found. The environmental assessments of the ADB-financed KEIIP programme give the design period and the canals that receive the storm-water flow, but no rainfall intensity, return period or runoff coefficient (KMC, 2015 and 2017), and no design criteria were found for Howrah, Bidhannagar, New Town or any other town. Recent storms are far beyond such standards. On 23 September 2025 the IMD gauge at Alipore recorded 251.4 mm in 24 hours, 185.6 mm of it in three hours and 98 mm in the wettest hour (IMD, 2025), and the CWC's flood estimation report for the Lower Ganga Plains records 100 mm in one hour (24 August 1987) and 207 mm in three hours (25–26 August 1984) at Dum Dum (CWC, 1994). 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 **Receiving combined sewers.** Where the public drain or sewer that receives storm water from a site or a public drainage project also carries sewage (a combined sewer, as in much of Kolkata), this chapter applies to the storm-water system up to the point of connection, with the following additions:

- (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. Where the Authority allows only one connection to the combined sewer, the two systems shall meet only in a final chamber after both inspection chambers. 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 combined sewer, as at any other site outfall (Clause 4.5.1.3), so that its peak storm-water inflow to the combined system for each AEP checked is no more than the greenfield peak or, on the constrained-redevelopment route, no more than half the existing peak (Clause 4.5.6). 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 combined sewer at the connection in the coincident event, taken from the sewer owner's model where one exists and otherwise at the sewer's obvert (Clause 5.6.2). Where the combined sewer drains to a pumped or tide-locked outfall, the outfall-closed check of Clause 5.10 applies. A non-return valve (Clause 6.8.8) shall be fitted on every connection, storm or foul, to a combined sewer wherever the lowest drainage fitting or opening it serves is below the cover level of the public manhole at the connection.
- (d) **Major system.** The capacity of a combined sewer used in Clause 6.3.3 shall be the capacity left after its dry-weather flow, from the owner's records. Flow above that capacity, or above what the inlets admit, shall be carried on the surface by the major system of this chapter (Clauses 6.3.2 and 6.9), and floor levels shall be set under Clause 6.11 with the combined sewer surcharged.
- (e) **Separation and storage planned by the Authority.** Where the receiving system is combined, the Authority shall identify in its master plan (Chapter 11) the areas where a separate public storm drain is feasible and, elsewhere, the storage that will hold back the peak of the combined flow from the pumping stations and outfalls, including ponds and other waterbodies kept under Chapter 7, and shall plan for them. 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 combined sewer.
- (f) **Reporting.** The Conveyance Design Report (Form 6-1) shall state whether each receiving drain is separate or combined, the source of that information, and how items (a) to (e) are met.

> **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 Kolkata 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 West Bengal. Much of Kolkata drains to combined sewers, and the law assumes it. The Kolkata Municipal Corporation Act, 1980 requires the Corporation to construct drains and sewers and "provide a safe and sufficient outfall … for the effectual drainage and proper discharge of storm-water and sewage of Kolkata" without flooding the city "or the country surrounding the outfall" (s.277(1)); vests all public drains in the Corporation (s.280); and lets the Municipal Commissioner require "one drain for sewage, offensive matter and polluted water and an entirely distinct drain for rain water and unpolluted sub-soil water", each emptying into separate municipal drains or other suitable places (s.292). Section 292 is a power, not a duty. (The quotations are from a scanned compilation of the Act and have been read through poor character recognition.) Wards 1 to 100 have an organised combined system, while the areas added to the city in 1984 had little organised sewerage and drainage until the ADB-financed KEIP and KEIIP programmes, whose new works are still combined (KMC, 2015). Each KEIIP pumping station has separate pumps for dry-weather flow and for storm-water flow, and in a storm the "SWF mixed with sewage" is pumped to the canals (KMC, 2015). The ADB-financed KMC-SHARP project, approved in 2025, is reported to add 84 km of combined trunk and secondary sewers and 176 km of combined laterals (ADB, 2025; press reports). Whether New Town, Bidhannagar and the municipalities outside Kolkata are drained by separate or combined systems was not confirmed during research, so Clause 6.3.6 turns on what the receiving drain is, which the designer establishes from its owner.

The clause takes three positions. First, a site keeps its storm water separate up to the connection (6.3.6(a)), as section 292 already allows the Commissioner to require, so that the city can separate its system street by street without going back into every plot. Second, a development shall not add to the peak of the combined flow (6.3.6(b)). Storm water that enters a combined sewer is lifted at a pumping station whose storm pumps send it, mixed with sewage, to a canal, so each added litre adds sewage-laden discharge to the canals and the East Kolkata Wetlands as well as flooding. Chapter 4 already holds regulated sites to the greenfield peak; item (b) adds only the small plot that adds a roof. Third, separating the public system is for the Authority to plan, not for each site (6.3.6(e)). Where separation is not practical in old, narrow streets, storage that holds back the combined peak, including the ponds that are already the city's de facto detention, is the alternative. The non-return valve of item (c) matters more than on a storm drain, because what comes back up a surcharged combined sewer is sewage; the manhole-cover test is set by this Manual.

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: Kolkata, Howrah and Bidhannagar 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

Element	Design AEP (return period)	Check event	Basis
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 Kolkata, wards 1 to 100 of the Kolkata Municipal Corporation, the older city served by an organised combined sewerage and drainage system (KMC, 2015);
- (b) the area of the Howrah Municipal Corporation, and the Salt Lake township in the Bidhannagar Municipal Corporation area, which has a chapter of its own in the West Bengal Municipal (Building) Rules 2007; 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.

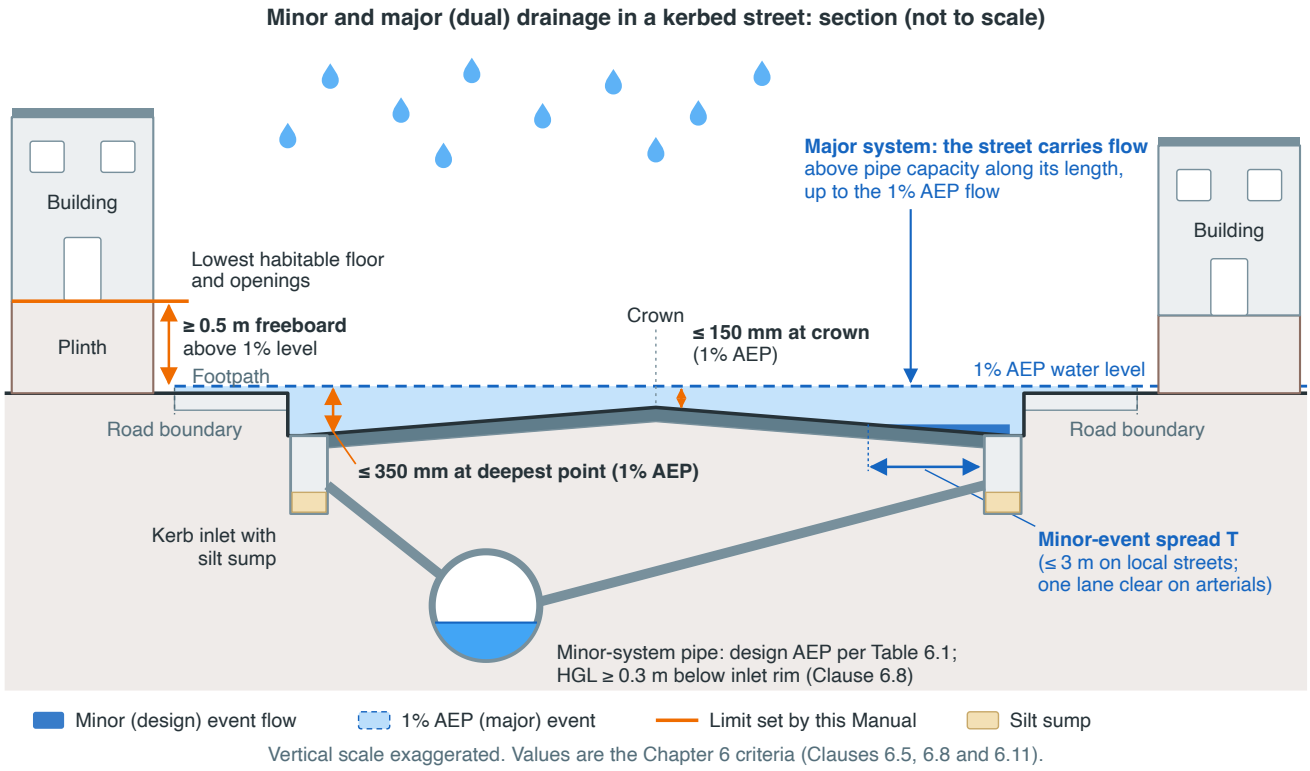


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

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 West Bengal 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.

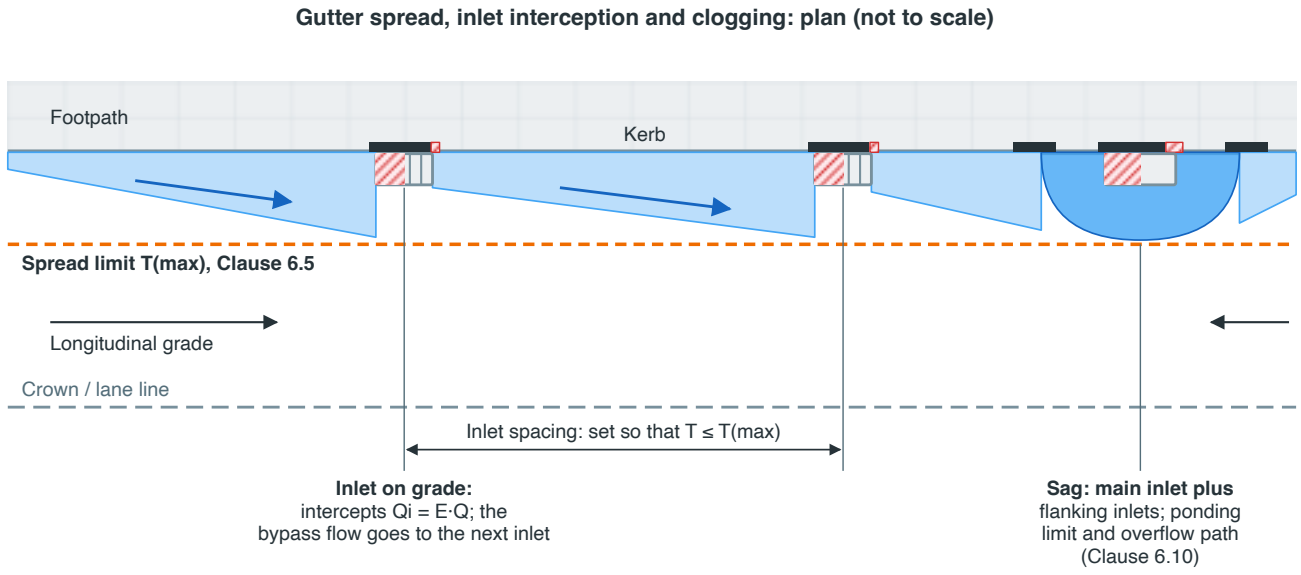
6.6.5 **Sag inlets.** At a sag on a kerbed road:

- (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
Grade	**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 West Bengal 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. 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 in Kolkata and the delta are very flat, since the land falls only gently east from the Hooghly's levee, which shortens the calculated spacing anyway. 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 Darjeeling, Kalimpong, Kurseong and other hill towns with the approving authority's agreement;
- (c) maximum velocity in unlined and vegetated channels: Chapter 9, Table 9.2;
- (d) the Froude number of flow in open and covered drains shall not exceed 0.8 at the design flow, unless the drain is designed for supercritical flow under Chapter 9.

6.7.4 **Gradient.** Each pipe and drain shall be laid at a gradient that achieves Clause 6.7.3(a). Where flat terrain or a fixed outfall level makes this impossible, the designer shall:

- (a) report the velocity achieved;
- (b) double the sediment allowance of Clause 6.7.8; and
- (c) provide access for mechanical desilting at the spacing of Clause 6.13.2.

6.7.5 **Pipe flow condition.** Pipes shall be sized so that the minor design flow does not exceed the pipe-full capacity. The greater discharge that a circular pipe carries at about 0.95 of its depth shall not be relied on.

6.7.6 **Minimum sizes.**

- (a) Pipes: 300 mm internal diameter; **450 mm** for public mains.
- (b) Open drains: bed width 0.3 m.
- (c) Covered public drains (drains closed by cover slabs): clear internal width **0.6 m** and clear internal depth **0.6 m**.

6.7.7 **Cover to pipes.** Pipes shall have at least 0.6 m of cover to finished level, and at least 0.9 m under carriageways unless a structural design for the traffic load is submitted. Where the seasonal high groundwater table is within 1 m of the pipe crown, the pipe shall be checked for flotation with the pipe empty (CPHEEO 2019, Table 11.2) and anchored where necessary.

6.7.8 **Sediment allowance.** The design capacity of open drains, covered drains and pipes of 600 mm diameter or more shall be computed with the following depth of sediment at the invert:

- (a) open and covered drains: the greater of **75 mm** and **10%** of the clear internal depth;
- (b) pipes of 600 mm diameter or more: **5%** of the internal diameter;
- (c) pipes below 600 mm: no allowance, but Clause 6.7.3(a) shall be met.

The Manning n for the reduced section shall be that of the drain material in Table 6.6.

6.7.9 **Freeboard in open and covered drains.** At the minor design flow, the water surface (computed with the sediment allowance) shall be below the top of the drain wall, or below the soffit of the cover slab in a covered drain, by at least the freeboard of Table 6.7.

Table 6.7 — Minimum freeboard in open and covered drains

Drain	Minimum freeboard	Source
Bed width up to 300 mm	100 mm	CPHEEO 2019 Table 5.3 (from IRC:SP:50-2013)
Bed width 300–900 mm	150 mm	CPHEEO 2019 Table 5.3
Bed width 900–1,500 mm	300 mm	CPHEEO 2019 Table 5.3
Wider drains and engineered channels, Q < 3 m³/s	450 mm	CPHEEO 2019 Table 5.12 (from IS 7784 (Part 1): 1993)
Q 3 to < 30 m³/s	600 mm	As above
Q 30 to < 300 m³/s	900 mm	As above
Q 300 to < 3,000 m³/s	1,200 mm	As above
Q ≥ 3,000 m³/s	1,500 mm	As above

Drain	Minimum freeboard	Source
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.

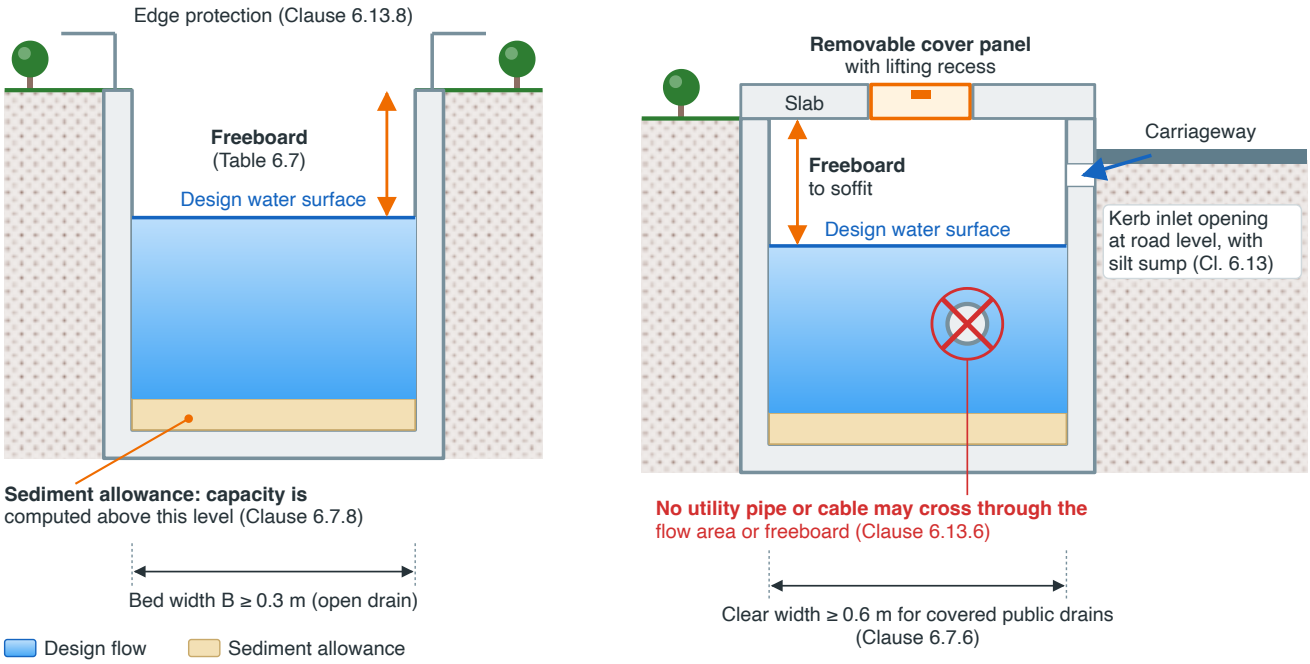


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

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 West Bengal 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 Kolkata flood of 23 September 2025, when 251.4 mm fell at Alipore in 24 hours (IMD) and "disfigured drainage and choked canals, coupled with heightened high tide" were blamed for the waterlogging (press reports). 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. Kolkata'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 Kolkata, the drains discharge to canals and outfall channels that stand high at high tide: at the KEIIP pumping station at Behala Flying Club the basin stays flooded because discharge through the outfall "is partially achieved due to high water levels in the canal, particularly during tidal period" (KMC, 2015), and the waterlogging of 23 September 2025 was blamed in part on a "heightened high tide" (press reports). Howrah is lower than the Hooghly beside it (CPHEEO appraisal of the Howrah drainage project). A drain whose HGL is started from a free outfall, at a canal or river that stands high for hours of a monsoon storm, fails in exactly that way. An HGL computed from the outfall, with the tidal tailwater of Chapter 5, exposes those errors at design stage. The MHWS plus 0.3 m starting level is from CPHEEO (2019) Table 6.2. The access-hole method is described in HEC-22 from the 2009 edition onward.

6.9 Major system: overland flow paths, easements and drainage reserves

6.9.1 **Streets as the primary major system.** Streets shall be graded so that the 1% AEP major-system flow is carried along the road reserve to a receiving waterway without being trapped, except at sags designed under Clause 6.10.

6.9.2 **Overland flow paths outside streets.** Where a major-system path leaves the road reserve, it shall be:

- (a) in public land, in the open space of a layout, or in an easement recorded on the layout approval and the title;
- (b) at least as wide as the 1% AEP flow top width plus 0.5 m on each side, and not less than 3.0 m;
- (c) kept free of buildings, compound walls, fences, fill, stored materials and planting that would obstruct flow;
- (d) graded to a continuous fall with no sag that lacks an outlet; and
- (e) within the hazard limits of Table 6.3.

6.9.3 **Compound walls.** A compound wall or fence shall not be built across a mapped overland flow path. Where a wall must cross one, it shall have openings with a total area that passes the 1% AEP flow with a 50% blockage, without raising the upstream water level above the limits of this chapter.

6.9.4 **Access along open drains.** Open drains with a top width of 2 m or more shall have a maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m.

6.9.5 **Supply channels, surplus courses and tanks.** Tank supply channels and surplus courses are part of the major system and shall be protected under Chapter 7.

6.9.6 **Drainage reserves.** A drainage reserve is a strip of land, including the drain, kept free of buildings so that the drain can be maintained, widened and used as a flood path. A drainage reserve shall be provided:

- (a) along every public drain or channel with an internal width of 1.0 m or more that runs through or along a layout or site being developed or redeveloped;
- (b) along every drain or channel shown in an adopted Basin Stormwater Master Plan (Chapter 11), at the width of the future drain in that plan; and
- (c) along every new public drain with an internal width of 1.0 m or more built by a public body.

6.9.7 **Width.** The reserve shall be not less than the width in Table 6.9, measured from the drain's internal width W. The width is based on the **required** drain size (for a planned drain, the size in the master plan), not the existing size. Where the access strip of Clause 6.9.4 is wider than the margin in Table 6.9, the wider governs.

Table 6.9 — Minimum drainage reserve width (adopted from PUB Singapore)

Internal width of drain, W	Open drain	Closed (covered) drain
1.0 m to 1.2 m	3.0 m	W + 0.6 m
more than 1.2 m to 3.0 m	W + 2.6 m	W + 1.6 m
more than 3.0 m to 4.5 m	W + 3.5 m	W + 1.6 m
more than 4.5 m to 6.0 m	W + 4.5 m	W + 3.0 m
more than 6.0 m to 9.0 m	W + 6.0 m	W + 3.0 m
more than 9.0 m to 25.0 m	W + 7.5 m	W + 3.0 m
more than 25.0 m	W + 12.0 m	W + 3.0 m

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

6.9.8 **Use and protection.**

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

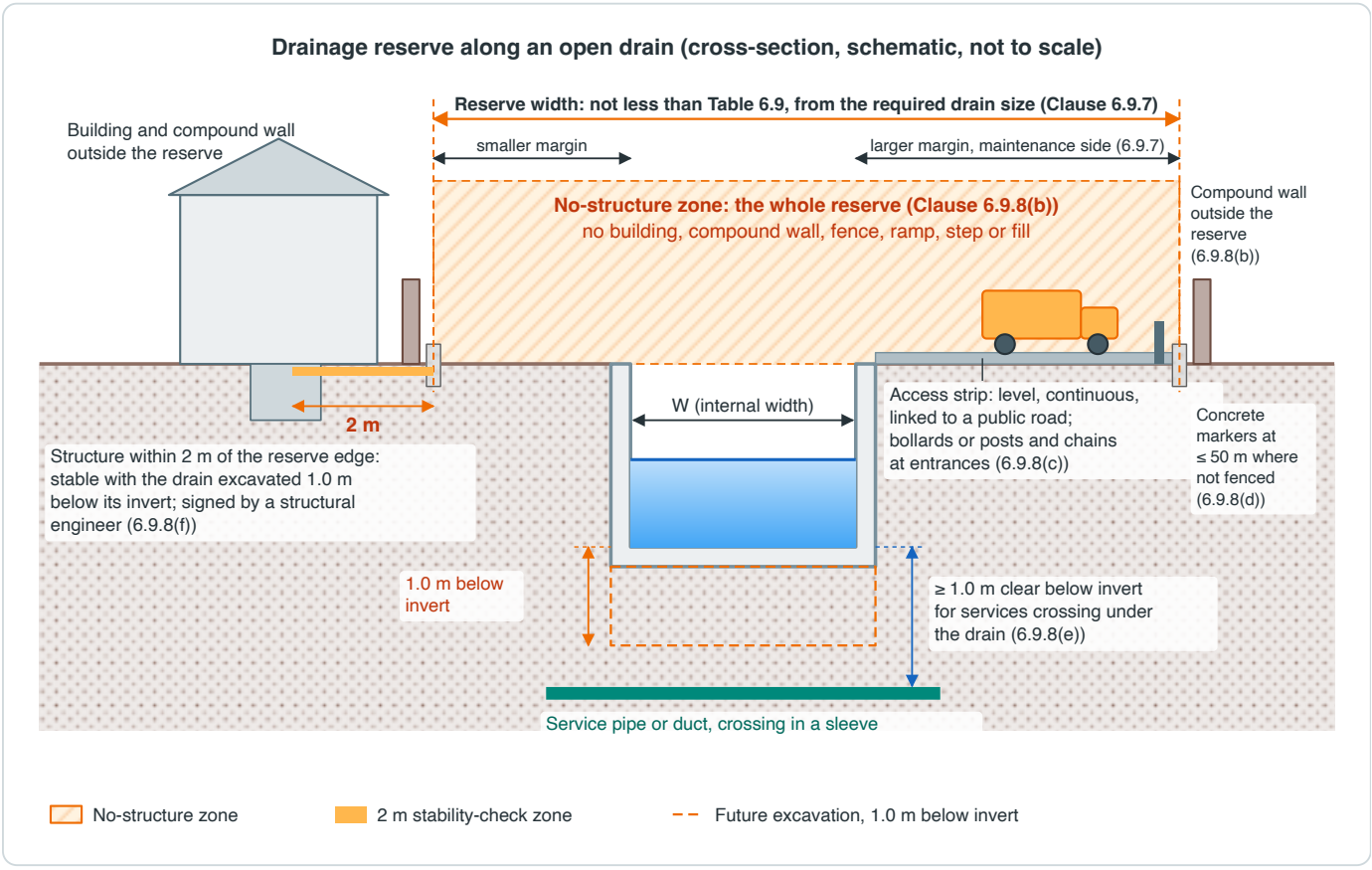


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 West Bengal, 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. West Bengal has almost no statutory distances that keep development back from a drain or khal. The KMC Building Rules 2009 set no setback from a khal, canal or pond. They reward keeping a water body instead: its area counts in the plot area for FAR (rule 2(27)), and the open spaces, height and internal road width may be relaxed where a water body or a heritage building, or both, cover at least 25% of the plot (rules 65A, 74(4) and 81(9)). The West Bengal Municipal (Building) Rules 2007, as reported, bar the filling of any canal, pond, water body, wetland, stream, drain or culvert without the prior approval of the State Government (rule 8(3)), and in the river zone within 15 m of a river bank cap buildings at 5 m in height, 20 m in length and 200 m² in covered area, with clear gaps of 15 m to 30 m between them according to the width of the river (rule 8(4)). That zone limits what may be built near a river, not whether, and does not reach khals or drains. The KMC Act 1980 keeps filth receptacles 15 m from a tank, well, water-course or reservoir, but sets no building line along a drain, and no statutory bank buffer along I&WD canals was found during research. This Manual therefore adds a **hydraulic corridor**: the reserve of Table 6.9, based on the drain size needed to carry the design flow (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along a khal, nala or channel that drains 8 ha or more, the setbacks of Clause 7.4 measured from its top of bank, with a Zone 1 of at least 15 m. The corridor is stricter than statute and is set by this Manual, and Clause 6.9.8(b) applies it to compound walls and fill as well as to buildings. Where the river zone of rule 8(4) is wider, the limits of that rule also apply within it. Along Kolkata's khals, such as Tolly's Nullah and the Bagjola, Kestopur, Beleghata and Circular canals, the reserve is transferred to I&WD under Clause 6.9.8(a) wherever the khal is an I&WD channel. I&WD is reported to own the main canals and outfalls, such as the Bagjola and Kestopur canals, but the division of the khals between I&WD and KMC was not confirmed during research. West Bengal has no flood lines along its rivers and no floodplain zoning law: the CAG asked I&WD in 2019 to adopt the model flood plain zoning bill (CAG, 2019), and no enactment was found. Along a river, khal or channel, the 1% AEP flood extent computed or mapped under Chapter 7 therefore also governs where it is wider. The corridor should be mapped and lodged with the land-use and development control plans made under the West Bengal Town and Country (Planning and Development) Act, 1979, rather than made a new NOC.

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 West Bengal 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. 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.

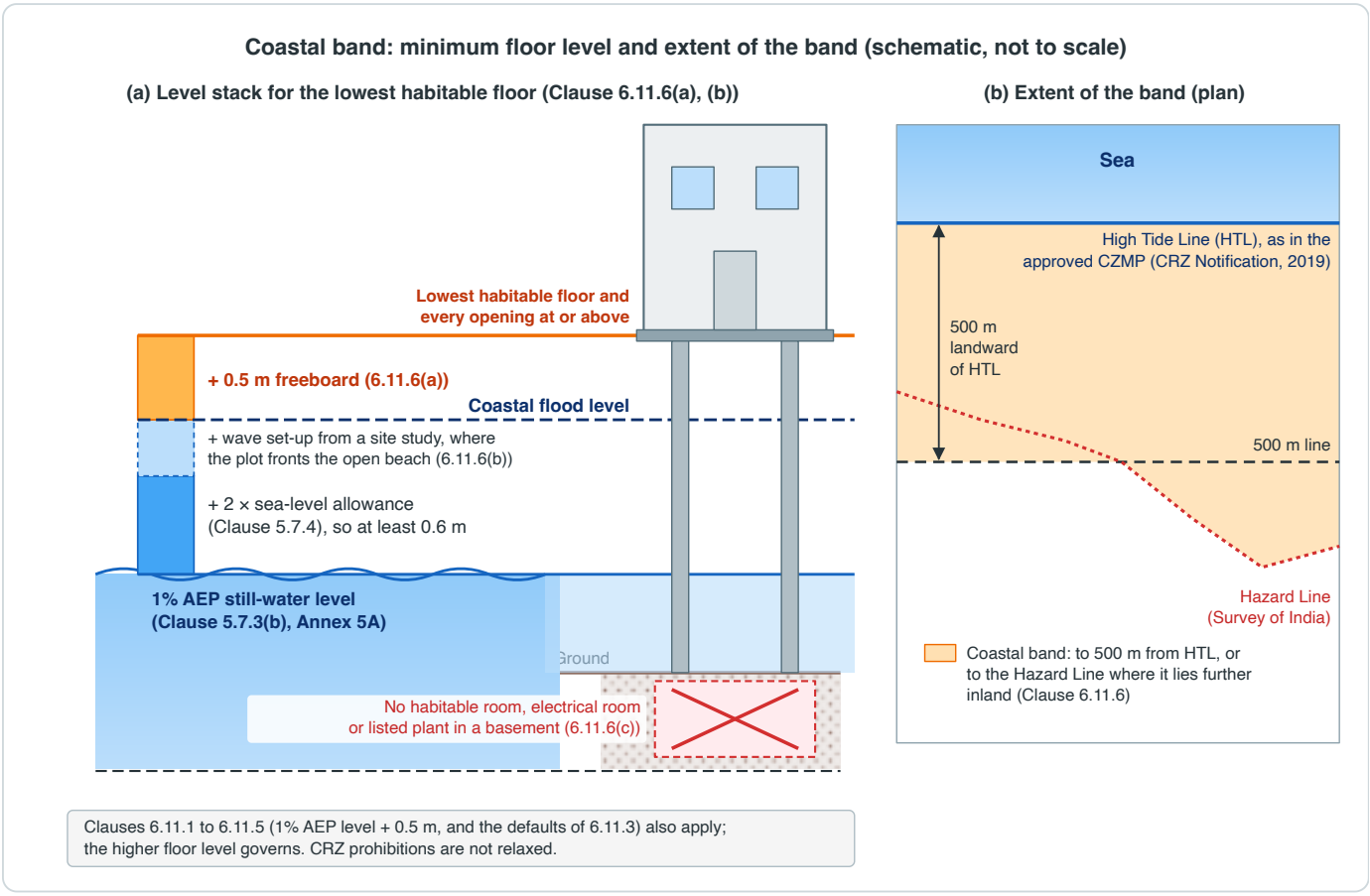


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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). West Bengal'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. In West Bengal, the Coastal Zone Management Plan under the CRZ Notification, 2019 had not been approved by December 2025. The draft for the whole State went to MoEF&CC on 4 October 2024 and was returned after the Technical Scrutiny Committee met on 17 December 2024; revised plans were sent for Purba Medinipur on 10 September 2025 and for North 24 Parganas on 29 October 2025, and the plan for South 24 Parganas, which includes the Sundarbans, was promised for January 2026 (affidavits of the West Bengal Coastal Zone Management Authority to the NGT, 2025). No later approval was found during research. Until a plan under the 2019 Notification is approved, the High Tide Line is taken from the approved plan made under the CRZ Notification, 2011, which the State's revised plans themselves overlay, and the designer should confirm the current plan with the West Bengal Coastal Zone Management Authority. That line is disputed. The State's coastal authority has told the Committee that on West Bengal's eroding, "retrograding" alluvial coast the High Tide Line of 2011 "no longer exists", while the Committee recommended keeping it (same source). Where the shoreline has moved inland of the 2011 line, the band of Clause 6.11.6 shall be measured from whichever of the 2011 High Tide Line and the present high-tide line gives the band that reaches further inland (set by this Manual). Much of the band lies behind embankments: about 3,122 km of them in the Sundarbans, of which Cyclone Aila breached about 177 km in May 2009 (I&WD). An embankment does not lower the coastal flood level of Clause 6.11.6(a), because it can breach. The Sundarbans Wetland has been a Ramsar site of 423,000 ha since 30 January 2019 (MoEF&CC). Drain widening, outfall extensions, bunds, sluices, gates and pumping stations in or beside a mangrove stand need CRZ clearance, and this Manual authorises none of them. Clause 6.11.6 adds a floor-level rule and relaxes neither.

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 West Bengal construction-practice requirements

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of West Bengal 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 West Bengal the south-west monsoon sets in during the first or second week of June in most districts and in the third week in Purulia (ICAR-CRIDA district contingency plans), but cyclones and nor'westers bring some of the heaviest falls before it. Cyclones Aila, Amphan, Yaas and Remal all struck in the second half of May (25 May 2009, 20 May 2020, 26 May 2021 and 26–27 May 2024), and the May records for a day include 353.2 mm at Cooch Behar (28 May 1989), 312.8 mm at Jalpaiguri (24 May 1999) and 295.1 mm at Contai (28 May 1960) (IMD). So Clause 6.13.10 refers to the south-west monsoon, Chapter 10 sets the 15 May deadline, and drains, gates and pumping stations should be checked again by 30 September, before the cyclones and depressions of October and November. The large canals are cleaned irregularly: dredging of the Kestopur and Bagjola canals, about 80 km together, began in 2022 after a gap of five years (press report).
>
> Clause 6.13.7 cannot be read alone in Kolkata, where the public drain that a site connects to is usually a combined sewer that carries sewage by design. Clause 6.3.6 sets how the storm-drain rules of this chapter apply there.

> 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 West Bengal 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, including the East Kolkata Wetlands and their bheris, the Sundarbans Wetland with its tidal creeks (khanris) and mangroves, the Hooghly estuary, the bils and baors of the Gangetic floodplain, and the pukurs, dighis and jhils of Kolkata and other towns;
- (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 West Bengal Inland Fisheries Act, 1984 (section 17A), the West Bengal Town and Country (Planning and Development) Act, 1979, the Kolkata Municipal Corporation Act, 1980, the West Bengal Municipal (Building) Rules, 2007 (rule 8), the East Kolkata Wetlands (Conservation and Management) Act, 2006, the Coastal Regulation Zone Notification as applied through the CZMP in force, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. No West Bengal Act for the protection of tanks or lakes as such was found during research for this Manual. Ponds are protected instead by fisheries law, planning law, municipal law and the courts. Section 17A of the West Bengal Inland Fisheries Act, 1984 (Chapter IIIA, inserted in 1993 and operative from 16 June 1994) bars the use of a "water area", or of depressed land that holds water for at least six months in a year, for any purpose other than fishery, and bars its filling "with a view to converting the same to solid land"; filling for a development scheme needs the prior approval of the Fisheries Department, the owner may be made to restore the area at his own cost, and the offence carries up to two years' imprisonment, a fine of up to ₹2 lakh, or both. The 1993 text applied only to areas of 5 cottahs (0.035 ha) or more; those words were omitted by the West Bengal Inland Fisheries (Amendment) Act, 2008, so the bar now applies whatever the size (all as reported; the Gazette text of the 2008 amendment was not read). Rule 8(3) of the West Bengal Municipal (Building) Rules, 2007 bars the filling of any "canal, pond, water body, wetland, rivulets, jhora, water source, natural spring, streams", drain or culvert in the municipal areas without reasons recorded in writing and the prior approval of the State Government (as

reported). In Kolkata, KMC acts through restoration notices under section 53 of the West Bengal Town and Country (Planning and Development) Act, 1979, notices of its Building Department under section 400(1) of the KMC Act, 1980, and police complaints, of which it had reportedly filed 870. The Calcutta High Court has held that the Corporation must first establish that a site is a "water area" before it acts under section 17A (*Anuradha Sen v. Kolkata Municipal Corporation*, 9 January 2024, as reported). The KMC Building Rules 2009 add an incentive: water bodies within a plot count in the plot area for FAR (Rule 2(27)), and setback, height and internal-road relaxations are available where a water body, a heritage building or both cover at least 25% of the land (Rules 65A, 74(4) and 81(9), in the copy of the Rules that appears to include later amendments). The East Kolkata Wetlands have their own Act of 2006 and the High Court's judgment of 1992 (Clause 7.12). Counts of Kolkata's ponds disagree: KMC listed 1,634 water bodies in 1996 and 3,874 in 2006, against about 8,731 estimated by NATMO and about 4,889 in a later satellite count, a loss of some 44% (as reported, on different bases). On the coast, the Coastal Zone Management Plan under the CRZ Notification, 2019 had not been approved by December 2025 (NGT filings). This chapter gives the design rules that protect waterbody storage and conveyance. It does not replace the fisheries, planning, municipal, wetland and coastal procedures that record and protect waterbodies in law, or the directions of the High Court and the National Green Tribunal.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river or tidal river (gang), stream, khal or nala, canal, lake or large tank (jhil, dighi, sayar), tank or pond (pukur, doba), floodplain wetland or marsh (bil, baor, jala), embanked fishery (bheri), tidal creek or estuary (khanri, mohana), mudflat or mangrove, abandoned brick-field pit, 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) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling.
Maximum water level (MWL)	The highest water level in a tank when the surplus weir passes the tank's design flood. For this Manual, it is the greater of the level recorded by the I&WD 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 channel, khal or nala)	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 gate or outlet, including a sluice through a river or Sundarbans 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.

Term	Meaning in this Manual
1% AEP flood extent	The land flooded by the 1% AEP (100-yr) flood with the climate factor of Clause 2.8, from a hydraulic model that meets Chapter 3 and Chapter 5, or from a map adopted by the Authority under Clause 7.3.4.
Floodway	The waterbody and the adjoining land that must be kept free of obstruction to pass the 1% AEP flood without raising the 1% AEP water level by more than **0.1 m** at any point (Clause 7.6.1). For a tank, all land below MWL.
Flood fringe	The part of the 1% AEP flood extent outside the floodway.
Zone 1 (waterbody protection zone)	The inner setback zone defined in Clause 7.4.3.
Zone 2 (flood fringe setback)	The outer setback zone defined in Clause 7.4.4.
Setback	Zone 1 and Zone 2 together.
Compensatory storage	Excavated storage that replaces flood storage lost to fill, under Clause 7.6.4.
Flood cushion	Storage below FTL kept empty, under a documented operating rule, to absorb a flood (Clause 7.8).

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

Term	Meaning in this Manual
Water area	The land that section 17A of the West Bengal Inland Fisheries Act, 1984 protects: a water area, with or without embankments, or naturally or artificially depressed land that retains water for at least six months in a year, of any size since the 2008 amendment (as reported). A water area is a tank or pond under Clause 7.2, whether or not it has a bund, an overflow or a sluice. Whether a particular site is a water area is for the competent authority to establish after inquiry (*Anuradha Sen v. KMC*, 2024, as reported); for design under this Manual, the boundary of Clause 7.13.1 applies.
Pukur; dighi; jhil	A pond or tank; a large and deep tank; a very large pond (Annex 7E). KMC's records classify plots as "Pukur (Pond)". Each is a tank or pond under Clause 7.2. Most urban pukurs have no surplus weir: their FTL is the level at which they spill to the street drains or to the next pond, found by survey.
Water body (East Kolkata Wetlands)	Under the East Kolkata Wetlands (Conservation and Management) Act, 2006, "water body" includes "any land holding water", and the East Kolkata Wetlands are the areas described in Schedule I of the Act and mapped in Schedule II (sections 2(c) and 2(k), as reported). Within that boundary, Clause 7.12 applies in addition to this chapter.
Bheri	An embanked low land used as a fishery (Annex 7E). In the East Kolkata Wetlands, a fishery pond fed with the city's sewage for fish culture, which the 2006 Act calls "sewage-fed pisciculture" (section 4, as reported). A bheri is a tank or pond under Clause 7.2 and, within the East Kolkata Wetlands, part of a wetland under Clause 7.12; its storage is not counted as detention for any development (Clause 7.12.5).
Khal	A canal or channel (Annex 7E), natural or cut, such as Tolly's Nullah, the Bagjola, Kestopur and Churial khals and the Circular Canal. A khal draining 8 ha or more is a natural channel under Clause 7.4.1(b), whether or not it was dug. In Kolkata a khal that receives storm-water flow pumped from a combined system is also a combined-system outfall channel (Clause 7.10.6 and Chapter 8).
Outfall channels (DWF and SWF channels)	The "two parallel channels from Bantala to Kulti (17 miles / 27 kms) to carry storm water and dry weather flow of the city separately" of the Kulti Outfall Scheme (I&WD). For this Manual they are channels under Clause 7.10 and the downstream end of every Kolkata cascade under Clause 7.7.2; their tailwater is the tide in the Kultigang (Chapter 5).
River zone	The zone "within 15 metres from river bank", and on the fronts of water bodies of more than 1,000 acres, in which rule 8(4) of the West Bengal Municipal (Building) Rules, 2007 limits a building to 5.00 m in height (6.50 m on stilts at least 3.00 m high and not walled in), 20 m in length and 200 m² in covered area, with clear gaps between buildings of 30 m, 20 m or 15 m for rivers more than 75 m, 50 to 75 m and less than 50 m wide (as reported). It limits buildings but does not keep the strip clear; Zone 1 of this Manual, not less than 15 m, excludes buildings, fill, paving and walls from the same strip (Clause 7.5.1).
Embankment (bandh)	A river or Sundarbans flood embankment. The I&WD counts about 3,122 km of embankment in the Sundarbans (I&WD, Aila account). A sluice through an embankment is a controllable outlet under Clause 7.8 only where its gates can be operated to a written rule; a breach or cut in an embankment is governed by Clause 7.14.5.

Term	Meaning in this Manual
Brick-field pit	An abandoned brick-field pit, which rule 8(5) of the West Bengal Municipal (Building) Rules, 2007 requires to be kept as a water body (as reported). It is a tank or pond under Clause 7.2.
Filled-up tank	Land declared in a KMC building application as a "solid/filled up tank or part tank" (KMC Building Rules 2009, application form). For this Manual, a filled tank is a waterbody under Clause 7.3.3, and its recorded extent governs, unless the competent authority has approved the filling in law.

7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with the I&WD and the Land and Land Reforms 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 I&WD, KMC or another municipal corporation, a Municipality, NKDA, KMDA or another development authority, EKWMA, the Gram Panchayat, the Fisheries Department, the Land and Land Reforms Department (through the District Collector), the Forest Department, the private owner of a pond or bheri, 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) mouza maps and land records of the Land and Land Reforms Department, including land recorded as pukur (pond), doba, khal, bil or jala (KMC's notices cite the L.R. plot "classified as Pukur (Pond)"); the water-body lists of KMC and other ULBs and KMC's GIS mapping of ponds; land shown as a water body in a land-use map or notification of KMDA or another development authority under the West Bengal Town and Country (Planning and Development) Act, 1979; the map of the East Kolkata Wetlands in Schedule II of the 2006 Act; and, in the coastal districts, the High Tide Line and mangroves of the Coastal Zone Management Plan (CZMP) in force;
- (b) I&WD and Gram Panchayat tank registers and records of FTL and MWL;
- (c) the Authority's inventory (Clause 7.3.1) and any list published under court directions;
- (d) historical topographic maps and satellite imagery, including the ISRO National Wetland Inventory and Assessment; and
- (e) a site survey by a licensed surveyor, levelled to the datum stated in Clause 7.3.5.

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

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

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

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

> Commentary. No 1% AEP flood map of any West Bengal city was found, and West Bengal has no system of statutory flood lines. The CAG recommended in 2019 that the State enact the Model Flood Plain Zoning Bill, and found that flood management projects were "taken up at different locations depending on priority and availability of funds without being linked to a comprehensive plan" (CAG, Report No. 2 of 2019). KMC has begun GIS mapping of its ponds, and its website was reported to show pond lists for 141 of its 144 wards (as reported); in the case at Behala that came before the National Green Tribunal, KMC detected the filling of a pond by comparing the site with the NRSA aerial map (NGT, OA 258/2024). KEIIP's third tranche of work was to include an early-warning system for flood risk and an update of KMC's land use maps "to incorporate climate change principles" (ADB, 2016); no published flood map from it was found. The National Green Tribunal directed in November 2021 that the boundary of the East Kolkata Wetlands be demarcated with pillars within six months (as reported); whether that was done was not established. On the coast, the CZMP under the CRZ Notification, 2019 was not approved by December 2025, and the State and the Technical Scrutiny Committee disagreed over whether to keep the High Tide Line of 2011, which the State's coastal authority says "no longer exists" on an eroding coast (NGT filings, 2025). Clause 7.3.4 lets the Authority adopt larger-scale flood maps once they are issued. Until then, the Applicant must produce the extent for larger and flood-sensitive sites, and because West Bengal has no flood lines, that extent governs wherever it has been mapped. 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 (no West Bengal statute or building rule sets a general setback from khals, ponds or wetlands, and the 15 m river zone of rule 8(4) of the West Bengal Municipal (Building) Rules, 2007 limits the height and size of buildings in it rather than keeping it clear; see the Disclosure below);
- (b) the outer edge of the floodway (Clause 7.6.1); and

- (c) for a tank, the MWL contour.

7.4.4 **Zone 2 width.** Zone 2 extends from the outer edge of Zone 1 to the **1% AEP flood extent plus 10 m**. Where the 1% AEP flood extent lies inside Zone 1, Zone 2 is 10 m wide.

7.4.5 **Statutory and approval setbacks.** Where a statute, a statutory rule, a condition of planning permission or the I&WD's consent for a work on one of its rivers, embankments, khals or outfall channels, the Fisheries Department's permission under section 17A of the West Bengal Inland Fisheries Act, 1984, the sanction of EKWMA under the East Kolkata Wetlands (Conservation and Management) Act, 2006, a WBSCZMA recommendation or CRZ clearance, or a permission of the wetland authority sets a setback wider than Zone 1 or Zone 2, the wider setback governs for the uses it restricts.

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

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

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

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

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

> Commentary. The 15 m minimum is set by this Manual, because the KMC Building Rules 2009, the West Bengal Municipal (Building) Rules, 2007 and the West Bengal Acts that protect waterbodies set no general setback from khals, ponds or wetlands. Rule 8(4) of the 2007 Rules limits buildings within 15 m of a river bank to 5 m in height (as reported), but does not keep the strip clear; this Manual uses the same 15 m as a corridor (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 West Bengal flood maps are mostly coarser than US maps, the Gangetic delta around Kolkata, Howrah and the 24 Parganas and the islands of the Sundarbans are very flat and low, and Kolkata's ground falls only gently eastward from the natural levee of the Hooghly (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).

West Bengal's rules set almost no distances from waterbodies. No setback from khals, ponds or wetlands was found in the KMC Building Rules 2009; instead the Rules reward keeping a water body on a plot (Rules 2(27), 65A, 74(4) and 81(9)). The KMC Act, 1980 keeps any filth receptacle 15 m from a tank, well, water-course or reservoir (heading in Chapter XVIII, read from a poor scan), but sets no building line along a khal. Rule 8 of the West Bengal Municipal (Building) Rules, 2007, which applies in the municipal areas, notified areas and industrial townships, bars the filling of ponds, canals, wetlands, streams, drains and culverts without the State's approval, and in the river zone within 15 m of a river bank limits the height, length and covered area of buildings and the gaps between them (as reported); it does not keep the zone clear. The West Bengal Inland Fisheries Act, 1984 and the East Kolkata Wetlands (Conservation and Management) Act, 2006 protect the waterbody itself: the first bars filling a water area, and the second bars any change in the area or character of the wetlands without sanction and requires a water body of no less area to be created within the wetlands for any that is filled (sections 9 and 10, as reported). Neither sets a distance. No bank buffer for the I&WD's khals and outfall channels was found. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

Disclosure. West Bengal has **no general statutory setback from khals, ponds or wetlands**. 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. It is not found in the KMC Building Rules 2009, the West Bengal Municipal (Building) Rules, 2007, the New Town Kolkata (Building) Rules, 2009 or any West Bengal Act read for this Manual. Because West Bengal has **no statutory flood lines**, the 1% AEP extent of this Manual, where it has been mapped (Clause 7.3.4), is the only flood-based line, and it governs Zone 2. The setback is applied as **the larger of the corridor and any statutory line**, so the Manual is **stricter than statute** almost everywhere. What does exist, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The river zone of rule 8(4) of the West Bengal Municipal (Building) Rules, 2007.** Within 15 m of a river bank, and on the fronts of water bodies of more than 1,000 acres, a building may be no more than 5 m high, 20 m long and 200 m² in covered area (as reported). Zone 1 covers the same 15 m and excludes buildings from it altogether; where a river's floodway or the 1% AEP extent is wider, Zone 1 or Zone 2 extends to it.
- **Bars on filling.** Section 17A of the West Bengal Inland Fisheries Act, 1984, rule 8(3) of the 2007 Rules and sections 9 and 10 of the East Kolkata Wetlands (Conservation and Management) Act, 2006 bar or control the filling of ponds, water areas, canals and wetlands. They protect the waterbody, not a strip around it.
- **CRZ Notification, through the CZMP in force.** The State's CZMP under the CRZ Notification, 2019 had not been approved by December 2025: revised plans for Purba Medinipur and North 24 Parganas went to the Ministry in September and October 2025, and that for South 24 Parganas was promised for January 2026 (NGT filings). Until it is approved, the plan approved under the CRZ Notification, 2011, with its 2011 High Tide Line, is the one in use. Its widths along tidal rivers and creeks were not read for this Manual; the Applicant shall obtain the CRZ lines for the site from the WBSCZMA, and they govern wherever they lie outside Zone 1.
- **The East Kolkata Wetlands boundary.** Within the area mapped in Schedule II of the 2006 Act, no change of use is permitted without the sanction of EKWMA (section 10, as reported). The whole of that area is a waterbody for this chapter.

This Manual sets 15 m as the floor because it is the distance that West Bengal law already uses beside water, in the river zone of the 2007 Rules and in the KMC Act's provision that keeps filth receptacles 15 m from a tank or water-course; because it is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled; and because it leaves room for the maintenance track and desilting machinery that Kolkata's khals need for regular desilting. The reasons for the corridor are the waterlogging of Kolkata on 23 September 2025, the floods of July 2017, in which the CAG recorded 217 deaths and damage of ₹17,727.94 crore, the CAG's finding that flood works in the State were not linked to any basin plan, and the loss of ponds and wetlands in and around Kolkata. Until a statute, rule, notification or land-use plan adopts it, the 15 m minimum is this Manual's recommended standard and the statutory controls above remain the only legal minimum. Approving authorities should state in each approval which was applied.

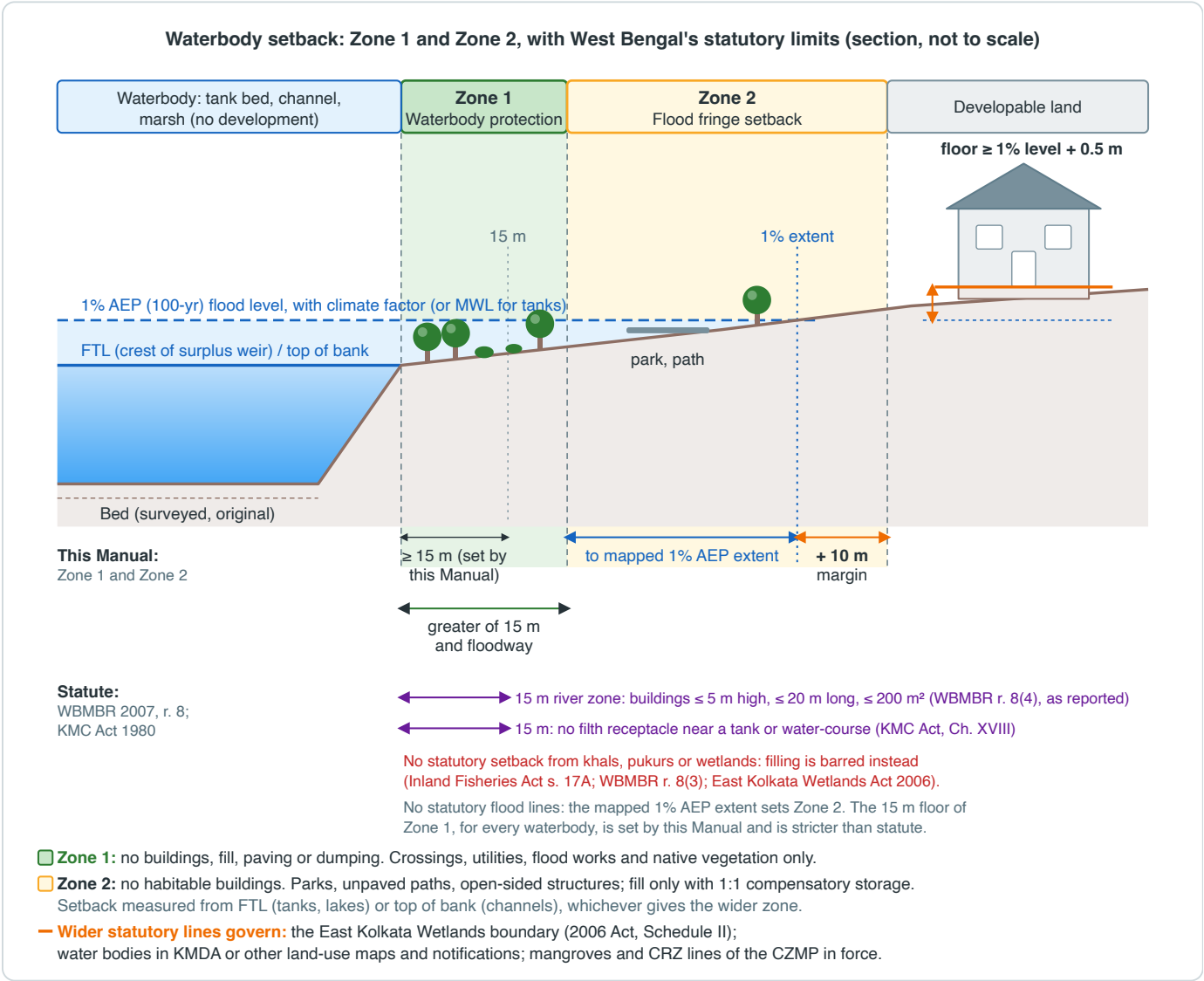


Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 mandatory open space required by the KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007, 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 West Bengal 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 Gangetic delta around Kolkata and Howrah and the embanked islands of the Sundarbans are flat and low, and Kolkata's ground is subsiding by 2.8 to 5.5 mm a year (Thakur et al., 2026), so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> No West Bengal rule protecting the land between a pond's full level and its flood level was found. Section 17A of the Inland Fisheries Act protects land that holds water for at least six months in a year (as reported), so the margin of a pukur that floods only in a heavy storm is not protected by it on its text, and the burden of showing that a site is a water area rests on the authority (*Anuradha Sen v. KMC*, 2024, as reported). The East Kolkata Wetlands Act is wider: within the wetlands, "water body" includes "any land holding water" (section 2(k), as reported). Kolkata's pukurs are part of its flood path. Most have no surplus weir and spill to the street drains, so

the land around them that floods in a storm stores water that would otherwise stand in the streets or reach the pumping stations. Treating all land below MWL as floodway (Clause 7.6.1) means that no new building or fill is approved in a tank foreshore.

The developed-fringe mechanism of Clause 7.6.6 is set by this Manual. Large parts of the South Suburban catchment of Kolkata, which suffers "frequent and prolonged waterlogging" (KMC, 2015), Howrah, which lies lower than the Hooghly (CPHEEO appraisal note), and the Ghatal basin 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.

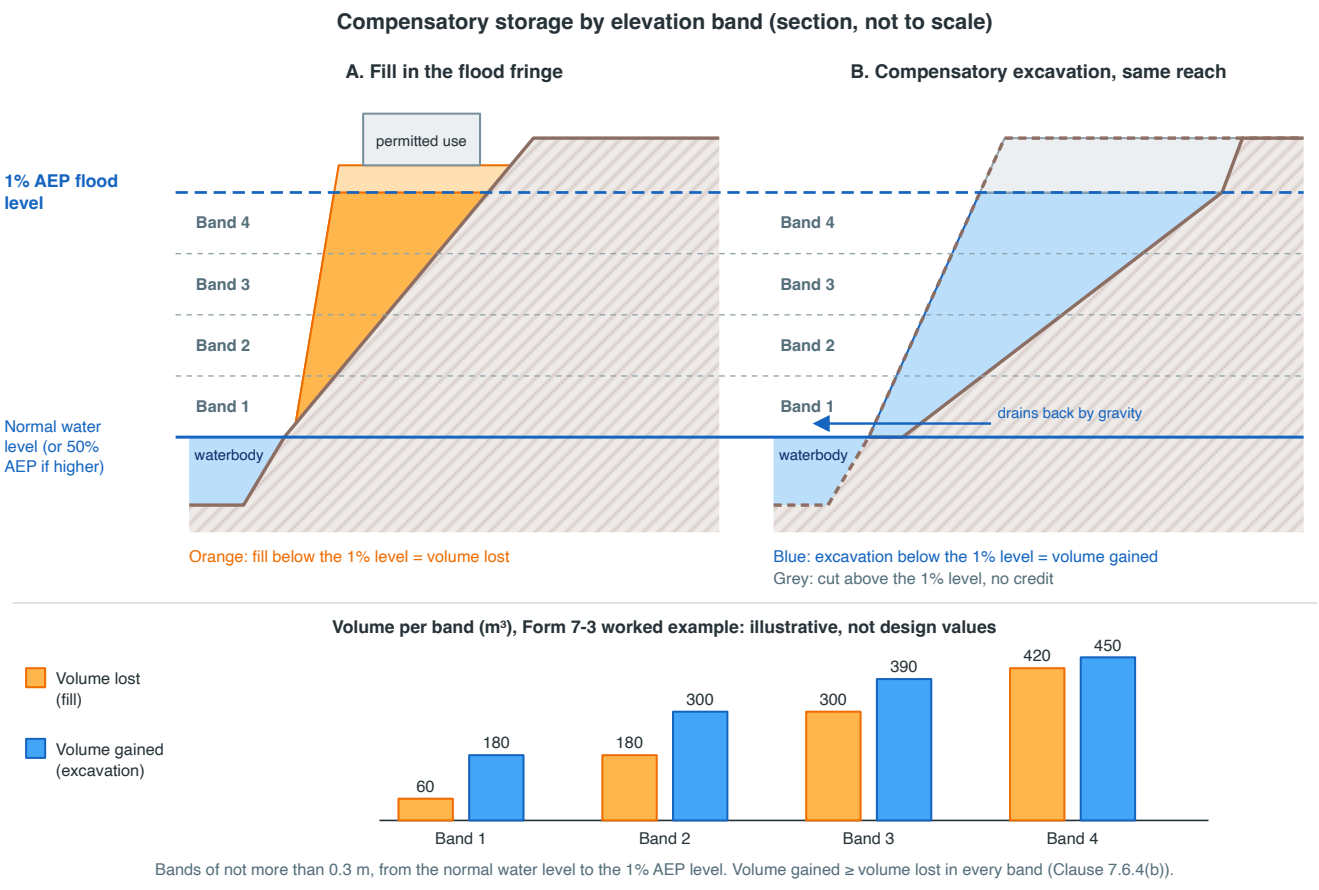


Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation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

West Bengal has no tank Act and few impounded tanks of the classic type, with an earthen bund, a waste weir and irrigation sluices, in its towns. The storages that matter for urban drainage are of five kinds. The first is the urban pukur or dighi, often privately owned, usually with no outlet structure, and protected by section 17A of the Inland Fisheries Act: KMC listed 3,874 water bodies in 2006 (as reported). The second is the bheri of the East Kolkata Wetlands, an embanked fishery pond fed with the city's sewage, beside the outfall channels that carry Kolkata's storm and dry-weather flow to the Kulti (I&WD); the wetlands' storage role in a design storm, and any rule for operating the bheris, were

not found (gap). The third is the floodplain wetland, the bil, baor or jala of the Gangetic plain. The fourth is the abandoned brick-field pit that rule 8(5) of the West Bengal Municipal (Building) Rules, 2007 requires to be kept as a water body. The fifth is the embanked island of the Sundarbans, which drains through sluices in its embankments when the tide outside is low, as a polder does (this Manual's reading). Clauses 7.7 and 7.8 apply to any of these whose storage is counted. In Kolkata, the chain of city drains, pumping stations, outfall channels, bheris and outfall works to the tidal Kulti is the cascade for Clause 7.7.2, and it is modelled as one system. DVC's reservoirs at Maithon and Panchet on the Damodar are not tanks for these clauses: their releases enter a design as inflow and tailwater (Chapter 5).

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.** I&WD, 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, in Kolkata, every pumping station, outfall channel and bheri of the East Kolkata Wetlands through which the outflow passes to the tidal Kulti, 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 I&WD'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.

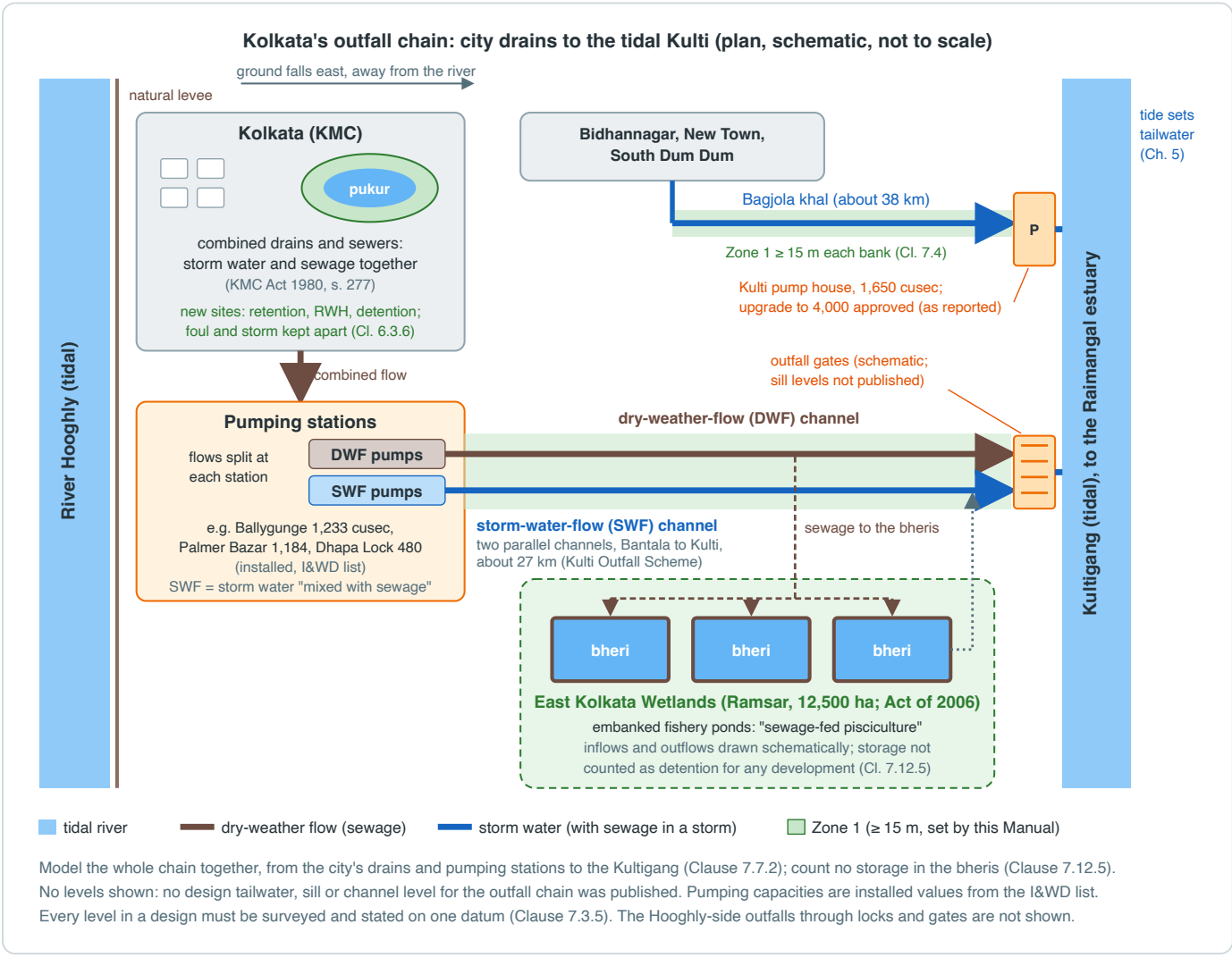
7.7.5 **Creditable volume.** The creditable design storage of a tank is the volume between the starting level (Clause 7.7.3) and the computed maximum level of Clause 7.7.4, less any volume already committed to another facility or scheme.

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. West Bengal's largest floods have come late in the south-west monsoon, when ponds, wetlands and channels are already high and the soils wet. In September 1978, 369.6 mm fell at Alipore on 28 September and 409.3 mm at Uluberia on the 29th (IMD). On 17 September 2024, the combined release from Maithon and Panchet reached about 2.5 lakh cusec (as reported, from a government statement), and on 23 September 2025, 251.4 mm fell on Kolkata in 24 hours, 185.6 mm of it in three hours (IMD, 2025). At the KEIIP pumping station at Behala Flying Club, the basin stays flooded because discharge through the outfall "is partially achieved due to high water levels in the canal, particularly during tidal period" (KMC, 2015): storage downstream that is already full gives no relief. 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.



Model the whole chain together, from the city's drains and pumping stations to the Kultigang (Clause 7.7.2); count no storage in the bheris (Clause 7.12.5). No levels shown: no design tailwater, sill or channel level for the outfall chain was published. Pumping capacities are installed values from the I&WD list. Every level in a design must be surveyed and stated on one datum (Clause 7.3.5). The Hooghly-side outfalls through locks and gates are not shown.

Figure 7.3 — Kolkata's outfall chain, in plan (schematic, not to scale): the city on the natural levee of the Hooghly, with ground falling east; combined drains and sewers carrying storm water and sewage together (KMC Act, 1980, section 277), with on-site retention, RWH and detention on new sites; pumping stations with separate dry-weather-flow and storm-water-flow pumps, of which three of KMC's main stations are named with their installed capacity from the I&WD list; the two parallel outfall channels from Bantala to Kulti, about 27 km, that carry the dry-weather flow and the storm-water flow "separately"; the bheris of the East Kolkata Wetlands, fed from the channels for sewage-fed fisheries; the

outfall works where the channels and the Bagjola khal meet the tidal Kultigang, which joins the Raimangal estuary; and the 15 m minimum Zone 1 of this Manual along the khals and around the ponds. The bheri inflows and outflows and the gates at the outfall are drawn schematically: no plan of the wetlands' connections, and no sill or tailwater level at the outfall, was published. Original drawing for this Manual; concept from the I&WD's account of the Kolkata Metropolis Drainage and the Kulti Outfall Scheme, the KEIIP environmental examination (KMC, 2015) and the East Kolkata Wetlands (Conservation and Management) Act, 2006.

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, WBSDMA alerts, and city forecast systems where available) and the actions taken at each trigger;
- (f) communication with downstream ULBs and residents before any release; and
- (g) the records to be kept: daily levels in the SW monsoon, releases, and gate settings.

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

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

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

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

> **Commentary.** No operating rule for a West Bengal pukur, bheri or floodplain wetland that keeps a flood cushion was found, and most pukurs have no controllable outlet, so Clause 7.8.3 applies to them. The controlled flows that matter are elsewhere. Kolkata's drainage runs through locks, gates and pumps: the Chitpur lock on the Circular Canal dates from 1833, the main KMC pumping stations at Ballygunge, Palmer Bazar and Dhapa Lock lift the city's flow into the outfall channels, and the Bagjola khal ends in a pump house at Kulti of 1,650 cusec that is reported to be inadequate, with an upgrade to 4,000 cusec approved by the Central Water Commission (I&WD; as reported; the upgrade's status is not known). Lock-gate operators have warned of damage at full-moon high tides, and KMC has planned lifting stations so that drainage can continue while lock gates are shut (as reported). Upstream, the Damodar's floods are regulated by DVC's dams. In September 2024, the combined release from Maithon and Panchet reached about 2.5 lakh cusec on 17 September, and the State Government and the Union Ministry then disagreed in public over how the releases had been made (as reported; release figures from different sources also disagree). Without an agreed rule with dates, levels and a named operator, storage behind a

gate cannot be relied on. Clause 7.8.2 turns that principle into a rule that can be checked, with a reliability test, because a cushion that is usually refilled by the early monsoon rain gives no protection in a July to September monsoon depression or a May or October–November cyclone. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.

Fish culture remains the purpose for which section 17A of the Inland Fisheries Act protects ponds, and the bheris of the East Kolkata Wetlands are working fisheries. Drawing a pond or bheri down before a storm has a cost to those who fish it, which is why Clause 7.8.2(d) requires the custodian, and for a private pond its owner, to accept it.

7.9 Restoration, desilting and deepening

7.9.1 **Pre-works survey.** Before any desilting or restoration, the proponent shall:

- (a) survey the waterspread, foreshore, bund, weirs and sluices (Clause 7.7.1(a) and (b));
- (b) find the original bed level by test pits or augering on a grid, and from historical records where available; and
- (c) where the tank receives urban runoff or sewage, test the silt for heavy metals and other contaminants before disposal is planned.

7.9.2 **Desilting limit.** Desilting shall remove accumulated sediment down to the original bed level. It shall not deepen the tank below the original bed, except under Clause 7.9.3.

7.9.3 **Deepening.** Deepening below the original bed is permitted only where a hydrogeological report shows that:

- (a) it will not cut through a clay or silt layer that holds water in the tank or protects an aquifer from polluted water;
- (b) in coastal areas, it will not draw saline water into the tank or the aquifer; and
- (c) the extra storage will be refilled and used, and will not stand stagnant below the sluice sill.

Storage created below the lowest sluice sill shall not be counted as flood storage.

7.9.4 **Safe edges.** Where the public has access to the waterbody edge:

- (a) side slopes shall be no steeper than **1V:4H** from 0.5 m above FTL down to 1.2 m below FTL, or a level safety bench at least 3 m wide shall be provided between 0.3 m and 0.5 m below FTL; and
- (b) no isolated deep pit or vertical cut shall be left in the bed.

7.9.5 **Storage not to be reduced.** Restoration shall not reduce the storage below MWL. Islands, walkways, bund widening into the waterspread, ring roads, parking, buildings and "lake-front" platforms within the waterspread or foreshore shall be counted as lost storage and shall be offset under Clause 7.6.4.

7.9.6 **Silt disposal.** Desilted material shall not be placed within the setback, on the bund (except for approved bund strengthening), or on any flood path. Silt found to be contaminated shall be disposed of as the West Bengal Pollution Control Board 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 **15 May** each year (Chapter 10).

Commentary. Desilting of the khals is a main pre-monsoon work in Kolkata. The dredging of the Kestopur and Bagjola canals, about 80 km together, began in 2022 after a gap of five years, and 28 to 31 canals were listed for desilting in a later season (as reported). Bengali has a word for the work on ponds: pukur jhalano, "to dredge a

tank" (Samsad). In the north, the Teesta flood of October 2023 left silt in the Teesta–Mahananda link canal, which then had to be dredged (as reported). In the Ghatal basin, seven river stretches totalling 115.80 km were re-excavated in 2018–21 at a cost of ₹341.49 crore from the State budget (as reported). No published KMC deadline for desilting was found. The 15 May deadline matches the pre-monsoon inspection date of Chapter 10. The limits on deepening are set by this Manual. Deepening tanks to "increase capacity" is common, but it can breach the silt and clay layer that holds water in the tank, it can let polluted urban water reach the aquifer, it can draw salt water toward the coast, and it creates storage below the sluice sill that never empties and gives no flood benefit. Deep pits with steep sides are also a drowning hazard. The slope and bench values in Clause 7.9.4 are adapted from common pond-safety practice; they have no West Bengal 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. Kolkata's khals are its outfall system, and most of them were dug. Tolly's Nullah was opened in 1777 and runs 27.2 km to the Bidyadhari at Samukpota; the Circular Canal followed in 1820, the Chitpur lock in 1833, the Bhangor Khal in 1897–98 and the Keshtapur Khal in 1910; the Bidyadhari, the city's old outfall river, silted and "was finally abandoned by the Govt. in 1928", and the Kulti Outfall Scheme replaced it (I&WD). The Bagjola khal, about 38 km long, is reported to be the main outlet for South Dum Dum, New Town and Bidhannagar.

The KMC Act vests every public drain in the Corporation (section 280), but the main canals and outfalls are the I&WD's (as reported), and where one ends and the other begins was not established. Where the outfall "deteriorates by the decay of existing river channels or otherwise", the State may require KMC to act at the cost of the Municipal Fund (section 277(2)). Rule 8(3) of the West Bengal Municipal (Building) Rules, 2007 bars the filling of a canal, drain or culvert without the State's approval (as reported). The CAG found that the I&WD's Kandi Master Plan raised and strengthened embankments but "failed to create the additional waterways by reconstructing/renovating bridges and culverts" (CAG, Report No. 2 of 2019), which is the failure Clause 7.10.3 is 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 West Bengal the nearest existing forms of shared storage are the KMC Building Rules' reward for keeping a water body on a plot, which lets it count in the plot area for FAR and earns relaxations where it covers at least 25% of the land (Rules 2(27) and 65A), and the East Kolkata Wetlands Act's requirement that a water body filled with sanction be replaced by one of no less area within the wetlands (section 10, as reported). Bidhannagar was reported in 2024 to have identified more than 150 water bodies for restoration. 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 West Bengal State Wetland Authority;

- (b) the Ramsar sites of West Bengal: the East Kolkata Wetlands (listed as the East Calcutta Wetlands, designated on 19 August 2002, 12,500 ha) and the Sundarbans Wetland (listed as the Sunderbans Wetland, designated on 30 January 2019, 423,000 ha);
- (c) the East Kolkata Wetlands as described in Schedule I and mapped in Schedule II of the East Kolkata Wetlands (Conservation and Management) Act, 2006, including their bheris, the dry-weather-flow and storm-water-flow channels from Bantala to Kulti, and the tidal Kultigang;
- (d) the tidal creeks (khanris), rivers, mudflats and mangroves of the Sundarbans, the Hooghly estuary and the Purba Medinipur coast;
- (e) the bils, baors and jalas of the Gangetic floodplain; and
- (f) any other marsh, wetland or creek that the Authority notifies, that the wetland authority lists, or that a court or the National Green Tribunal directs to be protected.

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

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

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

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

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

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

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

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

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

> **Commentary.** West Bengal has two Ramsar sites, both large and both next to cities: the East Kolkata Wetlands (12,500 ha, designated on 19 August 2002) and the Sundarbans Wetland (423,000 ha, designated on 30 January 2019) (MoEF&CC, 2024). The East Kolkata Wetlands lie east of the city, between it and its outfall. The Calcutta High Court restrained their further reclamation in *People United for Better Living in Calcutta v. State of West Bengal* (24 September 1992, AIR 1993 Cal 215), and directed the State to maintain their character (as reported). The East Kolkata Wetlands (Conservation and Management) Act, 2006, deemed in force from 16 November 2005, set up the East Kolkata Wetlands Management Authority (EKWMA), chaired by the Chief Secretary, with the Secretaries of the Environment, Urban Development, Irrigation and Waterways, Fisheries and Municipal Affairs Departments, the Chief Executive Officer of KMDA, the Commissioner of KMC and the District Magistrates of North and South 24 Parganas among its members. Its powers extend to demarcation, stopping unauthorised development, pollution abatement and "sewage-fed pisciculture" (section 4). Landholders must keep the area and character of the wetlands intact (section 9); a change of use is allowed only with sanction and only for "improvement or upkeep of the local environment", and a water body that is filled must be replaced by one of no

less area within the wetlands (section 10); offences carry up to three years' imprisonment, a fine of up to ₹1 lakh, or both (section 18) (all as reported; the Gazette text was not read). Salt Lake and New Town were built on reclaimed wetland (as reported). The National Green Tribunal made orders on encroachment in the wetlands from 2019 to 2021, directed an integrated management plan in December 2020 and boundary pillars in November 2021, and in May 2026 the State Wetland Authority told it that KMC had not cleared encroachments at Ukil Bheri (as reported). In the Sundarbans, the I&WD's embankments are the line between the islands and the tide: Cyclone Aila (25 May 2009) washed out or breached about 177 km of them and severely damaged a further 601 km (I&WD), and the stretches rebuilt after Aila, only about 84 km, were reported to have held in Amphan and Yaas while mud embankments breached at many points. On the coast, the State's coastal authority told the Tribunal that the 2011 High Tide Line "no longer exists due to erosion of the soft unconsolidated alluvial coast and ingress of sea" (NGT filing, March 2025). A drain outfall, khal widening, sluice or pumping station in a mangrove belt or on a tidal creek therefore needs CRZ clearance through the WBSCZMA as well as compliance with this chapter, and any work within the East Kolkata Wetlands needs EKWMA's sanction. 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. In Kolkata, sewage reaches the khals and the wetlands by design. The KMC Act, 1980 makes the Corporation provide "a safe and sufficient outfall … for the effectual drainage and proper discharge of storm-water and sewage" without flooding the city or the country round the outfall (section 277(1)); the Commissioner *may* require a separate drain "for rain water and unpolluted sub-soil water" (section 292), but the system the Act describes is combined (Clause 6.3.6). KEIIP's pumping stations have separate dry-weather-flow and storm-water-flow pumps, and in a storm the storm-water flow, "mixed with sewage", is pumped to the canals (KMC, 2015). The Kulti Outfall Scheme carries the city's storm water and dry-weather flow to the Kulti in separate channels (I&WD), and the bheris of the East Kolkata Wetlands are fed with the sewage for fish culture. Clauses 7.10.6(d) and 7.12.3 therefore cannot be met by the existing outfalls of a combined system. In West Bengal they apply in full to every new separate storm outfall; an outfall from a combined system is a sewage overflow, which Clause 8.9.6 permits only where the sewerage agency shows that no alternative exists, with screening and with the overflow frequency stated.

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.** West Bengal's main controls on filling and building in waterbodies are the Inland Fisheries Act, the planning Act, the municipal Acts and the orders of the Calcutta High Court and the National Green Tribunal. A case at Behala shows how they are used. KMC's Environment and Heritage Department found part of an 875.64 m² pond, recorded as "Pukur (Pond)", filled, by comparison with the NRSA aerial map; it issued a notice under section 53 of the West Bengal Town and Country (Planning and Development) Act, 1979 in September 2021, giving seven days to restore, and lodged a police complaint; after the High Court's order in *Sumitra Mondal v. KMC* (28 November 2023) it issued a fresh notice and a second complaint followed in March 2024, while its Building Department issued a notice under section 400(1) of the KMC Act (NGT, OA 258/2024). KMC had reportedly filed 870 such complaints. The High Court quashed one KMC action under section 17A in January 2024 because the Corporation had not first shown that the Act applied to the site, and ordered a proper inquiry with notice (*Anuradha Sen v. KMC*, as reported). The National Green Tribunal has made orders on the filling of water bodies in Howrah (2016) and of two ponds in Purba Bardhaman (2021), and on encroachment in the East Kolkata Wetlands (2019 to 2026) (as reported). KMC's building application asks whether the land is a "solid/filled up tank or part tank" (KMC Building Rules 2009). No statewide count of encroached waterbodies was found; Kolkata's counts are in the Commentary to Clause 7.1. This Manual cannot evict anyone. It can stop designs from treating encroachment as permanent (Clause 7.13.2), make public works restorable to full width (Clause 7.13.3), and make the setback visible on the ground and in property documents so that new buyers know it is there (Clause 7.13.4). The 30 m marker interval is set by this Manual.

7.14 Safety of tank bunds and embankments

7.14.1 **Dam Safety Act screening.** For every tank, and every embankment built or altered under this Manual, the designer shall determine whether it is a "specified dam" under the Dam Safety Act, 2021. Under the Act, a specified dam is a dam:

- (a) more than 15 m high, measured from the lowest point of the general foundation area to the top of the dam; or
- (b) between 10 m and 15 m high, where the crest length is not less than 500 m, or the reservoir capacity is not less than one million m³, or the maximum flood discharge dealt with by the dam is not less than 2,000 m³/s, or the dam has specially difficult foundation problems, or the dam is of unusual design.

Where it is a specified dam, the Act and the requirements of the State Dam Safety Organisation govern, in addition to this Manual.

7.14.2 **Hazard class.** Every tank bund and detention embankment that is not a specified dam shall be given a hazard class:

- **High hazard:** a breach could flood a habitable building, a school, a hospital, an arterial road or critical infrastructure.
- **Low hazard:** any other case.

7.14.3 **High-hazard embankments.** For high-hazard tank bunds and embankments:

- (a) the surplus weir or spillway shall pass the 1% AEP inflow at MWL with the freeboard of Clause 7.7.4(b), and shall be checked for the 0.2% AEP (500-yr) inflow without overtopping the bund (as for detention basins in Chapter 4);
- (b) a breach analysis shall map the area flooded by a breach at MWL;
- (c) an emergency action plan shall be prepared, with the warning and evacuation arrangements for the breach area; and

- (d) the design shall be certified and independently checked under Clause 10.6.

7.14.4 **Inspection.** Every tank whose storage is counted under Clause 7.7, and every high-hazard embankment, shall be inspected before the SW monsoon (by 15 May) and after every heavy-rainfall event (Chapter 10) for seepage, slips, cracks, animal burrows, trees on the bund, and blockage of the weir and sluices.

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

> Commentary. The definition of a specified dam is quoted from the Dam Safety Act, 2021 (Act 41 of 2021). The Act defines a "dam" as an artificial barrier constructed across rivers or tributaries to impound or divert water. It excludes flood embankments, dikes and guide bunds. The banks of most pukurs and the embankments of most bheris are low and are not expected to make them specified dams, but each shall be screened under Clause 7.14.1. The river and Sundarbans embankments of the I&WD are flood embankments, which the Act excludes. DVC's dams at Maithon and Panchet on the Damodar enter this Manual only as sources of inflow and tailwater (Chapter 5). Where the storage of a pukur, bheri or other pond is counted under Clause 7.7, its bank or embankment is a tank bund for Clause 7.14.2. Whether a tank bund that is not across a river or tributary is a "dam" under the Act is not clear from its text. Dam releases and embankment failures have flooded West Bengal's towns. In September 2024 the combined release from Maithon and Panchet reached about 2.5 lakh cusec on 17 September, and parts of Howrah, Hooghly, the two Medinipurs, Bankura and Purulia were flooded, with the Shilabati above its danger level at Ghatal (as reported; other reports give higher figures). In October 2023 the outburst of South Lhonak lake in Sikkim washed away the Teesta-III dam and sent a flood down the Teesta through Kalimpong, Darjeeling, Jalpaiguri and Cooch Behar districts, with more than 8,000 m³/s reported released from the Teesta barrage (as reported). Cyclone Aila breached about 177 km of Sundarbans embankment in May 2009 (I&WD). No release protocol for the DVC dams, and no emergency action plan for an embankment, was read for this Manual. 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 SW monsoon season.
Hotspot	A land use with a high risk of spills or contaminated runoff (Clause 8.8.8).
Level of Service (LoS) / Value Rating (VR)	The scoring system of Clause 8.6, from the MARC/APWA BMP Manual (2012).

8.3 Objectives and pollutants of concern

8.3.1 Stormwater treatment under this Manual shall aim to:

- (a) remove litter, plastics and other gross pollutants before they reach a waterbody;
- (b) remove suspended sediment, and the metals, nutrients and oil carried on it;
- (c) keep sewage and sullage out of storm drains and waterbodies;
- (d) recharge groundwater where soils and groundwater depth allow, without polluting it; and
- (e) prevent erosion and sediment discharge during construction.

8.3.2 The design shall address the following pollutants for every site, and the hotspot pollutants of Clause 8.8.8 where they apply:

Table 8.1 — Pollutants of concern, sources and primary controls

Pollutant	Main sources in West Bengal 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 West Bengal 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 West Bengal, and because no treatment BMP works for long if they are not removed. CPHEEO (2019) notes that Indian drains carry night soil, urine and food waste (Part A §9.5). In its WSUD procedure it lists TSS, total nitrogen, total phosphorus and gross pollutants as the key pollutants (Part A Ch. 10). AMRUT 2.0 funds the harvesting of rainwater "through storm water drains into water body (which is not receiving sewage/effluent)" (Lok Sabha unstarred question AU1419), which only works if sewage is first kept out of the drains.

8.4 Water quality volume and design flow

8.4.1 **Water quality rainfall depth.** The water quality rainfall depth is:

$$P_{wq} = \max(P_{ret}, P_{3m})$$

where:

- P_{ret} = the retention depth for the site's zone (Annex 2E, Clause 2.10), mm; and
- P_{3m} = the 24-hour 3-month ARI depth for the site's zone (Annex 8A), mm.

8.4.2 **Water quality volume.** The WQv shall be computed as:

$$WQv = (P_{wq} / 1000) \times Rv \times A$$

where:

- WQv is in m³;
- A = the contributing area, m²;
- $Rv = 0.05 + 0.009 \cdot I$; and
- I = the impervious percentage of the contributing area (0–100), after the connectivity rules of Clause 3.9.

The Rv form above may be used only for sites under 0.5 ha and under the Tier B simplified method (Clause 4.14). This is the same limit as for the retention volume (Clause 4.4.2). For all other sites the WQv shall be computed with the SCS-CN method, as the retention volume is: WQv (m³) = 10 × Q_{wq} × A, where Q_{wq} (mm) is the SCS-CN runoff from P_{wq} for each sub-area and A is in ha.

8.4.3 **Climate factor.** The climate factor of Clause 2.8 shall not be applied to P_wq. P_ret and P_3m are frequency statistics of ordinary rainfall, not AEP design depths.

8.4.4 **WQv met by retention.** The volume retained on site under Chapter 4 counts toward the WQv in full. Where the retained volume is equal to or greater than the WQv, no further treatment is required for that area, except:

- (a) pretreatment of inflows to each retention facility (Clause 8.5.3);
- (b) hotspot controls (Clause 8.8.8); and
- (c) the outfall requirements of Clause 8.10, where the site discharges to a waterbody.

8.4.5 **Water quality design flow.** Flow-through devices (swales, filter strips, oil-grit separators, GPTs) and diversion weirs for off-line BMPs shall be sized for Q_wq. Q_wq shall be computed from the 3-month ARI intensity at the time of concentration of the contributing area:

- (a) by the Rational Method, where Chapter 3 allows it (a single element draining no more than 16 ha); or
- (b) as the peak of a hydrograph method using the 3-month ARI 24-hour depth with the alternating-block pattern of Clause 2.9.1.

8.4.6 **Bypass.** Flows above Q_wq shall bypass flow-through and off-line treatment devices without washing out the material already captured. The bypass shall be part of the minor or major system (Chapter 6).

8.4.7 **Drawdown.** Where the WQv is held in an extended-detention BMP (wet pond, constructed wetland or dry extended-detention basin), it shall be released over **24–48 hours** (Chapter 4).

> Commentary. The WQv depth is the runoff from the 3-month ARI storm or the retention depth, whichever is greater. The 3-month ARI is the Malaysian water quality design storm (MSMA 2, 2012). The Malaysian 2008 checklist gave its depth as about 40 mm and said it captures 90% or more of 24-hour storm runoff volume (DID, 2008). The West Bengal 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 West Bengal, 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.

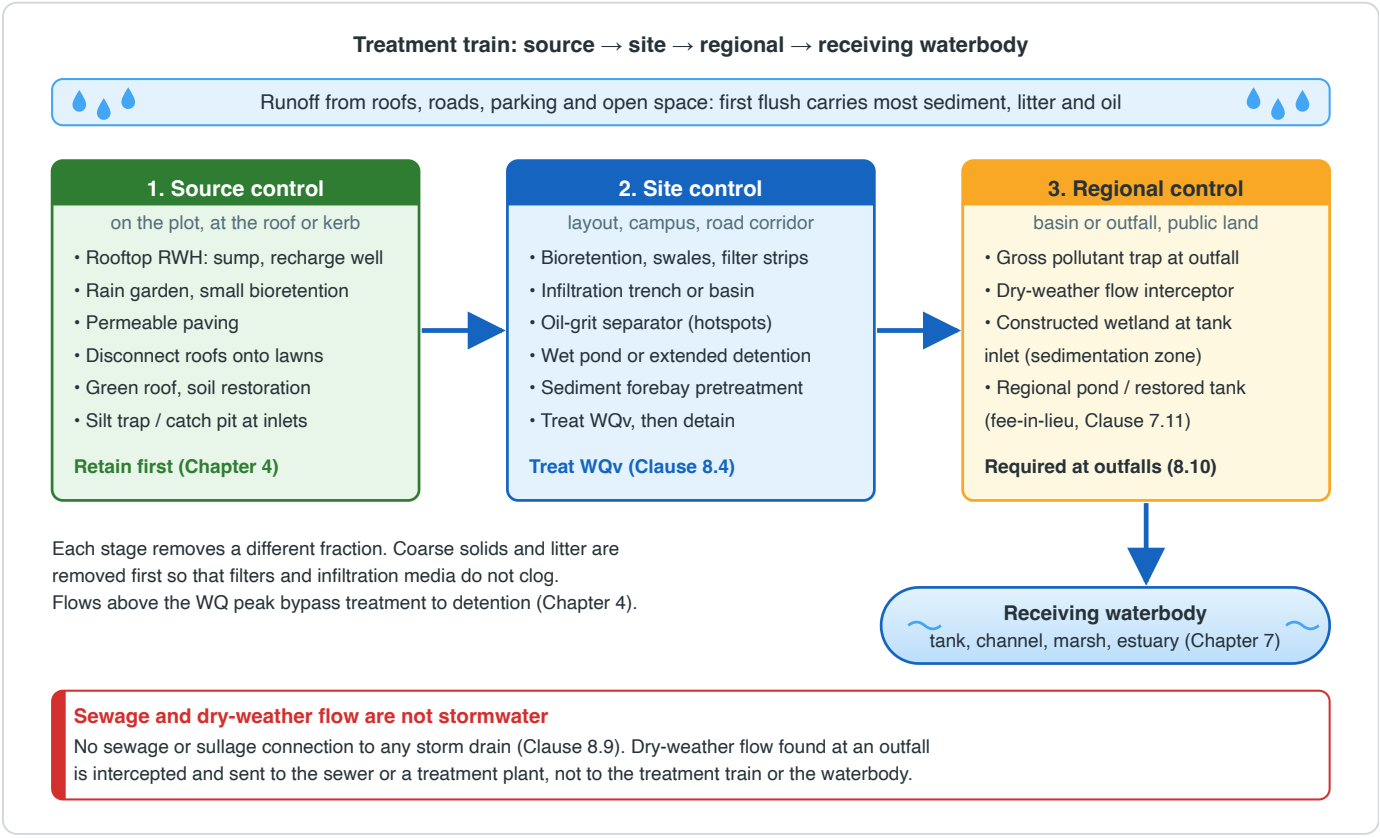


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater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

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Coastal dune sand / terai sandy loam	Laterite / hard rock	Deltaic clay / saline coastal	West Bengal 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	Coastal dune sand / terai sandy loam	Laterite / hard rock	Deltaic clay / saline coastal	West Bengal 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 West Bengal 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. West Bengal 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.

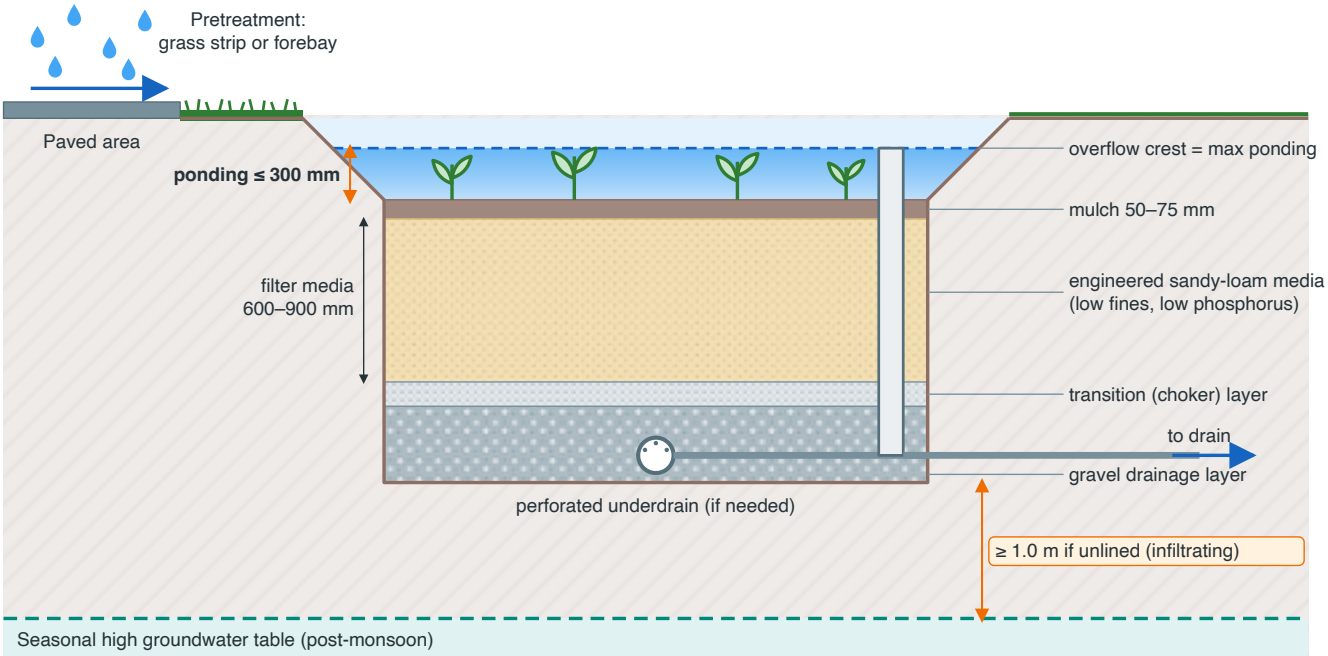
> **Commentary.** The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in West Bengal. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in West Bengal. 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.** About three-quarters of West Bengal's rain falls in the south-west monsoon (June–September): 1,418.7 mm of a State mean of 1,851.4 mm, and 1,367.5 mm of Kolkata's 1,852.3 mm (IMD, 2020, data for 1989–2018). In the south, May rain is of the same order as October rain (CWC Flood

Estimation Report, subzone 1(g)), and the cyclones of late May and of October and November bring storms outside the season. From December to the pre-monsoon storms, ponds fall unless they are fed. Section 17A of the Inland Fisheries Act protects the pond that holds water for six months or more, and many urban pukurs and bheris hold water all year. In the East Kolkata Wetlands, feeding ponds with sewage is not a fault but the system: the bheris are fed with the city's sewage for fish culture, and the 2006 Act names "sewage-fed pisciculture" among the matters for EKWMA (section 4, as reported). Clause 8.7.8 applies to BMPs, not to the bheris, which are protected wetland 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 West Bengal 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. The only exception is roof-only runoff in notified coastal sand areas over fresh groundwater (Clause 8.8.9(d)). In West Bengal, in any block listed by the CGWB, SWID or the Public Health Engineering Department as having arsenic in groundwater above the permissible limit, and wherever the groundwater at the seasonal high level is saline, no recharge well, recharge shaft or borewell shall receive runoff of any kind, including roof runoff, and the exception for recharge wells in Clause 8.11.3(c) does not apply; this limit is set by this Manual. 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.** In the coastal sand areas (for example the beach and dune sands of the Purba Medinipur coast at Digha, Shankarpur and Contai), subject to one limit, that where the groundwater at the seasonal high level is saline (as shown by SWID or CGWB data or by a test at the site) only roof runoff may be infiltrated and the reduced separation of item (d) does not apply:

- (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 and red gravelly soils of the western plateau, as in Purulia, west Bankura and the Asansol–Durgapur area, and the shallow hill soils over rock of the Darjeeling–Kalimpong hills):

- (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.

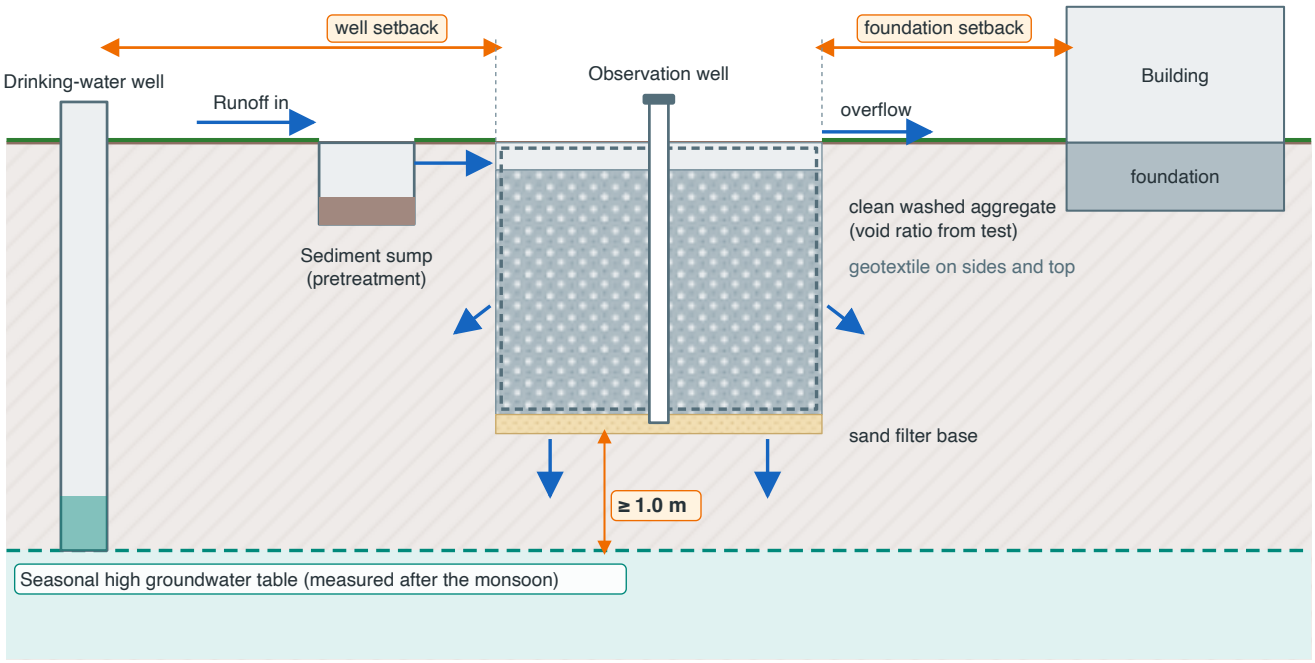
8.8.11 **Delta clays and black cotton soils.** In the deltaic clays of Kolkata, Howrah, Hooghly and the 24 Parganas, the saline clays of the Sundarbans and Purba Medinipur, the made ground of Salt Lake and New Town on reclaimed wetland, the Tal lowlands of Malda, and the silted beds of pukurs, bils and bheris 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 West Bengal precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. West Bengal RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.

No measured infiltration rates for West Bengal's soils were found, and the CGWB's groundwater yearbook for West Bengal could not be reached during research for this Manual, so no depth to the water table is given here and every infiltration design needs the tests of Clause 8.8.3. The soils change across the State (CWC Flood Estimation Reports, ICAR-CRIDA district plans): deltaic alluvium, clays and clay loams around Kolkata, Howrah, Hooghly and the 24 Parganas, with clayey-loamy soils over 87% of Purba Medinipur; deep loams in Nadia and Murshidabad; Barind clay-loam uplands and Tal lowlands in Malda; red and lateritic soils in Purulia and Bankura; terai sandy loams in the Duars; and brown forest soils in the hills. The interim soil groups of this Manual follow from these: the deltaic clays of Kolkata, Howrah and the 24 Parganas HSG D, because of their texture and the very high water table; clay loams C; loamy alluvium B, or C where a field test gives less than 6 mm/h; Barind uplands C; lateritic and red gravelly soils C; terai sandy loams B; hill soils C; saline Sundarbans soils D; and the dune sands of Digha and Contai A. In most of the delta, therefore, the 1.0 m separation of Clause 8.8.1 is rarely expected to be met (this Manual's reading), and retention must be met by storage for use and by surface measures rather than by infiltration. Two water-quality problems sit beneath the delta. The first is arsenic: the CGWB reported arsenic above the permissible limit of 0.05 mg/l in 79 blocks of 8 districts, other agencies count 8 to 11 districts, and in Murshidabad 19 blocks were affected, at 0.001 to 1.85 mg/l (as reported; the block lists are dated and differ). The shallow aquifers affected are drinking-water sources, and a recharge well or shaft delivers runoff to them past the surface clay. The effect of urban runoff injected into them was not studied for this Manual, so it takes the cautious course: in an arsenic-affected block, and wherever the groundwater is saline, no recharge well, shaft or borewell may receive runoff, even from roofs (Clause 8.8.1). This limit is set by this Manual. The second is salinity: the soils and shallow groundwater of the Sundarbans and parts of the Purba Medinipur coast are saline, and infiltrating runoff there adds nothing to fresh storage and can raise a saline water table toward foundations, so the lead of Clause 8.8.9 allows only roof runoff to be infiltrated where the groundwater is saline. That limit is also set by this Manual. Clause 8.8.9(b) addresses a specific mechanism: an open or leaky drain cut below the water table becomes a groundwater drain, carrying fresh groundwater to the sea and drawing salt water inland, which matters on the low Purba Medinipur and Sundarbans coast, where the soils and shallow groundwater are already saline in places.

Infiltration trench: section, not to scale



Test infiltration at the proposed base level. Design rate = measured rate ÷ safety factor. Empty within 72 h.

Setback distances and test methods: Clauses 8.8.3 to 8.8.6. Road and parking runoff is never piped into a well.

Sandy coastal soils: high rates, shallow groundwater. Laterite, hard rock: low rates. Delta clay: usually unsuitable.

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

8.9 Sewage cross-connections and dry-weather flow

8.9.1 **No sewage in storm drains.** No sewage or sullage (grey water from kitchens, bathrooms and laundries), septic tank effluent, or trade effluent shall be connected to, or discharged into, any storm drain, by any pipe, channel or opening.

8.9.2 **Condition of approval.** Before the completion certificate, the Applicant shall show, by a dye or smoke test witnessed by the Authority or the sewerage agency, that every sewage and sullage outlet on the site discharges to a sewer or to an approved on-site system, and that none discharges to a storm drain. Any existing cross-connection on the site shall be removed as a condition of approval, including on redevelopment and on additions to existing buildings.

8.9.3 **Where no sewer exists.** Where no sewer is available, sewage and sullage shall go to an approved on-site or decentralised treatment system. The treated effluent of such a system may be discharged to a storm drain only with the written consent of the West Bengal Pollution Control Board and the drain owner.

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

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

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

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

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

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

> **Commentary.** The prohibition of sewage connections and the removal of existing cross-connections as a condition of approval are core requirements of this Manual, and Clause 1.10.3 allows no variance from them. Sewage in storm drains is the single largest water quality problem of urban drainage in West Bengal. 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 West Bengal, much of Kolkata, and the new works of KEIIP and KMC-SHARP, drain to combined sewers (Clause 6.3.6), and this Clause applies to them as follows. A combined sewer is a sewer, not a storm drain: Clauses 8.9.1 and 8.9.2 are met when the site's sewage and sullage reach it through the site's own foul system, kept apart from the site's storm drains up to the boundary (Clause 6.3.6(a)), and no sewage may be led into a storm drain, khal or pond that is not part of the combined system. Each KEIIP pumping station pumps the dry-weather flow to its own main and, in a storm, the storm-water flow "mixed with sewage" to the canals (KMC, 2015). The dry-weather-flow pumps are the station's DWF interception under Clause 8.9.5, and the survey of Clause 8.9.4 applies to every storm drain and khal outfall in a combined area, because dry-weather flow at such an outfall means that the interception has failed or been bypassed. The storm-water-flow pumps are a sewage overflow under Clause 8.9.6: no new one shall be designed except where the sewerage agency shows that no alternative exists, with screening and with the overflow frequency stated. Cutting that frequency, by separation where it is practical and by the storage of Clause 6.3.6(e) elsewhere, should be the water-quality objective of the city's drainage master plan (Chapter 11). Section 279 of the KMC Act, 1980 bars the discharge of sewage into a water-course until it has been treated (as read from a poor scan of the Act), and the outfall channels carry the city's flow through the East Kolkata Wetlands, whose bheris use the dry-weather flow for fish culture (Clause 7.12, Commentary).

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 West Bengal 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 (KMC Building Rules 2009, rule 144(1): an RWH system, for direct use or for groundwater recharge or both, in a new building, housing complex or expansion "as per" the Environmental Impact Assessment Guideline of the State or Union government; West Bengal Municipal (Building) Rules, 2007: RWH and tree cover, under a rule numbered 171 in one source and 168(13) in another, whose thresholds were not read for this Manual), with the RWH that rule 28(4) of the New Town Kolkata (Building) Rules, 2009, as amended in 2021, requires for every new building or housing complex in New Town, continues to apply (Chapter 1). This Clause sets how RWH structures are counted under this Manual.

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

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

8.11.3 **Recharge structures.**

- (a) Roof runoff may be led to recharge wells, open wells, recharge pits and shafts after a filter or settling chamber.
- (b) Runoff from roads, parking and other paved areas shall not be led directly into any well, borewell or recharge shaft. It may be recharged only through an infiltration facility that meets Clause 8.8, with pretreatment.
- (c) Recharge structures shall meet the groundwater separation of Clause 8.8.1, measured from the base of the pit or the bottom of the filter media, except recharge wells that receive filtered roof water only.

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

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

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

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

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

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

> **Commentary.** The rule that RWH storage does not count as detention is set in Chapter 4. West Bengal's building rules make RWH part of the plan, but in Kolkata only for larger projects, and none of them sets a detention rule. Rule 144(1) of the KMC Building Rules 2009 requires that an RWH system "shall form a part of the building and shall have to be included in the plan, either for direct use of the rain water or for ground water recharging or both", for a new building, housing complex or expansion "as per Environmental Impact Assessment Guideline issued by the State Government/Government of India"; read literally, this applies only to projects that the EIA guidelines catch, and KMC's practice was not found. Rule 117(2) lets the Commissioner require rain-water pipes to connect

to a drain or sewer "and/or rain water harvesting system", and Rule 144(2) requires tree cover on at least 15% of the land for projects of 6,000 m² of floor area or more. New Town is stricter: since 2021, every new building or housing complex must include rooftop RWH, for use or recharge or both, with a 15% cut in the plan sanction fee for fitting it to an existing building, and roof gardens are mandatory on plots of more than 300 m² (New Town Kolkata (Building) Rules, 2009, rule 28(4), as amended). The West Bengal Municipal (Building) Rules, 2007 also mandate RWH, under a rule numbered 171 in one source and 168(13) in another; their thresholds were not read. The West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005 regulates wells through SWID, and no obligation in it to harvest or recharge rainwater was found (as reported). None of these rules sets a depth, filter or first-flush standard for recharge, requires any storage to be empty before a storm, or limits peak flow, and no figures on compliance were found. In the delta, where the water table is high and arsenic or salinity limits recharge (Clause 8.8.1), harvesting for use is the main function of RWH (Clause 8.11.2(a)): storage comes first, and recharge only where the tests of Clause 8.8 are met. RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a July to September monsoon depression or a May or October–November cyclone arrives after weeks of rain, which is why it cannot be counted as detention.

Clause 8.11.3(b) has no direct precedent; this Manual sets it because road runoff carries oil, metals and pathogens. A recharge shaft or borewell bypasses the soil that would otherwise filter it and delivers it straight to the aquifer that supplies wells nearby. The CGWB *Manual on Artificial Recharge of Ground Water* (2007) gives recharge structure types and filter designs; this Manual adds the source-water restrictions.

8.12 Construction-stage erosion and sediment control

8.12.1 **ESC plan.** Every development with land disturbance of **0.1 ha** or more, and every public drainage or road work, shall have an Erosion and Sediment Control (ESC) plan, approved with the drainage report. It shall show:

- (a) the sequence of clearing, earthworks and stabilisation;
- (b) the area exposed at each stage;
- (c) the measures of Clause 8.12.3, with their locations and sizes;
- (d) the protection of infiltration and retention areas (Chapter 10);
- (e) stockpile, concrete washout and fuel storage locations; and
- (f) the inspection and maintenance schedule.

8.12.2 **Monsoon timing.** Earthworks shall be planned so that:

- (a) the area exposed during the SW monsoon (June to September) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **15 May**; and
- (c) any area exposed between 1 June and 30 September has sediment controls in place before it is cleared.

8.12.3 **Measures.**

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

- (h) **Concrete washout** in a lined pit, never into a drain.

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

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

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

> Commentary. The 0.1 ha threshold is the applicability threshold of Chapter 1. The sediment basin volume of 250 m³/ha is the US EPA Construction General Permit minimum of 3,600 ft³ per acre drained, converted to SI (US EPA, 2022 CGP); the CGP allows the alternative of the 2-year, 24-hour runoff. This Manual requires the greater of the two, because West Bengal's 2-year 24-hour depths are high and construction sites are commonly left exposed through the SW monsoon. The 2 ha division between traps and basins, the 15 May stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 15 May date matches the pre-monsoon deadline of Chapter 10. Construction sediment is a direct flood hazard as well as a pollutant: it fills drains, culverts and tanks, and in Kolkata the dredging of the Kestopur and Bagjola canals, about 80 km together, began in 2022 after a gap of five years (as reported; Clause 7.9, Commentary).

8.13 Monitoring

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

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

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

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

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

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

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

8.14 Submittal requirements

Every drainage report under this chapter shall include:

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

8.15 Review and update

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

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Annexes and forms

Annex / Form	Content
8A	3-month ARI 24-hour depth and IDF by zone
8B	Redevelopment LoS table and treatment-train composite VR
8C	West Bengal 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 tidal or river-influenced water body shall be analysed with the tailwater conditions of Chapter 5: MHWS for minor-system design, HAT plus surge for major-system design, each with the sea-level allowance of Clause 5.7.4; the outfall-closed check of Clause 5.10 where the tide can close the outfall, which on the tidal Hooghly at Kolkata and Howrah, in the outfall channels to the Kulti and the Bidyadhari, in the creeks of the Sundarbans and on the Medinipur coast is the normal case; the riverine backwater of Clause 5.8, including

releases from the DVC dams on the Damodar and from the Teesta barrage, where the outfall is on a river reach that a release can raise; the level held in an outfall channel by any lock, sluice or pumping station downstream of the outfall, taken as a fixed control at its gate-closed level or at the start level of its pumps; and the joint case of Clause 2.12.

9.2.2 **Climate factor.** Design flows shall include the climate factor of Clause 2.8.

9.2.3 **Maintenance access.** Every structure shall be accessible for inspection and cleaning by the methods in Clause 9.12 and Chapter 10, without manual entry into confined spaces wherever practicable.

9.2.4 **Design life.** Structures shall be designed for a service life of at least 50 years for concrete and masonry works, and at least 25 years for mechanical and electrical equipment, unless the approving authority agrees otherwise.

9.2.5 **Blockage.** Where a structure can be blocked by debris, it shall be checked in the blocked condition set out in this chapter, and a safe overflow route shall exist for that condition (Chapter 6, Clause 6.3.2).

> Commentary. The design-life values in Clause 9.2.4 have no direct precedent; this Manual sets them because they are needed to decide when the climate factor applies (Clause 2.8.2 applies it to elements with a design life over 25 years).

9.3 Pipes and box drains

9.3.1 **Capacity and roughness.** Pipe and box-drain capacity shall be computed by Manning's equation with the design n of Chapter 6, Table 6.6. For precast or cast-in-situ RCC box drains, the design n shall be at least 0.015.

9.3.2 **Partly full flow.** Depth, velocity and discharge in partly full circular pipes shall be computed from the hydraulic-element relationships for circular sections (for example CPHEEO 2019, Table 5.5). The minimum velocity of Clause 6.7.3 applies at the design flow.

9.3.3 **Pressure flow.** Where a pipe runs full or surcharged, the HGL shall be computed under Chapter 6, Clause 6.8, with friction and structure losses.

9.3.4 **Steep pipes.** Where the design flow in a pipe is supercritical (Froude number above 1), the designer shall:

- (a) locate any hydraulic jump and show that it occurs in a structure designed to contain it, not in a pipe run;
- (b) provide air venting where the jump can seal the pipe; and
- (c) meet the maximum velocity of Clause 6.7.3(b).

9.3.5 **Changes of size and direction.**

- (a) Pipe size shall not decrease downstream.
- (b) Pipes shall join only at manholes or junction chambers, except that inlet connections may join pipes of 1,200 mm or more through a factory-made junction.
- (c) Changes of direction greater than 90° in a single structure are not permitted.

9.3.6 **Flotation.** Pipes and box drains in high groundwater shall be checked for flotation (Chapter 6, Clause 6.7.7).

> Commentary. The design n of 0.015 for box drains is set by this Manual to match the "fair" concrete value in Table 6.6. Clauses 9.3.4 and 9.3.5 follow common practice in FHWA HEC-22 and other manuals. A jump inside a pipe run causes pressure surges and can blow off manhole covers.

9.4 Culverts

9.4.1 **Method.** Culverts shall be designed by the methods of FHWA *Hydraulic Design of Highway Culverts*, HDS-5, 3rd edition (2012), or by software that implements them (for example FHWA HY-8). The design headwater is the **greater** of the headwater under inlet control (HWi) and the headwater under outlet control (HWo).

9.4.2 **Inlet control.** HWi shall be computed from the HDS-5 inlet-control equations or nomographs for the barrel shape, material and inlet edge condition actually built.

9.4.3 **Outlet control.** HWo shall be computed as:

> HWo = ho + H − L·S

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

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

where ho is the outlet water depth used for control (m), H is the total head loss through the barrel (m), L is the barrel length (m), S is the barrel slope (m/m), ke is the entrance loss coefficient (Table 9.1), n is the barrel roughness, R is the hydraulic radius (m), V is the barrel velocity (m/s), TW is the tailwater depth above the outlet invert (m), dc is the critical depth (m) and D is the barrel rise (m). Part-full barrels under outlet control shall be analysed by backwater calculation as set out in HDS-5.

Table 9.1 — Entrance loss coefficients ke (outlet control, full or partly full)

Barrel and inlet	ke
Concrete pipe, projecting from fill, socket (groove) end	0.2
Concrete pipe, projecting from fill, square-cut end	0.5
Concrete pipe, headwall or headwall with wingwalls, socket end	0.2
Concrete pipe, headwall or headwall with wingwalls, square edge	0.5
Concrete pipe, headwall, rounded entrance (radius = D/12)	0.2
Concrete pipe, mitred to conform to fill slope	0.7
Concrete pipe, bevelled edges	0.2
Corrugated metal pipe, projecting from fill	0.9
RCC box, headwall parallel to embankment, square edge on three sides	0.5
RCC box, headwall parallel to embankment, three edges rounded or bevelled	0.2
RCC box, wingwalls at 30°–75° to barrel, square-edged crown	0.4
RCC box, wingwalls at 10°–25° to barrel, square-edged crown	0.5
RCC box, wingwalls parallel (extension of sides), square-edged crown	0.7

Source: FHWA HDS-5 (2012), entrance loss coefficient table (Appendix C).

9.4.4 **Tailwater.** TW shall be the higher of:

- (a) the normal or backwater depth in the downstream channel at the design flow; and
- (b) the tailwater level of Clause 9.2.1, for culverts within tidal or river backwater reach.

9.4.5 **Headwater limits.** At the design AEP of Chapter 6, Table 6.1:

- (a) HW/D shall not exceed 1.2;
- (b) the headwater shall be at least 0.3 m below the edge of the road shoulder at the upstream face; and
- (c) the headwater shall not raise water levels at any upstream building or property boundary above the limits of Chapter 6, Clause 6.12.2(d).

9.4.6 **Road overtopping.** Flow over the road in the check and 1% AEP events shall be computed with the broad-crested weir equation:

> Qr = Cd · L · h^1.5

where Qr is the overtopping flow (m³/s), L is the length of the overtopping section (m) and h is the depth of the headwater above the road crest (m). Cd shall be taken from HDS-5 for the road surface and the ratio of h to road width, and shall not exceed 1.66 (SI). The culvert and overtopping flows shall be balanced at a common headwater. The overtopping depths and hazard shall meet Chapter 6, Clause 6.12.

9.4.7 **Outlet velocity.** The outlet velocity at the design AEP and at the 1% AEP shall be computed and the outlet protected under Clause 9.6.

9.4.8 **Barrels and debris.**

- (a) Multi-barrel culverts shall be avoided in debris-prone urban drains. Where they are used, one barrel shall carry the dry-weather flow, and the inlet shall have a debris fin or deflector.
- (b) Culverts shall meet the minimum size and blockage checks of Chapter 6, Clauses 6.12.4 and 6.12.5.
- (c) Culvert inverts shall match the bed of the drain. They shall not be set above the bed, which traps silt and water upstream.

9.4.9 **Headwalls and cut-offs.** Inlets and outlets shall have headwalls, wingwalls and cut-off walls designed to prevent piping and undermining.

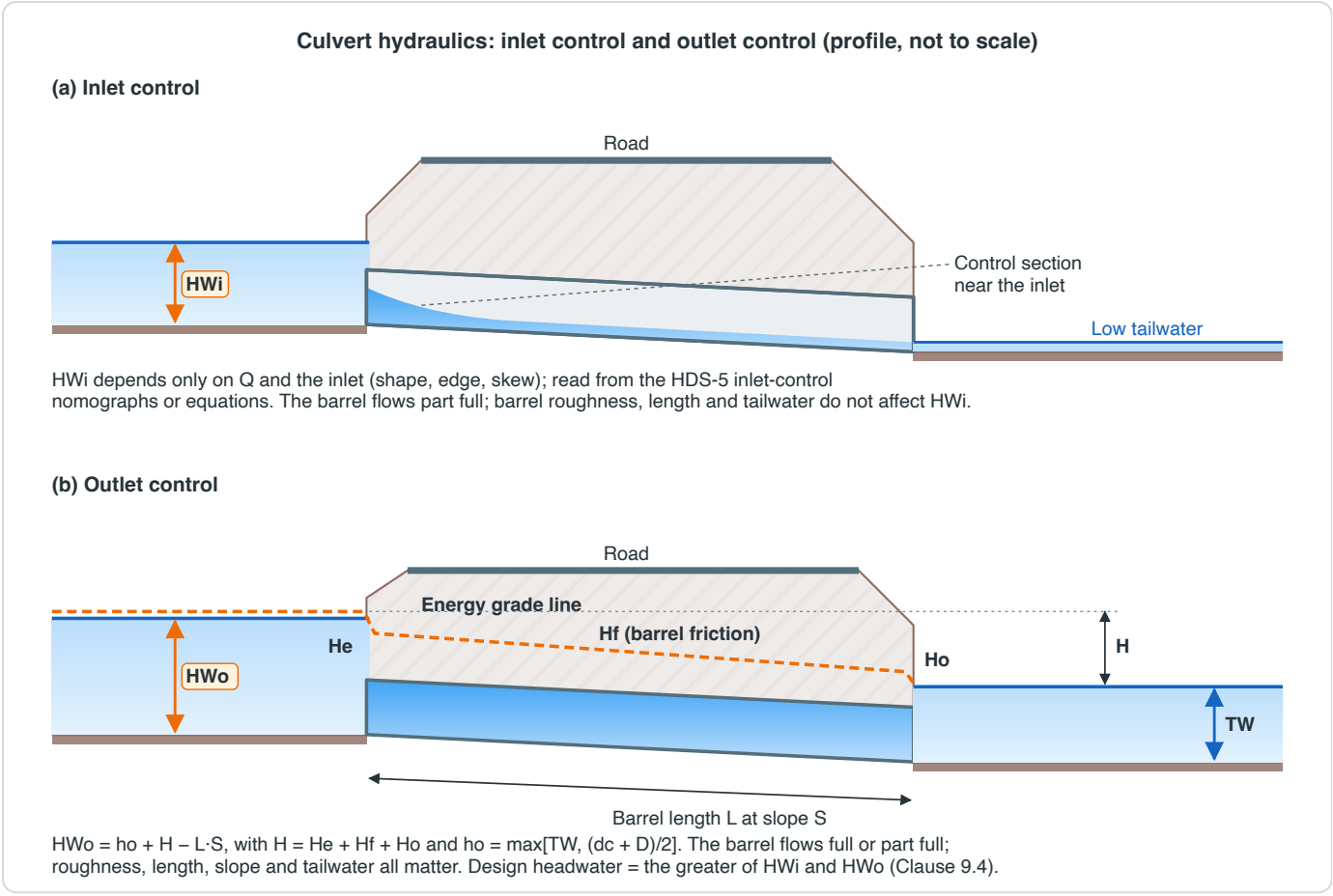

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

> **Commentary.** HDS-5 (3rd ed., FHWA-HIF-12-026, April 2012) merged the culvert design material of HEC-5, HEC-10 and HEC-13 and is the current FHWA culvert manual. The outlet-control equation in Clause 9.4.3 is the HDS-5 energy equation in SI units: the friction coefficient 19.63 equals 2g. The ke values in Table 9.1 are reproduced from HDS-5. The weir coefficient cap of 1.66 (SI) is the conversion of the APWA 5600 (2006) limit of C ≤ 3.0 (US units) for overtopping calculations. The headwater limits of Clause 9.4.5 are set by this Manual: HW/D ≤ 1.2 keeps the inlet from operating far into submerged-orifice flow at the design event, where small increases in flow give large increases in headwater. Clause 9.4.8(c) has no direct precedent; it is included because raised culvert inverts are common in West Bengal 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 in Kolkata and Howrah, where the drains discharge through pumping stations and lock gates to outfall channels held up by the tide and the Hooghly, in the Sundarbans and on the Medinipur coast, and on the lower Damodar, Mundeswari and Rupnarayan, whose level is set by DVC releases, is the normal case.

9.5.2 **Flow regime.** At the design flow, the Froude number shall not exceed 0.8 (CPHEEO 2019, §5.3), unless the channel is designed as a supercritical chute. Flows with a Froude number between 0.8 and 1.2 are not permitted at the design flow in any channel.

9.5.3 **Permissible velocities.** Mean velocity at the design flow shall not exceed the limits of Table 9.2.

Table 9.2 — Maximum permissible mean velocities in channels

Lining or soil	Maximum velocity (m/s)	Source
Concrete lining	3.0	CPHEEO 2019 Table 5.11
Riprap lining	1.8	CPHEEO 2019 Table 5.11
Grassed lining	1.2	CPHEEO 2019 Table 5.11
Stabilised earthen channel (modified natural channel)	2.0, or the critical velocity if less	CPHEEO 2019 §5.10.3
Unlined, fine sand	0.46	Fortier and Scobey (1926), clear water
Unlined, sandy loam	0.53	As above
Unlined, silt loam	0.61	As above
Unlined, firm loam	0.76	As above
Unlined, stiff clay	1.14	As above
Unlined, fine gravel	0.76	As above
Unlined, coarse gravel	1.22	As above

Flexible linings (vegetation, riprap, geosynthetics) may instead be designed by the permissible shear stress method of FHWA HEC-15, *Design of Roadside Channels with Flexible Linings*, 3rd edition (2005).

9.5.4 **Longitudinal slope.** In engineered channels, the longitudinal slope shall not exceed 0.4% for natural linings and 0.2% for concrete linings, unless drop structures (Clause 9.6.6) or a chute are provided (CPHEEO 2019, Table 5.11).

9.5.5 **Freeboard and bends.** Freeboard shall meet Chapter 6, Table 6.7, measured above the water level that includes superelevation at bends. Bend radii shall meet Chapter 6, Clause 6.7.10.

9.5.6 **Side slopes.** Unless a structural or geotechnical design supports a steeper slope:

- (a) unlined earth channels shall have side slopes no steeper than 1V:2H; and
- (b) grassed channels that are mown shall have side slopes no steeper than 1V:3H.

9.5.7 **Low-flow channel.** Channels with a bed width of 3 m or more shall have a defined low-flow channel that carries the dry-weather flow at the self-cleansing velocity of Clause 6.7.3.

9.5.8 **Transitions.** Changes of section shall use gradual transitions. Abrupt expansions and contractions are not permitted in supercritical flow.

9.5.9 **Linings in high groundwater.** Lined channels in areas of high groundwater or tidal influence shall have weep holes with filters, or shall be designed to resist uplift with the channel empty.

9.5.10 **Natural channels.** Natural channels shall be preserved where possible (CPHEEO 2019, §5.10.3 note; Chapter 7). Where a natural channel must be modified, its capacity shall meet the design AEP of Chapter 6 and its velocities shall meet Table 9.2.

> **Commentary.** The lined-channel velocities and slopes are CPHEEO (2019) Table 5.11 values. The unlined-soil values are the classic Fortier and Scobey (1926) permissible velocities for clear water, as reproduced in Chow (1959). They are given for soils common in West Bengal (the deltaic clays and clay loams of Kolkata, Howrah and the 24 Parganas, the saline soils of the Sundarbans, the loamy alluvium of Nadia, Murshidabad and Malda, the lateritic and red gravelly soils of the western plateau, the terai sandy loams of North Bengal, and the coastal

sands of Digha and Contai). 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 West Bengal 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 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D / TW)

where D50 is the median stone size (m), D is the culvert diameter or rise (m), Q is the design discharge (m³/s), g = 9.81 m/s² and TW is the tailwater depth (m). Where TW is not known, it shall be taken as 0.4D.

Apron length and thickness shall follow the HEC-14 riprap-class table (Table 9.3). The apron width at the outlet shall be at least 3D and shall flare to the downstream channel.

Table 9.3 — Riprap classes and apron dimensions (HEC-14)

Class	D50 (mm)	Apron length	Apron thickness
1	125	4D	3.5 D50
2	150	4D	3.3 D50
3	250	5D	2.4 D50
4	350	6D	2.2 D50
5	500	7D	2.0 D50
6	550	8D	2.0 D50

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

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

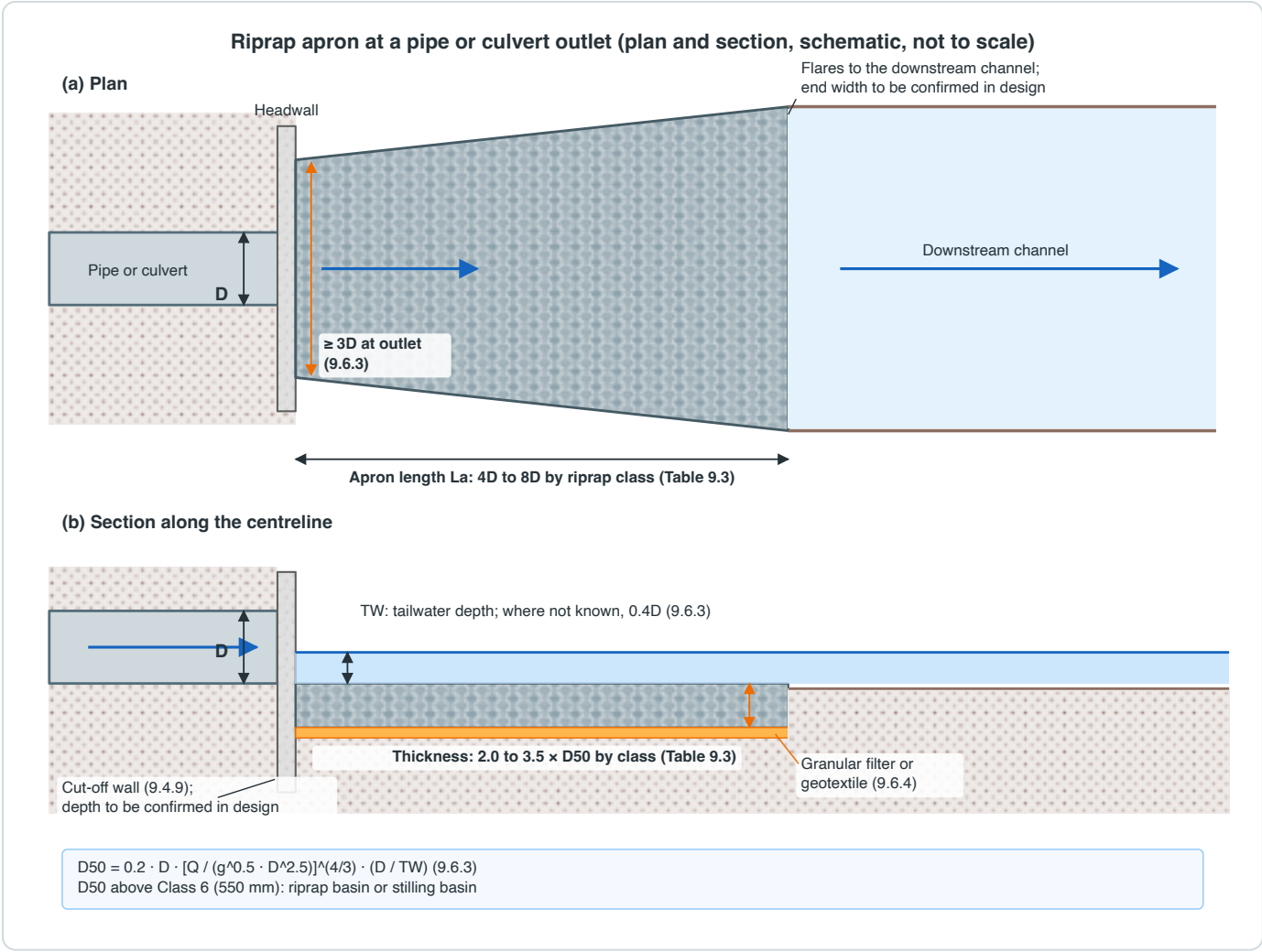

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design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

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

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

- (a) For a straight vertical drop, the drop number $D = q^2 / (g\,h^3)$ shall be computed, where q is the unit discharge (m²/s) and h is the drop height (m). The pool geometry shall be set from the Rand (1955) relationships: drop length Ld/h = 4.30 D^0.27; pool depth Yp/h = 1.00 D^0.22; sequent depths y1/h = 0.54 D^0.425 and y2/h = 1.66 D^0.27.
- (b) Baffled chutes and stepped drops shall be designed by HEC-14 or US Bureau of Reclamation methods.
- (c) The height of a single vertical drop in a public drain shall not exceed 1.5 m. Drops shall have edge protection under Chapter 6, Clause 6.13.8.

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

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

9.7 Detention outlet structures

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

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

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

> Q = Cd · A · (2 g h)^0.5

where A is the orifice area (m²) and h is the head (m) on the centroid of the orifice, or the difference between the upstream and downstream water levels where the orifice is submerged. Cd shall be 0.60 for a sharp-edged orifice in a thin plate. Other edge conditions shall use published tested values.

9.7.3 **Weirs.** Weir flow shall be computed as Q = Cw · L · H^1.5, with:

- (a) sharp-crested rectangular weirs: Cw = 1.84 (SI), with the effective length reduced by 0.1 H for each end contraction;
- (b) V-notch weirs: Q = 1.38 · tan(θ/2) · H^2.5 (SI), where θ is the notch angle; and
- (c) broad-crested weirs and spillway crests: Cw = 1.44 to 1.70 (SI), selected from published tables for the crest shape and head.

Submerged weirs shall be corrected for submergence from published relationships.

9.7.4 **Stage–discharge rating.** For multi-stage outlets (orifices and weirs in a riser, with an outlet pipe), the designer shall compute, at each stage, the discharge under every possible control (each orifice, each weir, riser crest, and the outlet pipe under inlet and outlet control) and use the **smallest** combined value. The rating shall be tabulated from the outlet invert to the emergency spillway crest plus the design head.

9.7.5 **Tailwater.** Ratings shall be computed with the tailwater of Clause 9.2.1. Where the receiving water can rise above the outlet, the outlet shall have a flap gate or non-return valve under Clause 9.10, and the storage shall meet the outfall-closed check of Chapter 5.

9.7.6 **Emergency spillway.** The emergency spillway shall pass the 1% AEP inflow with the primary outlet assumed blocked and the basin full at the start, with **0.3 m** freeboard to the embankment crest. High-hazard basins shall also be checked for the 0.2% AEP inflow (Chapter 4).

9.7.7 **Outlet pipes through embankments.** Outlet pipes through embankments shall have a filter diaphragm or seepage collars to prevent piping along the pipe, and a flared or headwalled inlet.

9.7.8 **Anti-vortex.** Riser outlets with a design head above the riser crest greater than the riser diameter shall have an anti-vortex plate.

> **Commentary.** The 50 mm minimum orifice with a trash screen, the emergency-spillway criterion and the drawdown times are core criteria of this Manual (Chapter 4). The minimum orifice is smaller than the APWA 5600 (2006, 5608.4) minimum of 3 in (about 75 mm). It allows the low release rates of the Chapter 4 mixed-frequency rule on small sites, and it relies on a good screen (Clause 9.8.5). The "no mechanical parts" rule follows APWA 5600 (2006, 5608.4), which requires the primary outlet to function unattended. The orifice and weir coefficients are standard textbook values (for example Brater and King, *Handbook of Hydraulics*; Chow 1959). The 1.84 sharp-crested coefficient and the 0.1H end-contraction correction are the Francis formula in SI units. The broad-crested range 1.44–1.70 is the SI equivalent of the US range 2.6–3.1 commonly tabulated. Clauses 9.7.7 and 9.7.8 follow common dam and detention practice.

9.8 Trash racks and screens

9.8.1 **Where required.** Trash racks or screens shall be provided:

- (a) where an open drain enters a pipe, covered drain or culvert longer than 30 m (Chapter 6, Clause 6.13.4);
- (b) at every detention outlet orifice (Clause 9.7.1);
- (c) at the inlet of every pump sump (Clause 9.9); and
- (d) at outfalls to waterbodies, as part of the gross pollutant trap of Chapter 8.

9.8.2 **Conduit-entrance racks.** Racks at the entrance to conduits and culverts shall have:

- (a) clear bar spacing not less than 75 mm and not more than half the smallest internal dimension of the conduit;
- (b) a gross area at least 4 times the conduit's cross-sectional area;
- (c) a mean velocity through the rack at the design flow, with 50% of the rack blocked, of not more than 1.0 m/s; and
- (d) an inclination no steeper than 1V:2H where the rack is to be raked by hand, with a working platform and handrail.

9.8.3 **Head loss.** Head loss through a clean rack shall be computed with the Kirschmer equation:

$$h_r = \beta \cdot (t / b)^{4/3} \cdot (V^2 / 2g) \cdot \sin\theta$$

where t is the bar thickness, b is the clear bar spacing, V is the approach velocity, θ is the angle of the rack from the horizontal, and β is the bar shape factor (2.42 for sharp-edged rectangular bars; 1.79 for circular bars). The HGL and headwater shall be checked with the rack **50% blocked** (head loss computed with half the open area).

9.8.4 **Overflow when blocked.** Every rack shall have an overflow route so that a fully blocked rack does not flood buildings or exceed the limits of Chapter 6.

9.8.5 **Detention outlet screens.** Screens over detention orifices shall have openings smaller than the orifice they protect, and an open area at least 10 times the orifice area.

9.8.6 **Pump sump screens.** Bar screens at pump-station inlets shall have a clear spacing smaller than the largest solid the pumps can pass, as stated by the pump manufacturer. Screens shall be built in removable modules, and a mechanically raked screen shall be used where the design inflow exceeds 1 m^3/s.

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

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

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 m³/s, or where the sump does not follow

standard ANSI/HI 9.8 geometry. The minimum clear space between adjacent pumps or motors is 0.6 m for small and medium units and 1.0 m for large units (CPHEEO 2019, §8.2.5).

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

9.9.8 **Controls and monitoring.**

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

9.9.9 **Power supply.**

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

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

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

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

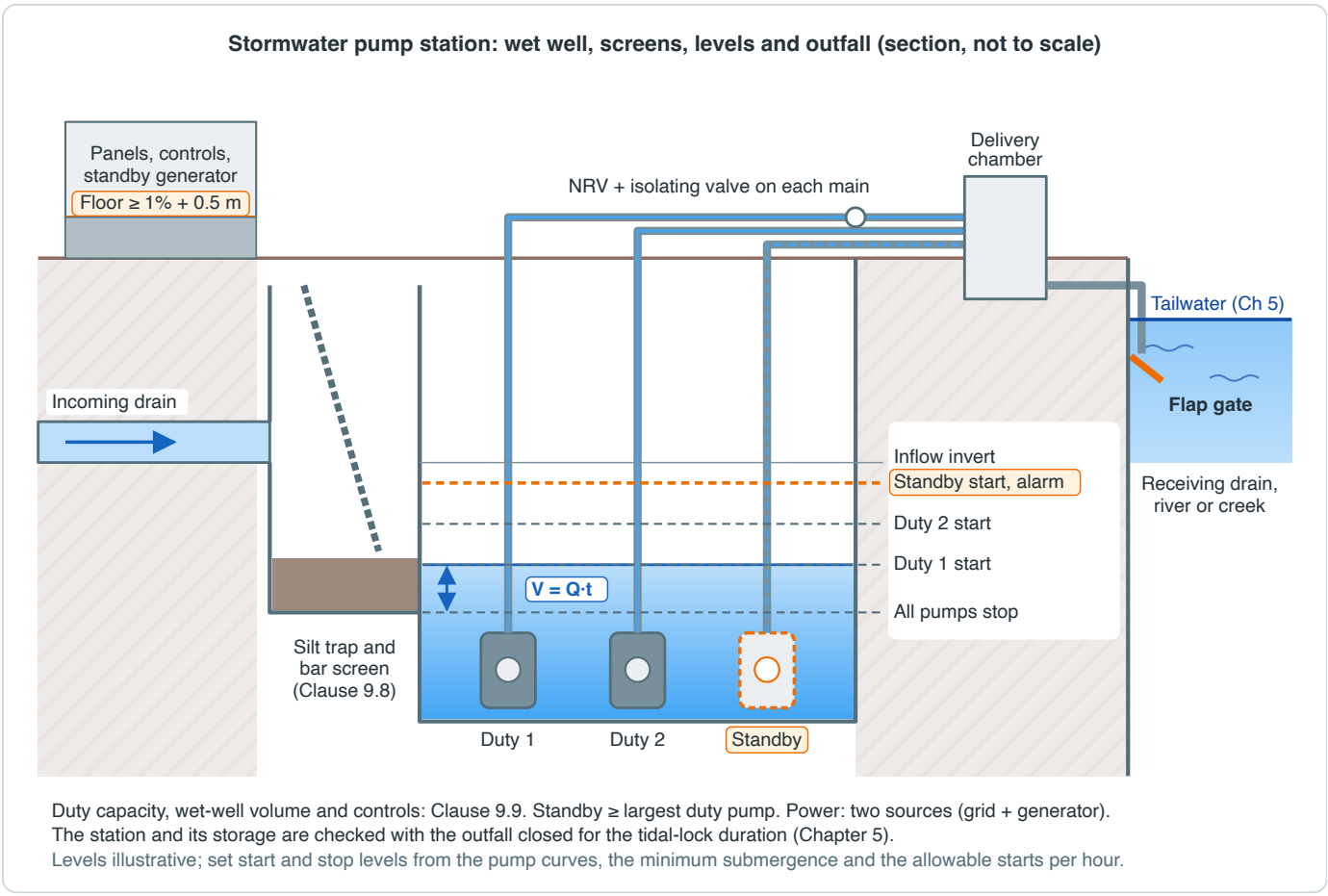

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

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

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". Gates are required below the 1% still-water level because most outfalls in Kolkata, Howrah and the coastal delta are closed by the tide or by a river in flood. Kolkata lies on the natural levee of the Hooghly and slopes east, away from the river. Its storm water and sewage therefore run east to outfall channels; the Bidyadhari was abandoned as the outfall in 1928, and under the Kulti Outfall Scheme two parallel channels carry storm water and dry-weather flow separately for 27 km from Bantala to the Kultigang, which joins the Raimangal estuary (I&WD). The flow is lifted by pumping stations: I&WD lists KMC's main stations at Ballygunge (1,233 cusec), Palmer Bazar (1,184 cusec) and Dhapa Lock (480 cusec), its own stations at Uttarbhag (1,000 cusec) and Chowbhaga, and more than twenty smaller ones (I&WD). The Bagjola canal ends at a pump house at Kulti of 1,650 cusec, reported to be inadequate, with an upgrade to 4,000 cusec approved by CWC whose status was not found (press reports). At the KEIIP Behala Flying Club station, discharge "is partially achieved due to high water levels in the canal, particularly during tidal period" (KMC 2015), and the flooding of 23 September 2025 was blamed in part on a high tide (press reports). INCOIS puts the 100-year extreme sea level at Diamond Harbour at 3.79 m above mean sea level, rising to 4.34–4.46 m by 2100 (INCOIS 2025). Kolkata is subsiding at 2.8–5.5 mm a year (Thakur et al. 2026), comparable to the sea-level trend of 3.73 mm a year at Diamond Harbour (PSMSL), so the relative rise at a Kolkata outfall is the sum of both. In the Sundarbans the islands drain through sluices in about 3,122 km of I&WD embankments, of which Cyclone Aila breached 177 km and severely damaged a further 601 km in May 2009 (I&WD). No operating rule for any lock, sluice or pumping station on the Kolkata outfall channels, and no tide level at Garden Reach on a stated datum, was found in the public domain. Clauses 9.10.3 and 9.10.5 are set by this Manual because a flap gate jammed open by silt, garbage or debris lets the tide or the river back into the drain network, and one jammed shut blocks it. The Hooghly carries a heavy silt load and a bore on practically every spring tide (CWPRS), the operators of the Chitpur lock gates have been reported to warn of damage at full-moon high tides (press reports), and the Sundarbans islands drain through sluices in their embankments that must close against every high tide, so a sluice that fails to close lets the sea in behind the embankment.

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 West Bengal 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 West Bengal 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 West Bengal 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 West Bengal locations to exposure classes, the 5 km coastal band, 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. No CAG audit of urban storm drainage in West Bengal was found: none of KMC's drainage, of KEIIP or of any other city's drains. The one relevant audit is of flood control by I&WD (CAG Report No. 2 of 2019). It found that "in the absence of basin-wise/river-wise holistic Master Plan, flood management projects were taken up at different locations depending on priority and availability of funds without being linked to a comprehensive plan". Under the Kandi Master Plan, due in March 2017 and still under way in 2019, only embankments had been raised and strengthened, and no additional waterway had been created at bridges and culverts; all the blocks under that plan and the Kaliaghai–Kapaleswari–Baghai scheme were flooded in July 2017. The audit recommended detention basins, diversion of flood water and a floodplain zoning law on the model Bill (CAG 2019). The approval route also shapes this chapter. West Bengal has no single building code. In Kolkata the Municipal Commissioner sanctions building plans under the KMC Building Rules 2009, with the Municipal Building Committee and the Mayor-in-Council for relaxations. The site plan must show the house drains and the "means of communication with any municipal drain", the terrace plan the roof drainage and rain-water pipes, and the application must say whether the land is a filled-up tank. A licensed plumber supervises the drainage work and certifies it under the KMC (Water Supply, Sewerage and Drainage) Regulations 1984. Where the Commissioner considers that a building "will put additional burden on the existing civic services" of the ward, including its drainage, the Commissioner may sanction it subject to conditions (KMC Building Rules 2009). In the municipalities the Board of Councillors sanctions plans under the West Bengal Municipal (Building) Rules 2007, which have a separate chapter for Salt Lake, and buildings over 14.5 m also need the approval of the Municipal Engineering Directorate (as reported). New Town has its own rules under NKDA. The building rules of Howrah, Siliguri, Asansol and the other Municipal Corporations were not read for this Manual. No rule asks for a drainage report or limits peak runoff. Every stormwater item in this chapter is therefore written so that the architect or engineer on record can

certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the Authority can check it at the plinth and completion stages; in Kolkata the Commissioner's power to impose conditions on a building that would burden the drainage is the natural hook for them. 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 (Table 10.1):

Table 10.1 — Submittal stages and linked approvals

Stage	Submittal	When	Linked approval
0	**Pre-application** meeting and **Form 1-1** (Applicability Determination)	Before the planning permission or layout application	None (advisory record)
1	**Preliminary drainage report**	With the planning permission or layout application	Planning permission / layout approval
2	**Final drainage design**	Before building permit, or before commencement where the permit is issued with the planning permission	Building permit / commencement
3	**Construction inspections** at hold points	During construction	None (records filed)
4	**As-built certificate** and verification tests	Before the completion certificate	Completion / occupancy certificate
5	**Maintenance declaration** registered, or **handover** of public assets	Before or with the completion certificate	Completion certificate; asset acceptance

Stage	Submittal	When	Linked approval
6	**Annual declarations** and inspection reports	Every year after completion	Continuing compliance

10.3.2 **Stage 0 is mandatory** for:

- (a) sites of 2 ha or more;
- (b) sites in a flood-sensitive catchment;
- (c) sites proposing a variance, waiver, regional facility or fee-in-lieu; and
- (d) sites draining to a tidal outfall or adjoining a waterbody.

For other sites, Stage 0 is optional, and Form 1-1 is lodged with Stage 1.

10.3.3 **Combined stages.** For sites of less than 1 ha outside flood-sensitive catchments, the Authority may accept Stages 1 and 2 as one submittal.

10.3.4 **Public works.** For a public work, Stage 1 is the drainage section of the DPR and Stage 2 is the drainage section of the tender drawings. The sanctioning authority shall not sanction or tender the work until the relevant stage has been reviewed under Clause 10.7.

10.3.5 **Changes after approval.** Any change that alters impervious area, levels, storage, outlet or outfall after Stage 2 shall be resubmitted, with the compliance calculator re-run, before the change is built.

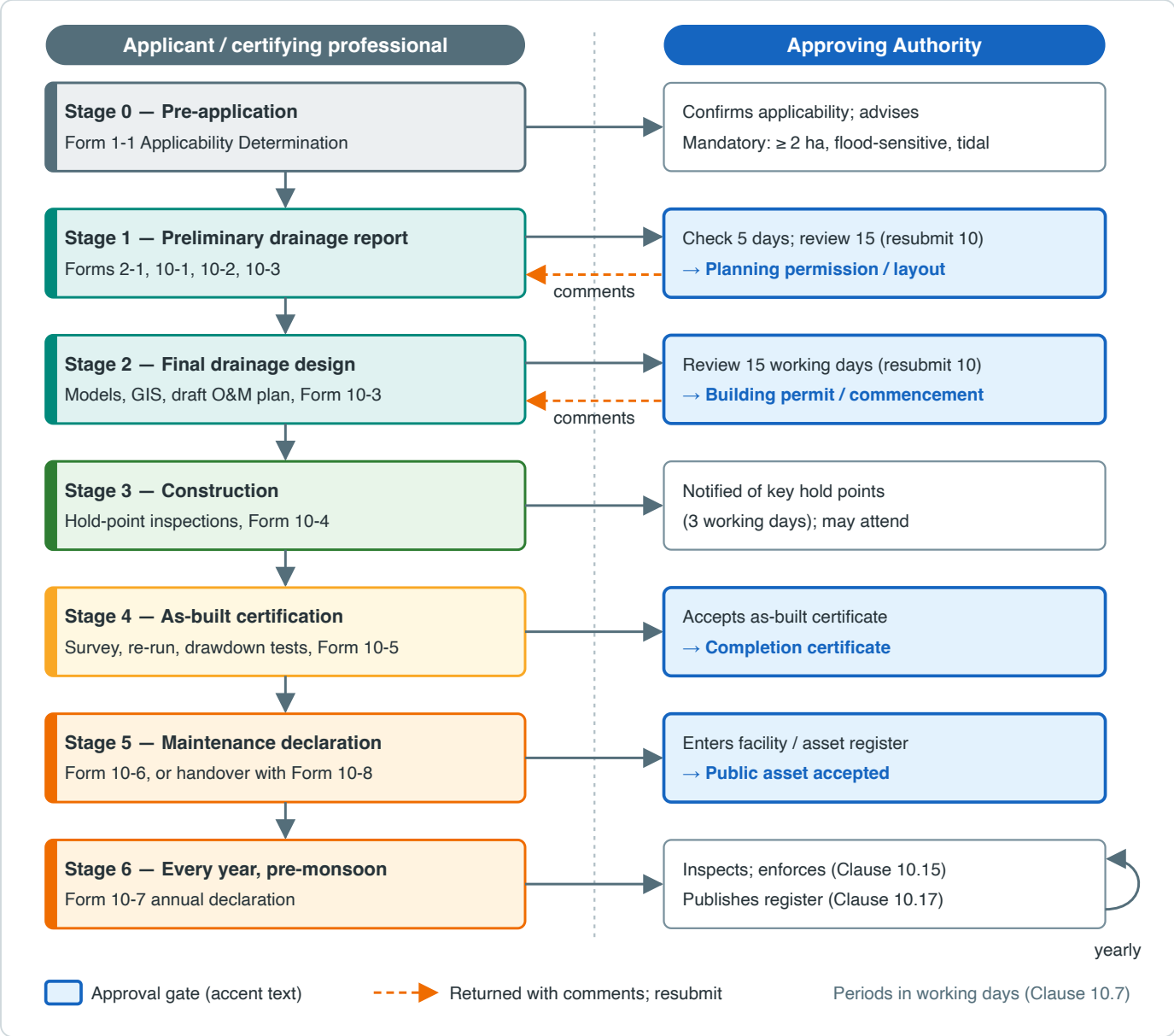

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **Commentary.** The stages follow the APWA 5600 sequence of preliminary and final stormwater studies, construction inspection and maintenance agreements (APWA 5600, 2006, §5608 and §5609), mapped onto the KMCBR/WBMBR steps a West Bengal 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 (45N), with attributes as listed in Annex 10B.
- (d) Levels shall be stated relative to a named vertical datum. The relationship to the tidal datums (chart datum of the nearest port, mean sea level on the GTS datum and, in Kolkata, the Kidderpore Old Datum (KOD)) used in Chapter 5 shall be stated.

10.4.5 **Summary of forms used in submittals** (Table 10.2):

Table 10.2 — Forms used in submittals

Form	Title	Stage
1-1	Applicability Determination	0 or 1
1-2	Variance / Waiver Request	1
2-1	Design Rainfall Sheet	1, 2
10-1	Drainage Report Checklist	1, 2
10-2	Compliance Calculator Summary	1, 2, 4
10-3	Professional Design Certificate	1, 2

Form	Title	Stage
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. The design basis of public drains in West Bengal is rarely published. Kolkata's first brick sewer, commissioned in 1876, was designed for 6.35 mm/h of rain (a quarter of an inch an hour) with 100% runoff; attempts were made in the 1970s to raise the capacity to 12.7 mm/h, but the city received 54 mm in one hour in 2003 (Gupta 2005). A KMC engineer is still quoted as saying that the network prevents waterlogging only if it rains up to 6 mm in an hour (press reports). The CMPO Drainage Master Plan for the metropolitan area "has been based on the design consideration, of flood frequency of once in two months (6 times in a year)" with an imperviousness of 70%, and its intensity–frequency–duration curve "has been adopted by KMDA / ULBs" (CPHEEO appraisal note); the curve itself was not found. KMC's works under KEIIP follow its Sewerage and Drainage Master Plan of December 2007 and its 2014 Action Plan to Mitigate Flood, Cyclone and Water Logging (ADB 2016), neither of which was found, and the KEIIP environmental examinations give the design period, the combined design and the canals that receive the storm flow, but no rainfall intensity, return period or runoff coefficient (KMC 2015; ADB 2017). No design-criteria document was found for Howrah, Bidhannagar, New Town, Siliguri, Asansol, Durgapur or Haldia. 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 West Bengal 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 UD&MA:

- (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 UD&MA 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 KMCBR/WBMBR 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 UD&MA list. The empanelled reviewer shall not have worked on the same site. The Authority remains the decision-maker.

10.7.5 **Concurrent clearances.** Where a WBCZMA recommendation (in the Coastal Regulation Zone), I&WD's consent for a discharge to or a work on one of its rivers, canals, khals, embankments or sluices, EKWMA's sanction within the East Kolkata Wetlands, or the Fisheries Department's permission under section 17A of the West Bengal Inland Fisheries Act 1984 to fill or alter a water area 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.

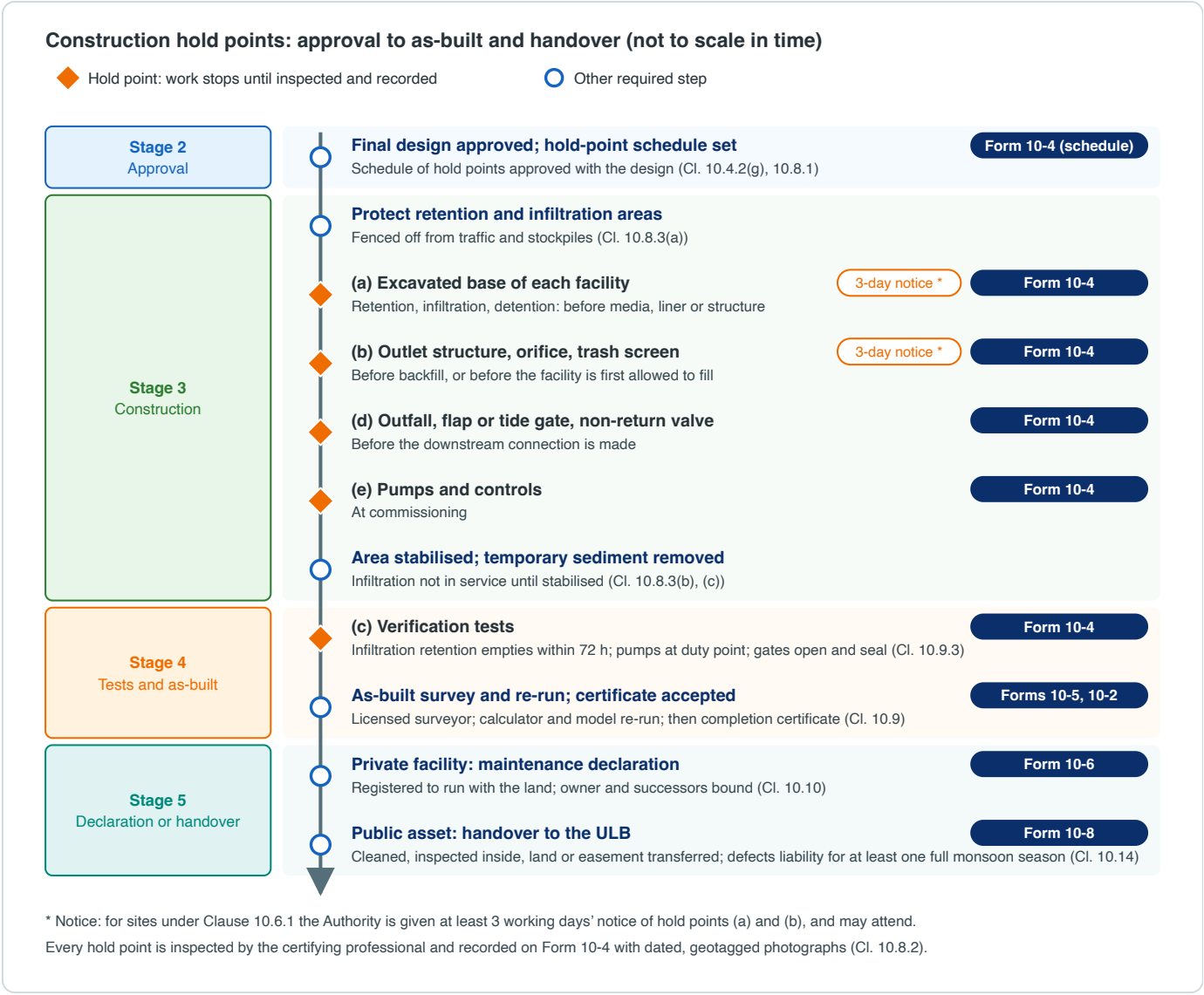

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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 **15 May** each year. The report shall be signed by the owner and, for facilities under Clause 10.6.1(c) and (d), by an empanelled professional. It shall state that the pre-monsoon inspection of Clause 10.12 has been done and any defects corrected.

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

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

detention tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 15 May date is set by this Manual to fall before the south-west monsoon (June–September), when most West Bengal 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. West Bengal's outfalls depend on locks, sluices and pumps whose operating rules are not published. Kolkata's storm water reaches the Kulti through pumping stations of KMC and I&WD; the three main KMC stations at Ballygunge, Palmer Bazar and Dhapa Lock have about 2,900 cusec installed between them (I&WD). The KEIIP stations have separate pumps for dry-weather and storm flow; Begore, for example, has 300 l/s of dry-weather pumping and 4,500 l/s of storm pumping in 6 + 2 units, and the storm pumps discharge storm water mixed with sewage to the Churial and other canals (KMC 2015). On the Hooghly side the drainage depends on lock gates such as Chitpur, and KMC was reported to plan lifting stations at five points in the outfall zones so that the city can drain while the lock gates are shut (press reports). Releases from DVC's Maithon and Panchet dams set the level of the lower Damodar: a State government statement put the combined peak release on 17 September 2024 at 2.5 lakh cusec, while other reports gave figures from 1.7 to 5 lakh cusec, and the Union Ministry said that the reservoirs are regulated by a committee that includes West Bengal and Jharkhand (press reports). Dredging of about 80 km of the Kestopur and Bagjola canals began in 2022 after a gap of five years (press report). No operating rules for the Kolkata pumping stations and locks, the Sundarbans embankment sluices or the DVC reservoirs were 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 15 May)	After a heavy-rainfall event
Retention / infiltration (soakaways, trenches, bioretention, permeable paving)	Every 6 months	Yes	Yes
Surface detention basin or multi-use open space area	Every 6 months	Yes	Yes
Underground or podium detention tank, gravity outlet	Every 6 months	Yes	Yes
Pumped detention, pumps and controls	Monthly test run	Yes, with full duty test	Yes
Flap / tide gate, non-return valve	Every 3 months	Yes, with seal test	Yes
Gross pollutant trap / first-flush device	Every 3 months	Yes	Yes
Private drains and inlets	Every 6 months	Yes	—

A heavy-rainfall event, for this Clause, is a day on which the nearest approved gauge records rainfall at or above the IMD "heavy rainfall" category, or a day for which a red alert is issued for the district. In West Bengal, pumped facilities, flap and tide gates, sluices, non-return valves and regional facilities shall also be inspected a second time by **30 September**, with the pump duty and gate seal tests of the pre-monsoon column, so that they are ready for the cyclone storms of October and 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).

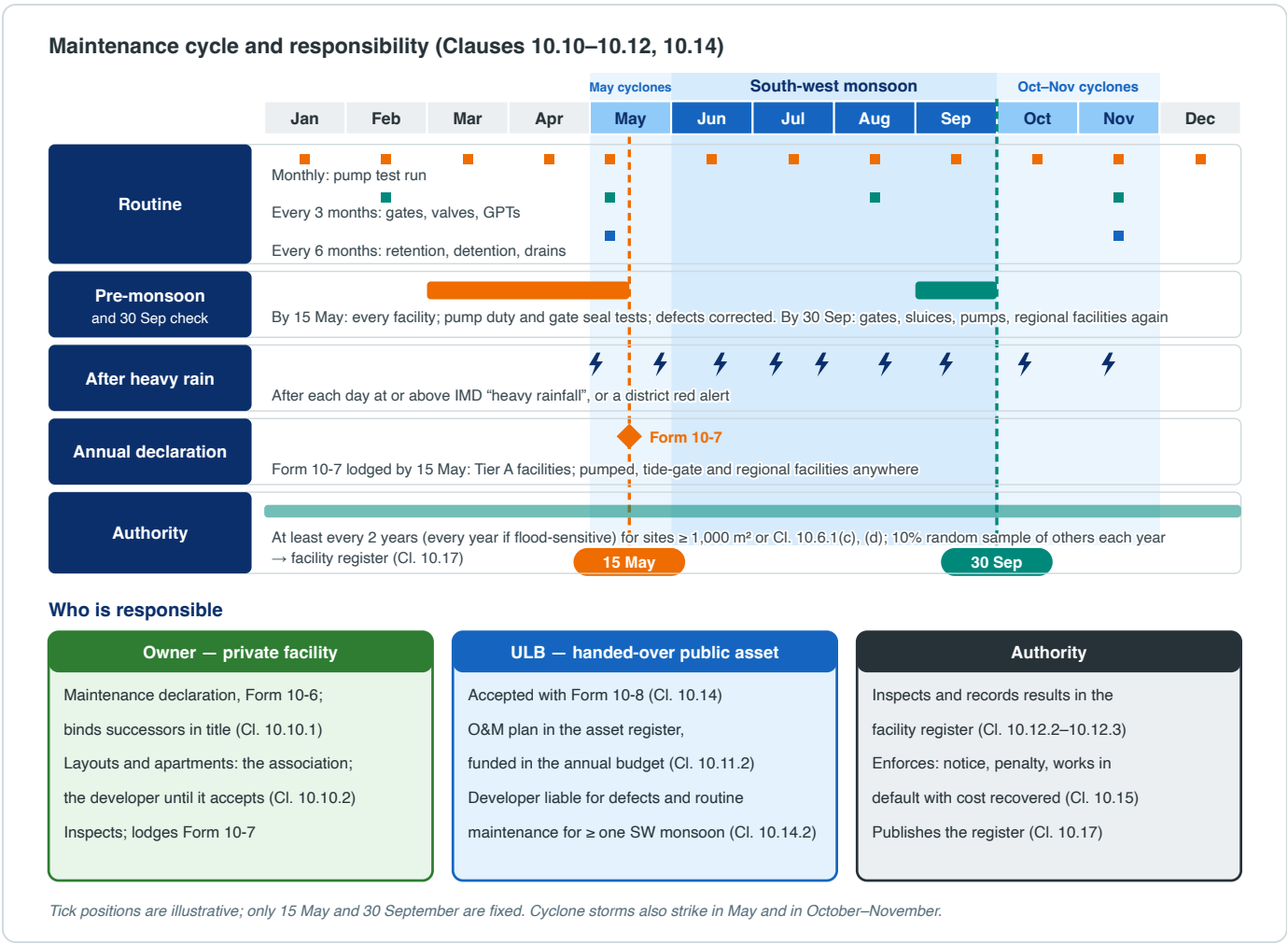

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 15 May) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the south-west monsoon (June–September); tick positions within the year are illustrative.

Commentary. The split in Clause 10.12.2 follows the MBBL 2016 inspection regime for RWH, which requires 100% monitoring of buildings over 1,000 m² and a 10% random check below that (MBBL 2016, §9.6). The inspection intervals in Table 10.3 are set by this Manual. The pre-monsoon deadline is set for the cyclone season as well as the SW monsoon. The monsoon sets in during the first week of June in most districts, the second week in Nadia and Darjeeling and the third week in Purulia (ICAR-CRIDA district plans). NDMA (2010) sets 31 March for pre-monsoon desilting nationally, and no published desilting deadline was found for KMC or any other West Bengal city. The State's most damaging recent cyclones struck in the second half of May: Aila on 25 May 2009, Amphan on 20 May 2020, Yaas on 26 May 2021 and Remal on 26 May 2024 (I&WD; IMD; press reports). May storms are also heavy inland: Dum Dum recorded 220.0 mm on 8 May 1949, Cooch Behar 353.2 mm on 28 May 1989 and Jalpaiguri 312.8 mm on 24 May 1999, and Diamond Harbour's all-time 24-hour record, 290.7 mm, fell on 27 May 1993 (IMD). This Manual therefore adopts 15 May statewide. For the storms of October and November it adds the second inspection of gates, sluices, pumps and regional facilities by 30 September, after the monsoon and before the cyclone months: Midnapore recorded 325.1 mm on 17 October 1942, and Haldia, Dum Dum and Uluberia all set their post-monsoon records on 9 November 1986 (IMD). The post-event inspections of Table 10.3 cover storms at any time of year.

10.13 Maintenance access

10.13.1 Every facility shall have permanent access for inspection and maintenance, shown on the approved drawings and protected by the maintenance declaration or, for public facilities, by an easement or land transfer.

10.13.2 **Surface facilities.** Basins, ponds and open channels shall have a vehicle access route to the inlet, the outlet and the base, and a maintenance strip along at least one side. Ramps into basins shall be suitable for the plant needed to remove sediment.

10.13.3 **Underground facilities.** Tanks shall have:

- (a) an access opening over the inlet, the outlet and each chamber;
- (b) fixed ladders or steps, and ventilation for confined-space entry;
- (c) a sump or low point for sediment removal; and
- (d) headroom sufficient for manual cleaning.

10.13.4 **Outlets.** Orifices and screens shall be reachable for cleaning without entering a full facility.

10.13.5 Access routes shall not be built over, fenced off or used for parking in a way that prevents access.

> Commentary. APWA 5600 (2006, §5608) required a 15-ft (about 4.5 m) maintenance access strip for detention facilities. Plot sizes in West Bengal 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 south-west monsoon season** 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 West Bengal drainage show up only in the first SW monsoon.

10.15 Enforcement

10.15.1 **Offences.** The following are contraventions of this Manual:

- (a) building without an approved drainage design where one is required;
- (b) building a facility other than as approved;
- (c) removing, filling, covering, reducing or changing the use of a facility without approval;
- (d) failing to maintain a facility, or to submit Form 10-7;
- (e) a sewage connection to a storm drain;
- (f) building or filling in a waterbody setback or no-fill zone (Chapter 7);
- (g) obstructing a natural drainage path or major-system flow path; and
- (h) false or negligent certification.

10.15.2 **Graduated response.** The Authority shall respond in the following order, moving to a later step where an earlier one fails or where the contravention is serious (Table 10.4):

Table 10.4 — Graduated enforcement response

Step	Action
1	Written notice stating the contravention, the clause breached, the remedy and a compliance period.
2	Stop-work order, or withholding of the completion certificate, for development not yet complete.
3	Penalty under the applicable Act or rules.
4	Works in default by the Authority, with the cost recovered from the owner.
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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 are made and from the municipal Acts. The graduated steps are set by this Manual. The powers exist, but much of the enforcement has come through notices, police complaints and the courts. KMC must construct drains and sewers and provide "a safe and sufficient outfall … for the effectual drainage and proper discharge of storm-water and sewage" of Kolkata without flooding the city or the country around the outfall (KMC Act 1980, section 277). All public drains vest in KMC (section 280), the Commissioner may require "an entirely distinct drain for rain water" (section 292), and no premises may be built or occupied without a drain of the size and level the Commissioner requires (section 293). Against the filling of ponds KMC issues restoration notices under section 53 of the West Bengal Town and Country (Planning and Development) Act 1979 and notices under section 400(1) of the KMC Act, followed by police complaints, as in a Behala pond case before the National Green Tribunal in 2024 (DM South 24 Parganas 2024), and it was reported to have filed 870 such complaints (press report). Section 17A of the West Bengal Inland Fisheries Act 1984 bars the filling of a water area, and a 2008 amendment is reported to have removed its minimum size of 5 cottahs (as reported); but in *Anuradha Sen v. KMC* (January 2024) the Calcutta High Court set aside KMC's action because the Corporation had not first established that the site was a "water area" (as reported). In the municipalities, rule 8 of the West Bengal Municipal (Building) Rules

2007 bars the filling of any pond, canal, wetland or drain without the State's prior approval (as reported). The East Kolkata Wetlands have been protected since the Calcutta High Court's judgment of 1992 in *PUBLiC v. State of West Bengal* and by the East Kolkata Wetlands (Conservation and Management) Act 2006, yet in May 2026 the State Wetland Authority told the National Green Tribunal that KMC had not cleared encroachments at Ukil Bheri (press report). This shows that a rule without routine enforcement does little. 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) tide and river levels at the outfalls, each on a named datum, the state of every lock, sluice, tide gate and pumping station on the outfall and its channel, and releases from the DVC dams or any other dam or barrage upstream;
- (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), WBSDMA, 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. West Bengal has few published technical reviews of floods. After the Kolkata storm of 23 September 2025, IMD published an analysis of the rainfall: 185.6 mm in three hours at Alipore and a peak hour of 98 mm, below its 100 mm criterion for a cloudburst (IMD 2025). The Calcutta High Court, hearing petitions on the deaths, most of them by electrocution, sought reports from KMC on its drainage, from the power utility CESC and from the State (press reports); those reports were not found. IMD's report on Cyclone Amphan records the track, winds, rainfall and storm tide of May 2020 (IMD 2020). After the DVC releases of September 2024 the State government called the flooding "man-made" and the Union Ministry pointed to the joint regulation committee (press reports), but no technical review was found. The CAG used CWC's data on the July 2017 floods, which affected 8.7 million people, took 217 lives and caused ₹17,727.94 crore of damage, in its audit of flood control (CAG 2019). I&WD publishes daily and annual flood reports, which could not be read for this Manual. The State Disaster Management Plan and any urban flood procedure of WBSDMA were not reviewed. 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 the information on which West Bengal's drainage depends could not be found in the public domain: KMC's Sewerage and Drainage Master Plan (2007) and its 2014 Action Plan to Mitigate Flood, Cyclone and Water Logging; the design rainfall, return period and runoff coefficients of the KEIIP and KMC-SHARP works; the CMPO intensity–frequency–duration curve; the present capacities and operating rules of the pumping stations, locks and sluices on the Kolkata outfall channels, and the status of the Kulti pump-house upgrade; MHWS and HAT on chart datum at Garden Reach, Haldia and Sagar, and the relation of the Kidderpore Old Datum to mean sea level; the DVC reservoir regulation rules; the components and progress of the Ghatal Master Plan; the drainage plans of Howrah, Siliguri, Asansol and Durgapur; and consolidated texts of the KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 with their amendments. West Bengal government websites could not be reached during the research for this Manual, so several statutes were read only in extracts, and KMC's ward rain-gauge records appear only as totals in the press. Publishing inputs and facility records lets the public, researchers and other agencies check that the city's growing stock of private storage actually exists. The open-format requirement is set by this Manual.

10.18 Review of this chapter

10.18.1 This chapter shall be reviewed with the Manual under Clause 1.12. The forms and the compliance calculator may be revised by the State Stormwater Technical Committee between reviews, under Clause 10.5.3.

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Annexes and forms

Annex / Form	Content
10A	Compliance calculator and user guide
10B	GIS data specification and attribute schema
10C	Maintenance access dimensions
10D	Model O&M plans by facility type
10E	Empanelment criteria for Stormwater Design Professionals and reviewers
Form 10-1	Drainage Report Checklist
Form 10-2	Compliance Calculator Summary
Form 10-3	Professional Design Certificate
Form 10-4	Hold-Point Inspection Record
Form 10-5	As-built Certificate
Form 10-6	Maintenance Declaration
Form 10-7	Annual Maintenance Declaration and Inspection Report
Form 10-8	Asset Handover Certificate
Form 2-1	Design Rainfall Sheet (Chapter 2)

CHAPTER 11

Basin and City Stormwater Master Plans

11.1 Purpose and scope

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

11.1.2 A BSMP shall:

- (a) map flood hazard for the basin under existing and future conditions;
- (b) set the level of service each part of the drainage system must achieve (Clause 11.6);
- (c) identify the works, storage and land needed to reach that level of service, and rank them (Clauses 11.7 and 11.8);
- (d) reserve land for regional storage, 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. Kolkata has drainage master plans, but they are not published. KMC's sewerage and drainage works under KEIIP follow its Sewerage and Drainage Master Plan of December 2007 and its 2014 Action Plan to Mitigate Flood, Cyclone and Water Logging (ADB 2016), neither of which was found. The older metropolitan Drainage Master Plan of CMPO was based on a storm of "once in two months (6 times in a year)" with 70% imperviousness, and a CPHEEO appraisal under JNNURM recorded that 75% of its primary drains but only 20% of its pumping stations had been built (CPHEEO appraisal note). The ADB-funded Kolkata Environmental Improvement Project (from 2000) and KEIIP (approved in 2013) built combined sewers, drains and pumping stations, mostly in the areas added to the city in 1984, when KMC served 45% of its population with sewerage and drainage (ADB 2016); ADB approved a further USD 200 million for the KMC Sustainability, Hygiene and Resilience (Sector) Project (KMC-SHARP) in February 2025, including combined trunk sewers and a larger flood early-warning system (ADB 2025). Outside Kolkata, I&WD's Ghatal Master Plan for the Shilabati, Kangsabati and Rupnarayan basin is reported to be funded by the State alone from 2025–26, at ₹1,500 crore over two years, although another report says the Centre approved it (press reports), and Siliguri Municipal Corporation sought experts for a drainage master plan for its 47 wards in 2022 (press report). No storm water master plan or stated design return period was found, in the sources reviewed for this Manual, for Howrah, Bidhannagar, New Town, Asansol, Durgapur or Haldia. A site-

level manual cannot fix basin-level problems: lost tank storage, outfalls locked by the tide or held up by the Hooghly, pumping stations too small for the storm, river reaches raised by DVC releases, 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 West Bengal's pumped and tide-locked outfalls in Kolkata and Howrah, where the city slopes away from the Hooghly and drains east through outfall channels and the East Kolkata Wetlands to the Kulti; its combined sewers, which carry storm water and sewage together; the pukurs that once stored the city's rain; the rivers whose levels are set by DVC releases on the lower Damodar and at Ghatal, and by the Teesta and the Mahananda in North Bengal; the embanked islands of the Sundarbans; and a SW monsoon flanked by damaging cyclone storms in May and in October and November.

11.2 Definitions

Term	Meaning in this Manual
Basin	The land draining to one outfall to the sea, a river, or a major waterbody, as delineated under Clause 11.3.
Basin Stormwater Master Plan (BSMP)	The plan for one basin prepared under this chapter.
Lead Authority	The body responsible for preparing a BSMP (Clause 11.4).
Level of service (LoS)	The flood performance a part of the drainage system must achieve, expressed as an AEP and an outcome (Clause 11.6).
Flood hazard map	A map of flood extent, depth, velocity and hazard class (H1–H6, Chapter 6) for a stated AEP and scenario.
Regional facility	A storage, conveyance or outfall work serving more than one development, identified in a BSMP.
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 For the main urban areas, and for the river reaches that flood every few years, the basins are at least the following:

- **Kolkata, eastern outfall basins (to the Kulti):** the basins that drain east through the pumping stations of KMC and I&WD (including Ballygunge, Palmer Bazar and Dhapa Lock) and the storm-water and dry-weather-flow channels from Bantala to the Kulti through the East Kolkata Wetlands, with the level of the Kultigang as the boundary condition and the catchment of each main pumping station as a sub-basin;
- **Kolkata, north-east, with Bidhannagar and New Town:** the **Kestopur** canal from the Chitpur lock, and the **Bagjola** canal to the Kulti pump house, each with its whole catchment across KMC, South Dum Dum, Bidhannagar and New Town;
- **Kolkata, south: Tolly's Nullah (Adi Ganga)**, from the Hooghly to the Bidyadhari, with the tidal Hooghly as its boundary condition, and the added-area catchments of KEIIP (Churial, Begore, Monikhali and the South Suburban catchment) that drain to the Churial and other canals;
- **Howrah:** the basins of Howrah Municipal Corporation, whose land lies lower than the Hooghly, with the tidal Hooghly as the boundary condition;
- **Lower Damodar and Ghatal:** the **Damodar–Mundeswari** reach below the DVC dams and the **Shilabati, Kangsabati and Rupnarayan** basin at **Ghatal**, with releases from Maithon and Panchet as a boundary condition;
- **Siliguri:** the **Mahananda** through the city, with the Teesta–Mahananda link canal and the Teesta below the Gajoldoba barrage, including the bed raised by the sediment of the October 2023 flood, as boundary conditions to be checked; and
- **Sundarbans:** each embanked island with a Tier A or Tier B body on it, as a polder basin draining through the sluices in its embankment to the tidal creeks.

Other Tier A bodies, including Asansol, Durgapur and the Municipalities of the Kolkata Metropolitan Area, shall define their basins in the first BSMP that covers them. Where I&WD or DVC has a design flood, a high flood level, an embankment crest level or an operating rule for a river, canal, lock, sluice or dam that a town lies on, the BSMP shall take its river boundary conditions from it, and shall show those levels against its own 1% AEP map.

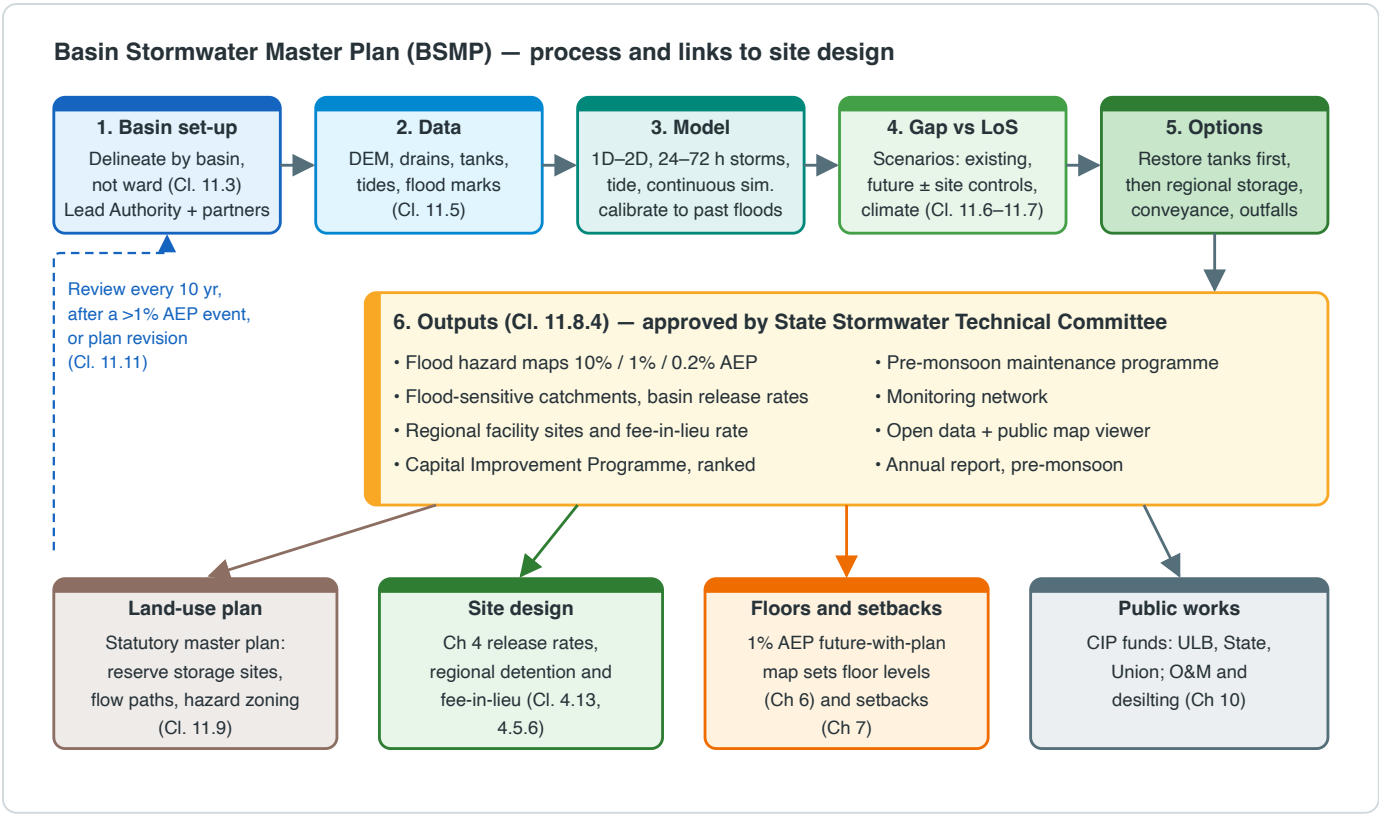


Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

> **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. Responsibility in West Bengal is divided by body as well as by boundary. KMC owns every public drain in Kolkata and must provide its outfall (KMC Act 1980, sections 277 and 280), but the rivers, the embankments and the main outfall canals beyond the city, such as the Bagjola and Kestopur canals and the channels to the Kulti, are I&WD's (I&WD; press reports). The exact boundary between KMC's drains and I&WD's khals was not found. Section 277(2) lets the State require KMC to pay for outfall works when the river channels decay, as the Bidyadhari did. KMDA plans the metropolitan area, NKDA develops and regulates New Town, and Howrah, Bidhannagar and the other Corporations and Municipalities own their own drains. The canals show why the basin has to be the unit. The Bagjola canal is the main outlet for South Dum Dum, New Town and Bidhannagar and ends at a pump house at Kulti that is reported to be too small (press reports); the Kestopur canal runs from the Chitpur lock on the Hooghly towards the Bidyadhari (I&WD). Downstream, the storm-water and dry-weather-flow channels to the Kulti pass through the East Kolkata Wetlands, which EKWMA manages under the East Kolkata Wetlands Act 2006. On the lower Damodar, the river level at the outfalls of Howrah and Hooghly districts is set by releases from DVC's Maithon and Panchet dams, not by local rain. This clause makes the basin the planning unit. It also requires the Bagjola canal to be treated as a link, because it already carries the storm water of several local bodies to one outfall.

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For a basin wholly within Kolkata: KMC.
- For a basin of the Kolkata Metropolitan Area that crosses local-body boundaries (for example the Bagjola and Kestopur basins, which drain parts of KMC, South Dum Dum, Bidhannagar and New Town): KMDA, with KMC, the Municipal Corporations, the Municipalities and NKDA in the basin as partners.
- For a basin wholly within Howrah: Howrah Municipal Corporation; for one wholly within New Town: NKDA; for one wholly within Bidhannagar: Bidhannagar Municipal Corporation.
- For Siliguri: Siliguri Municipal Corporation, with SJDA as partner. For Asansol and Durgapur: the Municipal Corporation concerned, with ADDA as partner.
- For basins that drain to a river, canal, khal or embankment under I&WD's control (for example the outfall channels to the Kulti, the Bagjola and Kestopur canals, Tolly's Nullah, the lower Damodar and Mundeswari, the Ghatal basin and the Mahananda at Siliguri): the urban body above as Lead Authority for the urban basin, with I&WD for the river, canal or embankment and as partner. Where the river level is set by releases from DVC dams or the Teesta barrage, the BSMP shall take its release scenarios from DVC or I&WD and record them.
- For the embanked islands of the Sundarbans and other polders: I&WD, with the local bodies on the island as partners.
- For other basins that cross local-body boundaries: the Municipal Corporation or Municipality with the largest share of the basin, with the development authority for the area and the other local bodies as partners.
- In Tier B bodies: the Lead Authority is named by UD&MA. Basins draining to a common river reach or canal may be grouped into one district-level plan.

WBCZMA shall be consulted on every BSMP that proposes works in the Coastal Regulation Zone, and EKWMA on every BSMP whose basin drains through the East Kolkata Wetlands. Every BSMP that proposes a discharge to an I&WD canal or khal shall record I&WD's consent to it.

I&WD 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 and coast	Tidal datums and surge values (Annex 5A), with the datum of every level named (chart datum, GTS/MSL or the Kidderpore Old Datum); outfall invert levels against high tide and against river flood levels; locks, sluices, tide gates and pumping stations on the outfall channels, with their capacities and operating rules; embankment crest levels and breach history; the high flood levels of I&WD; releases from the DVC dams and the Teesta barrage upstream
Rainfall and levels	All available rain gauges (IMD, including the Kolkata (Alipore), Dum Dum, Diamond Harbour, Canning, Haldia, Digha, Bankura, Malda, Jalpaiguri and Bagdogra stations; the rain and river gauges of I&WD under the National Hydrology Project; and KMC's ward and borough rain gauges) and water-level records, including those for the September 1978 (south Bengal), May 2020 (Cyclone Amphan), October 2023 (the Teesta), September 2024 (DVC releases on the lower Damodar and at Ghatal) and September 2025 (Kolkata) events
Flood evidence	Surveyed flood marks and mapped flood extents from past events, including public reports
Land use	Existing land use and imperviousness; future land use from the statutory master plan
Soils and groundwater	HSG map (Annex 3A); seasonal high groundwater; aquifer and recharge zones
Sewer interaction	Known sewage cross-connections, dry-weather flow in drains, and solid-waste hotspots

> **Commentary.** The 0.15 m accuracy has no direct precedent; this Manual sets it because on the flat delta of Kolkata and Howrah, on the embanked islands of the Sundarbans and on the floodplains of the lower Damodar and the Ghatal basin 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 September 1978 (south Bengal), May 2020 (Cyclone Amphan), October 2023 (the Teesta), September 2024 (DVC releases on the lower Damodar and at Ghatal) and September 2025 (Kolkata) events are the best calibration data West Bengal 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 nobody has measured. Section 17A of the West Bengal Inland Fisheries Act 1984 has barred the filling of water areas since 1994, rule 8 of the West Bengal Municipal (Building) Rules 2007 bars it in the municipalities without the State's approval, and the East Kolkata Wetlands Act 2006 requires a water body of no less area to be made within the wetlands for any that is filled (all as reported). Yet KMC's own pond lists, 1,634 water bodies in 1996 and 3,874 in 2006 (as reported), do not agree with each other or with the NATMO count, and no survey of their storage was found. KMC has begun GIS mapping of its ponds, and Bidhannagar identified more than 150 water bodies for restoration in 2024 (press reports).

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.

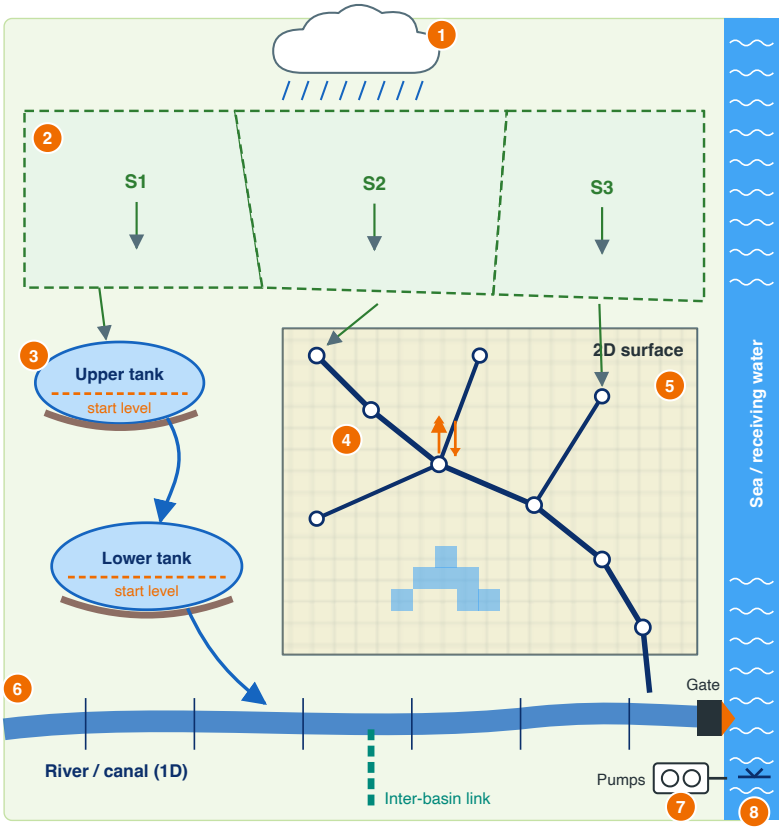
11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms 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, the sea-level allowance of Chapter 5 and, in Kolkata and the delta, land subsidence over the design life (Kolkata is subsiding at 2.8–5.5 mm a year, comparable to the rise in sea level at Diamond Harbour).

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the September 1978 (south Bengal), May 2020 (Cyclone Amphan), October 2023 (the Teesta), September 2024 (DVC releases on the lower Damodar and at Ghatal) and September 2025 (Kolkata) events where data exist.

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



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

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

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

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

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

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

7 **Outfall**
Flap or tide gates and pumps; joint and outfall-closed cases of Ch. 5

8 **Downstream boundary**
Tide (MHWS; HAT + surge + sea-level allowance) or river level, per Ch. 5

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

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and 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:** locks, sluices and tide gates on the outfall channels, pumping stations and the storage behind them, and the sluices through the Sundarbans and river embankments;
5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example the flood early-warning system built for KMC under KEIIP, I&WD's daily flood reports and river gauges, IMD district rainfall and cyclone warnings read with the predicted spring tides, and advance notice of releases from DVC's Maithon and Panchet dams), 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, arsenic-affected aquifers and saline intrusion (Chapter 8);
- effect on downstream basins and the Bagjola canal; and
- who benefits.

11.8.3 **Basin release rates.** Where scenario (c) does not meet the level of service, the BSMP may set a basin-specific **permissible site discharge** (m³/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 Kolkata's storage is being lost while its drains are being enlarged. A NATMO estimate put the city's ponds at about 8,731 and a later count from satellite imagery about 4,889, a loss of about 44% (as reported), and Salt Lake and New Town were built on reclaimed wetland (as reported). The pukurs and the East Kolkata Wetlands still hold much of the city's rain. The storm of 23 September 2025, 185.6 mm in three hours at Alipore (IMD 2025) and about 332 mm in a few hours at a KMC gauge in Garia (press reports), was many times the 6.35 mm/h for which the city's first sewers were built (Gupta 2005), so storage and flow paths have to take what conveyance cannot. Conveyance upgrades on their own move water faster to an outfall that may be tide-locked, or limited by the capacity of its pumping station. Groundwater sets narrow limits on recharge in most of West Bengal. In the delta the soils are clays and clay loams over a high water table, and arsenic above the permissible limit has been reported in 79 blocks of 8 districts (CGWB, as reported; an older count), so recharge wells that carry surface water into the aquifers are not suitable there (Chapter 8). Kolkata is subsiding at 2.8–5.5 mm a year, over a growing area (Thakur et al. 2026), and an earlier study linked faster subsidence near Salt Lake to pumping from the confined aquifer (as reported). In the Sundarbans and on the Medinipur coast the soils and groundwater are saline. The lateritic plateau of Purulia, Bankura and Asansol–Durgapur is where recharge structures are most likely to work, subject to soil tests. The CGWB year book for West Bengal could not be obtained for this Manual. This is why groundwater, arsenic and saline intrusion are 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 land-use and development plans made under the West Bengal Town and Country (Planning and Development) Act 1979 by KMDA, SJDA, ADDA and the other development authorities, the plans of NKDA for New Town, and, for the East Kolkata Wetlands, the management plan under the East Kolkata Wetlands (Conservation and Management) Act 2006. 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. West Bengal has no flood-line system and no floodplain zoning law. CAG asked I&WD to enact the Model Flood Plain Zoning Bill (CAG 2019), and no such law was found. The KMC Building Rules 2009 require a plinth of at least 60 cm, placed in relation to the crest of the road so that the site drains, and let an owner raise the whole site by up to 600 mm, with the Commissioner's permission, where the area is prone to waterlogging (Rules 105 and 76), but they fix no flood level. In the municipalities, rule 8 of the West Bengal Municipal (Building) Rules 2007 limits buildings within 15 m of a river bank to a height of 5 m, a length of 20 m and 200 m² of covered area, with gaps of 15 to 30 m between them (as reported). No metre setback from a khal or pond was found in the KMC rules, which instead reward owners who keep a pond (Rules 65A, 74(4) and 81(9)). The East Kolkata Wetlands Act 2006 bars any change in the character of the wetlands without sanction. On the coast, the State's Coastal Zone Management Plan under the CRZ Notification 2019 had not been approved by December 2025, and the State has

disputed keeping the 2011 high tide line, which WBCZMA says "no longer exists" on its eroding coast (NGT affidavits). A BSMP gives the land-use plans the 1% AEP drainage-flood map that they need. Using open space land as storage or flow path has no direct precedent; this Manual adopts it because the KMC Building Rules 2009 already allow sewers, underground reservoirs and septic tanks within the mandatory open space of a plot, exclude a garden covered with permeable material from floor area and height, and relax the setback, height and road-width rules where a water body and any heritage building together cover at least a quarter of the plot (Rules 65A, 74(4) and 81(9)); because that land then serves as open space, storage placed in it must stay usable as one. Placing it on the flow path costs the developer nothing extra and gives the basin storage it would otherwise have to buy.

11.10 Consultation and publication

11.10.1 A draft BSMP shall be published for public comment for at least **60 days**, with public meetings in each affected local body.

11.10.2 After approval, the following shall be published as open data:

- the model files;
- the flood hazard maps;
- the data of Clause 11.5.1, except security-sensitive asset details; and
- the CIP.

They shall also be shown on a public map viewer.

Commentary. Publishing the maps lets buyers, lenders, insurers and residents see flood hazard before they build or buy. Publishing the model lets designers use the same boundary conditions as the Authority, so site designs and the basin plan stay consistent. This matches the publication approach of Chapter 10.

11.11 Approval, review and reporting

11.11.1 **Approval.** BSMPs shall be approved by the State Stormwater Technical Committee (Chapter 1), after review of the model and of the public comments.

11.11.2 **Review.** Each BSMP shall be reviewed:

- every **10 years**;
- within **2 years** of an event exceeding the 1% AEP design depth in the basin (Clause 2.14); and
- when the statutory land-use plan is revised.

11.11.3 **Annual report.** The Lead Authority shall publish an annual implementation report before each SW monsoon (by 15 May). The report shall show:

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

11.12 Interim arrangements

11.12.1 Until a BSMP is approved for a basin:

- (a) all site criteria of Chapters 4 to 8 apply in full;
- (b) regional detention and fee-in-lieu under Clause 4.13 are not available, except the holding of fees under Clause 4.5.6.3;
- (c) floor levels and setbacks use the best available mapping, and the methods of Chapters 6 and 7 where no mapping exists; and
- (d) public drain projects shall include a basin-level check that their outfall and downstream reaches can take the design flow under the Chapter 5 tailwater cases.

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Annexes and forms

Annex / Form	Content
11A	BSMP terms of reference template
11B	Basin lists and boundaries for Tier A bodies
11C	Depth–damage curves for West Bengal 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 Kolkata Metropolitan Area and of the Siliguri Jalpaiguri and Asansol Durgapur planning areas

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

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

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

Item	Tier A authority	Clause
(a)	Kolkata Municipal Corporation (KMC)	1.6.1(a)
(b)	Every Approving Authority within the Kolkata Metropolitan Area, including the Howrah and Bidhannagar Municipal Corporations, NKDA in New Town, KMDA where it is the Approving Authority, and the Municipalities of the area	1.6.1(b)
(b)	Siliguri Municipal Corporation, and every Approving Authority within the planning area of SJDA	1.6.1(b)
(b)	Asansol and Durgapur Municipal Corporations, and every Approving Authority within the planning area of ADDA	1.6.1(b)
(c)	Every other Municipal Corporation constituted under any Act of the State	1.6.1(c)
—	A Tier B authority that opts into Tier A by council resolution, or that the Government notifies as Tier A	1.6.4

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

To be prepared. This annex will contain the full list, by name, of every Approving Authority within the Kolkata Metropolitan Area and the planning areas of SJDA and ADDA, and of every Municipal Corporation, with the date from which each is Tier A, and the boundaries of those areas as a map and as a GIS layer. It needs the notified boundaries of the Kolkata Metropolitan Area and of the SJDA and ADDA planning areas (UD&MA, KMDA, SJDA, ADDA), the current list of Municipal Corporations, Municipalities and Notified Area Authorities (UD&MA), and local body boundaries (the Land and Land Reforms 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 / Municipality / Notified Area Authority / 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 KMA, SJDA and ADDA 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)	Low-lying Kolkata and its outfall-channel catchments	The catchment of every drainage pumping station and outfall of KMC, all of which pump to canals and outfall channels that are held up by the tide, including the South Suburban, Churial and Monikhali basins and the low-lying wards of Behala, Tollygunge and Garden Reach; and, outside KMC, the catchments of Bidhannagar, New Town and South Dum Dum that drain to the Bagjola and Kestopur canals and the Kulti outfall
(b)	Low-lying Howrah	The parts of the Howrah Municipal Corporation area, and of the municipalities beside it on the right bank of the Hooghly, that lie below the level of the river at high tide
(c)	Lower Damodar and Ghatal	The catchments that drain to the Damodar, the Mundeswari, the Rupnarayan or the Shilabati below the DVC dams, in Howrah, Hooghly, Purba Bardhaman and Paschim Medinipur districts, including Amta, Udaynarayanpur, Arambagh, Khanakul and the Ghatal basin
(d)	Embanked islands of the Sundarbans	Every town and settlement on an island or tract protected by the embankments of I&WD in South and North 24 Parganas, including Canning, Gosaba, Kakdwip, Namkhana and Sagar, whose drainage leaves through sluices in the embankments
(e)	Siliguri and the Teesta towns	The catchments within the Siliguri Municipal Corporation area that drain to the Mahananda, and the towns on the Teesta below the Gajoldoba barrage, including Jalpaiguri and Mekhliganj
(f)	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 drainage network (I&WD, Survey of India); the drainage basins, pumping stations and their catchments, and the canals and outfall channels with their gates and levels on a stated datum (KMC, I&WD, KMDA); KMC's ward-level lists of waterlogging locations; the low-lying areas and pumped outfalls of Howrah (Howrah Municipal Corporation); the land flooded on the lower Damodar and at Ghatal in September 2024 and earlier, and the Ghatal Master Plan (I&WD, the District Disaster Management Authorities); the embankments and sluices of the Sundarbans (I&WD); the land flooded on the Mahananda and the Teesta, the Siliguri drainage master plan and the Teesta channel since October 2023 (Siliguri Municipal Corporation, SJDA, I&WD); and the land-use and development plan maps (KMDA, SJDA, ADDA, UD&MA). Haldia, Digha and the towns of the Medinipur coast, Malda on the Mahananda, Cooch Behar on the Torsa, Bardhaman and the Asansol–Durgapur area are candidates for notification under Clause 4.5.4 once their flood records are documented. 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 (e), or the notification under Clause 4.5.4	text
notification_ref	Gazette notification number, where notified	text
notified_on	Date of notification	date
applies_from	Date from which the rule applies to applications (Clause 4.5.4.2, step 5)	date
boundary_source	Source and date of the boundary	text
area_km2	Catchment area	km²

Annex 1C — Policy Supplement: text of alternatives S-1 to S-5 and model council resolution

Supports Clauses 1.6.3, 1.6.5 and 1.7.1 to 1.7.3 of Chapter 1.

Model text for consideration by a competent authority. Not in force. The text below shows how the Policy Supplement of Clause 1.7 could be written. It has no effect unless and until it is issued by the Government and adopted by an Approving Authority under Clause 1.7.3.

Part 1 — General provisions

P1.1 **Scope.** This Supplement sets out alternatives S-1 to S-5 to the requirements of the West Bengal Stormwater Design Manual (the Manual) named in each alternative. An alternative applies within the area of an Approving Authority (the Authority) only from the date on which the Authority adopts it under P1.3.

P1.2 **No lower criterion.** No alternative lowers any criterion of the Manual. S-1 and S-2 are simplified methods for meeting the same criterion (Clause 1.7.3(a)).

P1.3 **Adoption.**

- (a) A Tier B authority adopts an alternative by council resolution in the form of Part 3, and sends a copy to the State Stormwater Technical Committee (the Committee) within 30 days of the resolution.
- (b) A Tier A authority adopts an alternative only after the Committee has concurred in writing.
- (c) The Authority publishes the alternatives it has adopted on its website and in the register of Clause 10.17.

P1.4 **Retention.** No alternative replaces the retention requirement (Annex 2E depth), except where fee-in-lieu under S-5 funds equivalent retention in the same basin (Clause 1.7.3(d)).

P1.5 **Tables.** The tables used by S-1, S-2 and S-3 are those issued by the Committee, and are reviewed with Chapter 2 of the Manual (Clauses 1.7.3(e) and 2.14). An alternative that depends on a table cannot be used until that table is issued.

P1.6 **Record.** An Applicant who uses an alternative states it on Form 1-1 and in the drainage report, with the resolution or concurrence under which it was adopted.

Part 2 — The alternatives

S-1 — Design-aid route for storage

S-1.1 *Replaces:* storage sized by a hydrograph method under Chapter 3.

S-1.2 *Alternative:* retention and detention volumes may be taken from the unit-storage tables issued for Annex 4B (m³ per ha, by rainfall zone, hydrologic soil group and impervious fraction) and the compliance calculator, by the method of Clause 4.14.2.

S-1.3 *Eligibility:* sites of 2 ha or less outside flood-sensitive catchments, and of 0.5 ha or less within them (Table 1.2; Clause 4.14.1).

S-1.4 *Conditions:* the post-development imperviousness used shall be that shown on the approved plans; the outlet, spillway, RWH accounting and safety provisions of Clause 4.14.2 apply; the compliance calculator may be the sole calculation (Table 1.1).

S-2 — Permissible site discharge (PSD)

S-2.1 *Replaces:* the release rate $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$ computed for the site (Clause 2.11.2).

S-2.2 *Alternative:* the release rate for each AEP may be taken as the tabulated unit-area release rate for the site's zone and AEP, multiplied by the site area. The tabulated rates are derived from the $0.9 \times Q_{pre}$ rule (Table 1.2).

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

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

S-3 — Fixed-width waterbody setback

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

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

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

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

S-4 — Downstream screening checklist

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

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

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

S-4.4 *Conditions:* the checklist is signed by the registered professional who signs the drainage report (Clause 10.6); flood-prone locations are those recorded by the local body, WBSDMA, the Department of Disaster Management and Civil Defence, a District Disaster Management Authority or I&WD (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 / Municipality), dated _____

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

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

- (i) the West Bengal 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 / Executive Officer: _____ Date: _____

Annex 1D — Model KMCBR/WBMBR 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 at which the new rule and the conditions would be inserted, and the enabling sections of the West Bengal Town and Country (Planning and Development) Act, 1979 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007

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

- (1) These rules may be called the Kolkata Municipal Corporation Building (Stormwater Management) Amendment Rules and the West Bengal Municipal (Building) (Stormwater Management) Amendment Rules, _____.

- (2) They shall come into force on the date six months after their publication in the Kolkata Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building rules for Kolkata and for the municipal areas of the State, the following rule shall be inserted:

> **Rule [_____]. Stormwater management.**
>
> (1) *Definitions.* In this rule, "the Manual" means the West Bengal 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 West Bengal 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 — West Bengal 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 — 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 (KMC Building Rules 2009, rule 144(1): new or expanded building or housing complex "as per" the EIA guideline; New Town Kolkata (Building) Rules 2009, rule 28(4) as amended in 2021: every new building or housing complex, and every expansion; West Bengal Municipal (Building) Rules 2007: as those rules set [TBC]) — 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 — West Bengal 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 rain gauges and hydromet stations of I&WD, the rainfall reports of the District Disaster Management Authorities and KMC's ward gauges), and district and basin boundaries (Survey of India, I&WD). 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
WB-Z1 Darjeeling–Kalimpong hills	The hill areas of Darjeeling district and Kalimpong district: Darjeeling, Kalimpong, Kurseong, Mirik. CWC subzone 2(a). Boundary [TBC]	[TBC] (candidates: Darjeeling 42295, Kalimpong 42296)	Annual about 3,000–3,300 mm (Darjeeling 3,092 mm, CWC 2(a) Plate 4; Darjeeling district 3,334 mm, IMD 2020). IMD 24-h records Darjeeling 492.8 mm (25 Sep 1899), Kalimpong 419.2 mm (5 Oct 1968); Mongpoo 546.1 mm and Kurseong 501.7 mm (June 1950; FER 2(a) Table 7). FER 50-yr 24-h about 320–360 mm at Darjeeling (2(a) Plate 9); 1-h ratio 0.260. Steep slopes, short times of concentration, landslides and debris; hill brown forest soils, shallow over rock
WB-Z2 Terai and Duars	The plains of Darjeeling district (Siliguri), and Jalpaiguri, Alipurduar and Cooch Behar districts: Siliguri, Jalpaiguri, Alipurduar, Cooch Behar, Mal, Dhupguri, Mekhliganj. CWC subzone 2(a); Siliguri on the 1(f)/2(a) boundary (Clause 2.3.6(a)). Boundary [TBC]	[TBC] (candidates: Bagdogra (A) 42398, Jalpaiguri 42399, Cooch Behar (A) 42403)	Annual about 3,000–4,000 mm (Jalpaiguri district 3,721; Cooch Behar 3,050; IMD 2020), the wettest plains in the State. IMD 24-h records Jalpaiguri 474.0 mm (10 Jul 1999), Cooch Behar 417.3 mm (27 Sep 1970), Bagdogra 395.5 mm (21 Jul 1988); May records Cooch Behar 353.2 mm (28 May 1989) and Jalpaiguri 312.8 mm (24 May 1999); Buxa 538.5 mm (8 Jun 1921; FER 2(a)). FER 50-yr 24-h about 320 mm at Siliguri, 360–400 mm at Jalpaiguri and Cooch Behar, more than 480 mm in the Buxa–Jayanti duars (2(a) Plate 9). Teesta, Jaldhaka, Torsa and Mahananda backwater; boulder-laden flash floods; Teesta bed raised by silt since October 2023 (as reported); terai sandy loams
WB-Z3 North Bengal Gangetic plains	Malda, Uttar Dinajpur and Dakshin Dinajpur districts and the north of Murshidabad district: English Bazar, Old Malda, Raiganj, Balurghat, Farakka. CWC subzone 1(f); the north edge of 1(g) in Murshidabad and where its plates cover Malda (Clause 2.3.6(a)). Boundary [TBC]	[TBC] (candidates: Malda 42503, Balurghat 42506)	Annual about 1,300–1,550 mm (Malda 1,521; IMD 2020). IMD 24-h records Malda 281.6 mm (7 Oct 2004) and Balurghat 275.2 mm (4 Oct 1984), both October storms. FER 1(g) 50-yr 24-h about 280–360 mm at Malda and Farakka, with a cell of more than 360 mm on the Ganga (1(g) Plate 9); 1(f) values read by OCR only [TBC]; 1-h ratio 0.31 (1(f)) or 0.350 (1(g)). Ganga and Mahananda backwater; Barind clay-loam uplands and Tal lowlands; Diara loams
WB-Z4 Western plateau	Purulia district, the west of Bankura district, Paschim Bardhaman district (Asansol–Durgapur), Jhargram and the west of Paschim Medinipur district, and the west of Birbhum district: Asansol, Durgapur, Purulia, Bankura, Bishnupur, Jhargram, Suri. CWC subzone 1(g), hilly region. Boundary [TBC]	[TBC] (candidates: Bankura 42707, Purulia 42705, Suri 42710; Durgapur 32734 has fewer than 30 years)	Annual about 1,330–1,500 mm (Purulia 1,382; Bankura 1,490; IMD 2020); onset in the third week of June in Purulia (ICAR-CRIDA). IMD 24-h records Suri 400.0 mm and Durgapur 387.7 mm (27 Sep 1978), Bankura 292.4 mm (22 Jun 1922), Purulia 190.6 mm (19 Oct 1999); recording gauge at Durgapur 388 mm in 24 h, 308 mm in 12 h and 86 mm in 1 h (FER 1(g)). FER 50-yr 24-h about 200–240 mm at Asansol and Durgapur, 240–280 mm at Purulia and 280–320 mm at Bankura, with a cell of more than 320 mm west of Bishnupur (1(g) Plate 9); 1-h ratio 0.350. Lateritic and red gravelly soils, shallow and crusting; Damodar under DVC releases; mining subsidence in the coalfield not researched [TBC]

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
WB-Z5 Central and Gangetic delta	Kolkata, Howrah, Hooghly, North 24 Parganas (except the coastal and Sundarbans blocks), Nadia, Purba Bardhaman, the east of Birbhum and Bankura districts and the south of Murshidabad district, including the Kolkata Metropolitan Area: Kolkata, Howrah, Bidhannagar, New Town, Barrackpore, Chandannagar, Bardhaman, Krishnanagar, Berhampore. CWC subzone 1(g), plain region. Boundary [TBC]	[TBC] (candidates: Kolkata (Alipore) 42807, Kolkata (Dum Dum) (A) 42809, Uluberia 42805, Burdwan 42709, Berhampore 42603)	Annual about 1,260–1,850 mm (Nadia 1,259; Kolkata 1,852; IMD 2020). IMD 24-h records Alipore 369.6 mm (28 Sep 1978), Dum Dum 383.2 mm (6 Jun 1984), Uluberia 409.3 mm (29 Sep 1978); recording gauge at Dum Dum 100 mm in 1 h (24 Aug 1987) and 207 mm in 3 h (25–26 Aug 1984), at Alipore 236 mm in 6 h (27 Sep 1978) (FER 1(g)); Alipore 98 mm in 1 h and 185.6 mm in 3 h on 23 Sep 2025 (IMD). FER 50-yr 24-h about 280–320 mm at Kolkata and Howrah, less than 240 mm in Nadia (1(g) Plate 9); 1-h ratio 0.350. Tide-locked, pumped drainage to the Hooghly and east to the Kulti; combined sewers in Kolkata; Damodar backwater in Howrah and Hooghly; subsidence; deltaic clays with a high water table; arsenic in shallow aquifers
WB-Z6 Coastal belt and Sundarbans	South 24 Parganas district (including Sagar, Kakdwip, Namkhana, Canning, Gosaba and Diamond Harbour), Purba Medinipur district (Haldia, Contai, Digha) and the coastal and Sundarbans blocks of North 24 Parganas. CWC subzone 1(g), plain region. Boundary [TBC]	[TBC] (candidates: Haldia 02206, Diamond Harbour 42811, Canning 42812, Contai 42900, Digha 42901)	Annual about 1,750–1,960 mm (South 24 Parganas 1,959; Purba Medinipur 1,813; IMD 2020). IMD 24-h records Contai 447.1 mm (3 Sep 1967), Digha 325.3 mm (9 Jun 1988), Haldia 294.6 mm (5 Jun 1984), Diamond Harbour 290.7 mm (27 May 1993); Contai 295.1 mm in May (28 May 1960). FER 50-yr 24-h about 320–360 mm at Haldia and Diamond Harbour and about 360 mm at Contai and Digha, more than 360 mm over the Sundarbans (1(g) Plate 9); 1-h ratio 0.350. Cyclone surge with spring tide (Aila, Amphan, Yaas, Remal); about 3,122 km of embankments; 100-yr extreme sea level 3.79 m above mean sea level at Diamond Harbour (INCOIS, 2025); saline soils and water; coastal dune sands at Digha and Contai

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, not lower than the CWC Flood Estimation Report ratios for the subzone in Table 2B.1 (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
WB-Z1 Darjeeling–Kalimpong hills	CWC FER 2(a), 50-yr (interim design ratios, Clause 2.3.6(d))	0.260		0.457	0.615	0.805	1.00
WB-Z1 Darjeeling–Kalimpong hills	NIH-DHAARA						1.00
WB-Z2 Terai and Duars	CWC FER 2(a), 50-yr (interim design ratios, Clause 2.3.6(d))	0.260		0.457	0.615	0.805	1.00
WB-Z2 Terai and Duars, Mahananda side of Siliguri	CWC FER 1(f), 50-yr (OCR, not checked against the page image; interim design ratios, Clause 2.3.6(d))	0.31		0.50	0.65	0.82	1.00
WB-Z2 Terai and Duars	NIH-DHAARA						1.00
WB-Z3 North Bengal Gangetic plains	CWC FER 1(f), 50-yr (OCR, not checked against the page image; interim design ratios, Clause 2.3.6(d))	0.31		0.50	0.65	0.82	1.00
WB-Z3 North Bengal Gangetic plains, 1(g) area	CWC FER 1(g), 10-yr (interim design ratios, Clause 2.3.6(d))	0.350		0.515	0.640	0.800	1.00
WB-Z3 North Bengal Gangetic plains	NIH-DHAARA						1.00
WB-Z4 Western plateau	CWC FER 1(g), 10-yr (interim design ratios, Clause 2.3.6(d))	0.350		0.515	0.640	0.800	1.00
WB-Z4 Western plateau	NIH-DHAARA						1.00
WB-Z5 Central and Gangetic delta	CWC FER 1(g), 10-yr (interim design ratios, Clause 2.3.6(d))	0.350		0.515	0.640	0.800	1.00
WB-Z5 Central and Gangetic delta	NIH-DHAARA						1.00
WB-Z6 Coastal belt and Sundarbans	CWC FER 1(g), 10-yr (interim design ratios, Clause 2.3.6(d))	0.350		0.515	0.640	0.800	1.00
WB-Z6 Coastal belt and Sundarbans	NIH-DHAARA						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, I&WD), the benchmark points of Annex 2A, and a stated method for deriving the factors. Until it is published, design depths are taken as point values from NIH-DHAARA or an approved station IDF (Clauses 2.3.1 and 2.3.2). Grid-average values are not used as design depths unless a conversion agreed with the Authority is recorded on Form 2-1 (Clause 1.11.5).

2C.1 The commentary to Clause 2.7 shows why the factors matter, and in West Bengal the error runs both ways. Near Kolkata the IMDAA cell of NIH-DHAARA (about 12 km) at Dum Dum gives a 50-year 24-hour depth of about 244 mm, below the 280–320 mm of the CWC isopluvials, and on 23 September 2025 a KMC gauge at Garia was reported to have taken 332 mm while the IMD gauge at Alipore took 251.4 mm; reanalysis cells smooth convective peaks of this kind. In the north and on the coast the cells give far more than the plates or any gauge: about 677 mm for the 50-year 24-hour depth at Siliguri against about 320 mm, and 790 mm at Cooch Behar, where the station record is 417.3 mm (NIH-DHAARA, queried 6 Nov 2026; IMD; CWC). Values of this kind are grid-average values and need these factors before any use as point depths; under Clause 2.3.6 they are not used as design depths in West Bengal until this annex and Annex 2A are published.

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 — West Bengal 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 West Bengal 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, I&WD and KMC), separated into independent storms by a stated rule, and the south Bengal storm of 26–29 September 1978, the Dum Dum bursts of 25–26 August 1984 and 24 August 1987, the rain of cyclone Amphan on 20–21 May 2020 and the Kolkata storm of 22–23 September 2025 among them. Until it is published, design storms use the alternating-block pattern of Clause 2.9.1 and the 48- and 72-hour pattern of Clause 2.9.2; for catchments of 25–5,000 km², the CWC Flood Estimation Report curves may be used with a sensitivity run under Clause 2.9.1 (Clause 2.9.4). SCS Type distributions are not used (Clause 2.9.3). For the disaggregation of daily records in continuous simulation (Clause 11.7.3), the method is agreed with the Authority and recorded (Clause 1.11.5).

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

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

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
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, I&WD) 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
WB-Z1 Darjeeling–Kalimpong hills					
WB-Z2 Terai and Duars					
WB-Z3 North Bengal Gangetic plains					
WB-Z4 Western plateau					
WB-Z5 Central and Gangetic delta					
WB-Z6 Coastal belt and Sundarbans					

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

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

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

No.	Item (clause)	Entry
E2	CWC subzone 1(f) / 1(g) / 2(a) 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 June–September in WB-Z1 and WB-Z2, of July–September elsewhere, and of May and October–November in WB-Z6, whatever its duration; 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 — West Bengal 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 West Bengal to its hydrologic soil group (HSG), in both the drained and the undrained state, and (b) a map of the depth to the seasonal high groundwater table in the south-west monsoon (June–September). It needs NBSS&LUP and State agricultural universities of West Bengal 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 SWID, supplemented by piezometers in the deltaic clays of Kolkata, Howrah and the 24 Parganas, the Sundarbans and the saline coastal belt, the coastal dune sands of Digha and Contai, the margins of the Hooghly and the other tidal rivers and khals, the Terai and Duars, and the Tal lowlands of Malda. Until it is published, use the interim rules of Chapter 3: assign HSG from measured saturated hydraulic conductivity and depth to an impermeable layer or water table by the criteria of NEH Part 630, Ch. 7 (Clause 3.7.2); verify it by site infiltration tests wherever retention relies on infiltration (Clause 3.7.3); take the seasonal high water table from site piezometers, trial pits or the nearest observation well (Clause 3.10.2); and assign HSG D wherever that level is within 0.6 m of the ground surface (Clause 3.10.1).

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

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

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

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

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

Annex 3B — West Bengal CN calibration and supplementary land covers (paddy, bheris, tea gardens, mangroves)

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 West Bengal 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: bunded paddy fields of the delta and the plains (ponded and fallow), the bheris (embanked fishery ponds) of the East Kolkata Wetlands and the coastal belt, the tea gardens of the Darjeeling hills and the Terai and Duars, and the mangrove forest of the Sundarbans. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from I&WD 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)
Paddy, bunded, ponded (delta and plains)						
Paddy, bunded, fallow between seasons						
Bheri, embanked fishery pond (East Kolkata Wetlands; coastal belt), embankments and margins						
Tea garden (Darjeeling–Kalimpong hills; Terai and Duars)						
Mangrove forest and tidal mudflat (Sundarbans)						
Other (state)						

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

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

Annex 3C — Benchmark test problems for software acceptance

Supports Clauses 3.5, 3.6, 3.8, 3.9, 3.11, 3.12 and 3.16 of Chapter 3.

Purpose. Software not listed in Clause 3.16.1 shall reproduce the results of the five problems below (Clause 3.16.3). Each problem is fully specified and uses only the methods and tables of Chapter 3, so every answer can be checked by hand. The acceptance tolerance is ±5% on each tabulated result, the equivalence threshold of Clause 3.16.2; for closed-form results (Problems 3C-1 to 3C-4), software should agree to the rounding shown. The submittal shall report the software result next to each answer below.

Illustrative — not design values. The inputs (areas, intensities, rainfall depths, slopes and the basin) are chosen for testing only. They are not design data for any site.

Problem 3C-1 — Rational Method peak (Clause 3.5)

Inputs. A 2.0 ha catchment draining to one inlet: 1.2 ha concrete paving and roofs, C = 0.90 (Table 3.2, upper half of 0.80–0.95); 0.8 ha lawns on sandy soil, average slope, C = 0.15 (Table 3.2, upper half of 0.10–0.15). Design AEP 1% (100-yr). Rainfall intensity at Tc, including the climate factor: i = 120 mm/h.

Part (b): a separate 0.5 ha fully paved catchment, C = 0.90, design AEP 1%, i = 150 mm/h.

Table 3C.1 — Problem 3C-1 solution

Step	Calculation	Result
Composite C (Clause 3.5.4)	(1.2 × 0.90 + 0.8 × 0.15) / 2.0	0.60
Frequency factor (Table 3.3)	1% AEP	Cf = 1.25
C · Cf (≤ 1.0)	0.60 × 1.25	0.75
Peak flow (Clause 3.5.1)	0.75 × 120 × 2.0 / 360	**Q = 0.500 m³/s**
Part (b): C · Cf	0.90 × 1.25 = 1.125, capped at 1.0 (Clause 3.5.3)	1.00
Part (b): peak flow	1.00 × 150 × 0.5 / 360	**Q = 0.208 m³/s**

Problem 3C-2 — Time of concentration by the segment method (Clause 3.6)

Inputs. Pre-development flow path: sheet flow over greenfield, n = 0.15 (Clause 3.6.3), L = 30 m, S = 0.01; P2 (50% AEP 24-hour rainfall, no climate factor) = 80 mm. Shallow concentrated flow, unpaved, L = 200 m, S = 0.01. Channel flow, L = 400 m, bank-full velocity V = 1.0 m/s (given).

Table 3C.2 — Problem 3C-2 solution

Segment	Calculation	Travel time
Sheet flow (Clause 3.6.2(a))	0.091 × (0.15 × 30)^0.8 / (80^0.5 × 0.01^0.4) = 0.2138 h	12.83 min
Shallow concentrated (Clause 3.6.2(c))	V = 4.918 × 0.01^0.5 = 0.4918 m/s; 200 / (3,600 × 0.4918) = 0.1130 h	6.78 min
Channel (Clause 3.6.2(d))	400 / (3,600 × 1.0) = 0.1111 h	6.67 min
Tc (Clause 3.6.1; ≥ 10 min)	12.83 + 6.78 + 6.67	**26.27 min**
Lag (Clause 3.6.5)	0.6 × 26.27	15.76 min

Problem 3C-3 — SCS-CN runoff depth, AMC and Ia sensitivity (Clause 3.8)

Inputs. Pre-development reference on HSG C: CN = 74 at AMC II (Table 3.5), all pervious. Cumulative rainfall P = 100 mm; second case P = 25 mm.

Table 3C.3 — Problem 3C-3 solution

Case	S (mm)	Ia (mm)	Runoff Q (mm), P = 100 mm	Runoff Q (mm), P = 25 mm
(a) AMC II, Ia = 0.2S: S = 25,400 / 74 − 254	89.24	17.85	**39.38**	**0.53**
(b) AMC III, Ia = 0.2S: CN(III) = 23 × 74 / (10 + 0.13 × 74) = 86.75	38.80	7.76	**64.93**	—
(c) AMC II, Ia = 0.05S: S0.05 = 25.4 × 1.33 × (89.24 / 25.4)^1.15	143.31	7.17	**36.49**	**1.97**

Runoff is $Q = (P - Ia)^2 / (P - Ia + S)$. Case (c) gives less runoff than case (a) at 100 mm but more at 25 mm, as Clause 3.8.5 and Figure 3.3 describe.

Problem 3C-4 — Separate vs composite impervious representation, and SCS unit hydrograph peak (Clauses 3.9 and 3.11.2)

Inputs, part (a). A site that is 50% directly connected impervious (CN 98) and 50% open space on HSG B (CNp = 61), AMC II, Ia = 0.2S, P = 25 mm.

Inputs, part (b). A sub-area of A = 2.5 km² with Tc = 1.0 h and computation interval Δt = 0.1 h.

Table 3C.4 — Problem 3C-4 solution

Step	Calculation	Result
(a) Impervious half (Clause 3.9.2)	S = 5.18 mm, Ia = 1.04 mm; Q = 23.96² / (23.96 + 5.18)	19.70 mm
(a) Pervious half	S = 162.39 mm, Ia = 32.48 mm > P	0 mm
(a) Area-weighted runoff, separate sub-areas	0.5 × 19.70 + 0.5 × 0	**9.85 mm**
(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			
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			

Problem	Result	Benchmark	Software result	Difference (%)	Within ±5%?
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.

To be prepared. This annex will contain peak rate factors calibrated for unchannelled, flat coastal-plain and deltaic land in West Bengal, such as the embanked islands of the Sundarbans, the coastal plain of Purba Medinipur and the flat land east of Kolkata that drains towards the East Kolkata Wetlands, with the limits of slope, drainage density and land cover within which each factor may be used. It needs observed rainfall and flow or water-level records for small, flat, undrained catchments (I&WD river gauges and hydromet stations, gauges at the sluices of the embanked islands, the records of KMC's drainage pumping stations), catchment geometry from survey or a DEM, and calibration of the SCS unit hydrograph peak to those events under Clause 3.15. Until it is published, use the standard factor 484 (PRF' = 0.208) for all land (Clause 3.11.5): a lower factor may be used only after the authority adopts calibrated values in this annex (Clause 3.11.5(c)), and then only for land that stays unchannelled, in the same way in both the pre- and post-development runs (Clause 3.11.5(a) and (b)).

Table 3D.1 — Calibrated peak rate factors (layout)

Catchment	Area (km²)	Mean slope (m/m)	Drainage condition	Events used	Calibrated PRF (US customary)	PRF' (SI)	Range of applicability

Annex 3E — CWC SUH parameters for subzones 1(f), 1(g) and 2(a), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzones 1(f) (Middle Ganga Plains), 1(g) (Lower Ganga Plains) and 2(a) (North Brahmaputra), the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs the three CWC Flood Estimation Reports that cover West Bengal: the Lower Ganga Plains subzone 1(g) (revised, Design Office Report LG-1(g)/R-1/23/94, November 1994), which covers the whole of south Bengal and gives separate relationships for a hilly region and a plain region; the North Brahmaputra subzone 2(a) (NB/18/1991), which covers the Teesta, Jaldhaka and Torsa basins of Darjeeling, Kalimpong, Jalpaiguri, Alipurduar and Cooch Behar; and the Middle Ganga Plains subzone 1(f) (GP/10/1984, October 1985), which covers the Mahananda basin of Malda, the two Dinajpurs and the Mahananda side of Siliguri and was read for this draft only by optical character recognition (see the References of Chapter 3), with the subzone boundaries within West Bengal confirmed on the reports' index maps, 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 1(g), hilly region	Subzone 1(g), plain region	Subzone 2(a) relationship	Subzone 1(f) relationship (optical character recognition only) [TBC]
Time from centre of unit rainfall to peak	tp	h	tp = 1.1808 (L·Lc/√S)^0.285	tp = 1.8833 qp^−0.940	tp = 2.164 qp^−0.940	tp = 1.217 qp^−1.034
Peak discharge per unit area	qp	m³/s per km²	qp = 2.0972 tp^−0.927	qp = 0.6617 (L/√S)^−0.515	qp = 2.272 (L·Lc/S)^−0.409, as printed; L·Lc/√S [TBC]	qp from L/√S; coefficient and exponent not legible [TBC]
Width of UH at 50% of peak	W50	h	W50 = 1.2622 tp^0.828	W50 = 1.7897 qp^−1.006	W50 = 2.084 qp^−1.065	W50 = 1.743 qp^−1.104
Width of UH at 75% of peak	W75	h	W75 = 0.7896 tp^0.711	W75 = 0.8955 qp^−1.061	W75 = 1.028 qp^−1.071	W75 = 0.902 qp^−1.108
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.5357 tp^0.745	WR50 = 0.5524 qp^−1.012	WR50 = 0.856 qp^−0.865	WR50 = 0.736 qp^−0.928
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.3825 tp^0.647	WR75 = 0.2984 qp^−1.012, as printed (the same exponent as WR50) [TBC]	WR75 = 0.440 qp^−0.918	WR75 = 0.478 qp^−0.902
Base width of UH	TB	h	TB = 5.5830 tp^0.824	TB = 12.4755 tp^0.721	TB = 5.428 tp^0.852	TB = 16.432 tp^0.646 (6-hour unit graph)

Parameter	Symbol	Unit	Subzone 1(g), hilly region	Subzone 1(g), plain region	Subzone 2(a) relationship	Subzone 1(f) relationship (optical character recognition only) [TBC]
Design storm duration	TD	h	TD = 1.1 tp	TD = 1.1 tp	TD = TB, rounded to the nearest whole hour	By tp: 3–5 h, 6 h; 6–11 h, 12 h; 12–17 h, 18 h; 18–72 h, 24 h
Design loss rate	—	mm/h	2.7 (printed "0.27 cm/hr" for every catchment in the subzone; modal value of 46 events on 11 catchments)	2.7 (the subzone value; the modal value of the 1(f) catchments used for this region is 3.0)	2.4 (printed "0.24 cm/hr"; modal value of about 233 events on 21 catchments)	3.0
Design base flow	—	m³/s per km²	0.05	0.05	0.05	0.05
Ratio of t-hour to 24-hour rainfall	—	—	10-yr: 1 h 0.350; 3 h 0.515; 6 h 0.640; 9 h 0.735; 12 h 0.800; 15 h 0.860; 18 h 0.915; 24 h 1.000	as hilly region	50-yr: 1 h 0.260; 3 h 0.457; 6 h 0.615; 9 h 0.720; 12 h 0.805; 15 h 0.875; 18 h 0.930; 24 h 1.000	50-yr: 1 h 0.31; 3 h 0.50; 6 h 0.65; 9 h 0.75; 12 h 0.82; 15 h 0.89; 18 h 0.94; 24 h 1.00
Time distribution of 24-hour rainfall	—	cumulative fraction, hours 1 to 24	[TBC]	[TBC]	[TBC]	[TBC]
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	1.15	1.15	1.15
Areal reduction factor	ARF	—	Annex 4.2 of the report, read by optical character recognition only [TBC]	as hilly region [TBC]	[TBC]	[TBC]
Catchment area for which the relationships apply	A	km²	25–1,000; up to 5,000 with judgement	25–1,000; up to 5,000 with judgement	25–2,500; up to 5,000 with judgement	30–4,500 [TBC]
Report reference	—	—	Tables 3.1 and 3.2 (pp. 13–14), §3.5 and §3.6 (pp. 15–16)	Tables 3.1 and 3.2 (pp. 13–14), §3.5 and §3.6 (pp. 15–16)	Table on p. 19, §2.3 and §2.4 (p. 21)	[TBC]

Note: relationships as printed in the three CWC reports that cover West Bengal (References of Chapter 3). The subzone 1(g) and 2(a) relationships, loss rates and rainfall ratios were read from scanned copies and checked against the page images. The subzone 1(f) values were read only by optical character recognition and have not been checked against the page images; every 1(f) entry is to be confirmed before use [TBC], and its peak equation could not be read at all. The 1994 revision of subzone 1(g) covers the whole of south Bengal and divides it into a hilly region, on the Chota Nagpur plateau and its foothills (Purulia, the west of Bankura and the upper Damodar and Subarnarekha, with slopes above about 2 m/km), and a plain region (the delta). The hilly-region relationships were derived from 11 railway-bridge catchments in the upper Damodar valley, with 46 floods of 1956–67. Only three usable gauged sites were found in the plain region, too few for a regression, so the plain-region relationships were derived again, for a 1-hour unit graph, from the data of 22 catchments of subzone 1(f) in Bihar and Uttar Pradesh. No gauged deltaic, tidal or urban catchment in

West Bengal lies behind any relationship in this table. The report also gives a simplified flood formula for the hilly region only, and none for the delta. The 1985 report for subzone 1(f) records, as read by optical character recognition, that the original subzone 1(g) of 1978 had been split, with the Damodar and Subarnarekha left in 1(g) and the rest added to 1(f); the 1994 revision reverses that split, and is the report to be used in south Bengal. In the 2(a) peak equation the printed term is L·Lc/S; the other relationships use √S, and whether √S was meant is to be checked against a clean copy of the report [TBC]. The 2(a) report sets the design storm duration equal to the base width of the unit hydrograph, which gave the higher peak on 16 of its 21 catchments, and limits it to 24 hours in its worked example (railway bridge 373 on the Alipurduar–Bongaigaon line, 595.7 km², for which it gives a 50-yr peak of about 1,270 m³/s). In the 1(g) plain region the WR75 exponent is printed the same as the WR50 exponent, which may be a misprint [TBC]. The design loss rates, 2.4 to 3.0 mm/h, are low, and each shall be used only within its own subzone. Where a catchment drains across the boundary between two subzones, this Manual requires the SUH to be computed with the parameters of each subzone and the higher 1% AEP peak to be adopted, unless calibration under Clause 3.15 supports the other. Siliguri lies on the boundary between subzones 1(f) and 2(a), and both shall be computed there. In Kolkata, Howrah and the other flat, pumped or tide-locked catchments of the delta the SUH describes neither the catchment nor its outfall: it is a benchmark for the natural condition only (Clause 3.11.4(c)), and the design is made with a hydrograph model and the tailwater of Chapter 5. Subzone by basin, to be confirmed on the index maps of the reports [TBC]: 1(g), the Bhagirathi–Hooghly and the rivers of south Bengal, the Dwarka, Mayurakshi, Ajay, Damodar, Rupnarayan, Haldi (Kasai) and Subarnarekha, with the hilly region for Purulia, the west of Bankura and Asansol, and the plain region for Kolkata, Howrah, Hooghly, the 24 Parganas, Nadia, Murshidabad, Bardhaman, Birbhum, the Medinipurs and the Sundarbans; 2(a), the Teesta, Jaldhaka and Torsa (Darjeeling, Kalimpong, Jalpaiguri, Alipurduar, Cooch Behar and the Teesta side of Siliguri); 1(f), the Mahananda (Malda, Uttar and Dakshin Dinajpur and the Mahananda side of Siliguri). No CWC report covers any West Bengal district outside these three subzones. The subzone is chosen by the catchment's outfall, not by its district.

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

A. Point of comparison (Clause 3.14.2)

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

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

B. Peak flows (Clauses 3.14.7–3.14.10)

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

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

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

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

C. Volumes and storage (Clauses 3.14.8–3.14.10)

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

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

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

D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

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

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

E. Associated checks (Clause 3.14.12)

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

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

F. Statement by the responsible engineer

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

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

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — West Bengal 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 deltaic clay zone of Kolkata, Howrah and the 24 Parganas, the Sundarbans and the saline coastal belt, the margins of the Hooghly and the other tidal rivers and khals, the coastal dune sands of Digha and Contai, and the Tal lowlands and other floodplain lowlands, and any area where the groundwater table lies within 3 m of the surface at any time of year (Clause 4.12.1).

To be prepared. This annex will contain (a) the boundaries of the flood-sensitive catchments as a GIS layer and as maps at a scale fit for deciding whether a plot lies inside them, and (b) a map of the shallow-groundwater zone of Clause 4.12.1, with the seasonal high groundwater depth during and after the SW monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (I&WD, NRSC, Survey of India), the pukurs and other water bodies on the lists kept by KMC and the municipalities and the land recorded as "pukur" in the land records (the Land and Land Reforms Department), the boundaries of the East Kolkata Wetlands in the Schedules to the East Kolkata Wetlands (Conservation and Management) Act, 2006 (EKWMA) and of the Sundarbans Wetland Ramsar site, the canals, outfall channels and embankments of I&WD, the flood-affected areas in the Annual Flood Reports of I&WD, the mangroves in the Coastal Zone Management Plans in force (the West Bengal State Coastal Zone Management Authority), town boundaries (UD&MA, KMDA and the other development authorities, NKDA, and the Municipal Corporations and Municipalities), flood maps held by WBSDMA, observation-well records of the CGWB and the SWID, and the extent of the deltaic clays, the saline soils of the Sundarbans and the coast, the coastal dune sands, and the Tal lowlands from soil survey maps (NBSS&LUP, the State agricultural universities of West Bengal). Until it is published: (a) the catchments named in Clause 4.5.3.2 apply, and whether a site lies in one is decided and recorded as set out in Annex 1B; and (b) every site to which Clause 4.12.1 may apply establishes its design groundwater level from site piezometer readings over one June–November season or, failing that, from the nearest CGWB or State observation well plus 0.5 m and the level of any adjacent tidal water body at MHWS (Clause 4.12.1(b)). For the flotation check in the deltaic clay zone 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	Deltaic clay zone; Sundarbans or saline coastal belt; margin of a tidal river or khal; coastal dune sand; Tal or other floodplain lowland; other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, SW monsoon season	m
shgw_basis	Wells or piezometers used, and period of record	text
tidal_influence	Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b))	yes / no
source	Source agency and date of the data	text
geometry	Zone boundary	polygon

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

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

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

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

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

4B.2 PSD and SSR (Table 4.3)

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
WB-Z1 Darjeeling–Kalimpong hills	C / D	50% / 70% / 90%	—	—	—	—	—
WB-Z2 Terai and Duars	B / C / D	50% / 70% / 90%	—	—	—	—	—
WB-Z3 North Bengal Gangetic plains	B / C / D	50% / 70% / 90%	—	—	—	—	—
WB-Z4 Western plateau	C / D	50% / 70% / 90%	—	—	—	—	—
WB-Z5 Central and Gangetic delta	B / C / D	50% / 70% / 90%	—	—	—	—	—
WB-Z6 Coastal belt and Sundarbans	A / 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 the Gangetic delta near Kolkata; 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 a tide-locked, pumped outfall is in Annex 5C.

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

4C.1 **Inputs.**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4C.8 **Routing.** Each storm is routed by level-pool continuity (Clause 4.6.1): over each 5-minute step, the change in storage equals inflow volume minus outflow volume. The computation used six 50-second sub-steps per 5-minute step. Each row of Table 4C.7 can be checked by hand as ΔS ≈ (I − Ō) × 300 s, where I is the mean inflow over the 5-minute step ending at the time shown and Ō is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: ΔS = 2,853.0 − 2,613.3 = 239.7 m³, and (1.0891 − (0.2655 + 0.3069)/2) × 300 = 240.9 m³.

Table 4C.7 — Routing of the 100-yr 72-hour storm through the trial outlet, around the peak (Illustrative — not design values)

Time (h:min)	Rainfall in step (mm)	Inflow I (L/s)	Outflow O (L/s)	Storage S (m³)	Stage h (m)
60:00	8.44	286.3	169.5	2,164.0	0.866
60:05	36.33	354.2	184.1	2,216.9	0.887
60:10	11.61	703.3	218.0	2,367.1	0.947
60:15	6.88	1,066.0	265.5	2,613.3	1.045
60:20	5.23	1,089.1	306.9	2,853.0	1.141
60:25	4.34	897.5	334.8	3,025.0	1.210
60:30	3.77	653.2	349.9	3,117.6	1.247
60:35	3.36	403.6	353.8	**3,132.9**	**1.253**
60:40	3.05	301.5	352.3	3,117.3	1.247
60:45	2.81	254.8	348.6	3,088.7	1.235
60:50	2.61	224.9	343.7	3,052.4	1.221
60:55	2.45	203.3	337.9	3,011.3	1.205

Storage is greatest at the end of the step ending at 60:35. In the next step the mean inflow (302 L/s) is below the outflow (about 352 L/s), so storage falls.

Table 4C.8 — Routing of the 100-yr 72-hour storm through the trial outlet, hourly (Illustrative — not design values)

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
12	35.0	14	8	0.130	325
24	70.0	15	12	0.215	536
36	105.0	16	14	0.264	660
48	140.0	16	15	0.294	736
54	181.7	47	19	0.469	1,172
57	213.5	69	23	0.623	1,559
59	248.5	120	91	0.789	1,971
60	293.3	286	170	0.866	2,164
61	378.0	187	332	1.187	2,967
62	399.3	106	237	0.968	2,421

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
63	414.5	80	142	0.829	2,072
66	446.9	51	52	0.771	1,927
72	489.5	33	33	0.768	1,920
84	489.5	0	18	0.405	1,012
96	489.5	0	10	0.167	418
108	489.5	0	4	0.058	146

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

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

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

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

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

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

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

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

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

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

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

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

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
0.085	213	8.8	0.0	8.8
0.17	425	17.6	0.0	17.6
0.30	750	28.0	0.0	28.0
0.40	1,000	33.9	0.0	33.9
0.50	1,250	38.9	0.0	38.9
0.60	1,500	43.3	0.0	43.3
0.70	1,750	47.3	0.0	47.3
0.76	1,900	49.6	0.0	49.6
0.80	2,000	51.0	88.3	139.3
0.90	2,250	54.5	165.3	219.7
1.00	2,500	57.7	216.4	274.1
1.10	2,750	60.8	257.5	318.3
1.17	2,925	62.8	282.8	345.6
1.20	3,000	63.7	293.0	356.7
1.30	3,250	66.5	324.6	391.1

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

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

Findings:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A. Eligibility (Clause 4.14.1)

Table 4F.12 — Form 4-2: eligibility

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

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

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

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

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

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

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

Line	Quantity	Computation	Value
C7	Q_PSD,100 (L/s)	B5 × A	

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

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

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

E. Statement

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

Table 4F.16 — Form 4-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — West Bengal 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 — West Bengal 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 — West Bengal 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))	—

To be prepared. This annex will give, for each coastal segment of West Bengal (the Hooghly estuary, from Garden Reach at Kolkata to Diamond Harbour, Haldia and Sagar Island; the Sundarbans, in South and North 24 Parganas; and the open coast of Purba Medinipur, from Digha and Contai to the mouth of the Hooghly) and for the tidal outfall channels (the Kultigang at the outfall of Kolkata's storm-water flow channel, and the tidal creeks behind the Sundarbans embankments): the reference port or gauge; MSL, MHWS and HAT relative to chart datum; the connection from chart datum to the Survey of India datum and to the Kidderpore Old Datum (KOD) and any other local datum used by KMC, I&WD or the port; the 10% AEP storm surge; the 1% AEP still-water level; where an outfall faces the open sea, the wave set-up; and the measured rate of land subsidence. It needs the current Indian tide tables of the National Hydrographic Office or the Survey of India and the tidal levels of the Syama Prasad Mookerjee Port for Garden Reach, Diamond Harbour, Haldia, Gangra and Sagar, tide-gauge records and benchmark connections (Survey of India, INCOIS, the port), I&WD river and canal gauges with tidal records and the design water levels of the outfall channels, surge return-level analyses or hindcasts (INCOIS, IMD, NCCR), and subsidence surveys (levelling or PS-InSAR), with the coastal segments agreed with WBSDMA and the port. Values found during research, for reference only: at Diamond Harbour the INCOIS (2025) modelled tidal maximum is 2.57 m and the surge and wave set-up 1.16 m above mean sea level, and the 100-year extreme sea level 3.79 m above mean sea level at present, 4.34 m (SSP2-4.5) or 4.46 m (SSP5-8.5) by 2100; the maximum tidal range at the mouth of the Hooghly is about 17 ft (CWPRS, data of 1963–64), and the range at Diamond Harbour about 4.5 m (secondary source); Cyclone Aila's surge at Sagar Island in May 2009 was observed to be "around 3.3" above the predicted level, with no unit stated (I&WD); IMD reported tidal waves of 15 ft over low-lying parts of the 24 Parganas and Purba Medinipur in Cyclone Amphan (IMD, 2020), and a surge of more than 2 m above the astronomical tide was reported at Digha, Mandarmani, Fraserganj and Gosaba in Cyclone Yaas in May 2021 (secondary sources); the sea-level trend is 3.73 ± 0.53 mm/yr at Diamond Harbour (1948–2015) and 2.62 ± 0.47 mm/yr at Haldia (1971–2023), while the Sagar record (1937–1987) gives −2.05 ± 1.85 mm/yr and the Garden Reach record is flagged for quality control (PSMSL); Kolkata's ground is sinking at 2.8–5.5 mm/yr (Thakur et al., 2026); MHWS and HAT relative to chart datum for Garden Reach, Haldia and Sagar are [TBC]. The INCOIS tidal maximum is a model value and is not a substitute for the tide-table HAT. Until the annex is published: the designer obtains MHWS, HAT and MSL directly from the current tide tables or port authority levels and records the edition and port (Clause 5.7.2(d)); takes the 10% AEP surge and the 1% AEP still-water level from a site-specific study using INCOIS, IMD or NCCR hindcasts or return-level analyses, stating its source, method and record length (Clause 5.7.3(c)); uses the tide-table levels of the nearest port on the Hooghly (Clause 5.7.2(a)) and, for an outfall between two ports or up a canal, khal or creek, the higher of the two ports' levels unless measurements or a calibrated model justify a lower value (Clause 5.7.2(c)); states every level with its datum (chart datum, GTS (mean sea level), KOD or a port or municipal datum) and the conversion used; applies an SLA of at least +0.3 m (Clause 5.7.4); and, in Rainfall Zones WB-Z5 and WB-Z6, adds the subsidence allowance of Clause 5.8.5(f).

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

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
Hooghly, Kolkata and Howrah reach, with Chitpur lock and the other locks at the city canals	Kolkata, Howrah	Riverine outfall reach; tidal; lock-gated outfalls	5.7.2, 5.8.1, 5.8.5
Tolly's Nullah, the Circular Canal and the Beleghata, Kestopur and Bagjola canals	Kolkata and its suburbs	Major drains; riverine outfall reaches; pumped and lock-gated outfalls	5.2, 5.8.1, 5.8.5
Canals receiving the storm-water flow of the KMC pumping stations, including the Churial, Begore, Rania, Western and Parnashree canals	Kolkata	Major drains; pumped outfalls	5.2, 5.8.5
Storm-water flow channel, Bantala to the Kultigang, with the Kulti pump house	Kolkata; East Kolkata Wetlands; South and North 24 Parganas	Major drain; riverine outfall reach; tidal at the outfall; no storage credit in the wetlands	5.2, 5.8.1, 5.8.5
Damodar, Mundeswari and Rupnarayan below Maithon and Panchet	Howrah, Hooghly, Purba Bardhaman	Riverine outfall reaches; releases from Maithon and Panchet included	5.8.1, 5.8.3, 5.8.5
Shilabati, Kangsabati and Rupnarayan, Ghatal basin	Paschim Medinipur	Riverine outfall reaches; backwater	5.8.1, 5.8.5
Teesta below the Gajoldoba barrage	Jalpaiguri	Riverine outfall reach; barrage releases included; bed survey after October 2023	5.8.1, 5.8.3, 5.8.5
Mahananda, Jaldhaka and Torsa	Siliguri, Malda, Jalpaiguri, Alipurduar, Cooch Behar	Riverine outfall reaches	5.8.1
Hooghly at Diamond Harbour, Haldia and Sagar	South 24 Parganas, Purba Medinipur	Riverine outfall reach; tidal	5.7.2, 5.8.1
Tidal rivers and creeks behind embankment sluices	Sundarbans; Purba Medinipur coast	Gated outfalls; land behind routed as closed storage; breach check	5.8.1, 5.8.5
Maithon and Panchet; Teesta barrage at Gajoldoba	Damodar; Teesta	Releases to be included in river levels	5.8.3
I&WD drainage channels, khals and irrigation canals receiving storm water	Statewide	Major drains; I&WD consent, design water level and flap gate	5.2, 5.8.5
River and creek mouths of the Purba Medinipur coast and the Sundarbans	Coastal districts	Mouth status to be confirmed by pre-monsoon survey	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 I&WD mouth-maintenance programme. It needs I&WD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (I&WD), the drain inventories of KMC 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, I&WD canal, the khals and outfall channels of Kolkata and its suburbs (such as Tolly's Nullah, the Circular Canal, the Beleghata, Kestopur and Bagjola canals and the storm-water flow channel from Bantala to the Kultigang), any khal or drainage channel maintained by I&WD or a local body, any irrigation canal that receives storm water 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 any river or creek on the Purba Medinipur coast or in the Sundarbans that a pre-monsoon survey shows closed or restricted by sand or silt are assumed closed at the start of the SW monsoon unless I&WD 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	I&WD 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	I&WD 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 beside a khal in Kolkata's eastern suburbs

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 low-lying land beside a khal in the eastern suburbs of Kolkata. It discharges through its own outlet chamber to a public storm drain, which outfalls through a flap gate to the khal. The khal reaches the river only through a pumping station and is subject to tide-lock when the outfall channel is high (Clause 5.8.5(a)), so Clause 5.10.1 applies to the facility.

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

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

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

Lock windows (Clause 5.10.3)

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

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

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

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

Results

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

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

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

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

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

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

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

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

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
24	20	Open	18	0.18	445
28	39	Open	24	0.25	621
32	59	Open	32	0.36	906
34	85	Open	37	0.47	1,166
36	286	Closed	0	0.78	1,944
38	106	Closed	0	1.73	4,321
40	66	Closed	0	1.96	4,904
42	51	Open	529	1.79	4,472
44	42	Open	204	0.87	2,181
46	37	Open	49	0.74	1,854

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
48	33	Open	47	0.70	1,756
50	0	Closed	0	0.71	1,784
54	0	Closed	0	0.71	1,784
56	0	Open	43	0.58	1,459
60	0	Open	32	0.37	921
66	0	Open	16	0.16	397
72	0	Open	7	0.06	162

Assessment

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

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

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

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

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

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

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 15 May 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 deltaic clay zone 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)

Item	Value
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 — West Bengal 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. Pumped and lock-gated outfalls, East Kolkata outfall channels, embankment sluices, dam-release and backwater reaches, I&WD channels and khals, and subsidence: operator of each station, lock or sluice identified, installed capacity, operating levels and gate sills obtained; canal or khal behind it routed with its whole catchment, present storage and the pumping confirmed available (not more than installed capacity less the largest pump); lock extended; embankment-breach check; Kultigang tidal level at the outfall, no storage credit in the East Kolkata Wetlands; releases of every upstream dam and barrage combined as in the largest recorded event; downstream boundary at the tidal boundary or recorded level, or shown not to matter; not below the highest recorded flood level for the major system; post-2023 bed survey on North Bengal rivers; I&WD consent, permitted rate, design water level and flap gate; subsidence rate used and its source (Clause 5.8.5)	

G. Joint cases (Clause 5.9; Clause 5.14, item 6)

Table 5F.8 — Form 5-1: joint-case results

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
J1				
J2				
J3				
J4				
R1				
R2				

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

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

Field	Entry
H1. Reason the check applies (Clause 5.10.1)	
H2. Storm: AEP, 48 h and 72 h, AMC III (Clause 5.10.2)	
H3. Lock duration and basis: default of two 6-hour windows, or site study (Clause 5.10.6); extension for sand-bar closure (Clause 5.13.5)	
H4. Lock windows of the two runs (start and end times) (Clause 5.10.3(d))	
H5. Maximum stage in each facility, against its 1% AEP maximum water level (Clause 5.10.4(a))	
H6. Maximum stage in the minor and major systems, against the Chapter 6 limits (Clause 5.10.4(b))	

Field	Entry
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	

Field	Entry
K2. Mouth assumed closed, or open with I&WD certification attached (Clause 5.13.2)	
K3. Bar crest level from the most recent pre-monsoon survey (m) and the closed-mouth tailwater (Clause 5.13.3)	
K4. Extension of the lock duration, where required (Clause 5.13.5)	

L. Inspection and maintenance (Clause 5.14, item 11)

Table 5F.14 — Form 5-1: inspection and maintenance

Field	Entry
L1. Gate and valve inspection before 15 May and after closure events (Clause 5.11.5)	
L2. Pump test runs before 15 May (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 West Bengal Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 5 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

Table 5F.15 — Form 5-1: statement by the registered professional

Field	Entry
Name	
Qualification and registration number	
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — West Bengal Stormwater Design Manual, Draft v1.0.

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — West Bengal 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, KMC, WBSDMA, I&WD (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 — West Bengal 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 West Bengal 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 West Bengal streets (kerb-opening, grate and combination inlets, including the road-level wall opening into a covered drain) and, for each type, capacity curves on grade and in a sag. It needs a fixed set of standard inlet geometries agreed with the road-owning agencies, and rating tests of those geometries (laboratory or full-scale), or HEC-22 calculations for each geometry checked against tests (data and likely sources: Public Works Department (PWD), NHAI and Kolkata Municipal Corporation standard details, IIT Kharagpur, IIEST Shibpur, Jadavpur University or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

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

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

Item	Requirement	Clause
Grate pattern	Openings parallel to the direction of travel not wider than 25 mm	9.11.3(a)
Load class	D400 in carriageways and medians; C250 within 0.5 m of the kerb; B125 in footpaths and cycle tracks (or the equivalent IS class)	9.11.2
Connection pipe	At least 300 mm diameter; gradient giving at least 0.9 m/s at the inlet's design flow	6.6.6
Silt sump	At least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7, 9.11.6

The intended layout of the annex is given in Tables 6A.2 to 6A.4.

Table 6A.2 — Register of standard inlet types (layout)

Type code	Description	Grate size or kerb opening (mm)	Gutter depression (mm)	Load class	Standard drawing
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6A.3 — Capacity on grade (layout; one table per inlet type)

Cross slope Sx (m/m)	Longitudinal slope SL (m/m)	Gutter flow Q (L/s)	Spread T (m)	Clean intercepted flow (L/s)	Design intercepted flow after clogging (L/s)	Bypass flow (L/s)
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Table 6A.4 — Capacity in a sag (layout; one table per inlet type)

Ponded depth at the inlet (mm)	Clean capacity (L/s)	Clogging factor (Table 6.5)	Design capacity (L/s)	Flow regime (weir, orifice or transition)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Annex 6B — Sediment yield for silt-trap sizing and calibration of the sediment allowance

Supports Clauses 6.7.4, 6.7.8, 6.13.3 and 6.13.10 of Chapter 6.

To be prepared. This annex will contain sediment yields for urban drains in West Bengal, by land use and drain type, for sizing the silt traps of Clause 6.13.3, and a calibration of the sediment allowance of Clause 6.7.8 against measured silt depths. It needs desilting records (volume or mass removed per drain length and per catchment area, with dates), silt-depth surveys before and after the south-west monsoon, and catchment land-use and soil data (data and likely sources: desilting records of Kolkata Municipal Corporation and other urban local bodies, I&WD records for channels, land cover from NRSC, soils from the West Bengal 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.

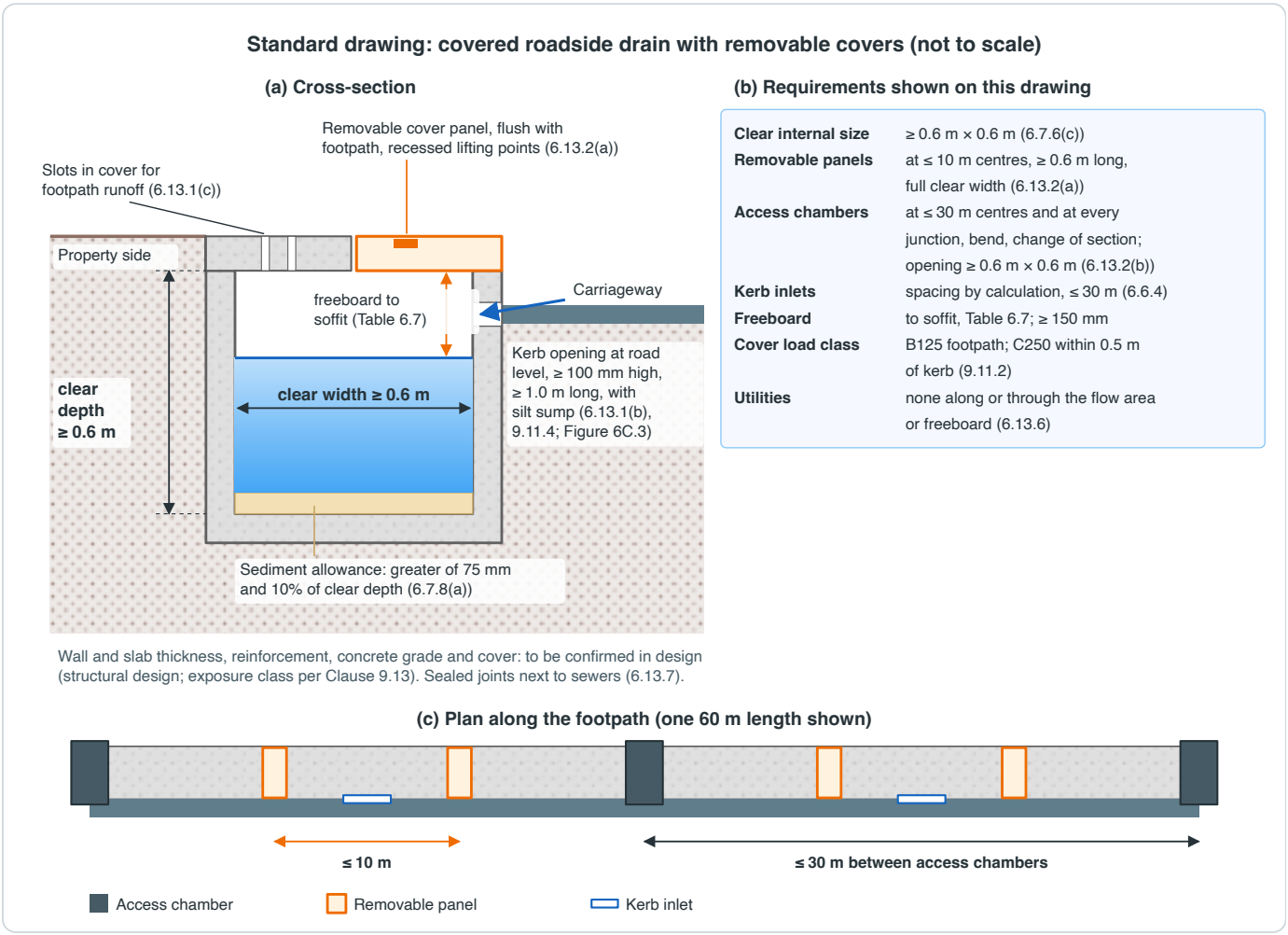

Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

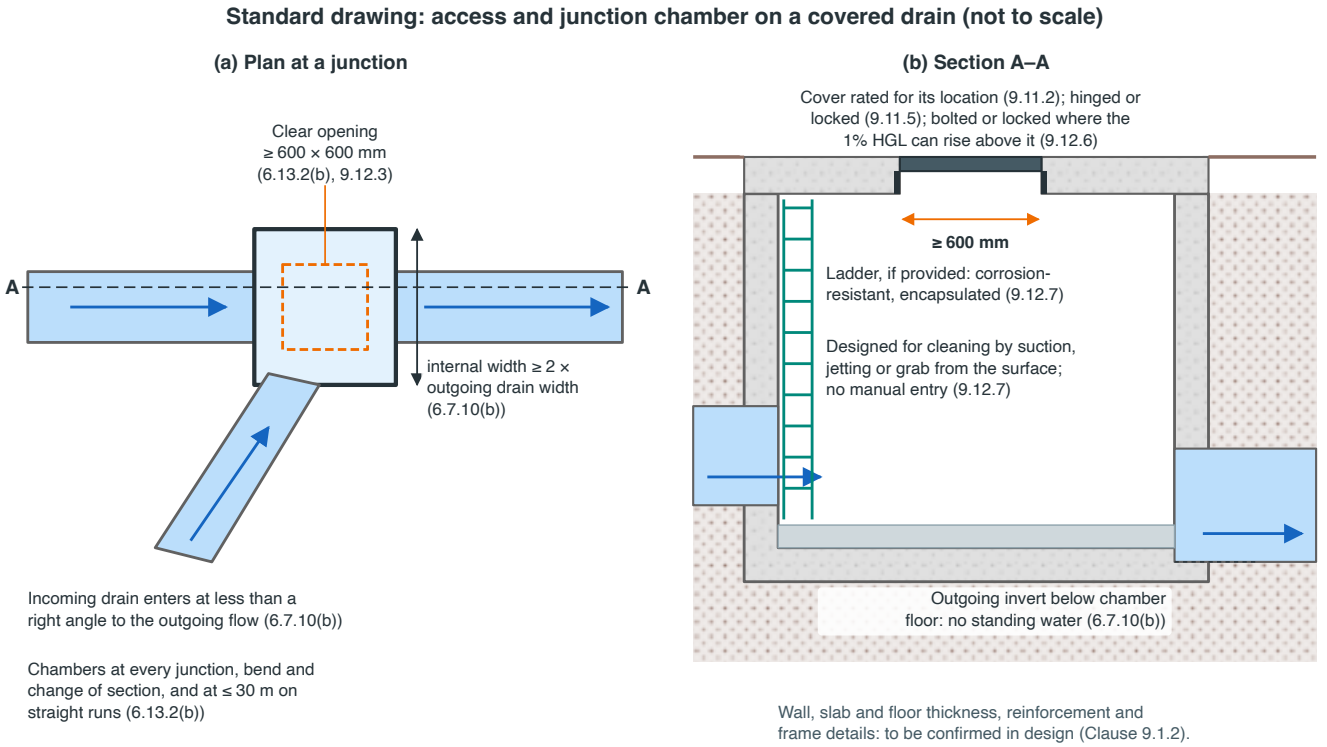

Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

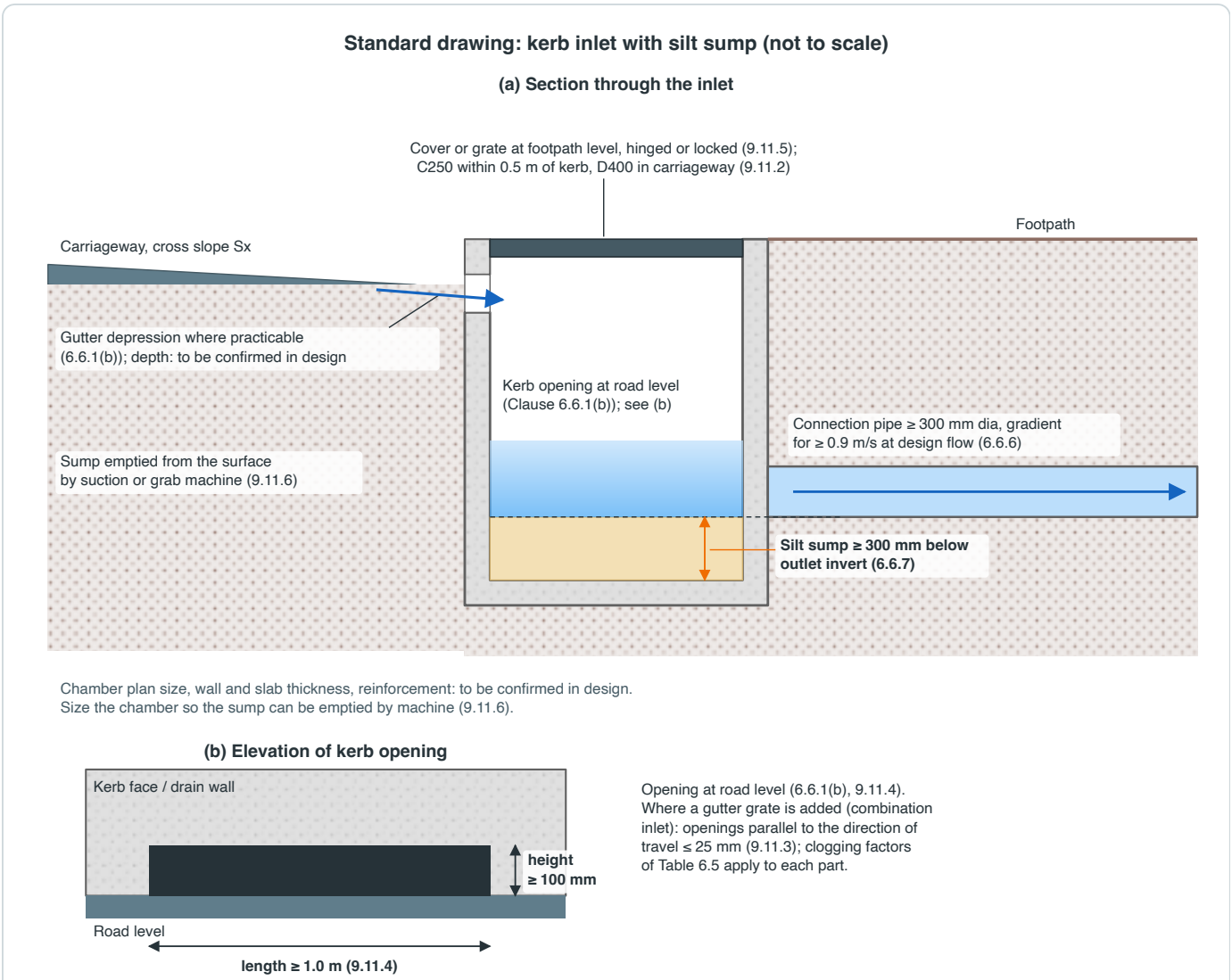

Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th 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 — West Bengal 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 — West Bengal 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 the I&WD and the Land and Land Reforms Department. It needs the mouza maps and land records of the Land and Land Reforms Department, including land recorded as pukur (pond), doba, khal, bil or jala (KMC's notices cite the L.R. plot "classified as Pukur (Pond)"); the water-body lists of KMC and other ULBs and KMC's GIS mapping of ponds; land shown as a water body in a land-use map or notification of KMDA or another development authority under the West Bengal Town and Country (Planning and Development) Act, 1979; the map of the East Kolkata Wetlands in Schedule II of the 2006 Act; and, in the coastal districts, the High Tide Line and mangroves of the Coastal Zone Management Plan (CZMP) in force; the I&WD and Gram Panchayat tank registers with FTL and MWL; surveyed levels on a common datum; the ISRO National Wetland Inventory and Assessment (NRSC); Survey of India topographic maps; and any list of waterbodies published under court directions. Until it is published, each Applicant identifies waterbodies from all the sources of Clause 7.3.3, with the larger extent governing, and records them on the Waterbody Sheet (Form 7-1).

The field specification below is complete. It is written so that every field the chapter asks for (Clause 7.3.1(a) to (g)) has a defined name, type and source, and so that the same fields can be filled from a project's Form 7-1.

7A.1 Layers

- **WB_POLY** — one polygon per waterbody: the Revenue record boundary (Clause 7.3.1(c)).
- **WB_FTL** — the surveyed FTL contour (tanks, lakes, ponds) or top of bank (channels), as a polygon or line.
- **WB_MWL** — the MWL contour of each tank, as a polygon.
- **WB_FLOOD** — the 1% AEP flood extent, where mapped (Clause 7.3.1(f)), with the floodway where delineated (Clause 7.6.1).
- **WB_STRUCT** — points for surplus weirs, sluices, regulators, inlets and drain outfalls.
- **WB_LINK** — lines for supply channels, surplus courses and the links between tanks in a cascade (Clause 7.3.1(e)).
- **WB_ENCR** — polygons of known encroachments, each with the date recorded (Clause 7.3.1(g)).
- **WB_SETBACK** — Zone 1 and Zone 2 polygons (Clause 7.4), derived from the layers above.

All layers shall carry the waterbody identifier (WB_ID) so that they can be joined. All levels shall be stated to one datum (Clause 7.3.5), named in the layer metadata.

Table 7A.1 — Attribute fields of the waterbody inventory (WB_POLY)

Field	Type	Unit / domain	Required	Content	Clause
WB_ID	Text	District code + serial	Yes	Unique identifier, never reused	7.3.1
WB_NAME	Text	—	Yes	Name as in Revenue and I&WD 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, block 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	I&WD record / 1% AEP computed	Tanks	Which value governs MWL	7.2
TBL	Number	m (datum)	Tanks	Top bund level, lowest point	7.3.1(d)
WEIR_CREST	Number	m (datum)	Tanks	Surplus weir crest level	7.3.1(d)
WEIR_LEN	Number	m	Tanks	Surplus weir crest length	7.3.1(d)
WEIR_TYPE	Text	—	Tanks	Surplus weir type (for example fixed crest, with shutters or falling boards)	7.3.1(d)
SLUICE_N	Integer	—	Tanks	Number of sluices; details in WB_STRUCT	7.3.1(d)
SUPPLY_CH	Text	WB_ID(s)	Tanks	Supply channel(s) feeding the tank	7.3.1(d)
SURPLUS_CS	Text	WB_ID(s)	Tanks	Surplus course(s) leaving the tank	7.3.1(d)
UPSTR_WB	Text	WB_ID(s)	Cascades	Upstream tank(s) in the cascade	7.3.1(e)
DNSTR_WB	Text	WB_ID	Cascades	Downstream tank, river, drain or sea outfall	7.3.1(e)
CATCH_AREA	Number	ha	Channels	Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1)	7.4.1
DATUM	Text	—	Yes	Datum of all levels; conversion from any older I&WD 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

Field	Type	Unit / domain	Required	Content	Clause
FLOODWAY	Code	Delineated / whole 1% extent / below MWL	Yes	Basis of the floodway	7.6.1
ENCR_KNOWN	Code	Yes / No	Yes	Known encroachment; details in WB_ENCR	7.3.1(g)
CREDITED	Code	Yes / No	Tanks	Storage counted under Clause 7.7, with the scheme reference	7.7.1
WETLAND	Code	Notified / listed / other	Wetlands	Status under Clause 7.12.1	7.12.1
SOURCES	Text	—	Yes	Sources used, from the list in Clause 7.3.3(a) to (e)	7.3.3
UPDATED	Date	—	Yes	Date of the last edit, and by whom	7.3.1

Table 7A.2 — Code lists

Code list	Values	Clause
WB_TYPE	River or tidal river (gang); stream; khal or nala; canal; lake or large tank (jhil, dighi, sayar); tank or pond (pukur, doba); floodplain wetland or marsh (bil, baor, jala); embanked fishery (bheri); tidal creek or estuary (khanri, mohana); mudflat; mangrove; abandoned brick-field pit; supply channel; surplus course	7.2
CUSTODIAN	I&WD; KMC or other municipal corporation; Municipality; NKDA, KMDA or other development authority; EKWMA; Gram Panchayat; Fisheries Department; Land and Land Reforms Department (District Collector); Forest Department; private owner; other (name)	7.3.1(b)
Structure (WB_STRUCT)	Surplus weir; sluice; regulator; inlet; drain outfall; gross pollutant trap; crossing	7.3.1(d), 7.10
Encroachment (WB_ENCR)	Building; fill; road; wall; dumping; cultivation; other — each with date recorded, area (m²) and source	7.3.1(g), 7.13

Table 7A.3 — Attribute fields of structures (WB_STRUCT)

Field	Type	Unit	Content	Clause
STR_ID	Text	—	Unique identifier	7.3.1(d)
WB_ID	Text	—	Waterbody served	7.3.1(d)
STR_TYPE	Code	Table 7A.2	Structure type	7.3.1(d)
CREST_SILL	Number	m (datum)	Weir crest or sluice sill level	7.7.1(a)
LENGTH_SIZE	Text	m	Weir crest length, or sluice opening size	7.7.1(a)
GATED	Code	Yes / No	Controllable outlet (needed for a flood cushion, Clause 7.8.2(a))	7.8.2
CONDITION	Code	Serviceable / defective	Result of the latest pre-monsoon inspection, with date	7.7.1(d), 7.14.4

Annex 7B — Fixed-width setback table (alternative S-3, with Annex 1C)

Supports Clauses 7.3.4, 7.4.3, 7.4.6 and 7.4.7 of Chapter 7, and alternative S-3 of the Policy Supplement (Annex 1C).

7B.1 When the table may be used

The fixed-width setback may be used only where all of the following apply:

- (a) the Authority has not adopted a 1% AEP flood extent map for the waterbody (Clause 7.3.4);
- (b) Clause 7.3.4 does not require the Applicant to determine the 1% AEP extent by a hydraulic study: the site is not in a flood-sensitive catchment, is not a site of 1 ha or more adjoining a waterbody, and the Authority has not asked for a study; and
- (c) the waterbody is one to which setbacks apply (Clause 7.4.1): any recorded or found waterbody, and any natural channel draining 8 ha or more at the site.

Where an Authority adopts alternative S-3 under Clause 1.7, the table below is the S-3 table. Clause 1.7.3(e) provides for the S-3 table to be issued by the State Stormwater Technical Committee. Until it is issued, the values are those of Clause 7.4.6, repeated here without change.

Table 7B.1 — Fixed-width setback by waterbody class (alternative S-3)

Waterbody class	Drainage area at the site	Total setback (Zone 1 + Zone 2)	Of which Zone 1	Measured from
Channel, small	8 ha to 65 ha	25 m	15 m	Top of bank (Clause 7.4.3)
Channel, medium	65 ha to 20 km²	40 m	15 m	Top of bank
Channel, large, and rivers	More than 20 km²	50 m	20 m	Top of bank
Tank, lake or pond	Any	MWL contour + 25 m	To the MWL contour, and not less than 15 m from FTL	FTL contour (Zone 1); MWL contour (total)
Marsh, estuary or backwater	Any	As notified by the Authority, and not less than 50 m	15 m	The waterbody boundary of Clause 7.13.1

Values from Clause 7.4.6 (Table 7.1). Zone 2 is the total setback less Zone 1.

7B.2 Rules of application

- (a) **Measurement.** Measure horizontally on plan, outward from the boundary of Clause 7.13.1: the larger of the Revenue record boundary and the surveyed FTL (or top of bank). Where FTL and top of bank both apply, use whichever gives the wider zone (Clause 7.4.3).
- (b) **Drainage area.** For a channel, use the drainage area at the downstream end of the reach that adjoins the site. Where a reach crosses a class limit within the site, apply the wider setback to the whole reach within the site.
- (c) **Both banks.** The setback applies on each bank of a channel and all round a tank, lake, pond or marsh.
- (d) **Minimum set by this Manual.** Zone 1 is never less than 15 m (Clause 7.4.7). A wider statutory or approval setback governs for the uses it restricts (Clause 7.4.5).
- (e) **Stricter of the two.** Where a hydraulic study is made voluntarily, the setback is the wider of Table 7B.1 and Clauses 7.4.3 and 7.4.4.
- (f) **Record.** The basis of the setback (fixed width) shall be stated on the Waterbody Sheet (Form 7-1) and in the approval (Clause 7.4, Disclosure).
- (g) **Review.** The table shall be reviewed within 2 years of the Authority adopting 1% AEP flood maps (Clause 7.16.1).

7B.3 Source of the channel widths

The channel widths were set by this Manual with reference to the 2006 Kansas City APWA default stream buffers, rounded up and floored at the 15 m minimum (Clause 7.4.6, commentary). The source values, as cited in the chapter, are:

Table 7B.2 — Source buffers cited in Clause 7.4.6 (KC APWA 5600, 2006, §5605.3)

Drainage area (source, acres)	Approximate SI equivalent	Source buffer
Less than 40 ac	Less than 16 ha	40 ft (12 m)
40–160 ac	16–65 ha	60 ft (18 m)
160–5,000 ac	65 ha – 20 km²	100 ft (30 m)
More than 5,000 ac	More than 20 km²	120 ft (37 m)

The 65 ha and 20 km² class limits in Table 7B.1 are the SI equivalents of 160 ac and 5,000 ac. The 8 ha lower limit is the 20-acre trigger of APWA 2025.01 (Clause 7.4.1(b)).

Annex 7C — Template tank operating rule, with flood cushion

Supports Clauses 7.7.1(c), 7.7.3, 7.8 and 7.14.4 of Chapter 7.

Model text for consideration by a competent authority. Not in force. For tanks under I&WD control, the operating rule is I&WD'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, block, district].
2. Custodian: [I&WD division / ULB / Gram Panchayat / other].
3. Cascade position: upstream tank(s) [ ]; downstream tank, river or drain [ ].
4. Datum: [ ]. Surveyed levels (Clause 7.7.1(a)), date of survey [ ]: FTL [ ] m; MWL [ ] m; TBL (lowest point) [ ] m; surplus weir crest [ ] m, length [ ] m; sluice sills [ ] m.
5. Stage–storage curve (Clause 7.7.1(b)): survey date [ ]; attached as Schedule 1.
6. Controllable outlets (Clause 7.8.2(a)): [gated sluice / regulator / none]; capacity at FTL [ ] m³/s.

7C.2 Purposes and priority

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

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

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

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

Period	Target level (m)	Upper limit (m)	Lower limit (m)	Purpose
[1 Jan – date]	[ ]	FTL	[ ]	Holding for irrigation / supply

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

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

7C.4 Flood cushion (Clause 7.8.2)

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

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

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

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

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

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

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

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

Trigger	Source	Action	By whom
IMD district heavy-rainfall warning for the catchment	IMD	Read gauges [ ] hourly; check outlets are free; confirm the tank is at or below its rule level	[ ]
IMD or WBSDMA red alert	IMD, WBSDMA	Begin releases needed to reach the rule level, within the maximum release rate; notify downstream bodies (paragraph 21)	[ ]
City forecast system warning, where available	[ ]	[ ]	[ ]
Tank level reaches FTL	Gauge	Record outflow hourly; inspect bund and weir	[ ]
Tank level reaches [MWL − [ ] m]	Gauge	Emergency procedure; warning to the breach area of any emergency action plan (Clause 7.14.3(c))	[ ]

7C.7 Records and review (Clause 7.8.1(g))

22. During the SW monsoon (1 June to 30 September) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the SW monsoon, records shall be kept [weekly].
23. Records shall be kept with the O&M plan (Chapter 10) and given to the Authority on request.
24. The tank shall be inspected before the SW monsoon (by 15 May) and after every heavy-rainfall event (Clause 7.14.4).
25. This rule shall be reviewed after any event in which the tank surplused at a level above [ ] m, after any change to the weir, sluices or bund (Clause 7.7.6), and in any case with the review of the Manual.

Schedules: 1 stage–storage curve; 2 continuous simulation report; 3 yield and compensation; 4 downstream check of the maximum release; 5 communication list.

Annex 7D — Desilting and restoration specification

Supports Clauses 7.7.1(b), 7.9 and 7.14.4 of Chapter 7.

This specification applies to every desilting, restoration or deepening of a tank, pond or other waterbody under Clause 7.9. Values are those of Chapter 7. Where the chapter does not set a value, it is marked "to be confirmed in design" and shall be stated in the works design.

7D.1 Pre-works survey (Clause 7.9.1)

- (a) **Topographic and bathymetric survey** of the waterspread, foreshore (to the MWL contour), bund, surplus weir and sluices, levelled to the datum of Clause 7.3.5. Survey grid and point density: to be confirmed in design.
- (b) **Original bed level** found by test pits or augering on a grid (grid spacing to be confirmed in design), and from historical records where available. Each pit log shall show the silt thickness, the level of the original bed, and any clay or silt layer below it.
- (c) **Silt testing** where the tank receives urban runoff or sewage: samples from the pits of (b), tested for heavy metals and other contaminants before disposal is planned. The parameters and limits shall be those the West Bengal Pollution Control Board 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 West Bengal Pollution Control Board 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 **15 May**. No excavation shall be left open, and no sluice or weir left dismantled, during the SW monsoon.

7D.8 Completion records

- (a) As-built survey and revised stage–storage curve. The curve is the one that Clause 7.7.1(b) requires "after the last desilting".
- (b) Volume removed, its disposal site, and the silt test results.
- (c) Photographs of the bund, weir, sluices and inlet works.
- (d) Update of the inventory record (Annex 7A: SSC_DATE, LEVEL_DATE, CONDITION).

Table 7D.1 — Hold points for desilting and restoration works

Hold point	Check	Clause
1. Before excavation	Pre-works survey, pit logs, silt tests, and hydrogeological report if deepening	7.9.1, 7.9.3
2. Original bed reached	Levels checked against pit logs; no excavation below the original bed unless approved	7.9.2
3. Edges formed	Side slopes or safety bench as 7D.3	7.9.4
4. Inlet works	Forebay, wetland inlet zone or GPT built	7.9.7
5. Completion (by 15 May)	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 Bengali words for waterbodies and their parts. Spellings in Roman script vary (for example dighi and dīghi, jhil and jheel, bil and beel), and usage differs between regions. The name used in the Land and Land Reforms, I&WD, municipal or Gram Panchayat record for each waterbody should be recorded in the inventory (Annex 7A) alongside the Manual's term. Only terms whose meaning was confirmed in the *Samsad Bengali–English Dictionary* (Biswas, 3rd edition, 2000, as served by the Digital South Asia Library), or in a statute or official report, are listed in Tables 7E.1 to 7E.3; the meanings are Samsad's, with its print page, unless another source is named, and modern usage may be narrower or wider. Others are listed in Table 7E.4 as not yet verified. The list is to be extended by the State Stormwater Technical Committee, with modern I&WD, KMC and land-record usage.

Table 7E.1 — Waterbodies and land

Bengali term	Meaning	Source of the term	Manual term (Clause 7.2)
পুকুর (pukur)	"a pond, a tank, a pool"	Samsad, p. 653; "Pukur (Pond)" as a land classification in KMC notices (NGT, OA 258/2024)	Tank or pond (pukur)
দিঘি, দীঘি (dighi, dīghi)	"a large and deep tank or pond"	Samsad, pp. 499, 501	Tank or pond; large tank
ঝিল (jhil)	"a very large pond"	Samsad, p. 417	Lake or large tank
সায়র (sāyar)	"a sea; a large pond"	Samsad, p. 1008	Lake or large tank
ডোবা (ḍobā)	"a pit full of water; a small pool of water"	Samsad, p. 436	Tank or pond
জলাশয় (jalāśay)	"a water-reservoir; a pond, a tank, a pool, a lake, a river etc."	Samsad, p. 396	Waterbody (general term)
বিল (bil)	"a hole … a cavity … a fen; a marsh"	Samsad, p. 770	Floodplain wetland or marsh
বাঁওড় (bā̃oṛ; baor)	"the bend of a river where the current is obstructed"	Samsad, p. 734	Floodplain wetland (oxbow lake)
জলা, জলাভূমি (jalā, jalābhūmi)	"a marsh, a bog"; "a marsh, a swamp, a bog"; জলাজমি, "wetlands"	Samsad, pp. 395–396	Marsh or wetland
বাদা (bādā)	"an extensive marsh or fen; a wooded region"	Samsad, p. 742	Marsh (its use for the Sundarbans tracts is not confirmed)

Bengali term	Meaning	Source of the term	Manual term (Clause 7.2)
দহ (daha)	"the unfathomable and whirling part of a river … a lake (usu. a large and natural one)"	Samsad, p. 491	Deep pool or lake
গাং, গাঙ (gāṅ)	"(coll.) a river, a stream", as in the Kultigang	Samsad, p. 305	River or tidal river
খাঁড়ি (khā̃ṛi; khanri)	"an estuary; an inlet, a creek"	Samsad, p. 277	Tidal creek or estuary
মোহানা, মোহনা (mohānā)	"(of a water-reservoir, pond etc.) a conduit, a channel; (of a river) a mouth, an estuary"	Samsad, p. 884	Tidal creek or estuary; outfall
চর (car; char)	"a strip of sandy land rising out of the bed of a river or a sea above the water-level"	Samsad, p. 348	River island or shoal (within the waterbody)
ভেড়ি (bheṛi; bheri)	"an embankment, a dam; an embanked low land used as a fishery, a fishery dam"	Samsad, p. 823; sewage-fed fishery ponds of the East Kolkata Wetlands	Embanked fishery (bheri), see the definitions after Clause 7.2

Table 7E.2 — Channels, drains and parts of the system

Bengali term	Meaning	Source of the term	Manual term (Clause 7.2)
খাল (khāl; khal)	"a canal; a strait; a channel; a quagmire; a pit; lowland"	Samsad, p. 281; names of Kolkata's canals (Bagjola, Kestopur, Bhangor)	Khal (channel), see the definitions after Clause 7.2
নালা (nālā; nala)	"a duct; a drain; a canal; a wayside gutter", as in Tolly's Nullah	Samsad, p. 567	Drain or channel
নর্দমা, নর্দামা (nardamā)	"a drain; a gutter; a sewer"	Samsad, p. 558	Drain (minor system) or sewer
নয়নজুলি (nayanjuli)	"a trench esp. for carrying off filthy water, a gutter"	Samsad, p. 557	Roadside drain
নিকাশ, নিকাশি (nikāś, nikāśi)	"act of letting out, drainage" (জলনিকাশ); "relating to coming or getting out" (জলনিকাশি ব্যবস্থা, a drainage system)	Samsad, p. 570	Drainage
বাঁধ (bā̃dh; bandh)	"a dam; a breakwater, a bulwark; (geog.) a dyke"	Samsad, p. 735	Embankment (bund, Clause 7.14)
পলি (pali)	"silt; alluvium"; পলি-পড়া, "silted up"	Samsad, p. 629	Silt (Clause 7.9)
পুকুর ঝালানো (pukur jhālāno)	"to dredge a tank"	Samsad, p. 653	Desilting (Clause 7.9)

Table 7E.3 — Floods, tides and statutory terms

Term	Meaning
বন্যা, প্লাবন (banyā, plāban)	"a flood; an inundation; a deluge"; "a flood, a deluge" (Samsad, pp. 722, 699)
জোয়ার (joyār); ভাঁটা (bhā̃ṭā)	"high tide, flow tide, flow"; জোয়ার-ভাটা, "ebb and flow" (Samsad, pp. 408, 808)
water area	The land that section 17A of the West Bengal Inland Fisheries Act, 1984 protects; see the definitions after Clause 7.2

Term	Meaning
water body (East Kolkata Wetlands)	Under the East Kolkata Wetlands (Conservation and Management) Act, 2006, it includes "any land holding water" (section 2(k), as reported)
river zone	The 15 m zone along a river bank in rule 8(4) of the West Bengal Municipal (Building) Rules, 2007; see the definitions after Clause 7.2
sewage-fed pisciculture	Fish culture in the bheris using the city's sewage, one of the matters within the powers of EKWMA (section 4 of the 2006 Act, as reported)
DWF and SWF	Dry-weather flow and storm-water flow, the two flows that KEIIP's pumping stations pump separately and that the Kulti outfall channels carry separately (KMC, 2015; I&WD)

Table 7E.4 — Terms not yet verified

The following terms are in published use for West Bengal's waterbodies, but their meaning was not confirmed in Samsad or an official source during research for this Manual. They shall not be used in a record or a drawing as defined terms until verified.

Term	Reported meaning	Status
ঝোরা (jhora)	A hill stream, as in the list of waterbodies in rule 8(3) of the West Bengal Municipal (Building) Rules, 2007	The word is in the rule (as reported); its meaning was not looked up
নদী (nadī)	River	Common usage; not looked up
জল জমা, জলাবদ্ধতা (jal jamā, jalābaddhatā)	Waterlogging	Press usage; জলমগ্ন and জলাবদ্ধ are not Samsad headwords. Not verified
পয়ঃপ্রণালী (payaḥpraṇālī)	Sewerage	Not a Samsad headword. Not verified
ail	An embankment of a Sundarbans island	English-language reports only; not verified
bheri, as used in the East Kolkata Wetlands Act	Sewage-fed fishery pond	The Act's own use of the word and its spelling were not read (Samsad spells it ভেড়ি)
গরান (garān)	Samsad gives "the mangrove or its timber" (p. 300) without naming a species	Not to be used for a particular species

The Manual uses the terms in the last column of Tables 7E.1 and 7E.2, and the West Bengal 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 — West Bengal 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): Mouza maps and L.R. records, ULB water-body lists, KMDA land-use maps, EKW Schedule II map, CZMP maps □; I&WD / Gram Panchayat registers □; Authority inventory or court list □; historical maps and imagery, including NWIA □; site survey □	_____	7.3.3
A8	Where sources conflict: which extent governs (the larger)	_____	7.3.3
A9	Datum of all levels, and conversion from any I&WD 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 (I&WD 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
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4

No.	Field	Entry	Clause
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider statutory line: the boundary of the East Kolkata Wetlands (Schedule II of the 2006 Act), a water body or other protected land use in a land-use map or notification of KMDA or another development authority, a mangrove or other CRZ line of the CZMP in force; 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 — West Bengal Stormwater Design Manual, Draft v1.0. One sheet per tank whose storage is counted. Storage that fails any item in Section B shall not be counted (Clause 7.7.1).

Table 7F.5 — Form 7-2, Section A: Tank and scheme

No.	Field	Entry	Clause
A1	Tank name and inventory ID (Annex 7A); custodian	_____	7.3.1
A2	Scheme in which storage is counted: basin plan / regional facility / fee-in-lieu (S-5)	_____	7.7.1, 7.11
A3	Cascade modelled: uppermost tank _____ to outfall _____	_____	7.7.2
A4	Datum	_____	7.3.5

Table 7F.6 — Form 7-2, Section B: Conditions for counting storage

No.	Condition	Date / reference	Met (yes / no)	Clause
B1	FTL, MWL, TBL, weir crest and length, sluice sills surveyed within the previous 5 years	_____	_____	7.7.1(a)
B2	Stage–storage curve from a bathymetric and topographic survey within 5 years or after the last desilting, whichever is later	_____	_____	7.7.1(b)
B3	Documented operating rule agreed with the custodian (Annex 7C)	_____	_____	7.7.1(c), 7.8
B4	Weir, sluices and bund under an O&M plan; latest pre-monsoon inspection found them serviceable	_____	_____	7.7.1(d), 7.14.4
B5	Custodian's written concurrence	_____	_____	7.7.1(e)

Table 7F.7 — Form 7-2, Section C: Levels and creditable volume

No.	Item	Value	Clause
C1	Starting level: FTL, or cushion level under a rule meeting Clause 7.8.2, m	_____	7.7.3
C2	If a cushion is used: controllable outlet (type) and drawdown time, h	_____	7.8.2(a)
C3	If a cushion is used: reliability from continuous simulation, % of SW monsoon seasons (≥ 90%)	_____	7.8.2(c)
C4	Computed maximum level, 1% AEP inflow with climate factor routed through the cascade, m	_____	7.7.4
C5	MWL, m; is C4 ≤ MWL?	_____	7.7.4(a)
C6	Freeboard C4 to TBL, m; I&WD 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 — West Bengal 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 West Bengal 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 West Bengal 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 — West Bengal 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 West Bengal, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several SW monsoon seasons, with laboratory analysis to the CPCB methods, and the outfall monitoring of Clause 8.13.1 published under Clause 10.17. Until it is published, the Value Ratings of Table 8.3 (MARC/APWA 2012) apply, and a proprietary device earns a VR only from verified test data (Table 8.3).

The layouts below set the minimum records the programme shall keep, so that results from different authorities can be pooled.

Table 8C.1 — Monitoring site register (layout)

Site ID	BMP type (Table 8.3)	Location and authority	Catchment area (ha)	Impervious (%)	Soil and groundwater setting	Date commissioned	Pretreatment
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.2 — Event record (layout; parameters of Clause 8.13.2)

Site ID	Event date	Rainfall (mm)	Inflow volume (m^3)	Outflow volume (m^3)	TSS in / out (mg/L)	BOD in / out (mg/L)	COD in / out (mg/L)	Faecal coliform in / out (MPN/100 mL)	TN in / out (mg/L)	TP in / out (mg/L)	Oil and grease in / out (mg/L)	Heavy metals (industrial catchments)
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.3 — Performance summary and proposed VR (layout)

BMP type	Sites	Events	Volume reduction (%)	Median effluent TSS (mg/L)	Other findings	VR in Table 8.3	Proposed VR
_____	_____	_____	_____	_____	_____	_____	_____

Annex 8D — BMP design sheets, media specification, plant lists

Supports Clauses 8.5, 8.7, 8.8 and 8.11 of Chapter 8.

Each design sheet collects the requirements of Chapter 8 for one BMP. Values marked "recommended starting value" in Clause 8.7.1 may be departed from with justification. Values that the Manual does not set are marked "to be confirmed in design"; the designer shall state and justify them. Every BMP also needs: sizing for the WQv or Q_wq (Clause 8.6.4(a)), pretreatment (Clause 8.5.3), a safe bypass for flows above Q_wq (Clause 8.4.6) and maintenance access (Chapter 10).

8D.1 Design sheets

Table 8D.1 — Pretreatment (all BMPs)

Item	Requirement	Clause
Where needed	Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland, at each concentrated inflow	8.5.3
Types	Sediment forebay, grass filter strip, silt trap or proprietary device	8.5.3
Size	Holds at least 10% of the WQv of its contributing area; or sized for Q_wq (flow-through devices)	8.5.3
Access	Cleanable without entering or disturbing the main BMP	8.5.4
Silt traps and catch pits	At every inlet receiving runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody; sump at least 300 mm below the outlet invert; earn no VR	8.7.12

Table 8D.2 — Bioretention and rain gardens (Figure 8.2)

Item	Requirement	Clause
Ponding depth	≤ 300 mm above the mulch, with an overflow at maximum ponding level	8.7.2(a)
Ponding drawdown	Within 48 h	8.7.2(b)
Filter media	600–900 mm engineered sandy loam, low fines, low phosphorus (Table 8D.12)	8.7.2(c)
Mulch	50–75 mm	8.7.2(c)
Transition (choker) and gravel drainage layers	Required; thickness and grading to be confirmed in design	8.7.2(d)
Underdrain	Perforated; required where the design infiltration rate cannot meet the 48 h drawdown, or where lined; diameter to be confirmed in design	8.7.2(e)
Lining	Required where Clause 8.8 cannot be met, and at hotspots	8.7.2(f)
Plants	Native or naturalised, tolerant of waterlogging and long dry spells (Tables 8D.13 and 8D.14)	8.7.2(g)
VR	8.5 (rain garden / infiltration 9.0)	Table 8.3

Table 8D.3 — Vegetated swales

Item	Requirement	Clause
Section	Trapezoidal or parabolic; side slopes no steeper than 1V:3H	8.7.3(a)
Longitudinal slope	0.5% to 4%; check dams where steeper	8.7.3(b)
Flow at Q_wq	Depth not more than grass height; velocity ≤ 0.3 m/s	8.7.3(c)
1% AEP or bypass flow	No erosion (Chapter 9 permissible velocities)	8.7.3(d)
Underdrained ("dry") swale	Where slope < 1% or subsoil is poorly drained; filter media as Table 8D.12	8.7.3(e)
VR	4.0 (native vegetation swale)	Table 8.3

Table 8D.4 — Vegetated filter strips

Item	Requirement	Clause
Inflow	Sheet flow only; level spreader where flow arrives concentrated	8.7.4(a)
Length in flow direction	≥ 5 m	8.7.4(b)
Slope	1% to 8%	8.7.4(b)
Use	Mainly pretreatment for bioretention, infiltration and swales	8.7.4(c)
VR	5.0	Table 8.3

Table 8D.5 — Permeable pavement

Item	Requirement	Clause
Run-on	Impervious run-on area ≤ 2 × permeable area; none from unpaved or eroding areas	8.7.5(a)
Base reservoir	Clean open-graded aggregate holding its share of the WQv in its voids; void ratio confirmed by test	8.7.5(b)
Open (infiltrating) base	Only where Clause 8.8 is met; otherwise lined with underdrain and counted as filtration only	8.7.5(c)

Item	Requirement	Clause
Structure	Designed for traffic loading to the road authority's standards	8.7.5(d)
Exclusions	Not at hotspots; not where it will be resurfaced with impermeable material	8.7.5(e)
VR	7.5	Table 8.3

Table 8D.6 — Infiltration trenches and basins (Figure 8.3)

Item	Requirement	Clause
Pretreatment	Always (Table 8D.1)	8.7.6(a)
Fill	Clean washed aggregate, void ratio confirmed by test; geotextile on sides and top; sand base	8.7.6(b)
Observation well	To the base of each trench	8.7.6(c)
Storage	WQv (or Chapter 4 retention volume, if greater) held in the voids	8.7.6(d)
Drawdown	Empty within 72 h at the design infiltration rate	8.7.6(d), 8.8.7
Overflow	At grade, to the minor or major system	8.7.6(e)
Commissioning	Not in service until the contributing area is stabilised	8.7.6(f)
Criteria	All of Clause 8.8 (Table 8D.11)	8.8

Table 8D.7 — Wet ponds (extended wet detention)

Item	Requirement	Clause
Permanent pool	≥ WQv	8.7.7(a)
Extended detention	WQv above the pool, released over 24–48 h	8.7.7(a), 8.4.7
Forebay	At each inlet	8.7.7(b)
Flow path	Length-to-width ≥ 3:1; no short-circuiting	8.7.7(c)
Pool depth	1.0–2.5 m, with safety bench (Clause 7.9.4)	8.7.7(d)
Water balance	Monthly balance with IMD rainfall and pan evaporation: ≥ 50% of pool volume kept through the driest year in 10; no top-up with groundwater, potable water or sewage	8.7.8
Flood detention	Chapter 4 detention may sit above the extended detention level	8.7.7(f)
VR	5.0	Table 8.3

Table 8D.8 — Constructed wetlands

Item	Requirement	Clause
Layout	Inlet sedimentation pond (forebay), then shallow macrophyte zone	8.7.9(a)
Extended detention	WQv above normal water level, released over 24–48 h; depth ≤ 0.5 m	8.7.9(b)
Flow path	Length-to-width ≥ 3:1; deep zones across the flow path	8.7.9(c)
Bypass	High-flow bypass so that floods do not scour the macrophyte zone	8.7.9(d)
At a tank inlet	Within the tank's setback, outside its waterspread; not counted as tank storage	8.7.9(e)
Water balance	As wet ponds (minimum wetland depth kept)	8.7.8

Item	Requirement	Clause
VR	7.0 (extended detention wetland)	Table 8.3

Table 8D.9 — Gross pollutant traps and outfall screens

Item	Requirement	Clause
Treatment flow	Q_wq; all flows up to 1% AEP pass without washing out captured material	8.7.10(a)
Capture size	Down to about 5 mm	8.7.10(b)
Head loss	In the drain HGL (Chapter 9), screen 50% blocked	8.7.10(c), 8.10.3(a)
Storage	For the O&M cleaning interval; not less than 3-monthly cleaning	8.7.10(d)
Access	Vehicle access for suction or grab cleaning; safe cleaning platform	8.7.10(e), 8.10.3(d)
Blocked screen	Overflow or bypass path so that a fully blocked screen does not flood property	8.10.3(b)
Bar spacing	Chosen for the hazard: closer for litter capture, wider where blockage would cause flooding; to be confirmed in design	8.10.3(c)

Table 8D.10 — Oil-grit separators

Item	Requirement	Clause
Where	Fuel stations; vehicle workshops and washing bays; bus and truck depots; parking areas of more than 50 spaces	8.7.11(a)
Sizing	Q_wq, with high-flow bypass	8.7.11(b)
Not alone	Followed by a filtering BMP where the site needs a VR above 5; lined filtering BMP before any infiltration at hotspots	8.7.11(c), 8.8.8

Table 8D.11 — Infiltration and recharge criteria (all infiltrating BMPs)

Item	Requirement	Clause
Groundwater separation	Seasonal high groundwater ≥ 1.0 m below base (roof-only runoff in notified coastal sand: ≥ 0.5 m with mounding check, mound ≥ 0.3 m below base)	8.8.1, 8.8.9(d)
Bedrock or impermeable layer	Base ≥ 1.0 m above, unless designed for rock-aquifer recharge under Clause 8.8.10	8.8.2
Tests	Double-ring (ASTM D3385) for basins, bioretention, permeable pavement; falling-head borehole or trial-pit soakage (e.g. BRE Digest 365) for trenches, soakaways, pits, wells; ≥ 2 per facility and ≥ 1 per 100 m² of base or per 50 m of trench; Form 8-2	8.8.3
Design rate	Measured rate ÷ 2.0 (tests meet 8.8.3(c) and vary by no more than a factor of 2), otherwise ÷ 3.0	8.8.4
Minimum rates	≥ 13 mm/h full infiltration; 3–13 mm/h partial, with underdrain, credit only for volume infiltrated within 72 h; < 3 mm/h no credit	8.8.5
Setbacks (runoff from paved surfaces)	Foundations 3 m, basements 5 m; property boundary 1.5 m; drinking-water well or borewell 30 m; septic tank or soak pit 15 m; crest of slope steeper than 1V:3H 6 m	8.8.6
Expansive soils	Foundation setback doubled	8.8.11(b)

Item	Requirement	Clause
Drawdown	Empty within 72 h at design rate; tested after construction	8.8.7
Hotspots	No infiltration without treatment; none at all for waste sites and contaminated land	8.8.8
Road runoff	Never led directly into a well, borewell or recharge shaft	8.11.3(b)

8D.2 Bioretention drawdown check

The 48-hour ponding drawdown (Clause 8.7.2(b)) and the minimum rates of Clause 8.8.5 together decide whether a cell needs an underdrain.

- Rate needed to drain the maximum ponding depth in 48 h = 300 mm / 48 h = 6.25 mm/h.
- Design rate ≥ 13 mm/h: full infiltration, no underdrain, provided Clause 8.8 is met.
- Design rate from 6.25 mm/h to 13 mm/h: the ponding drains in time, but Clause 8.8.5(b) applies, so an underdrain is required.
- Design rate below 6.25 mm/h: the ponding cannot drain in 48 h by infiltration; an underdrain is required (Clause 8.7.2(e)), and below 3 mm/h no infiltration credit is given.

Illustrative — not design values. Two tests at the base of a proposed cell give 30 mm/h and 22 mm/h. The two results differ by a factor of 30 / 22 = 1.36, which is not more than 2, and the number of tests meets Clause 8.8.3(c), so the safety factor is 2.0. Taking the lower result, the design rate = 22 / 2.0 = 11 mm/h. This is above 6.25 mm/h, so the ponding drains in 300 / 11 = 27 h, within 48 h. It is below 13 mm/h, so the cell is a partial-infiltration design with an underdrain (Clause 8.8.5(b)).

8D.3 Filter media specification

Table 8D.12 — Bioretention filter media and layers

Layer	Requirement from Chapter 8	Values to be confirmed in design
Mulch	50–75 mm (Clause 8.7.2(c)); shredded hardwood or similar organic mulch that does not float away at the ponding depth	Material and source
Filter media	600–900 mm engineered sandy loam with low fines and low phosphorus content (Clause 8.7.2(c))	Particle size grading; fines (silt + clay) limit; organic matter content; phosphorus limit; saturated hydraulic conductivity of the compacted media; source and test certificate for each batch
Transition (choker) layer	Between media and gravel, to stop media washing into the gravel (Clause 8.7.2(d))	Thickness and grading, matched to the media and gravel
Gravel drainage layer	Below the transition layer, surrounding the underdrain (Clause 8.7.2(d))	Thickness, grading, washed
Underdrain	Perforated pipe where Clause 8.7.2(e) applies, with cleanouts	Diameter, slope, perforation, outlet level
Liner	Where Clause 8.7.2(f) applies (cannot meet Clause 8.8; hotspots)	Liner type and protection

Media shall be tested before placing, and placed in lifts without heavy compaction. The State Stormwater Technical Committee should set numeric limits for grading, fines, organic matter and phosphorus, with local sources of sand and compost, when it reviews this annex.

8D.4 Plant lists

The lists below are **indicative**. They name species that are native or long naturalised in West Bengal and known to tolerate both wet and dry periods. Bengali names are given only where the *Samsad Bengali–English Dictionary* (Biswas, 3rd edition, 2000) gives the name for the species or plant named; a dash means none was confirmed. Final selection shall be confirmed with a horticulturist or the Forest Department for the site's soil, salinity and climate. Delta sites need species tolerant of long waterlogging in heavy clay; western plateau sites species tolerant of dry lateritic soils; coastal and Sundarbans sites salt-tolerant species, not all listed here.

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

Use	Botanical name	Bengali name	Notes
Swales, filter strips, bioretention edges	*Chrysopogon zizanioides* (vetiver)	—	Deep-rooted clump grass; tolerates flooding and drought; binds soil on side slopes and pond banks. Samsad gives বেনা (benā) as "verbena" and বেনার মূল as "vertiver, cuscus" (p. 787), so the name of the root is confirmed but not that of the plant
Swales and filter strips (turf)	*Cynodon dactylon* (Bermuda grass)	—	Low turf; tolerates drought, traffic and short flooding. Samsad gives দূর্বা (dūrbā) only as "grass" (p. 511)
Trees beside bioretention and swales	*Syzygium cumini*	জাম (jām)	Native; tolerates wet ground. Samsad: "the rose-apple, the jambu" (p. 399); confirm the species locally
Trees beside bioretention and swales	*Lagerstroemia speciosa*	জারুল (jārul)	Native; tolerates seasonal waterlogging. Samsad: "a kind of tree … *Lagerstroemia flosreginae*" (p. 400), an older name of this species
Trees beside wet ponds and wetland margins	*Barringtonia acutangula*	হিজল (hijal)	Native tree of seasonally flooded land. Samsad: "the Indian oak, the *Barringtonia acutangula*" (p. 1057). Keep roots clear of underdrains
Trees beside bioretention and swales	*Millettia pinnata* (syn. *Pongamia pinnata*)	—	Native; tolerates waterlogging and drought. Samsad's করঞ্জ (karañja) is "a variety of sour fruit" (p. 205), so the name is not confirmed for this species
Trees beside bioretention and swales	*Terminalia arjuna*	—	Native riverbank tree; tolerates seasonal flooding. Samsad's অর্জুন (arjuna) is "a kind of tree" with a medicinal bark (p. 75), without naming the species
Bioretention (flowering, wet zones)	*Canna indica*	—	Naturalised; tolerates waterlogging; widely used in constructed wetlands in India

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

Zone	Botanical name	Bengali name	Notes
Shallow macrophyte zone	*Typha* spp. (e.g. *T. domingensis*, syn. *T. angustata*)	—	Native; spreads quickly and needs periodic harvesting. Samsad's হোগলা (hogalā) is "bulrush, a species of aquatic grass chiefly used in building the walls of huts" (p. 1063), without naming the genus; confirm locally
Shallow macrophyte zone	*Phragmites karka*	—	Native reed; vigorous; keep out of khals and channels where it would obstruct flow. Samsad's নল (nala) includes "a kind of reed" among other senses (p. 558)
Shallow macrophyte zone	*Canna indica*	—	As Table 8D.13

Zone	Botanical name	Bengali name	Notes
Open water and deep zones	*Nelumbo nucifera* (lotus)	পদ্ম (padma)	Native; for permanent pools only. Samsad: "the lotus, the lily" (p. 613)
Open water and deep zones	*Nymphaea* spp. (water lily)	—	Native; for permanent pools only. Samsad's শালুক (śāluk) is "a stalk of the waterlily" (p. 944)
Tidal margins (brackish or saline sites only)	*Heritiera fomes* (sundari)	সুন্দরী (sundarī)	Native mangrove tree of the Sundarbans. Samsad: "a kind of timber-tree grown in Sundarbans … *Heritiera sundari*, sundri" (p. 1018)
Tidal margins (brackish or saline sites only)	*Nypa fruticans* (nipa palm)	গোলপাতা (golpātā)	Native mangrove palm of tidal creeks. Samsad gives golpātā as the leaf of "a small tree akin to the fanpalm … *Nipa fruticans*" (p. 324), so the name is strictly the leaf's
Tidal margins (brackish or saline sites only)	*Avicennia* spp., *Excoecaria agallocha*, *Sonneratia apetala* and other mangroves	—	Native to the Sundarbans; no Bengali name was confirmed in Samsad for these species (Samsad's গরান, garān, is "the mangrove or its timber", p. 300, without a species). Plant mangroves only where the site is tidal and the species is native to it, with the advice of the Forest Department. Mangroves are protected under the CRZ Notification, and any work in or near them needs CRZ clearance (Chapter 7). Existing mangroves at an outfall shall be kept and the outfall designed around them; new planting shall not be placed where it would obstruct the flow from an outfall, a sluice through an embankment, or a tide gate

Table 8D.15 — Species not to be planted

Botanical name	Bengali name	Reason
Eichhornia crassipes (water hyacinth)	কচুরিপানা (kacuripānā)	Invasive; chokes pukurs, khals, bheris and screens. Samsad: "water hyacinth" (p. 193)
Prosopis juliflora	—	Invasive on pond beds, embankments and drain banks
Ipomoea carnea	—	Invasive in ponds and channels; obstructs flow

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Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

Table 8E.1 — Selection of measures (Clause 8.12.3)

Situation	Measure	Detail
Sheet flow leaving a disturbed area, along its downslope edge	Silt fence	Figure 8E.1
Concentrated flow from a disturbed area of up to 2 ha	Sediment trap	Figure 8E.2

Situation	Measure	Detail
Disturbed area of more than 2 ha	Sediment basin with surface dewatering outlet	Figure 8E.2
Existing drain inlet receiving site runoff	Inlet protection	Figure 8E.4
Vehicle exit to a public road	Stabilised construction exit, with wheel washing	Figure 8E.3
Stockpiles	Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the SW monsoon	Notes to Figure 8E.1
Dewatering	Through a sediment basin, settling tank or filter bag; never pumped directly to a drain or waterbody	Notes to Figure 8E.2
Concrete washout	Lined pit; never into a drain	Notes to Figure 8E.3

8E.1 Silt fence

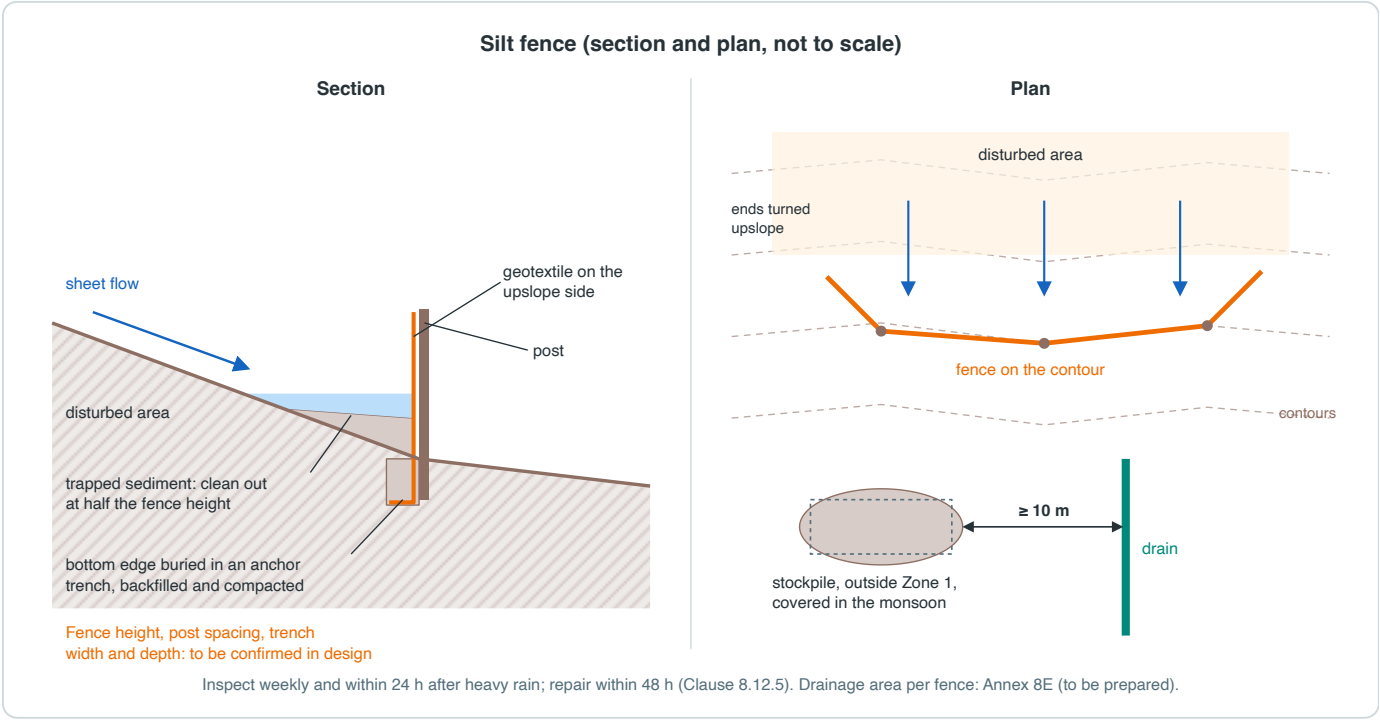


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

To be prepared. Clause 8.12.3(a) refers to this annex for the limit on the area draining to each silt fence. That limit, and the maximum slope length above a fence, need to be set by the State Stormwater Technical Committee for West Bengal rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

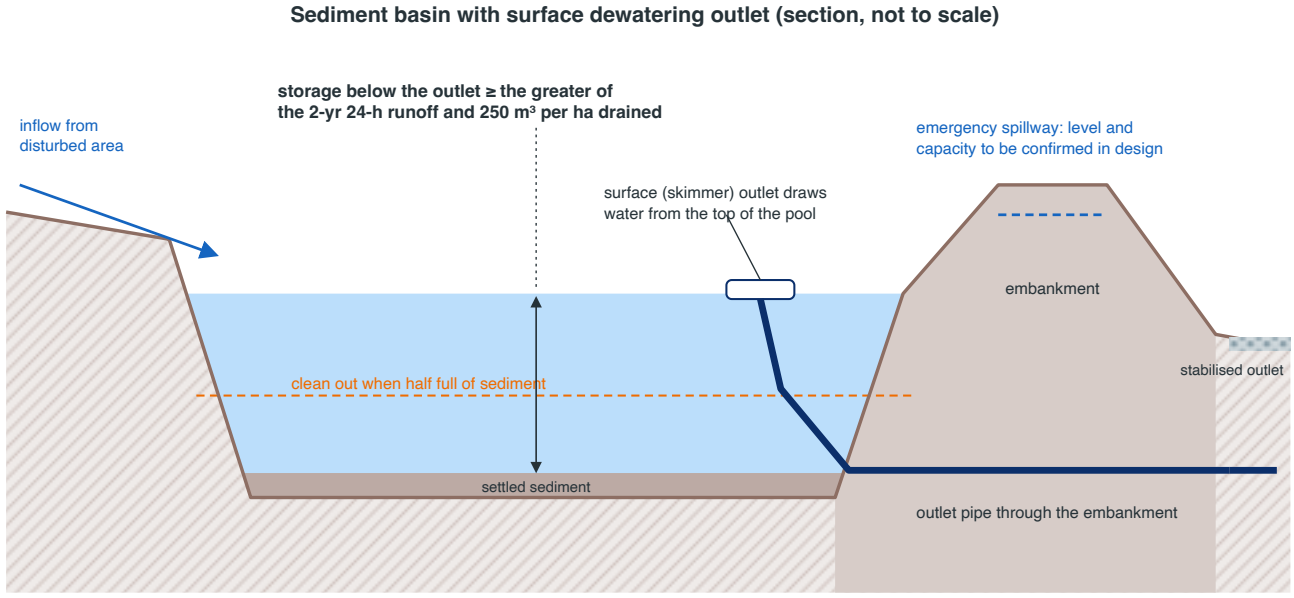
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used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

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

Notes:

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

8E.2 Sediment trap and sediment basin



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

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

Notes:

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

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

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

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

8E.3 Stabilised construction exit and concrete washout

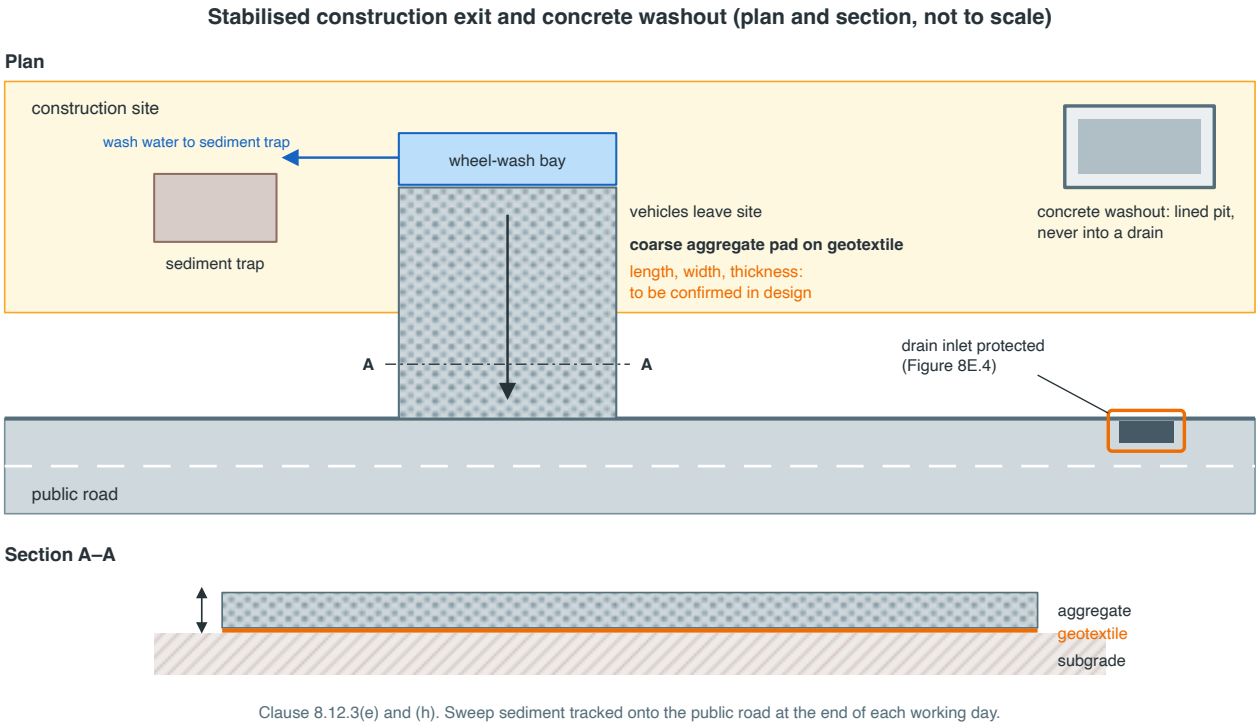


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing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

Notes:

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

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

8E.4 Inlet protection

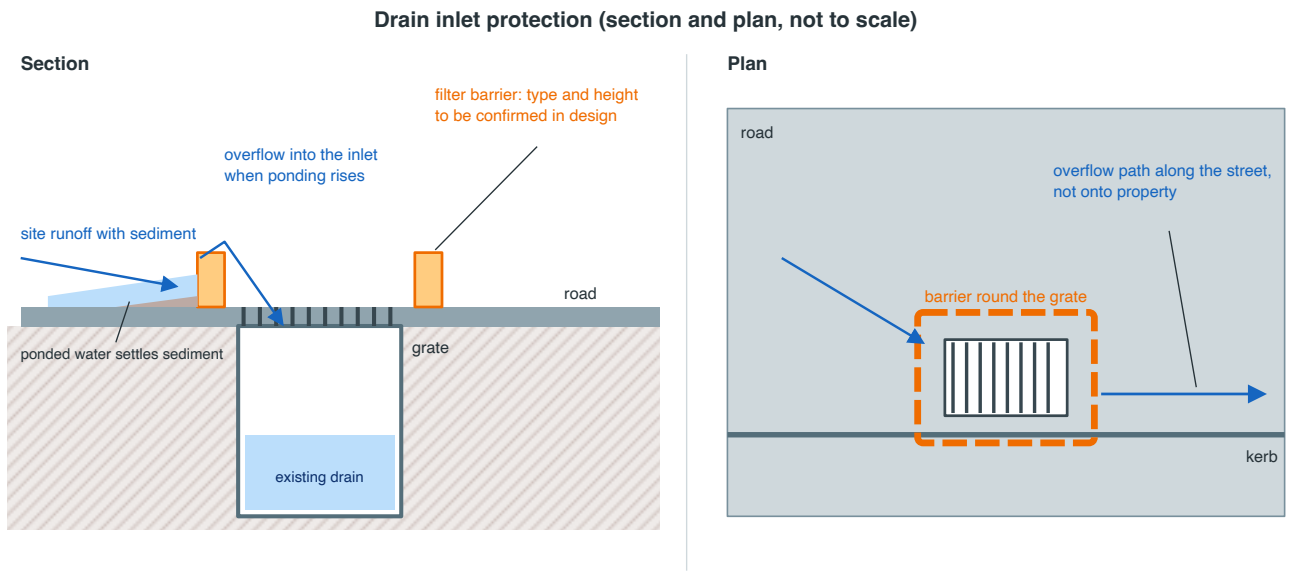


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual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

Notes:

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

8E.5 Timing and inspection

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

Item	Requirement
Completed earthworks	Stabilised by vegetation, mulch, matting or paving by 15 May
Area cleared between 1 June and 30 September	Sediment controls in place before clearing
Area exposed in the SW monsoon	As small as practicable
Inspection	Weekly, and within 24 h after every heavy-rainfall event (Chapter 10)
Repair	Within 48 h
Cleaning	When half full of sediment
Removal	Only after the area draining to the measure is stabilised

Form 8-1 — Water Quality Sheet

Supports Clauses 8.4, 8.6 and 8.14 of Chapter 8.

Draft form — West Bengal 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 — West Bengal 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.

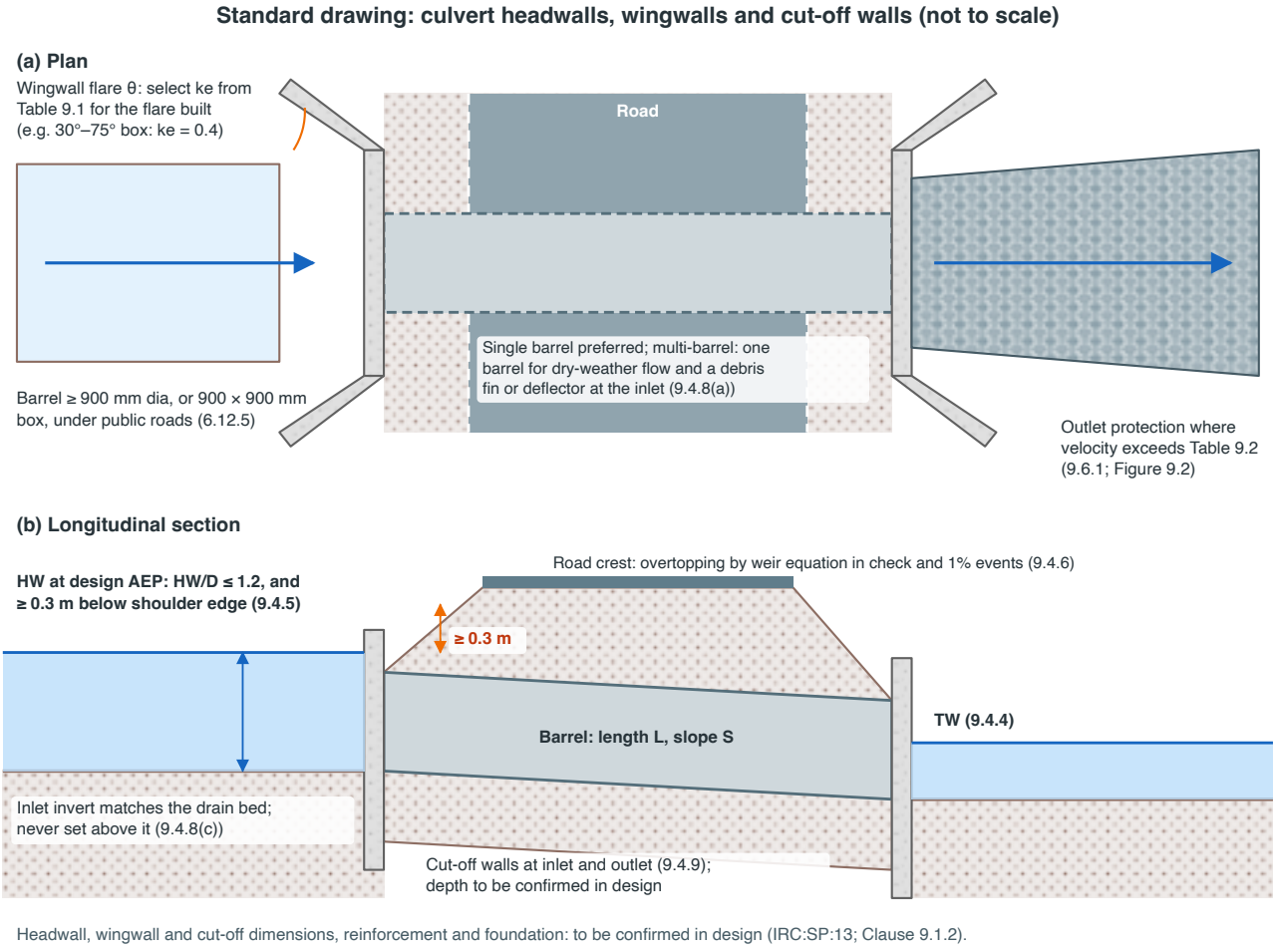


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

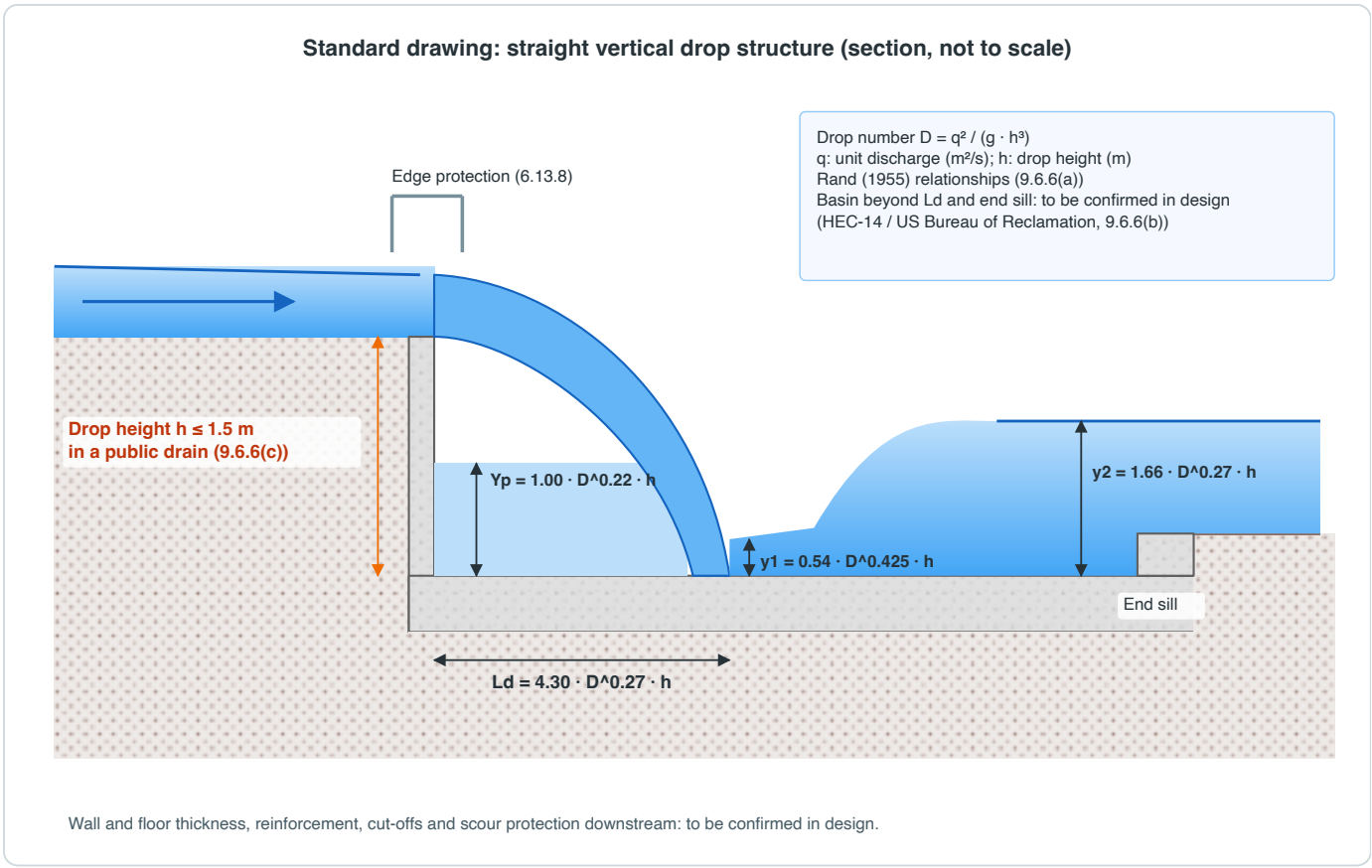


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

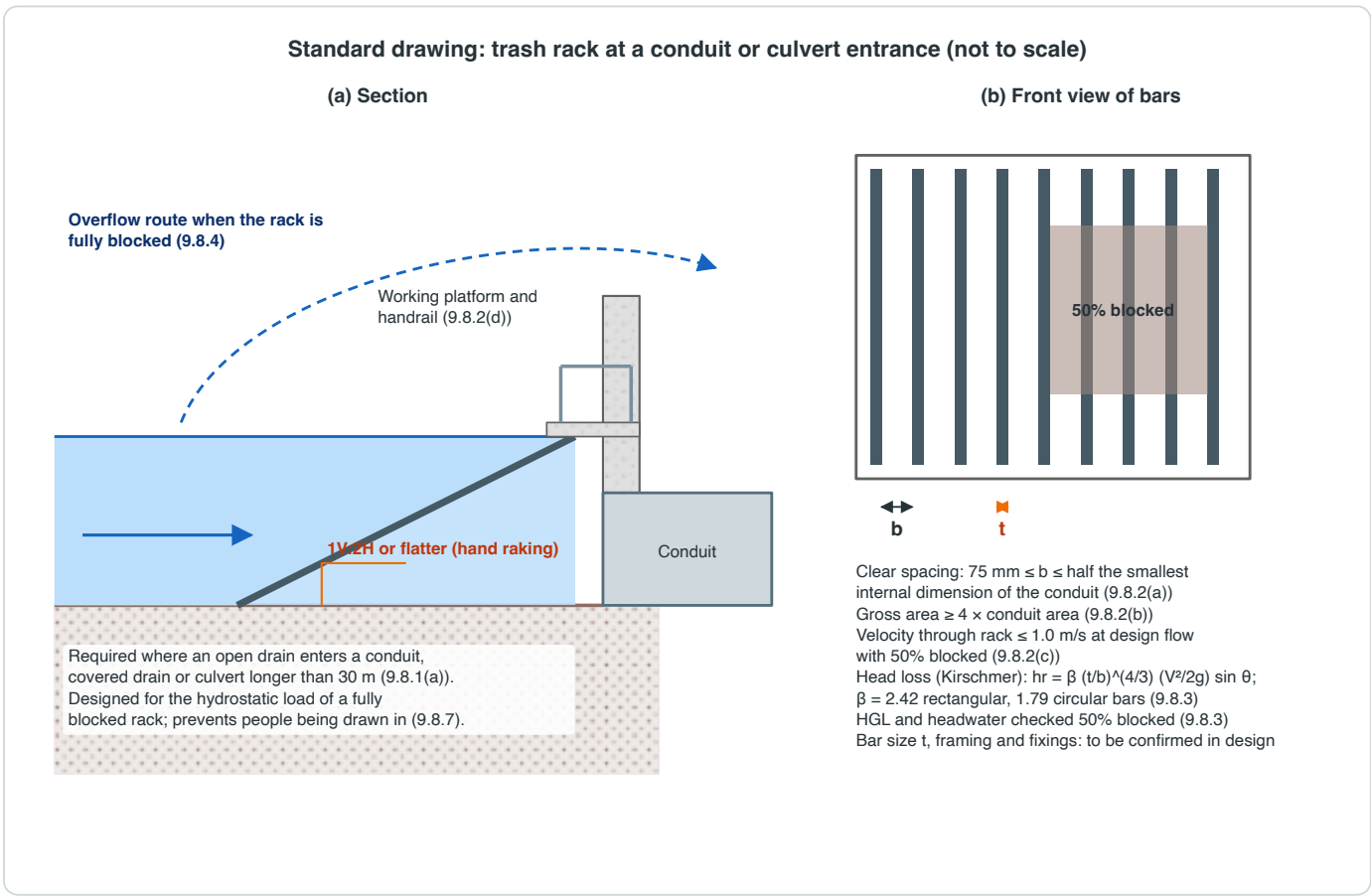


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

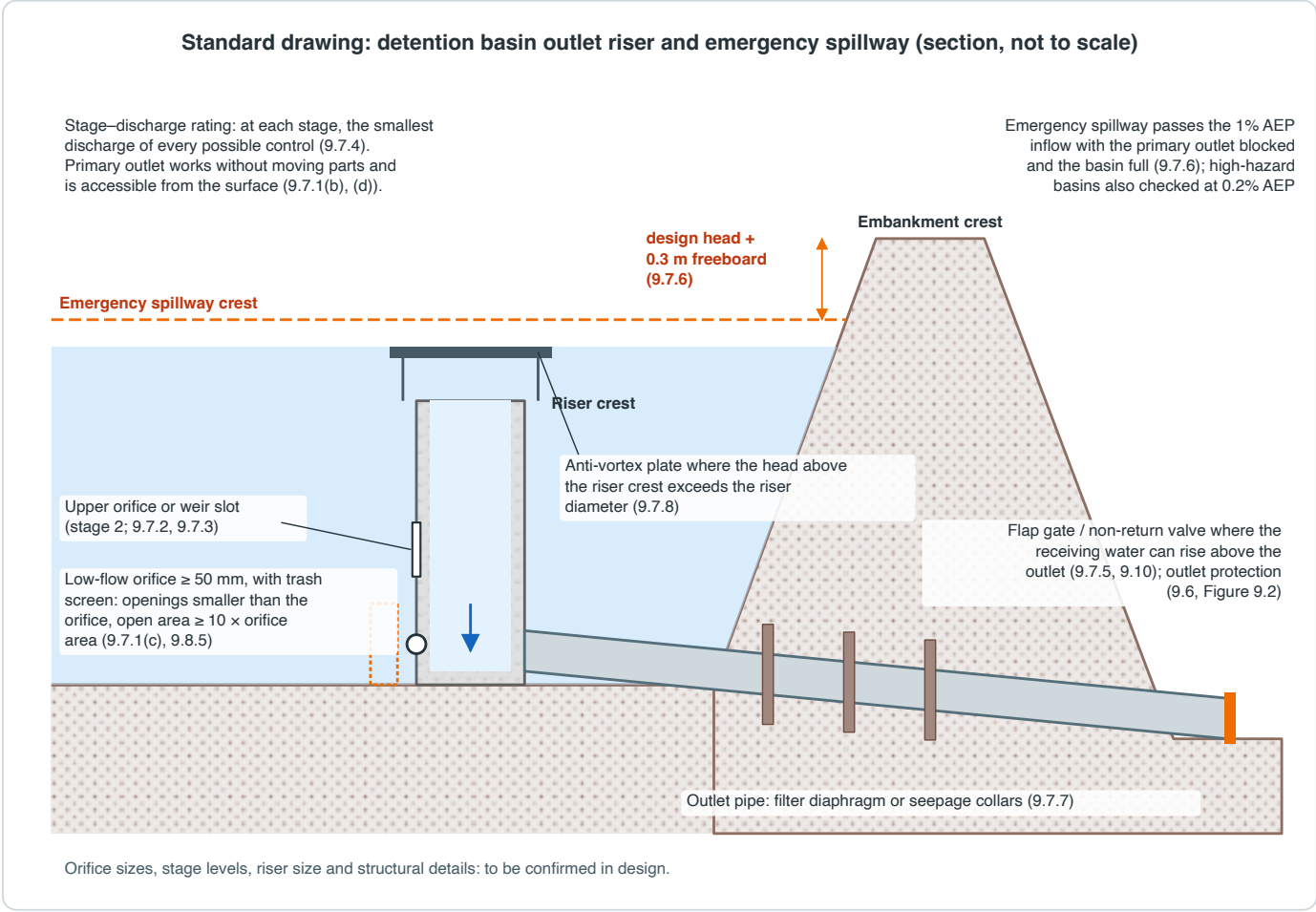


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — West Bengal Stormwater Design Manual, Draft v1.0. Not for statutory use.

Attach this checklist to the front of the Hydraulic Structures Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

Section A — Project

Table 9F.1 — Form 9-1, Section A: project

Field	Entry
Project name and location	_____
Local body, and Tier A or Tier B (Chapter 1)	_____
Applicant	_____
Designer (name and registration)	_____
Structures covered (culverts, channels, dissipators, outlets, screens, pumps, gates, inlets, manholes)	_____
Tailwater conditions used: MHWS, HAT + surge, sea-level allowance, joint case (Clause 9.2.1)	_____
Date and revision	_____

Section B — Contents required by Clause 9.14

Table 9F.2 — Form 9-1, Section B: contents required by Clause 9.14

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
1	Culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check	9.4, 6.12		
2	Channel water-surface profiles, velocities, Froude numbers and freeboard	9.5		
3	Outlet protection and dissipator design, with riprap sizing	9.6		
4	Detention outlet stage–discharge tables and the emergency spillway check	9.7		
5	Screen and rack design with the 50% blocked check	9.8		
6	Pump station design report: inflow hydrograph, storage, pump and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check (with Annex 9C)	9.9		
7	Gate and valve selection with head-loss data	9.10		
8	Inlet, grate and cover load classes	9.11		
9	Exposure class and materials statement	9.13		

Section C — Compliance checks

Table 9F.3 — Form 9-1, Section C: compliance checks

No.	Check	Limit	Clause	Complies (Yes / No / NA)
C1	Climate factor included in design flows	Clause 2.8	9.2.2	
C2	Blocked condition checked where debris can block; safe overflow route	—	9.2.5	
C3	Pipes and box drains: design n (box drains ≥ 0.015); supercritical pipes: jump located in a structure, air venting	—	9.3.1, 9.3.4	
C4	Pipe size does not decrease downstream; joins only at manholes or junction chambers; no change of direction over 90°	—	9.3.5	
C5	Culvert design headwater = greater of HWi and HWo	—	9.4.1	
C6	Culvert headwater at the design AEP	HW/D ≤ 1.2; ≥ 0.3 m below shoulder edge	9.4.5	
C7	Road overtopping weir coefficient	Cd ≤ 1.66	9.4.6	
C8	Culvert inverts match the drain bed; headwalls, wingwalls and cut-off walls	—	9.4.8(c), 9.4.9	
C9	Channel Froude number at the design flow	≤ 0.8; none between 0.8 and 1.2	9.5.2	
C10	Channel velocity	Table 9.2	9.5.3	
C11	Channel slope in engineered channels	≤ 0.4% natural, ≤ 0.2% concrete, or drops / chute	9.5.4	
C12	Side slopes; low-flow channel where bed width ≥ 3 m; uplift or weep holes	—	9.5.6, 9.5.7, 9.5.9	
C13	Outlet protection where outlet velocity exceeds Table 9.2	Table 9.3 apron, or basin	9.6.1, 9.6.3	
C14	Single vertical drop height	≤ 1.5 m	9.6.6(c)	
C15	Detention primary outlet: no moving parts; minimum orifice	≥ 50 mm with screen	9.7.1	
C16	Emergency spillway	1% AEP, outlet blocked, basin full, 0.3 m freeboard; 0.2% AEP for high-hazard basins	9.7.6	
C17	Outlet pipe through embankment; anti-vortex plate where needed	—	9.7.7, 9.7.8	
C18	Conduit-entrance racks	Spacing 75 mm to half the smallest conduit dimension; area ≥ 4×; ≤ 1.0 m/s at 50% blocked	9.8.2	
C19	Detention orifice screens	Openings smaller than the orifice; open area ≥ 10×	9.8.5	
C20	Pump station	Annex 9C checklist complete	9.9	
C21	Gates on outfalls below the 1% AEP still-water level; secondary closure; corrosion-resistant fittings	—	9.10	
C22	Grate load classes, parallel openings ≤ 25 mm, kerb openings ≥ 100 mm × 1.0 m, locked covers	—	9.11	
C23	Manhole sizes (Table 9.4), 600 mm access openings, drops, benching, surcharge covers	—	9.12	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
C24	Exposure class (Table 9.5); chloride and sulphate tests in coastal and delta areas; sulphide protection; metalwork within 5 km of the coast	—	9.13	

Section D — Variances

Table 9F.4 — Form 9-1, Section D: variances

Clause	Requirement not met	Reason and proposed alternative	Approved by and date
_____	_____	_____	_____

Section E — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). For a facility with an embankment, a high-hazard basin, a pumped facility, a tide gate or a regional facility, the signatory shall be an empanelled Stormwater Design Professional, and a second, independent empanelled professional shall sign as checker (Clauses 10.6.1(c), (d) and 10.6.4).

Table 9F.5 — Form 9-1, Section E: signatures

Role	Name	Registration or empanelment no.	Signature	Date
Designer	_____	_____	_____	_____
Independent checker (Clause 10.6.4, where applicable)	_____	_____	_____	_____

Draft form — West Bengal Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

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

Annex 10A — Compliance calculator and user guide

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

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

10A.1 General requirements

The calculator shall:

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

10A.2 Inputs

Table 10A.1 — Calculator inputs

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

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

10A.3 Calculations, by clause

Table 10A.2 — Calculations the calculator shall perform

Step	Calculation	Clause
C1	**Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies in Kolkata to new or expanded buildings and housing complexes "as per" the EIA guideline (KMC Building Rules 2009, rule 144(1)), in New Town to every new building or housing complex and every expansion (New Town Kolkata (Building) Rules 2009, rule 28(4), as amended in 2021), and in the municipal areas as the West Bengal Municipal (Building) Rules 2007 set (threshold not read for this Manual [TBC]).	1.5.2–1.5.8

Step	Calculation	Clause
C2	**Process flags.** Stage 0 mandatory (≥ 2 ha, flood-sensitive, variance or regional route, tidal outfall or waterbody); Stages 1 and 2 may be combined (< 1 ha, not flood-sensitive); empanelled signatory required; independent check required.	10.3.2, 10.3.3, 10.6.1, 10.6.4
C3	**Route eligibility.** Tier B simplified method: ≤ 2 ha, or ≤ 0.5 ha in a flood-sensitive catchment, and only once Table 4.3 is published. Fixed-coefficient route: ≤ 1 ha and none of the exclusions of Clause 4.14.3. Constrained redevelopment: existing ≥ 60% impervious and ≤ 1 ha. Regional detention or fee-in-lieu: only in a basin with an approved BSMP.	4.5.6.1, 4.13.1, 4.14.1, 4.14.3, 11.12.1(b)
C4	**Retention volume.** RRV = 10 × Q_R × A, with Q_R the SCS-CN runoff from P_R for each sub-area at AMC II, summed over sub-areas. The larger of the Ia = 0.2S and Ia = 0.05S results governs. The Rv form (RRV = 10 × P_R × Rv × A, Rv = 0.05 + 0.009 × I) is offered only for sites < 0.5 ha and the Tier B method. No climate factor.	4.4.2, 3.8.5(c), 2.8.3
C5	**Preservation credit.** Preserved areas are modelled at their pre-development CN in the post-development condition.	4.4.7
C6	**Retention checks.** Design infiltration rate ≤ half the measured rate; groundwater ≥ 1.0 m below the base; drawdown of the retained volume within 72 h at the design rate (or by the stated reuse demand). A practice that fails any check gets no credit; any shortfall is reported and treated as WQv.	4.4.3–4.4.5, 4.4.6.4
C7	**Water quality volume.** P_wq = max(P_ret, P_3m); WQv = 10 × Q_wq × A by SCS-CN, or (P_wq / 1000) × Rv × A (A in m²) for sites < 0.5 ha and the Tier B method. The retained volume counts toward the WQv in full. No climate factor.	8.4.1–8.4.4, 3.8.5(c)
C8	**Retention credit.** Tier A: the credit found by routing is entered (I16); the calculator does not compute it. Tier B: V_credit = C_R × RRV provided, with C_R = 0 until Annex 4B is published.	4.4.6
C9	**Design-aid route (S-1).** V = SSR × A − V_credit; Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages, from Table 4.3. Shown as "not available" until Table 4.3 is published.	1.7.2, 4.14.2
C10	**Permissible site discharge (S-2).** Q = PSD (m³/s/ha) × A for each AEP, from the S-2 tables. Shown as "not available" until they are issued.	1.7.2, 1.7.3(e)
C11	**Fixed-coefficient route.** Q_cap,10 = 2.78 × C_10 × i_10 × A and Q_cap,2 = 2.78 × C_2 × i_2 × A (L/s); V_100 and V_2 = max over d of [10 × C_v × P(d) × A − 1.8 × Q_cap × d] for d = 1 to 72 h, with pervious C ≥ 0.50 for d ≥ 12 h; V = max(V_100, V_2); retention added without credit. Coefficients from Table 4.3A (provisional).	4.14.4–4.14.7
C12	**Release-rate screen (full method).** For each AEP and duration: Q_post ≤ 0.9 × Q_pre (standard), or the two mixed-frequency caps (flood-sensitive). Report the governing duration and margin.	4.5.2, 4.5.3
C13	**Constrained redevelopment.** Q_post ≤ 0.5 × Q_existing for 2-, 10- and 100-yr at each duration; shortfall volume = greenfield storage − storage provided; fee = shortfall × unit rate.	4.5.6.2, 4.5.6.3
C14	**Minimum orifice.** Flag any orifice < 50 mm. Where a cap is below the discharge of a 50 mm orifice at the corresponding stage, report "50 mm orifice deemed to comply".	4.5.5.1, 4.8.2
C15	**Drawdown.** Report the detention drawdown (90% of the 10-yr stored volume within 48 h), the WQv release time (24–48 h) and the retention emptying time (≤ 72 h).	4.7
C16	**Fee-in-lieu.** Fee = detention volume required on site × notified unit rate.	4.13.3
C17	**Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide.	10.5.2(c)
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 45N (EPSG:32645), 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 tidal datums (chart datum of the nearest port, mean sea level on the GTS datum and, in Kolkata, the Kidderpore Old Datum (KOD)) 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 `KMC-BP-2026-0123_S2_20261015.gpkg`.
- (f) **Identifiers.** Every feature has an identifier unique within the submittal (FAC_ID, OUT_ID, CAT_ID, FLP_ID). The Authority replaces them with register identifiers on acceptance and returns the mapping to the Applicant.

10B.2 Layers

Table 10B.1 — Layers

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

10B.3 Attribute schema

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

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

Field	Type	Unit	Req.	Content	Source
FAC_ID	T	—	Yes	Facility identifier	10B.1(f)
FAC_TYPE	T	—	Yes	Code from Table 10B.7	Clause 4.10, Table 10.3
FAC_NAME	T	—		Name on the drawings	—
OWNER_TYP	T	—	Yes	PRIVATE / ASSOC / DEVELOPER / ULB / DEPT	Clauses 10.10, 10.14
OWNER_NM	T	—	Yes	Name of a corporate owner or association only; for an individual, "private individual" (Clause 10.17.3)	Clause 10.17.3
CTRL_AREA	R	ha	Yes	Area draining to the facility	Clause 4.5.1.3
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

Field	Type	Unit	Req.	Content	Source
PUMPED	T	—	Yes	Y / N	Clause 10.10.3
REGIONAL	T	—	Yes	Y / N	Clause 4.13
EMPANEL	T	—	Yes	Y / N: facility under Clause 10.6.1(c) or (d)	Clause 10.6.1
STATUS	T	—	Yes	Code from Table 10B.8	Clause 10.17.1(a)
APPR_DATE	D	—		Date of Stage 2 approval	Clause 10.3
ASB_DATE	D	—		Date the as-built certificate was accepted	Clause 10.9
DECL_REF	T	—		Registration reference of the Maintenance Declaration (Form 10-6)	Clause 10.10.1(e)
HAND_DATE	D	—		Date of the Asset Handover Certificate (Form 10-8)	Clause 10.14
LAST_INSP	D	—		Date of the latest inspection	Clause 10.12
INSP_RES	T	—		Code from Table 10B.9	Clause 10.17.1(a)
OUT_ID	T	—	Yes	Outfall to which the facility discharges	—

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

Field	Type	Unit	Req.	Content	Source
OUT_ID	T	—	Yes	Outfall identifier	10B.1(f)
RECEIVER	T	—	Yes	Receiving drain, channel, waterbody or sea, by name	Clause 4.5.1.3
RECV_TYPE	T	—	Yes	PUBLIC_DRAIN / CANAL / RIVER / TANK / SEA / OTHER	Chapter 5
INV_LEVEL	R	m	Yes	Outfall invert level	Clause 10.9.1(a)
SIZE_MM	R	mm	Yes	Diameter, or width × height written in the drawing	Chapter 6
TIDAL	T	—	Yes	Y / N	Chapter 5
GATE_TYPE	T	—		NONE / FLAP / TIDE / DUCKBILL / PENSTOCK / NRV	Clauses 5.11, 9.10
GATE_REQ	T	—	Yes	Y / N: invert below the 1% AEP still-water level	Clause 5.11.1
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1
Q_100	R	L/s		Design 1% AEP discharge	Chapter 5

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

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

Field	Type	Unit	Req.	Content	Source
NOTES	T	—		Free text	—

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

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

Table 10B.6 — Metadata (SW_META)

Field	Content
FILE_NO	Authority file number
STAGE	1, 2, 4 or HANDOVER
H_CRS	EPSG code of the horizontal reference system
V_DATUM	Name of the vertical datum
TIDE_REL	Relationship of the vertical datum to the Chapter 5 tidal datums (chart datum of the nearest port, mean sea level on the GTS datum and, in Kolkata, the Kidderpore Old Datum (KOD)) (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

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

Table 10B.8 — Status codes (STATUS)

Code	Meaning
PROPOSED	In a Stage 1 or Stage 2 submittal
APPROVED	Stage 2 approved; not yet built
ASBUILT	As-built certificate accepted (Clause 10.9)
HANDEDOVER	Accepted by the ULB (Clause 10.14)
ALTERED	Changed with the Authority's approval (Clause 10.3.5)
REMOVED	Removed with the Authority's approval

Table 10B.9 — Inspection result codes (INSP_RES)

Code	Meaning
OK	Working as designed; no defect
MINOR	Defect found and corrected; date in the inspection record
MAJOR	Defect affecting storage, outlet or safety; notice issued (Clause 10.15.2, step 1)
NOACCESS	Inspection could not be made
NOTFOUND	Facility missing, filled, covered or changed in use (Clause 10.15.1(c))

10B.5 Facility register extract

The public facility register of Clause 10.17.1(a) is an extract of SW_FAC: FAC_ID, FAC_TYPE, location (centroid), V_DET (and V_RET, V_WQ), Q_100 (and Q_2, Q_10), OWNER_NM, ASB_DATE, LAST_INSP and INSP_RES. It is published as CSV and GeoPackage under the licence of Clause 10.17.4. Personal data are not published (Clause 10.17.3).

Annex 10C — Maintenance access dimensions

Supports Clause 10.13 of Chapter 10.

Clause 10.13 sets access by function. This annex collects the access dimensions that the Manual already sets in other chapters, and lists the dimensions that it does not set. Where a dimension is not set by the Manual, the designer shall state it on the drawings, show that it suits the plant and equipment named in the O&M plan (Clause 10.11.1(h)), and mark it "to be confirmed in design".

Table 10C.1 — Access dimensions set by the Manual

Element	Requirement	Clause
Open drains with a top width of 2 m or more	Maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m	6.9.4
Drainage reserves	Width not less than Table 6.9, based on the required drain size; where the access strip of Clause 6.9.4 is wider, the wider governs	6.9.7
Covered drains, minimum section	0.6 m × 0.6 m clear	6.7.6
Covered drains, removable covers	Panels at not more than 10 m centres, each at least 0.6 m long and spanning the full clear width, liftable by two workers or a hand-operated device	6.13.2(a)
Covered drains, access chambers	Clear opening at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than 30 m centres on straight runs	6.13.2(b)
Manholes and access chambers on public drains	Clear access opening at least 600 mm	9.12.3
Inlet chambers on public roads	Silt sump at least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7
Underground tanks and vaults	Access openings over the outlet chamber and over every inlet; in tanks over 500 m², not more than 30 m apart; floor falling at least 1% to a sump at the outlet	4.10.2(b), (c)
Detention outlets serving more than 1 ha	A means of isolating the outlet (stop-log slot or penstock)	4.8.6
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 West Bengal 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)

Item	Content	Clause
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 15 May; after each heavy-rainfall day	No blockage; overflow clear	Table 10.3
Check drawdown at the observation well or surface	At each inspection after rain	Empties within 72 h of the end of rain; if not, investigate clogging	4.4.5, 8.7.6(c)
Clean pretreatment (forebay, filter strip, silt trap)	When the sediment trigger (item 3) is reached	Pretreatment cleaned without disturbing the main BMP	8.5.3, 8.5.4
Bioretention: mulch, plants, ponding	Every 6 months	Ponding drains within 48 h; dead plants replaced; mulch 50–75 mm	8.7.2
Permeable paving: surface	Every 6 months	Sweep or vacuum; no resurfacing with impermeable material	8.7.5(e)
Keep the contributing area stable	Each inspection	Bare soil stabilised; no sediment washing in	10.8.3(b)
Keep the facility in place and in use	Each inspection	Not filled, covered, paved or built over without approval	10.10.1(d)

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

Task	Frequency	Standard or trigger	Clause
Inspect inlets, outlet, orifice, trash rack and spillway	Every 6 months; before 15 May; after each heavy-rainfall day	Orifice and rack clear; spillway unobstructed	Table 10.3, 4.8, 4.9
Remove debris and sediment	When the sediment trigger is reached, and after events	Design volume restored	10.11.1(c)
Check that the basin drains	After rain	No low point ponds for more than 72 h	4.15.7
Vegetation	As set in the plan	Grass cut; no woody growth on embankments or in the outlet zone	10.11.1(b)
Safety features	Every 6 months	Signs in 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 15 May; after each heavy-rainfall day	Clear; vents open	Table 10.3, 4.10.2
Clean the sump and floor	When the sediment trigger is reached	Floor falls freely to the sump	4.10.2(c)
Inlet silt trap or GPT	Every 3 months (Table 10.3 row for GPTs)	Cleaned	4.10.2(e)
Overflow route	Each inspection	Operates when the outlet is blocked; route to the overland path unobstructed	4.9.5
Confined-space entry	Each entry	Entry procedure stated in the maintenance declaration followed; covers locked after	4.15.6
Use of the space	Each inspection	Not used for parking or storage; volume not reduced	10.10.1(d)

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

Task	Frequency	Standard or trigger	Clause
Test run of each pump, duty and standby	Monthly	Each pump starts on level control; roles alternate	Table 10.3, 9.9.4(c)
Full duty test	Before 15 May	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 15 May	Automatic changeover works; fuel for at least 72 h of all duty pumps on site	9.9.9
Level sensors, float back-up, alarms, telemetry	Monthly	High-level and fault alarms reach the control room	9.9.8
Screens and silt trap	Every 3 months and after events	Clean	9.9.7
Records	Continuous	Sump levels, run hours and power status logged; kept at least 5 years	9.9.8(c)
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 15 May	Seals against the receiving water	Table 10.3, 10.9.3
Beach, estuary and creek outfalls	After every high-tide or surge event in the monsoon season	Sand and debris cleared	9.10.5(b)
Isolation	Before 15 May	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 15 May	No corrosion that would stop the gate working	9.10.6

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

Table 10D.8 — Private drains and inlets

Task	Frequency	Standard or trigger	Clause
Inspect and clean drains, inlets and silt sumps	Every 6 months; before 15 May	Free of silt and debris	Table 10.3
Check for sewage connections	Each inspection	None; any cross-connection removed	1.5.4, 8.9
Overland flow paths	Each inspection	Not obstructed by walls, fill or stored material	6.9.2, 10.15.1(g)

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

Supports Clauses 10.6, 10.7.4 and 11.4.3 of Chapter 10.

> *Model text for consideration by a competent authority. Not in force.* Clause 10.6.2 assigns the issue of empanelment criteria to UD&MA. 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 KMC Building Rules 2009 and the West Bengal Municipal (Building) Rules 2007 (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 — West Bengal 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 tidal datums (chart datum of the nearest port, mean sea level on the GTS datum and, in Kolkata, the Kidderpore Old Datum (KOD))	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 — West Bengal 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 — West Bengal 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, KMCBR/WBMBR 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 West Bengal 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 — West Bengal 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 — West Bengal 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 — West Bengal 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, block, 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 15 May each year;
5. for underground tanks, to follow the confined-space entry procedure stated here: _____ (Clause 4.15.6);
6. on sale or transfer of the land or any part of it, to disclose this declaration and the latest Form 10-7 to the purchaser, who takes on these obligations from the date of transfer (Clause 10.10.4); and
7. for a multi-owner development, that the developer remains responsible until the body named at A5 is legally constituted and has accepted this declaration in writing (Clause 10.10.2).

Table 10F.23 — Form 10-6, Section C: Execution and registration

Field	Entry
Owner: signature, name, date	_____
Witness 1: signature, name, address	_____
Witness 2: signature, name, address	_____
Acceptance by the association or body at A5 (when constituted): signature, date	_____
Registration: office, document number, date	_____
For the Authority: received and recorded in the facility register; officer, date	_____

Form 10-7 — Annual Maintenance Declaration and Inspection Report

Supports Clauses 10.10.3, 10.11.1(d) and 10.12 of Chapter 10.

Draft form — West Bengal Stormwater Design Manual, Draft v1.0. Due by **15 May** each year from every owner of a facility in a Tier A area, and from every owner of a pumped facility, tide gate or regional facility anywhere (Clause 10.10.3). See Figure 10.3.

Table 10F.24 — Form 10-7, Section A: Owner and facilities

No.	Field	Entry
A1	Reporting year (1 June to 31 May)	_____
A2	Owner or association; Maintenance Declaration registration reference	_____
A3	Facilities covered (FAC_ID and type)	_____
A4	Any facility under Clause 10.6.1(c) or (d) (yes / no). If yes, Section E is required	_____

Table 10F.25 — Form 10-7, Section B: Inspections made during the year (Table 10.3)

Facility	Routine inspections (dates)	Pre-monsoon inspection (date)	After heavy-rainfall events (dates)	Monthly pump test runs (number)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Table 10F.26 — Form 10-7, Section C: Pre-monsoon checklist (one per facility)

No.	Item	Condition (OK / defect)	Defect and date corrected
C1	Inlets, pretreatment and silt traps clear	_____	_____
C2	Orifice, trash screen and outlet clear; orifice size unchanged	_____	_____
C3	Sediment below the trigger in the O&M plan	_____	_____
C4	Storage volume not reduced; no filling, covering or change of use	_____	_____
C5	Overflow and spillway route clear	_____	_____
C6	Retention drains within 72 h (observation well or surface)	_____	_____
C7	Pumps: full duty test; standby pump and standby power tested; fuel for 72 h on site	_____	_____
C8	Alarms and telemetry tested	_____	_____
C9	Flap or tide gates and non-return valves: operated and seal tested	_____	_____
C10	Safety: covers locked, fences, signs and depth markers in place	_____	_____
C11	Access routes clear and not used for parking	_____	_____

Table 10F.27 — Form 10-7, Section D: Declaration of the owner

Field	Entry
I/We declare that the pre-monsoon inspection of Clause 10.12 has been made, that the defects found have been corrected as listed in Section C, and that the facilities are maintained under the approved O&M plan. Owner: name, signature, date	_____

Table 10F.28 — Form 10-7, Section E: Empanelled professional (facilities under Clause 10.6.1(c) and (d))

Field	Entry
I have inspected the facilities listed and confirm Section C. Name, empanelment number, signature, date	_____

Table 10F.29 — Form 10-7, Section F: For the Authority

Field	Entry
Date received; on time (by 15 May) yes / no	_____
Entered in the facility register (Clause 10.17), date	_____
Follow-up action, if any (Clause 10.15)	_____

Form 10-8 — Asset Handover Certificate

Supports Clause 10.14 of Chapter 10.

Draft form — West Bengal 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 south-west monsoon season 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 West Bengal 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:** I&WD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, KMDA or UD&MA, WBSDMA] (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 Bagjola canal corridor]. Diversions between basins by canal, drain or surplus course shall be mapped and represented in the model (Clause 11.3.2).

11A.3 Team

1. The study shall be led by an engineer empanelled as a Stormwater Design Professional with the basin modelling endorsement of Annex 10E (Clause 11.4.3).
2. The team shall include at least: [a hydrologist; a hydraulic modeller; a coastal or tidal specialist where the basin has a tidal outfall; a GIS and survey lead; a planner; a cost engineer; a community engagement lead]. The client sets the minimum qualifications and experience of each.

11A.4 Tasks

Task 1 — Inception. Review existing studies, data and projects in the basin. Prepare a data inventory against Table 11.1, a gap list, a survey plan, a consultation plan, and the work programme. Deliver the inception report.

Task 2 — Data and surveys. Assemble, survey where missing, and quality-check every item of Table 11.1 (Clause 11.5.1):

- (a) terrain: DEM from LiDAR or photogrammetry with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum, with the accuracy test reported;
- (b) drain network: every public drain, culvert and outfall, with invert levels, sizes, condition and silt depth; private drains above 600 mm;
- (c) waterbodies: every tank, 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 and coast: tidal datums and surge values from Annex 5A or, until it is published, from the site-specific study of Clause 5.7, with the datum of every level named; outfall invert levels against high tide and river flood levels; locks, sluices, tide gates and pumping stations on the outfall channels, with their capacities and operating rules; embankment crest levels; the high flood levels of I&WD; releases from the DVC dams and the Teesta barrage upstream;
- (f) rainfall and water levels: all available records (IMD, including the Kolkata (Alipore), Dum Dum, Diamond Harbour, Canning, Haldia, Digha, Bankura, Malda, Jalpaiguri and Bagdogra stations; the rain and river gauges of I&WD under the National Hydrology Project; and KMC's ward and borough rain gauges), including the September 1978 (south Bengal), May 2020 (Cyclone Amphan), October 2023 (the Teesta), September 2024 (DVC releases on the lower Damodar and at Ghatal) and September 2025 (Kolkata) 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 September 1978 (south Bengal), May 2020 (Cyclone Amphan), October 2023 (the Teesta), September 2024 (DVC releases on the lower Damodar and at Ghatal) and September 2025 (Kolkata) 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, arsenic-affected aquifers and saline intrusion; effect on downstream basins and the Bagjola canal; and who benefits.

Task 8 — Basin inputs for site design. Where scenario (c) does not meet the level of service, propose basin release rates ($m^3/s/ha$) 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	[ ]

No.	Deliverable	Task	Due (months from start)
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, the drain, khal, canal and outfall network (in Kolkata, KMC's combined sewers and drains, the pumping stations of KMC and I&WD with their capacities, the locks on the Hooghly side and the storm-water and dry-weather-flow channels to the Kulti; in Howrah, the outfalls to the Hooghly), the pukurs and the East Kolkata Wetlands, the embankments and sluices of the Sundarbans and the lower Damodar, the high flood levels of I&WD, and the basin and sub-basin maps held by I&WD, KMDA, KMC, NKDA, SJDA, ADDA and the Municipal Corporations (other likely sources: Survey of India, NRSC, NATMO and the CZMP maps). Until it is published, the basins of Kolkata, Howrah, the lower Damodar and Ghatal, Siliguri and the Sundarbans 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); 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
Kolkata (KMC)	Eastern outfall basins to the Kulti	Pumped through KMC and I&WD stations (Ballygunge, Palmer Bazar, Dhapa Lock and others) to the storm-water and dry-weather-flow channels from Bantala to the Kulti through the East Kolkata Wetlands; Kultigang level as boundary; each main pumping station's catchment a sub-basin
Kolkata, South Dum Dum, Bidhannagar, New Town	Kestopur canal	From the Chitpur lock on the Hooghly towards the Bidyadhari; whole catchment across local bodies; Lead Authority KMDA
Kolkata, South Dum Dum, Bidhannagar, New Town	Bagjola canal	Main outlet for South Dum Dum, New Town and Bidhannagar; ends at the Kulti pump house (1,650 cusec; upgrade reported); link basin; Lead Authority KMDA

Tier A body or area	Basin	Note from Chapter 11
Kolkata (KMC)	Tolly's Nullah (Adi Ganga) and the KEIIP added-area catchments	Tidal Hooghly as boundary; Churial, Begore, Monikhali and South Suburban catchments to the Churial and other canals
Howrah	Howrah city basins	Land lower than the Hooghly; tidal Hooghly as boundary
Howrah, Hooghly and Paschim Medinipur districts	Lower Damodar–Mundeswari and Ghatal (Shilabati, Kangsabati, Rupnarayan)	Releases from DVC's Maithon and Panchet dams as boundary; Ghatal Master Plan
Siliguri	Mahananda	Teesta–Mahananda link canal and the Teesta below the Gajoldoba barrage, with the 2023 sediment, as boundaries to be checked
Sundarbans towns	Embanked islands	Polder basins draining through embankment sluices to tidal creeks; Lead Authority I&WD
Other Tier A bodies, including Asansol, Durgapur and the Municipalities of the Kolkata Metropolitan Area	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 I&WD 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 West Bengal 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 West Bengal 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 September 1978 (south Bengal), May 2020 (Cyclone Amphan), October 2023 (the Teesta), September 2024 (DVC releases on the lower Damodar and at Ghatal) and September 2025 (Kolkata) floods (Land and Land Reforms Department and WBSDMA damage assessments, insurers), and replacement costs (PWD schedules of rates). Until it is published, each BSMP shall state the depth–damage relations it uses and their source, and shall report the reduction in buildings and people flooded for every option (Clause 11.8.2), which does not depend on the curves.

Table 11C.1 — Depth–damage curve (layout, one table per building type)

Depth of water above floor level (m)	0	0.25	0.5	1.0	1.5	2.0	3.0
Structure damage (% of replacement cost)	_____	_____	_____	_____	_____	_____	_____
Contents damage (% of contents value)	_____	_____	_____	_____	_____	_____	_____
Building type, source and year of costs	_____						

11C.1 Use in option assessment

Expected annual damage (EAD) is computed for each scenario from the damages at the modelled AEPs. With damages D_1, D_2, … at annual exceedance probabilities P_1 > P_2 > …, using at least the 50%, 10%, 1% and 0.2% AEP results of Clause 11.7.2:

$$EAD \approx \Sigma \tfrac{1}{2} \times (D_i + D_{(i+1)}) \times (P_i - P_{(i+1)})$$

The reduction in EAD between scenario (c) and scenario (d), or between options, is the risk-reduction benefit used to rank works per rupee (Clause 11.8.4(e)). The BSMP shall state how damages beyond the 0.2% AEP and below the 50% AEP were treated.

Annex 11D — BSMP data and model publication standard

Supports Clauses 11.5.1 and 11.10 of Chapter 11, and Clause 10.17 of Chapter 10.

11D.1 What is published, and when

Table 11D.1 — Items to be published

Item	Format	At draft (Clause 11.10.1)	At approval (Clause 11.10.2)
BSMP report, with the level-of-service assessment and options	Searchable PDF	Yes	Yes, final
Flood hazard maps: extent, depth, velocity, hazard class, for each AEP and scenario of Clause 11.8.4(a)	GeoTIFF rasters; extents also as GeoPackage polygons	Yes	Yes

Item	Format	At draft (Clause 11.10.1)	At approval (Clause 11.10.2)
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, tidal, surge and river levels, 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 tidal datums (chart datum of the nearest port, mean sea level on the GTS datum and, in Kolkata, the Kidderpore Old Datum (KOD)) 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 `tollys_nullah_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 — West Bengal Stormwater Design Manual, Draft v1.0. Published by the Lead Authority for each basin with an approved BSMP before each south-west monsoon, by **15 May** (Clause 11.11.3).

Table 11F.1 — Form 11-1, Section A: Basin and plan

No.	Field	Entry
A1	Basin; Lead Authority; partners	_____
A2	BSMP version and date of approval	_____
A3	Reporting year (1 June to 31 May)	_____
A4	Date of publication (by 15 May) and web address	_____

Table 11F.2 — Form 11-1, Section B: CIP progress

CIP rank	Work	Agency	Cost in CIP (₹)	Spent this year (₹)	Spent to date (₹)	Status	Expected completion
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 11F.3 — Form 11-1, Section C: Fee-in-lieu ledger (Clauses 4.5.6.3(c) and 4.13.4)

Regional facility or tank	Volume credited to sites (m³)	Volume delivered (m³)	Fees received (₹)	Fees spent (₹)	Fees held, with year received
_____	_____	_____	_____	_____	_____
Basin total: volume owed and delivered	_____	_____	_____	_____	_____

Table 11F.4 — Form 11-1, Section D: Maintenance completed (Clause 11.8.4(f))

No.	Item	Planned	Done	Date completed
D1	Desilting of drains and canals (length, km; volume, m³)	_____	_____	_____
D2	Tank and 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	_____

SUPPLEMENT

Andaman and Nicobar Islands

Status. This Supplement is part of Draft v1.0 of the Manual. Neer prepared it as a proposal for applying the Manual in the Union Territory of the Andaman and Nicobar Islands. The Union Territory is administered by the President through an Administrator, the Lieutenant Governor, under Article 239 of the Constitution, so the authority that could adopt this Supplement is the Andaman and Nicobar Administration. The islands are linked to West Bengal through the jurisdiction of the Calcutta High Court and through language, not through law: no West Bengal Act, rule or authority applies in them.

Not adopted. This Supplement has not been adopted, notified or endorsed by the Andaman and Nicobar Administration or the Lieutenant Governor, or by any of the Administration's departments, the Sri Vijaya Puram Municipal Council, the Andaman Public Works Department (APWD), any panchayat or Tribal Council, the Andaman and Nicobar Coastal Zone Management Authority or any other agency, nor by the Government of West Bengal or any of its departments. Where it names a body, it describes the role that body would have if the Manual and this Supplement were adopted. It does not say the body has agreed to that role. Until the Administration adopts it, the regulations, bye-laws, Master Plans and approval conditions in force in the Union Territory continue to apply.

S1.1 Scope

S1.1.1 This Supplement applies to the Union Territory of the Andaman and Nicobar Islands, in its three districts:

- (a) **South Andaman**, including the **Sri Vijaya Puram Municipal Council** (SVPMC; formerly the Port Blair Municipal Council, renamed after Port Blair was renamed Sri Vijaya Puram in September 2024, as reported), with 24 wards over about 41 km², and the Port Blair Planning Area;
- (b) **North and Middle Andaman**; and
- (c) **Nicobar**.

It applies in the area of the Municipal Council, in the planning areas notified under the *Andaman and Nicobar Islands Town and Country Planning Regulation, 1994* (the TCP Regulation) and the *Andaman and Nicobar Islands Town and Country Planning Rules, 2005*, in panchayat areas, and to works of APWD and other departments of the Administration, subject to Clause S1.11 for tribal reserves.

S1.1.2 **How this Supplement works.** In the islands, the chapters and annexes of the Manual apply as written, except as modified by Table S1.1 and Clauses S1.3 to S1.12. Where the Manual names a West Bengal body, statute or rule, the Union Territory instrument or body in Table S1.1 or Table S1.2 is read in its place. Clauses S1.5 (subsided land and tide-locked outfalls) and S1.11 (tribal reserves) take precedence over any clause of the Manual that they contradict. Clause, table, annex and form numbers do not change.

S1.1.3 Values marked **[TBC]** are to be confirmed from the primary source before adoption. Until they are confirmed, the clause concerned states the rule that applies in the meantime.

S1.1.4 Large projects in the islands, including the Great Nicobar project, are subject to the conditions of their environmental clearance and of the Island Coastal Regulation Zone Notification, 2019. The Manual and this Supplement apply to them in addition to those conditions and do not relax any of them.

> **Commentary.** The islands differ from the West Bengal delta in almost every respect that matters to drainage. They are hilly, with short perennial streams, tidal creeks and mangrove-lined inlets; they receive about 2,800–2,900 mm of rain a year from two monsoons; and the city of Sri Vijaya Puram depends for its water on a dam, the Dhanikhari, and runs short every dry season. The earthquake of 26 December 2004 lowered much of the land around the city by nearly a metre, so that some of it now floods on ordinary tides. Their law is that of the Union Territory: the building bye-laws of the Municipal Council, the TCP Regulation and the regulations of the Administration. The Manual's engineering applies to the islands with the changes set out here. Bengali is the largest mother tongue in the Union Territory (about 28% at the 2011 Census, as reported), and Hindi and English are its official languages.

S1.2 How the Manual applies: clause-by-clause modifications

S1.2.1 The clauses of the Manual listed in Table S1.1 apply in the islands with the changes shown. Clauses not listed apply unchanged.

Table S1.1 — Modifications to the Manual for the Andaman and Nicobar Islands

Manual clause	What changes in the islands
1.3.1 Notification	Statutory effect would be given (a) within the Municipal Council, by an amendment to the *Port Blair Municipal Council Building Bye-Laws* (Notification No. 161/99/F.No.3-53/97-LSG of 13-10-1999), confirmed by the Lieutenant Governor under the municipal law in force (see the commentary below this table); (b) in the planning areas, by rules or Master Plan conditions under the TCP Regulation and the TCP Rules, 2005; and (c) in panchayat areas, by an amendment to the building-operation rules under the *Andaman and Nicobar (Panchayat Administration) Rules, 1997*, whose text could not be read for this draft **[TBC]**. The West Bengal instruments do not apply.
Building rules ("KMCBR/WBMBR" throughout)	Read as the Port Blair Municipal Council Building Bye-Laws, 1999, as amended (an amendment of 2018 is reported to have taken effect on 21-02-2019; its text was not read **[TBC]**), within the Municipal Council; and as the TCP Rules, 2005 and the Master Plans of the Port Blair Planning Area (2012) and of Swaraj Dweep and Shaheed Dweep (2015) in their planning areas. A *TCP (Amendment) Regulation, 2026* is reported to have been promulgated on 28-07-2026; its content was not read **[TBC]**.
1.3.2 State Stormwater Technical Committee	The committee would be constituted by the Lieutenant Governor. CPHEEO (2019) allows a committee "constituted by State/UT Government".
1.4.1 Approving Authority	The Municipal Council within its limits; the Town and Country Planning Unit of APWD (Chief Engineer and Town Planner) in the planning areas; the panchayat or other authority that grants building permission under the rules in force elsewhere; and APWD or the department concerned for its own works. Tribal areas: Clause S1.11.
1.5.3 RWH	Bye-law 4.8 applies: every person who constructs, reconstructs, adds to or alters a building "shall provide a proper spout /tank for collection of rain water which shall be utilized for various domestic purpose other than drinking". It sets no threshold, size or recharge rule. It is modified by Clause S1.8, which makes storage for use the first requirement.
1.6 Tiers	The Municipal Council and the Town and Country Planning Unit of APWD are **Tier B** authorities, and so are all other authorities in the islands (set by this Supplement). The Municipal Council may opt into Tier A under Clause 1.6.4.
1.8, 1.9 Other instruments and roles	The West Bengal instruments (the KMC Act 1980, KMCBR 2009, WBMBR 2007, the T&CP Act 1979, the West Bengal Inland Fisheries Act 1984 and the East Kolkata Wetlands Act 2006) do not apply in the islands. Roles are as in Table S1.2.
1.10.2 Waiver of detention	Applies, but not to a site that drains to land on the register of Clause S1.5.3 or to a creek or channel that is tide-locked under Clause S1.5.4.

Manual clause	What changes in the islands
2.3 Approved sources of design rainfall	Clause S1.4. The interim CWC source of Clause 2.3.6 and the CWC floor of Clause 2.3.3(b) do not apply: no CWC flood estimation subzone covers the islands. Where the Manual refers to the NIH-DHAARA value or to the value under Clause 2.3.6, the value under Clause S1.4.1 is meant.
2.11.4 Antecedent moisture; pre-monsoon dates	Clause S1.4.5.
4.4, 8.8, 8.11 Retention, infiltration and recharge	Modified by Clauses S1.8 and S1.9.
5.7 Tidal tailwater	Applies, with Clause S1.6. Every level shall be on the post-2004 datum of Clause S1.5.1.
5.8 Riverine backwater	Applies to the short perennial streams and tidal creeks of the islands. Below the Dhanikhari dam, the spill and release of the dam shall be included as in Clause 5.8.3; its operating rule and spillway capacity are **[TBC]**.
5.10, 5.11 Outfall-closed check; tide gates	Clauses S1.5.4 and S1.5.5.
5.13 Sand bars	Applies to creek mouths where a bar forms.
6.11 Floor levels	The plinth of bye-law 6.1, "not less than 30cm above the ground or site level", is a minimum only. Clause 6.11 applies, with the levels on the post-2004 datum of Clause S1.5.1, and the higher level governs. In the coastal band, Clause S1.7.4.
6.11.6, 7.12 Coastal band	Clause S1.7.
7.4 Setbacks	Bye-law 4.7 requires precautions within 15 m of "any tank, reservoir, water course, river fresh water channel or well" so that the drainage of a building does not pass into it, but it does not keep the bank clear. As in West Bengal, the hydraulic corridor of Clause 7.4 applies, with its Zone 1 minimum, and is stricter than the bye-laws (set by this Supplement).
Chapter 7 custodian and NOC	Whether APWD or the Municipal Council owns and maintains the major storm drains and nallahs of Sri Vijaya Puram is **[TBC]**. Until it is confirmed, where the Manual names I&WD as custodian or requires its NOC, the Authority shall consult APWD and record its response.
8.12 Erosion and sediment control	Clause S1.10.
10.4.4(c) GIS data	The islands lie in UTM zone **46N (EPSG:32646)**, not in zone 45N (EPSG:32645), which covers West Bengal.
10.16 Post-event review	Led by the disaster management authority of the Union Territory, in place of WBSDMA, with the Deputy Commissioner of the district; the names of the bodies are **[TBC]**.
Chapter 11 Basin plans	The planning unit is the island, and on South Andaman each creek catchment that drains to the harbour of Sri Vijaya Puram. Plans shall map the land on the register of Clause S1.5.3.

Commentary. The bye-laws of 1999 were confirmed by the Lieutenant Governor under section 202(3) of the *Andaman and Nicobar Islands (Municipal) Regulation, 1994*, and they cite that Regulation. The Municipal Council's own website, however, says it works under the *Andaman and Nicobar Islands (Municipal Board's) Regulation, 1957*. Which Regulation is now in force, and so the route by which an amendment to the bye-laws would be made, could not be resolved for this draft **[TBC]**; Table S1.1 therefore refers to the municipal law in force. The texts of the Municipal Regulation of 1994, the TCP Regulation and the Protection of Aboriginal Tribes Regulation, 1956 could not be retrieved from India Code. The bye-laws already contain the hooks this Supplement needs: site drainage by surface water drains "if the Authority so requires" (bye-law 4.1), "measures for checking the erosion of soil and sliding due to excavation" before any site is approved (4.5), precautions near water (4.7), rainwater collection (4.8), foundations that resist "sliding of the sub-stratum on sloping ground" (5.4) and a plinth

of at least 30 cm (6.1). What they lack is a size for the rainwater store, any detention or peak-flow rule, an erosion plan of stated content, and a floor level tied to the tide and to the subsidence of 2004. All authorities are Tier B because only one urban local body exists in the Union Territory and it issued 134 building permits in 2024-25.

Table S1.2 — Roles in the Union Territory

Body	Role under this Manual
Lieutenant Governor (Administrator); Andaman and Nicobar Administration	Would amend the bye-laws and rules (Table S1.1, 1.3.1) and constitute the committee of Clause 1.3.2; directions under Clause S1.11.
Sri Vijaya Puram Municipal Council	Approving Authority within its limits; maintenance of streets, roads and drains, a listed function of the Council; distribution of water; receives handed-over assets (Clause 10.14).
APWD: Town and Country Planning Unit (Chief Engineer and Town Planner)	Approving Authority in the planning areas; keeper of the Master Plans; would prepare the rules of Table S1.1.
APWD (works, water supply)	Bulk water supply, including the Dhanikhari dam; public works; custodian of drains and nallahs subject to the [TBC] in Table S1.1.
Panchayats; Tribal Councils	Approving Authority where the rules in force make them one; Tribal Councils as in Clause S1.11.
Andaman and Nicobar Coastal Zone Management Authority	Appraises ICRZ plans and clears projects under the ICRZ Notification (Clause S1.7).
Disaster management authority of the Union Territory; Deputy Commissioners	Warnings, event records, post-event review (Table S1.1, 10.16).
IMD (Meteorological Centre, Sri Vijaya Puram); INCOIS; Survey of India; National Hydrographic Office	Rainfall records and cyclone warnings; tide gauges and sea-level products; datums and tide tables (Clauses S1.4 to S1.6).

S1.3 West Bengal values and island soils

S1.3.1 Where the Manual gives a value or rule for a West Bengal zone, district or body, it does not apply in the islands unless this Supplement applies it. In particular, the rainfall zones of Annex 2A, the CWC subzones and the West Bengal soil classes of Chapter 3 do not extend to the islands.

S1.3.2 **Soils.** Until a field test is made, the hydrologic soil group shall be taken as **C** on the hill soils of the islands, and as **D** on the subsided land of Clause S1.5.3, on mangrove and tidal mud and on land within 100 m of a tidal creek (set by this Supplement). A field test is required above Tier B.

Commentary. No soil-group mapping for the islands was found. The hill soils over the siltstones, sandstones and ophiolites around Sri Vijaya Puram are shallow, and on steep slopes rain runs off quickly; subsided and tidal land is waterlogged. Clause S1.3.2 takes the cautious group in each case until a test is made.

S1.4 Design rainfall and season

S1.4.1 **Source.** NIH-DHAARA coverage of the islands is **[TBC]**. Until it is confirmed, design depths shall be taken as follows:

- (a) **Within 10 km of the IMD observatory at Sri Vijaya Puram**, from the station IDF relationship of Tamrakar and Goel (2018), Clause S1.4.2. For the purpose of Clause 2.3.2(b), this Supplement treats that relationship, published in IMD's journal *MAUSAM* from 32 years of IMD hourly records, as approved for this use (set by this Supplement).
- (b) **Elsewhere**, from a frequency analysis of the IMD record at the nearest IMD station with a long record (Sri Vijaya Puram, Mayabunder, Long Island, Hut Bay, Car Nicobar or Nancowry), or at another station agreed with the Authority: for 24 hours and longer, from the daily record; for shorter durations, from the recording-gauge record of the same station where it is available, and otherwise by ratios agreed with the Authority under Clause 2.6.2.
- (c) In every case, the method, record length and values shall be stated on Form 2-1. Where NIH-DHAARA covers the site, its value shall be reported and the greater of the two values used (Clause 2.3.2).

S1.4.2 **Port Blair IDF relationship.** Tamrakar and Goel (2018) fitted the Gumbel (EV1) distribution to annual maxima of 1 to 24 hours at Port Blair, 1969–2000, and recommend a relationship (their Eq. 3) with **K = 5.816, x = 0.232, a = 0.529 and b = 0.733**, with i in cm/h, T in years and t in hours. The form of the equation could not be read from the published copy; it is taken as **i = K·T^x / (t + a)^b [TBC]**, to be confirmed against the paper before use. Until it is confirmed, the designer shall check the values from it against Table S1.3 and report the check. The paper's conversion from 24-hour to shorter durations (its Eq. 11) shall not be used until its form is confirmed **[TBC]**.

Table S1.3 — Annual maximum rainfall depths at Port Blair, 1969–2000 (mm)

Duration	1 h	2 h	3 h	6 h	12 h	24 h
Mean of annual maxima	55.9	77.2	89.3	109.7	131.9	171.6
Largest annual maximum	122.0	205.2	249.2	272.1	285.7	404.8

Source: Tamrakar and Goel (2018), Table 1. Evidence for checking only; not design values (Clause 2.3.4(c)).

S1.4.3 **Annual and monthly rainfall.** For rainwater storage (Clause S1.8) the designer shall use the monthly record of the station of Clause S1.4.1. For Sri Vijaya Puram, the mean annual rainfall is **2,815 mm** over 1991–2020 and 2,914 mm over 1947–2023, computed from the annual series of the Directorate of Economics and Statistics. The "normal" of 3,180 mm printed on the same sheet shall not be used until its period is known.

S1.4.4 The climate factor of Clause 2.8 applies.

S1.4.5 **Season and antecedent moisture.** The islands have two rainy seasons: the south-west monsoon from May to September and a second season from October to December, of the north-east monsoon and cyclonic storms; January to April is dry. In the islands (set by this Supplement):

- (a) AMC III applies to every design storm from June to September, and to cyclone design storms in May and from October to December; AMC II applies otherwise;
- (b) the pre-monsoon date by which works are completed and earthworks stabilised, set at 15 May for West Bengal, is **30 April**; and
- (c) a second inspection of drains, sluices and tide gates shall be made by **30 September**, before the October–December season.

> Commentary. Port Blair's annual rainfall ranged from 1,950 mm (1979) to 4,362 mm (1961) over 1947–2023. In 2021–2023, less than 30 mm fell from January to April 2023, the monsoon arrived in May with 100–494 mm, and September 2023 brought 1,060 mm; October to December brought 86–307 mm a month. Other stations differ:

Long Island received 4,844 mm in 2019, Car Nicobar 2,317–2,985 mm in 2015–19. Tamrakar and Goel found that Port Blair falls in none of the zones of the generalised Indian IDF formulae, which Clause 2.3.4(a) already excludes. Their relationship meets Clause 2.3.2(a), with 32 years of hourly data, and 2.3.2(c) only near the observatory; it was published in IMD's journal but not issued by IMD, which is why Clause S1.4.1(a) states that this Supplement accepts it. The CWC flood estimation subzones stop at the mainland, so the CWC floor cannot apply. The single-day falls of Cyclone Lehar, which crossed near Port Blair on 25 November 2013, were 243 mm at Mayabunder and 213 mm at Port Blair (secondary source). The cyclone months are why the dates of Clause S1.4.5 differ from West Bengal's. These records are evidence only and are not design values.

S1.5 Subsided land and tide-locked outfalls

S1.5.1 **Post-2004 datum.** Every level used under the Manual in the islands (outfall inverts, tide and surge levels, flood levels, floor levels and ground levels) shall be referred to a datum established after the earthquake of 26 December 2004, connected to a Survey of India benchmark levelled after that date. The datum, the benchmark and the date of its levelling shall be stated on Form 5-1.

S1.5.2 **No pre-2005 levels without conversion.** Levels, drawings, tide-gauge records and tide-table datums from before 2005 shall not be used unless they have been converted to the datum of Clause S1.5.1 by a documented connection. No single offset for the subsidence shall be applied across a site or an island in place of a survey: the vertical movement varied from place to place (Commentary).

S1.5.3 **Register of tidal low land.** The Approving Authority should keep a register and map of land that has flooded on ordinary tides since 2004. Until the register is published, a designer shall treat as tidal low land any land that the site survey shows to be flooded at mean high water springs on the post-2004 datum. Tidal low land:

- (a) is part of the tidal waterbody for the purposes of Chapters 5 and 7, not land available for storage;
- (b) shall not be counted as detention or retention storage; and
- (c) shall not receive a drain outfall except through a sluice or tide gate designed under Clause S1.5.5.

S1.5.4 **Outfall-closed check.** The outfall-closed check of Clause 5.10 is the governing design case for every drain, storage facility and pumped system whose outfall discharges to a creek, inlet or tidal low land in South Andaman or the Nicobars. Where the tailwater of Clause S1.6 is above the outfall invert for the whole design storm, the outfall shall be treated as fully closed (Clause 5.9.4).

S1.5.5 **Sluices and tide gates.** Clause 5.11 applies to every sluice, flap gate and tide gate on a drain or creek. In addition (set by this Supplement):

- (a) every sluice or gate shall have an owner named in the drainage report and a maintenance schedule under Chapter 10;
- (b) it shall be inspected before 30 April and 30 September (Clause S1.4.5) and after every cyclone warning for the island; and
- (c) a gate that has failed shall be reported to the Approving Authority, and the land it protects shall be treated as tidal low land under Clause S1.5.3 until it is repaired.

Commentary. The earthquake moved the islands unevenly. GPS points measured before and after it show the control point at Port Blair down by 0.87 m, Car Nicobar down by 1.05 m and Campbell Bay down by 1.36 m, while Diglipur in the north rose by 0.63 m and Hut Bay by 0.36 m (Earnest et al., 2005). At the tide gauge in Port Blair, sea level after the earthquake stood "~1 m above the pre-earthquake datum, indicating subsidence of the gauge itself". At Sipighat, near the city, the same study found "flooding even during low tides", with houses "submerged to the level of window sills". Other studies give subsidence of 0.5–2.8 m along the islands (secondary source). Low land around the city therefore sits about a metre lower relative to the sea than it did before 2004, and

drawings and datums from before that date are offset by an amount that varies from place to place. Sluices matter: a defunct sluice at Kadakachang let seawater flood fields near Stewart Gunj, and a sluice at Wandoor, damaged by rain, let seawater into Wandoor and Humfraygunj (secondary sources). In June 2025 waterlogging at School Line, Mohanpura and Gandhi Market in Sri Vijaya Puram was reported to be worse "when tides run high" (secondary source). The tsunami of 2004 ran up about 3.5 m at Munda Pahar and Chidiya Tapu; the Manual does not design drainage for tsunami, which is a matter for the disaster management plan.

S1.6 Tides, surge and sea level

S1.6.1 **Tide levels.** Current values of MHWS and HAT at Sri Vijaya Puram, on the post-2004 datum, are **[TBC]** from the Survey of India or the National Hydrographic Office. Until they are confirmed, the designer shall take MHWS and HAT from the current Indian Tide Tables for Port Blair, state the edition and the chart datum used, and connect the chart datum to the datum of Clause S1.5.1 under Clause 5.7.2(b). Tide-gauge records of PSMSL station 206 (Port Blair) shall not be used to set design levels: the long record ends in 1964, and PSMSL notes that the recent data appear to use a different datum.

S1.6.2 **Extreme sea level.** For the coastal band (Clause S1.7.4) and for the check of critical assets, the designer shall report the INCOIS 100-year extreme sea level for Port Blair: **1.88 m** above the baseline mean sea level now, rising to **2.41 m** (SSP2-4.5) and **2.65 m** (SSP5-8.5) by 2100. The INCOIS baseline mean sea level is that of 1980–2014, a period that spans the subsidence of 2004; how it relates to the datum of Clause S1.5.1 is **[TBC]**, and the designer shall state the connection used.

S1.6.3 **Storm surge.** Until Annex 5A gives surge levels for the islands **[TBC]**, the surge terms of Clause 5.7.3 shall come from a site-specific study under Clause 5.7.3(c). The study shall report the surge of Cyclone Lehar (Clause S1.12) as a check.

S1.6.4 **Sea-level allowance.** Clause 5.7.4 applies. Because the INCOIS projection for Port Blair rises by 0.54–0.77 m by 2100, the sensitivity run of Clause 5.7.4(c) shall be reported for every element with a design life of more than 25 years (set by this Supplement).

> Commentary. The tide at Port Blair is moderate: a gauge on Ross Island from 1890 gave a mean range at ordinary springs of about 6.6 ft, or 2.0 m (secondary source), and INCOIS gives a tidal maximum of 1.19 m above mean sea level and a surge-and-setup term of 0.64 m. INCOIS notes that "the high ESL change at Port Blair results from the MSL rise". The difficulty is the datum, not the range: the land moved in 2004, the long PSMSL record ends in 1964, and no current table of MHWS and MLWS for the city was found for this draft.

S1.7 Coastal zone, mangroves and reefs

S1.7.1 **ICRZ.** Works shall comply with the *Island Coastal Regulation Zone Notification, 2019* (S.O. 1242(E), 8 March 2019) and with the ICRZ plan or Integrated Island Management Plan (IIMP) of the island approved under it. The High Tide Line is the one demarcated by NCSCM in that plan. Until the plan for an island is approved, the plans under the Island Protection Zone Notification, 2011 continue to be followed, as paragraph 5 of the 2019 Notification provides.

S1.7.2 **No-development zones.** No stormwater facility shall be built in a No Development Zone except as the Notification or the approved plan permits. The Notification sets the zone, measured landward from the High Tide Line, by the size of the island, subject to the exceptions it allows:

- (a) **100 m** on the larger islands (more than 1,000 km²: South, Middle and North Andaman and Great Nicobar);

- (b) **50 m** on the islands of the second group, such as Baratang, Little Andaman, Swaraj Dweep and Car Nicobar; and
- (c) **20 m** on the smaller islands managed through IIMPs.

Along tidal creeks the zone extends as the Notification provides.

S1.7.3 **Mangroves and corals.** Mangroves and corals are in ICRZ-IA. No drain, outfall or stormwater facility shall be built within the **20 m** buffer of a mangrove stand larger than 1,000 m², or on or across a coral area, except as the Notification permits. Every outfall in ICRZ-IA, and every outfall into a mangrove creek or a reef lagoon, shall have the clearance of the Andaman and Nicobar Coastal Zone Management Authority before approval.

S1.7.4 **Coastal band and floor levels.** Clause 6.11.6 applies, with the High Tide Line of Clause S1.7.1 and the levels on the datum of Clause S1.5.1.

S1.7.5 **Untreated runoff.** No runoff from a construction site, road or paved area shall be discharged directly into a mangrove stand, a reef lagoon or a coral area. Such runoff shall first pass through the treatment of Chapter 8 (Clause 8.10) and, during construction, the controls of Clause S1.10.

> Commentary. As of the Chief Secretary's affidavit to the National Green Tribunal in April 2024, the ICRZ plans of Great Nicobar (1 June 2021) and Little Andaman (12 September 2022) had been approved, seven plans had been reviewed by the Technical Scrutiny Committee, and the plans for South Andaman and the Shaheed Dweep IIMP had been sent to NCSCM; whether the South Andaman plan has since been approved is **[TBC]**. Mangrove cover in the islands is about 400 km² (secondary source). Dense mangrove was lost after 2004 through subsidence and the tsunami, and part of it has recovered; around the south-west of Port Blair most mangroves died, and *Rhizophora* survived (secondary sources). Sediment washed from land is one of the factors studied in the recovery of the islands' reefs after bleaching (secondary source), which is why Clauses S1.7.5 and S1.10 keep construction runoff off them.

S1.8 Water scarcity: rainwater storage first

S1.8.1 **Rooftop storage.** Every new building, and every building that is reconstructed, added to or altered, shall collect roof water through gutters, a first-flush diverter and a filter into a storage tank for use, as bye-law 4.8 requires. The tank shall be sized by the designer for a stated non-potable demand through the dry months of January to April, using the monthly rainfall of Clause S1.4.3, and the size and the calculation shall be stated in the drainage report. A minimum capacity per square metre of roof is **[TBC]** for the Approving Authority to set.

S1.8.2 **Use.** Bye-law 4.8 limits stored rainwater to domestic uses "other than drinking". That limit continues unless the Administration's health authority decides otherwise.

S1.8.3 **Retention.** The retention requirement of Clause 4.4 is met first by rooftop storage drawn down by use, and then by infiltration under Clause S1.9. A storage tank counts toward retention only for the volume its stated demand draws down within 72 hours (Clause 8.11.4), and it is assumed full at the start of every design storm and is not counted as detention (Clauses 4.11 and 8.11.5).

S1.8.4 **Overflow.** Clause 8.11.6 applies: the overflow shall discharge at grade to the site drainage, never to a neighbouring plot.

> Commentary. The islands receive nearly 3,000 mm of rain a year, yet water is short every dry season. Sri Vijaya Puram depends on the Dhanikhari dam, whose storage was raised by a heightening of about 5 m (the reported capacities after it conflict). In March 2023 supply was cut by 30% after a weak monsoon, and in September 2025 supply from the Garacharma plant fell to 30%, with water every third day, and residents were asked to "use

rainwater for non-domestic needs" (secondary sources). On these islands, rainwater is a supply to be stored first, and recharge comes second. Bye-law 4.8 already requires a tank but gives it no size; Clause S1.8.1 adds the sizing basis.

S1.9 Groundwater, infiltration and hill slopes

S1.9.1 **Saline intrusion.** No recharge well, recharge shaft or borewell shall receive stormwater or roof water:

- (a) on tidal low land (Clause S1.5.3);
- (b) within the coastal band of Clause 6.11.6, or within the same distance of a tidal creek; or
- (c) elsewhere, unless a hydrogeological report accepted by the Authority shows fresh water at the recharge depth.

This rule is set by this Supplement. Infiltration at the surface (vegetated open space, shallow depressions and permeable paving) meeting Clause 8.8 is allowed.

S1.9.2 **Hill slopes.** On ground steeper than **15°**, on ground above such a slope, and in any area mapped as prone to landslides (set by this Supplement):

- (a) no infiltration facility, recharge structure or soakaway shall be built unless a geotechnical report accepted by the Authority shows that it will not destabilise the slope;
- (b) roof and pavement water shall be collected and led in lined drains or chutes to the foot of the slope or to a stable outfall, with energy dissipation at the outlet (Chapter 9); and
- (c) the drainage report shall show how the measures required by bye-laws 4.5 and 5.4 against erosion and sliding are met.

Commentary. CGWB reports "a constant threat of saline sea water intrusion" in the Port Blair municipal area, with brackish water in deeper formations (secondary source; the CGWB site could not be reached for this draft). Recharge that draws salt water up would harm the wells that rural areas use. Landslides are a drainage matter in the city. A study of the Kamaraj landslide at Brookshabad found a slope of about 30° (55%) and a slip surface about 6 m deep, and concluded that "most of the landslides … took place owing to the steep slopes, which consist of weak materials and high rainfall"; Cyclone Vardah's three to four days of continuous rain in December 2016 "triggered minor to moderate landslides" around Port Blair (Ansary et al., 2023). A study of shallow landslides around Port Blair flagged slopes of 15–35° as highly prone (secondary source), which is why Clause S1.9.2 starts at 15°. In September 2025 a road in the city was closed for fear of a landslide after rain, and slips have recurred at Haddo and on Fire Brigade Road (secondary sources).

S1.10 Erosion and sediment control

S1.10.1 Clause 8.12 applies in the islands with these changes (set by this Supplement):

- (a) an ESC plan is required for every development with land disturbance, whatever its area; below the 0.1 ha threshold of Clause 8.12.1 the Authority may accept a simplified plan showing items (a), (c) and (f) of that clause;
- (b) in Clause 8.12.2, the monsoon period is **May to December** and the date for stabilisation is **30 April**;
- (c) sediment basins under Clause 8.12.3(c) shall be sized for the May–September monsoon; and
- (d) no dewatering discharge or sediment-laden runoff shall reach a mangrove stand, a reef lagoon or a coral area.

> **Commentary.** Bye-law 4.5 already requires measures against erosion and sliding before a site is approved. Clause S1.10.1 turns that requirement into a plan with stated content and extends it to every site, because on steep island catchments a small cleared plot can deliver sediment straight to a creek and the reef beyond.

S1.11 Tribal reserves

S1.11.1 Nothing in the Manual or this Supplement applies to, or authorises any work in, an area declared as a reserved area or buffer zone under the *Andaman and Nicobar Islands (Protection of Aboriginal Tribes) Regulation, 1956*. Drainage works in such an area are a matter for the Administration under that Regulation, and the Manual applies there only as the Administration directs.

S1.11.2 In the Nicobar district, where the Tribal Councils are the local bodies, the Manual applies only as the Administration directs, in consultation with the Tribal Council concerned.

> **Commentary.** Section 3 of the 1956 Regulation empowers the Administrator to declare reserved areas (secondary source); a later amendment added buffer zones, but its year is reported as both 2010 and 2012 **[TBC]**. The Jarawa reserve on South and Middle Andaman and the Onge reserve are among the reserved areas (secondary sources). The Nicobar district has seven Tribal Councils, at Car Nicobar, at Chowra, Teressa, Katchal, Nancowry and Kamorta, and for Great and Little Nicobar (Directorate of Economics and Statistics, 2024-25).

S1.12 Event evidence

> **Commentary.** The earthquake and tsunami of 26 December 2004 are described in Clause S1.5. Cyclone Lehar made its first landfall near Port Blair on 25 November 2013, with winds of about 110 km/h and a storm surge of about 1–1.5 m that "inundated low-lying areas" (secondary source); about 2,000 people were evacuated on Little Andaman and 1,500 on Havelock (Swaraj Dweep). Cyclone Vardah brought three to four days of heavy rain to Port Blair in December 2016 and set off landslides (Clause S1.9); its rainfall totals are **[TBC]**. In June 2025 drains in Sri Vijaya Puram were reported to be "not designed to handle the volume" at School Line, Mohanpura and Gandhi Market, and the main market was waterlogged again in June 2026 (secondary sources). These records are evidence only and are not design values (Clause 2.3.4(c)).

To be confirmed

The following are needed before this Supplement could be adopted:

1. which municipal law is in force (the Municipal Regulation of 1994 or the Municipal Board's Regulation of 1957), and the text of the 2018 amendment to the bye-laws;
2. current MHWS and HAT at Sri Vijaya Puram on a post-2004 datum, from the Survey of India or the National Hydrographic Office, and the connection of the INCOIS baseline to that datum;
3. the form of Eq. 3 and Eq. 11 of Tamrakar and Goel (2018);
4. whether NIH-DHAARA covers the islands;
5. whether the South Andaman ICRZ plan has been approved since April 2024;

6. whether APWD or the Municipal Council owns the major storm drains and nallahs of Sri Vijaya Puram, and whether a drainage master plan exists;
7. the TCP Rules, 2005, the TCP (Amendment) Regulation, 2026 and the Panchayat Administration Rules, 1997, for any drainage or rainwater clause;
8. the operating rule and spillway capacity of the Dhanikhari dam;
9. surge levels for the islands for Annex 5A, the rainfall of Cyclone Vardah, and a minimum rainwater tank capacity;
10. the names of the disaster management bodies for Clause 10.16; and
11. the year of the amendment to the PAT Regulation that added buffer zones.

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