HARYANA

Stormwater Design Manual

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

Preserve | Retain | Detain | Convey | Maintain

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Prepared by

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About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Haryana or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Town and Country Planning Department or its Directorate (DTCP), Haryana Shehri Vikas Pradhikaran (HSVP), the Urban Local Bodies Department, the Irrigation and Water Resources Department (I&WRD), the Haryana Pond and Waste Water Management Authority (HPWWMA), the Gurugram Metropolitan Development Authority (GMDA), the Faridabad Metropolitan Development Authority (FMDA), the Panchkula Metropolitan Development Authority (PMDA), any Municipal Corporation, Municipal Council, Municipal Committee or other local body, or any other agency. Where it names a body, such as the Revenue and Disaster Management Department, the Haryana State Disaster Management Authority (HSDMA), the Haryana Water Resources Authority (HWRA), the Haryana State Pollution Control Board (HSPCB), the Wetland Authority of Haryana, the Haryana State Drought Relief and Flood Control Board, the Public Health Engineering Department (PHED), the Development and Panchayats Department, the Haryana State Industrial and Infrastructure Development Corporation (HSIIDC), the Municipal Corporation of Gurugram (MCG), a district administration, or a body outside the State, such as the Irrigation and Flood Control Department of Delhi, it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. The Haryana Building Code 2017 as applied by each Competent Authority, development plans, licence conditions, drainage schemes, notifications under section 45 of the Haryana Canal and Drainage Act, 1974, orders of courts and tribunals and approval conditions in force continue to apply.

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

- **Gurugram** was called **Gurgaon** until 2016, and IMD's observatory there (42178), the CGWA notification of 2011 and older documents use Gurgaon. In the same way, **Hisar** is **Hissar** on the IMD observatory (42131) and in older sources, **Sonipat** is written Sonepat, **Jagadhri** Jagadhari, **Yamunanagar** Yamuna Nagar and **Nuh** district was called **Mewat** until 2016. The district map has also changed: before 1995 Ambala district included today's Yamunanagar and Panchkula, Palwal was carved from Faridabad in 2008 and Charkhi Dadri from Bhiwani in 2016. IMD and CWC sources, and the rainfall data in this Manual, use the districts of their time, and a clause that names a district must be checked against the current list;
- where a shared clause names the State's main city or its municipal corporation, this Manual names **Gurugram** and the **Municipal Corporation of Gurugram (MCG)**, the State's largest urban drainage system. Gurugram is not the capital. The capital of Haryana is **Chandigarh**, which is also the capital of Punjab and is itself a Union Territory; this Manual does not cover Chandigarh, but uses its IMD observatory as the reference gauge for Panchkula;
- Gurugram's three master storm drains are **Leg-I**, **Leg-II** and **Leg-III**, also written Leg 1, 2 and 3. **Leg-III** is the **Badshahpur drain**, also called the Badshahpur nala, which carries the runoff of the Aravalli slopes south of the city. All three discharge into the Najafgarh drain, and a fourth, Leg-IV, has been reported under construction. Badshahpur is also the name of a place in Faridabad, where FMDA runs a sewage treatment plant; it has nothing to do with the Gurugram drain;
- **Outfall Drain No. 8** is the I&WRD drain that receives the Sahibi at RD 17.5 km and ends at the **Dhansa regulator** (RD 42.59 km), from where its water falls into the Najafgarh drain in Delhi. It is not **Diversion Drain No. 8** (DD8), a channel reported to carry raw water from Mahra, near Gohana, to the Yamuna at Dahesra in Sonipat district;

- the **Najafgarh drain** is in Delhi. It is the continuation of the Sahibi below Dhansa and receives Outfall Drain No. 8 and Gurugram's master drains on its way to the Yamuna. The **Najafgarh jheel** (*jhil*) is the seasonal lake and marsh on its course, across the border between Haryana and Delhi. Where this Manual names the drain or the jheel, it names a place that Haryana's drainage depends on, not a place that Haryana manages;
- **Hathnikund** is the barrage on the Yamuna in Yamunanagar district, built in 1999 to replace the older weir at **Tajewala**, and river flows before then are Tajewala figures. Its releases, like most river and drain flows in Haryana's sources, are given in **cusecs** (cubic feet a second; 1 cusec = 0.0283 m³/s) and **lakh cusecs** (100,000 cusecs). This Manual quotes them as given and adds the metric value where it matters for design. Levels on the State's Ghaggar gauges are reported in feet on gauges whose zero has not been found tied to mean sea level, and are quoted as reported [TBC];
- a **choe** is a seasonal torrent from the Shivalik hills, dry for most of the year, with a wide bed of sand, gravel and boulders, such as the choes of Panchkula, Ambala and Yamunanagar and the Sukhna choe of Chandigarh. A choe rises and falls within hours, and carries debris as well as water; and
- the **Shivalik** hills, also written Siwalik, rise in the north-east of the State, above Panchkula, Kalka, Morni and Kalesar; the **Aravalli** hills run as low, broken ridges through Gurugram, Faridabad, Nuh, Rewari and Mahendragarh in the south. Between them the State is a flat alluvial plain, with **khadar** (the low floodplain of the Yamuna and the Ghaggar) and **bangar** (the older upland alluvium above it), sand dunes in the south-west, and a waterlogged, saline belt around Rohtak and Jhajjar. **Ahirwal** is the region around Rewari and Mahendragarh, and **Mewat** the region of Nuh. The names describe regions, not administrative units.

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

- a **Municipal Corporation** is constituted under the Haryana Municipal Corporation Act, 1994. Under that Act all public drains, and all drains in, alongside or under a public street, vest in the Corporation (s.193), and so does the adjacent land (not private property) that appertains to a public tank (s.161). **Municipal Councils** and **Municipal Committees** are constituted under the Haryana Municipal Act, 1973. All three are urban local bodies (ULBs), overseen by the **Urban Local Bodies Department**;
- **DTCP** in this Manual is the Town and Country Planning Department and its Directorate. It issues the Haryana Building Code, grants licences for colonies under the Haryana Development and Regulation of Urban Areas Act, 1975 (HDRUA Act), whose external and internal development works include storm drains, and prepares development plans under the Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Act, 1963. **HSVP** is Haryana Shehri Vikas Pradhikaran, formerly the Haryana Urban Development Authority (**HUDA**), constituted under the HUDA Act, 1977. It develops the sectors of the State's Urban Estates and executes their external development works; it was renamed in 2017, as reported (the amending Act was not read), and documents issued before then are cited under the name HUDA;
- **GMDA** is the Gurugram Metropolitan Development Authority (Act 34 of 2017), whose notified area covers MCG, the Municipal Committees of Farukhnagar, Sohna and Pataudi and 41 Gram Panchayats, and which runs the master drains of Gurugram; under its Act a drain that connects two or more sectors, colonies or villages is "infrastructure development work". **FMDA** is the Faridabad Metropolitan Development Authority (Act of 2018) and **PMDA** the Panchkula Metropolitan Development Authority (Act 23 of 2021);
- **I&WRD** is the Irrigation and Water Resources Department, which builds and runs the State's canals, rural and regional drains, embankments and barrages. Its "drainage works" under the Haryana Canal and Drainage Act, 1974 exclude "works for the removal of sewage from towns" (s.2(7)). Under s.45 of that Act the State may notify limits along a river, stream or drainage channel within which obstruction is prohibited; the notified reach then becomes a drainage work. Flood-control schemes are approved by the **Haryana State Drought Relief and Flood Control Board**, chaired by the Chief Minister;
- **HPWWMA** is the Haryana Pond and Waste Water Management Authority, constituted under the Haryana Pond and Waste Water Management Authority Act, 2018 (Act 33 of 2018), called the Pond Authority in this Manual. **HWRA** is the Haryana Water Resources (Conservation, Regulation and Management) Authority,

constituted under the Act of 2020 of that name, which issues groundwater permissions in the State and is named in this Manual as the State groundwater agency;

- a **johad** (जोहड़; in the dictionary, *kachcha talab*, an earthen tank) is the village pond of Haryana, natural or dug, that stores rainwater runoff; the State's pond law spells it **johar** ("talab, johar, tank"). In Rajasthan the same word also names the earthen check-bunds of village watershed works; in this Manual it means a pond, not a check dam. *Talab* (तालाब) is the standard Hindi equivalent; and
- a **tehsil** is the revenue subdivision of a district, under a Tehsildar.

Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2 and 3; this Manual does not use it for any municipal body;
- MC is written out in this Manual, because in Haryana it can mean a Municipal Corporation, a Municipal Council or a Municipal Committee. MCG is the Municipal Corporation of Gurugram and MCF the Municipal Corporation of Faridabad;
- HFL is the highest flood level recorded at a gauge, as CWC uses it. It is not a design level, and sources sometimes give different values for the same gauge. The floodplain notified under s.45 is called a flood plain zone (FPZ) in this Manual; this Manual proposes how a design flood line is drawn (Chapter 7);
- RD (reduced distance) is the chainage along a canal or drain, from its head; and
- SWD is a storm water drain.

The sense is clear from the context. Hindi and Haryanvi terms used in the text, such as *johad*, *talab* (तालाब, a pond or tank), *jhil* or *jheel* (झील, a large, shallow, often seasonal lake or marsh), *dabar* (डाबर, low ground where rainwater collects), *bandh* or *bund* (बाँध, an earthen embankment, such as the old flood-holding bunds of Gurugram at Ghata and Wazirabad), *khadar* and *bangar*, *choe*, *nala* (natural drain or large storm drain) and *nali* (small street drain), 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

Haryana's cities flood for three reasons. Gurugram showed the first on 28 July 2016, when about 50 mm of rain, as reported, jammed the national highway through the city for more than 18 hours; the Yamuna and the Ghaggar showed the second in July 2023, when the Yamuna rose higher at Delhi than ever recorded and the Ghaggar broke its banks from Ambala to Sirsa; and Rohtak and Jhajjar show the third every monsoon, where the water table stands within 3 m of the ground over almost half of each district while the aquifers of most of the State are drawn down year after year.

1. **Short, intense storms on fast-growing cities whose channels were built for 25 mm an hour.** The National Capital Region Planning Board (NCRPB) reported in 2016 that "The intensity of rainfall adopted is 25mm per hour and run off coefficient is 1/8 for designing of storm water drainage channels in Haryana urban area". Storms in Gurugram and Faridabad, which share Delhi's climate, are far larger. On 28 July 2016 ("Gurujam") 46 mm in three hours was reported by the State's Chief Secretary, and other reports give 52 or 54 mm for the day; the highway was jammed between Rajiv Chowk and Hero Honda Chowk for more than 18 hours, and prohibitory orders were imposed. On 19 August 2020, "within half an hour of rain, the entire city was waterlogged", as reported. On 31 July 2024 three people were electrocuted near the IFFCO Chowk metro station when a live cable fell into ponded water, as reported. On 9–10 July 2025 133 mm was reported in 12 hours, 103 mm of it in 90 minutes, and on 1 September 2025 more than 100 mm in four hours; in September 2026 the Punjab and Haryana High Court recorded that "Gurugram is facing severe waterlogging during the monsoon season". Days far larger than these are on record: Gurgaon recorded 282.2 mm on 14 July 1968 and 261.2 mm on 30 June 1981, when Rohtak recorded 297.9 mm, and on 9 September 1875 Palwal recorded 398.8 mm and Ballabgarh 299.7 mm. In the north, on 9 July 2023, Chandigarh recorded 302.2 mm in a day and Ambala 224.1 mm, both new July records, and Ambala flooded. Roofs, roads, basements and underpasses now send more water to the drains, and faster.
2. **Drains and rivers that back up.** The ground falls about 78 m from the Aravallis above Gurugram to the Najafgarh drain in Delhi, as reported, and the city cannot drain faster than that drain and the bottlenecks on the way to it allow. The capacity of the Badshahpur drain, Leg-III, is given as 3,702 cusecs on DTCP's master drainage drawing of 2012 and from 500 to 3,800 cusecs in reports, and in 2021 its flow was reported as 2,300 cusecs, falling to 800 cusecs at the Khandsa bottleneck. Outfall Drain No. 8, which carries the Sahibi and the drainage of the Rohtak–Jhajjar belt to the Najafgarh drain, has a capacity of 4,000 cusecs, and 5,000 cusecs was observed at the Dhansa regulator in the monsoon of 2022. In the east, the Yamuna stands above the outfalls of the riverside towns when it floods: Hathnikund barrage passed 8.28 lakh cusecs on 18 August 2019, the highest since it was commissioned, as reported, and 3,59,760 cusecs on 11 July 2023, two days before the river reached 208.66 m at Delhi's Old Railway Bridge, its highest recorded level. In the north-west the Ghaggar, fed by choes from the Shivalik hills, has no flood gauge of the Central Water Commission (CWC) anywhere in its basin. In July 2023 a major breach at Ambala was plugged with the help of the Army; 82,400 cusecs was reported at Kaithal on 12 July, breaches were reported there and in Fatehabad and Sirsa districts, and by 14 July 1,385 villages of the State were reported affected.
3. **A State with both too little and too much groundwater.** In 2024 Haryana drew 135.96% of its extractable groundwater, and 88 of its 143 assessment units were over-exploited. In June 2023 the water lay deeper than 30 m under 97.2% of Kurukshetra district and 51.1% of Gurugram district. Yet every block of Rohtak and Jhajjar is "safe", because their water table is near the surface: within 3 m over 49.9% of Rohtak and 42.6% of Jhajjar, where the land is waterlogged and the soils saline and sodic. The State's waterlogged or waterlogging-prone land, within 3 m, grew from about 2.93 lakh ha in June 2023 to about 3.79 lakh ha in October, as the monsoon raised the water table. Recharge that is right for Gurugram is wrong for Rohtak, and the High Court has recorded both halves of the problem in one city: in Gurugram, rainwater "is not being effectively utilized for the purpose of replenishing the depleting groundwater levels" while the city waterlogs.

Behind all three lies lost storage. Gurugram's water bodies were counted at 641 in the revenue record of 1956, 487 in a Survey of India report of 1976 and 557 in satellite imagery of 2011–12, with only 123 common to all three counts; the bunds built in the late nineteenth century at Ghata, Chakarpur, Jharsa and Wazirabad, which once held back the runoff

from the ridge, were reported in 2025 to have been made obsolete by urbanisation. The Haryana Pond and Waste Water Management Authority Act, 2018 protects every public pond of 0.5 acre or more recorded as a talab, johar or tank, with its green belt, catchment and feeder inlets, and bars construction on them, and the obstruction of their inflow and outflow, without the Authority's permission (s.14); 19,665 ponds were on its register in February 2024. In 1996 the Supreme Court barred construction in the green belt and within 1 km of the Badkhal and Surajkund lakes in Faridabad, and made all plans within 1 to 5 km subject to the prior approval of the pollution control boards. Two Ramsar sites lie in the State, Sultanpur (143 ha) and Bhindawas (412 ha), both designated on 25 May 2021; no wetland notified under the Wetlands Rules, 2017 was confirmed, and the Najafgarh jheel had not been notified as of March 2024.

Design for Haryana therefore has to cover a monsoon that is short and late, on foothill gravels, alluvium, saline clays, rock and sand, in cities that drain to a drain in another State, to rivers raised by barrage releases and to a water table that in some places is already at the surface. The monsoon normally reaches Sonipat by 27 June, Ambala and Chandigarh by 28 June, Bhiwani by 30 June and Hisar by 3 July, and withdraws between 21 September at Hisar and 25 September at Sonipat. Annual normals run from 325.3 mm in Sirsa district and 396.5 mm in Hisar to 577.8 mm in Gurgaon, 695.8 mm in Karnal and 988.0 mm in Ambala, and 1,073.6 mm at Chandigarh. Large days fall outside the season too: the storm of 30 June 1981, which gave Rohtak 297.9 mm and Gurgaon 261.2 mm, came within days of the normal onset, and 141.6 mm fell at Ambala on 5 October 1973, 130.3 mm at Karnal on 9 October 1956 and 128.3 mm at Hissar on 17 October 1998.

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 receiving drain, the Najafgarh drain or the river is high, when a regulator or barrage is being operated, or when the flap gate on its outfall is shut.

The Manual also sets how public drains, roads, nalas, johads, lakes and other water bodies, gated and 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 Haryana's south-west monsoon from late June to September and the short, intense bursts and rare multi-day storms that come with it; the Yamuna, the Ghaggar and its Shivalik tributaries, the Sahibi and the I&WRD drains that carry their water, the barrages and regulators that control them, and the Najafgarh drain beyond the border; the gravels and choes of the Shivalik foothills, the alluvium of the Yamuna and Ghaggar plains, the saline and sodic soils of the centre, the rock of the Aravallis and the dunes of the south-west, over aquifers drawn down across most of the State and brimming in a few places; the johads, talabs and old bunds; and cities whose new sectors, basements and underpasses lie across the natural lines of drainage.

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 Report* for subzone 1(e) Upper Indo-Ganga Plains, which covers almost the entire State, as the interim source, with floors for short storms where its ratios understate them; in Gurugram, Faridabad and the rest of the NCR south, the floors that the Delhi edition of this Manual sets from Delhi's observed bursts. The report for zone 7 (Western Himalayas) is used as a check on catchments that rise in the Shivalik hills. IMD's rainfall intensity curve for Hissar (Das et al., 2022) repeats a curve printed for many other cities and is not used; no station analysis of short-duration rainfall was found for any Haryana station; and frequency analysis of gridded rainfall by the National Institute of Hydrology (NIH), Roorkee, is used for comparison only.

4. **Monsoon practice.** The PUB Singapore *Code of Practice on Surface Water Drainage* (7th ed., 2025), for the fixed-coefficient route for small sites and drainage reserves. Malaysia's MSMA 2 (2012), for monsoon design storms and simplified on-site detention.
5. **Runoff reduction and treatment.** The Georgia Stormwater Management Manual (2016), for runoff reduction and downstream analysis. CIRIA C753 *The SuDS Manual* (2015), for the treatment train. The Mile High Flood District criteria manual, for outlet and storage design.
6. **Local rules.** The Haryana Building Code 2017; the Haryana Development and Regulation of Urban Areas Act, 1975 and the HUDA Act, 1977; the Haryana Municipal Corporation Act, 1994 and the Haryana Municipal Act, 1973; the Acts of GMDA, FMDA and PMDA; the Haryana Canal and Drainage Act, 1974; the Haryana Pond and Waste Water Management Authority Act, 2018; the Haryana Water Resources (Conservation, Regulation and Management) Authority Act, 2020; the Punjab Land Preservation Act, 1900 in the Aravallis; the Wetlands (Conservation and Management) Rules, 2017; and the orders of the Supreme Court, the Punjab and Haryana High Court and the NGT on lakes, ponds, the Aravallis, drains, wetlands, floodplains and sewage. This Manual follows them or, where disclosed, makes them stricter. The Building Code was not made by notification in the Gazette: it was circulated by a memo of the Town and Country Planning Department of 7 March 2017, applies to the whole State from 6 January 2017, and is applied by each Competent Authority under its own Act; it is cited from an archived copy of the Department's text and a later copy hosted by HSVP. Its amendments, also issued by memo, of 27 May 2020 and 19 January 2022 were read; amendments of 8 December 2025 and 5 June 2026 and a proposal of November 2026 have been reported but were not read, and none of those read or reported concerns rainwater harvesting, plinths or basements. The GMDA Act is cited from the text of its Bill, the HDRUA Act as DTCP quotes it, and the Haryana Municipal Act from its section headings; the HUDA Act, the FMDA Act and the Punjab Land Preservation Act were not read. Every rule cited must be checked against the current text.

Why this Manual is needed

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

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

- **Return periods.** CPHEEO recommends 5 years for drains in Class I cities and 2 years elsewhere, and lets a State committee adopt higher values. A 2023 CPHEEO presentation shows a different table. IRC:SP:50-2013 suggests 1–2 years for urban road drains; IRC:SP:42-2014 suggests 25 years. An engineer designing a drain in Haryana 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 one panel for the State, Hissar, and it repeats the curve printed for many other cities: it implies a 2-year day of about 170 mm, against a district normal of 396.5 mm a year. The CWC report for subzone 1(e), which covers almost the entire State, dates from 1984; it takes the 1-hour rain as 0.34 of the 24-hour rain and assumes a loss of 3.0 mm/h. Its maps are exceeded at most of the State's long-record stations: Hissar recorded 346.7 mm on 16 August 1926 against a 100-year day of about 200–240 mm on the map, and a raingauge at Rohtak 484.1 mm on 19

September 1933 against about 200–220 mm. The reanalysis grids of NIH-DHAARA split the State the other way round: they read 139 mm for a 50-year day at Hisar, against about 200–220 mm on the map, but 320 mm at Panchkula, against about 262 mm.

Haryana has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of DTCP, HSVP, the Urban Local Bodies Department, I&WRD, GMDA, FMDA or any Municipal Corporation that fixes a return period or a design rainfall for city storm drains. What exists is practice, reported second-hand, and capacities without a design basis: urban channels sized for 25 mm/h with a runoff coefficient of 1/8, and rural drains by the Boston Society formula Q = 200√A (cusecs, square miles) cut by factors of 1/12 to 1/4 (NCRPB, 2016); rural drains sized for "three days rainfall of five years frequency to be drained in three days", and urban drains to CPHEEO, in the Town and Country Planning Department's Sub-Regional Plan for the Haryana Sub-Region of the NCR; and Gurugram's master drains, given as 541 cusecs for Leg-I, 1,305 for Leg-II and 3,702 for Leg-III on DTCP's drainage drawing of 2012, and up to 2,300 cusecs in HUDA's plan for the catchment of the Badshahpur drain (2017, revised 2020), neither of which states a return period. This Manual is offered as a technical companion to the Building Code, the Municipal Corporation Act, the Canal and Drainage Act, the Pond Authority Act and the development plans: it supplies the design storm, detention, water-level and buffer values that they leave open. It has not been adopted by DTCP or any other body. In particular:

- **The building rules require rainwater harvesting, but not detention.** The Building Code requires roof rainwater harvesting "in the areas specified by the Competent Authority, through a notification" where the rooftop is 100 m² or more, and groundwater recharge for all types of buildings on plots of more than 500 m², with the recharge well at least 10 m from any structure handling sewage; no occupation certificate is issued until an architect or engineer certifies that the system works, and the rule is to be "strictly implemented" in ten named towns, from Panchkula to Gurgaon (Code 8.1). Its predecessor was HUDA's notification of 31 October 2001, and a direction of the Chief Minister of 30 June 2026 to extend it to urban plots of more than 250 square yards was reported, but no notification was seen. For 5,000 to 20,000 m² of built-up area the Code requires that "The inlet and outlet point of natural drain system should be maintained with adequate size of channel", that at least 20% of the recreational open space be unpaved, and one recharge bore per 5,000 m² (Code 12.1). No rule requires on-site detention, limits peak runoff or sets "zero runoff"; the Code's "zero waste water discharge" (Code 11.7) concerns sewage, not rain;
- **There is no setback from water.** The Building Code sets no distance from any drain, nala, river, pond or lake, and no I&WRD rule barring construction within a set distance of a drain or canal was found. The Municipal Corporation Act bars building on a municipal drain without the Commissioner's written permission (s.206). Plinths must be 450 mm to 1.5 m high, "so located … that proper drainage of the site is assured" (Code 7.3), but "The responsibility of draining a basement storey and for protecting it from rain shall be that of the owner" (Code 7.16), and no rule keeps surface water out of a basement;
- **The pond law protects ponds, but gives no method.** The Pond Authority Act takes in a pond's green belt and catchment, lets the State notify a protected area around it (s.16), and requires the Authority's prior approval of any spatial or development plan that covers a pond (s.17). It sets no distance, no design flood and no storage to be kept, no protected area was found notified, and it does not apply to ponds of less than 0.5 acre or on private land, which include many of the depressions that hold a city's runoff;
- **A floodplain is notified on one river only.** Under s.45 of the Canal and Drainage Act the State notified a flood plain zone of the Ghaggar in Panchkula district on 27 October 2023, drawn for a 100-year flood of 2,933.45 cumecs computed by Gumbel's method from 54 years of data; in May 2024 the NGT found that "the requisite procedure for declaration of the Flood Plain Zone of River Ghaggar has not been followed". The State has told the NGT that all construction on river floodplains is banned under s.45, but no notification was found for the Yamuna, the Markanda, the Tangri, the Sahibi or any other river or drain. Apart from that 100-year flood and the five-year rural criterion, no design return period was found for any drain or river corridor in the State. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7); it does not replace any line that the State notifies or a court draws, and where such a line binds and is wider, it governs; and
- **No document sets the drain or river level for which an outfall is designed.** Gurugram's drains end in the Najafgarh drain in Delhi, whose level Haryana does not control; Outfall Drain No. 8 ran a quarter over its capacity in 2022; the CWC gauges on the Yamuna at Karnal and Mawi give danger levels and highest flood levels, which are flood-

warning levels and records, not design levels; and on the Ghaggar there are no CWC gauges at all.

So each agency and each local body interprets the central manual its own way. MCG and the other Municipal Corporations, the Municipal Councils and Committees, HSVP, GMDA, FMDA and PMDA, licensed colonisers, I&WRD, PHED, HSIIDC, road agencies, their consultants and funding agencies fill the gaps differently. Two drains on the same road, built by different agencies, can be sized for different storms from different rainfall sources. In Gurugram a drain inside a licensed colony is built by its coloniser, the sector drain outside it by HSVP, and the master drain it joins is run by GMDA, which empties into a drain in Delhi run by another government; none of them states the storm it was built for. The master drains also carry sewage: in 2020 GMDA reported about 139 MLD of untreated sewage entering Legs I to III, of which 51.30 MLD still had to be diverted, against the condition that water reaching the Najafgarh drain have a BOD of not more than 30 mg/l. And a reviewer has no common basis against which to check a design.

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

- one source and method for design rainfall across the State, in three rainfall zones, with a checked station analysis to govern where one exists, and floors where the CWC ratios understate short storms, set in Gurugram and Faridabad from Delhi's observed bursts (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites (Chapter 4);
- a required tailwater check for outfalls to drains, regulators and rivers, gated, flap-gated or pumped, against a design drain or river level, with coordination with Delhi where an outfall depends on the Najafgarh drain (Chapter 5);
- a design flood line, and corridors and setbacks along drains and nalas and around johads and lakes, which no rule now sizes, proposed by this Manual for use with the s.45 floodplain and the lines the courts have drawn (Chapter 7);
- recharge first where the water table is deep, no recharge credit where it lies within 3 m of the ground, as across much of the Rohtak–Jhajjar belt and the floodplains, and treatment where drains carry sewage (Chapter 8); and
- basin-wide master plans, so that the agencies that share a basin plan together (Chapter 11).

It uses the route the CPHEEO manual itself provides: a State may adopt standards higher than the national values (CPHEEO 2019, Table 4.1, Note 2). A Municipal Corporation, a metropolitan development authority or DTCP 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, para 6.6.2; MoHUA Model Building Bye-Laws (2016); Government of Haryana, Town and Country Planning Department, The Haryana Building Code, 2017, circulated vide PSTCP Memo No. Misc-138-A-Loose/7/5/2006-2TCP dated 7 March 2017 (archived copy of the Department's text and a copy hosted by HSVP), Codes 1.1, 1.2, 3.2, 3.4, 7.3, 7.16, 8.1, 11.7, 11.11 and 12.1; amendment memos No. Misc-2339-(ULB)-VOL-II/7/5/2006-2TCP of 27 May 2020 and No. Misc-2339-ULB-VOL-II-A/7/5/2006-2TCP of 19 January 2022; amendments of 8 December 2025 and 5 June 2026 and the proposal of November 2026 (as reported; not read); HUDA notification of 31 October 2001 (as quoted by I&WRD to the NGT); direction of the Chief Minister of 30 June 2026 (as reported); Haryana Municipal Corporation Act, 1994 (Act 16 of 1994), ss.161, 193–198, 202 and 206; Haryana Municipal Act, 1973 (Act 24 of 1973; section headings only); Haryana Development and Regulation of Urban Areas Act, 1975, ss.2(g), 2(i) and 3 (as quoted by DTCP to the NGT, report of 28 March 2022); Gurugram Metropolitan Development Authority Bill, 2017 (Bill No. 36-HLA of 2017; Act 34 of 2017); Panchkula Metropolitan Development Authority Act, 2021 (Act 23 of 2021); Haryana Canal and Drainage Act, 1974 (Act 29 of 1974), ss.2(7), 45–48; Haryana Pond and Waste Water Management Authority Act, 2018 (Act 33 of 2018), ss.1(3), 2(k), 14–17 and 20, and the Authority's written statement of 21 February 2024 in NGT O.A. 573/2023; Haryana Water Resources (Conservation, Regulation and Management) Authority Act, 2020 (Act 29 of 2020, as amended), s.21; Wetlands (Conservation and Management) Rules, 2017, and the notification reconstituting the Wetland Authority of Haryana (12 May 2020); I&WRD replies in NGT O.A. 421/2022 (Ghaggar flood plain zone) and the Tribunal's order of 22 May 2024 (as quoted); I&WRD committee report of 7 February 2024 in NGT O.A. 627/2022 (Sahibi and Outfall Drain No. 8); State of Haryana report in E.A. 35/2023 in NGT O.A. 673/2018; GMDA status report of 2 October 2020 in NGT O.A. 454/2018, and GMDA reports in O.A. 325/2015 and O.A. 523/2019, including DTCP drawing No. DTP(G) 2104/2012 of 9 November 2012 and HUDA's

management plan for the catchment of the Badshahpur drain (Rev. 2, 24 November 2020); Supreme Court of India, M.C. Mehta v. Union of India (Badkhal and Surajkund Lakes), I.A. 29 in W.P.(C) 4677/1985, order of 11 October 1996; Punjab and Haryana High Court, Sunil Singh v. MoEF, CWP-20032-2008 and connected cases, order of 22 September 2026; Haryana Vidhan Sabha, starred questions No. 1397 (2022) and No. 16 (September 2023); Lok Sabha reply of 8 August 2025 (as reported); Rajya Sabha reply of 13 February 2025 and PIB (August 2021) on the Ramsar sites; NCRPB, Functional Plan on Drainage for NCR (2016), §5.2.2 and Table 5.2; Town and Country Planning Department, Sub-Regional Plan for Haryana Sub-Region of NCR-2021, Chapter 9; CWC, Flood Estimation Report for Upper Indo-Ganga Plains Subzone 1(e) (approved July 1984; report number not on the copy read [TBC]), Plates 9 and 10 (read by eye), and the report for zone 7 (Western Himalayas); IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); IMD, Climate of Haryana and Union Territories of Delhi and Chandigarh (1991); IMD, Monthly Climate Summary, July 2023; IMD, Pai et al. (2020), new normal dates of onset and withdrawal of the south-west monsoon, Table 2; Das et al. (2022), MAUSAM 73(4), Fig. 4(viii); NIH-DHAARA (accessed 7 November 2026); CGWB and the State, Dynamic Ground Water Resources of Haryana, 2024; HWRA, Haryana Water Resources Atlas 2025; Ministry of Jal Shakti committee, interim report on the joint flood management study of the Yamuna between Hathnikund and Okhla barrages (January 2024); CWC list of flood forecasting sites (as copied by SANDRP); reports of the floods at Gurugram (2016, 2020, 2024, 2025), on the Ghaggar (2023) and the Yamuna (2019), of the Hathnikund peak of 2019, and of the capacities of Gurugram's master drains (press and secondary sources).

How to use this Manual

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

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

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

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

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

Where to start.

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

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2	Design Rainfall and Design Storms	Annexes 2
3	Hydrologic Methods	Annexes 3
4	Site Runoff Control: Retention and Detention	Annexes 4
5	Downstream and Tailwater Analysis	Annexes 5
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Abbreviations

Abbreviation	Meaning
AEP	Annual exceedance probability
AMC	Antecedent moisture condition
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
ARF	Areal reduction factor
AWS	Automatic weather station
BOD	Biochemical oxygen demand
BSMP	Basin Stormwater Master Plan
CAG	Comptroller and Auditor General of India
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
CN	Curve number (SCS/NRCS method)
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CSSRI	Central Soil Salinity Research Institute, Karnal
CWC	Central Water Commission
DD8	Diversion Drain No. 8 (not Outfall Drain No. 8)

Abbreviation	Meaning
DPR	Detailed project report
DTCP	Town and Country Planning Department, Haryana, and its Directorate
DWF	Dry-weather flow
EIA	Environmental impact assessment
ESC	Erosion and sediment control
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FMDA	Faridabad Metropolitan Development Authority
FPZ	Flood plain zone (notified under s.45 of the Haryana Canal and Drainage Act, 1974)
FTL / MWL	Full tank level / maximum water level
GMDA	Gurugram Metropolitan Development Authority
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Haryana)
HBC 2017	The Haryana Building Code 2017, as amended, applied by each Competent Authority
HDRUA Act	Haryana Development and Regulation of Urban Areas Act, 1975
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HPWWMA	Haryana Pond and Waste Water Management Authority (the Pond Authority)
HSDMA	Haryana State Disaster Management Authority
HSG	Hydrologic soil group
HSIIDC	Haryana State Industrial and Infrastructure Development Corporation
HSPCB	Haryana State Pollution Control Board
HSVP	Haryana Shehri Vikas Pradhikaran (formerly HUDA)
HUDA	Haryana Urban Development Authority (now HSVP)
HWRA	Haryana Water Resources (Conservation, Regulation and Management) Authority
I&FC	Irrigation and Flood Control Department, Government of the National Capital Territory of Delhi
I&WRD	Irrigation and Water Resources Department, Haryana
IDF	Intensity–duration–frequency
IMD	India Meteorological Department
IRC	Indian Roads Congress
MCF	Municipal Corporation of Faridabad
MCG	Municipal Corporation of Gurugram
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs

Abbreviation	Meaning
NCR	National Capital Region
NCRPB	National Capital Region Planning Board
NDMA	National Disaster Management Authority
NGT	National Green Tribunal
NIH	National Institute of Hydrology, Roorkee
NOC	No-objection certificate
ORB	Old Railway Bridge, the reference gauge on the Yamuna in Delhi
PHED	Public Health Engineering Department, Haryana
PMDA	Panchkula Metropolitan Development Authority
PSD	Permissible site discharge
RD	Reduced distance (chainage along a canal or drain)
RRV	Required retention volume
RWH	Rainwater harvesting
SANDRP	South Asia Network on Dams, Rivers and People
SLA	Sea-level allowance (coastal term; not applicable in Haryana)
SoI	Survey of India
SRP	Sub-Regional Plan for the Haryana Sub-Region of the NCR
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
SW monsoon / JJAS	South-west monsoon, June–September
SWD	Storm water drain
ULB	Urban local body (a Municipal Corporation, Municipal Council or Municipal Committee)
UTM	Universal Transverse Mercator
WQv	Water quality volume
WSUD	Water-sensitive urban design

CHAPTER 1

Policy, Applicability and Adoption

1.1 Purpose and objectives

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

1.1.2 The Manual has the following objectives:

- (a) to make stormwater management a **condition of development approval**, so that new development and redevelopment do not increase flood peaks or runoff volumes downstream;
- (b) to retain frequent rainfall on site, so that groundwater recharge is sustained and pollutant loads are reduced;
- (c) to size storage for the long-duration south-west monsoon storms of July–September, which fall on the waterlogged ground of the Rohtak–Jhajjar belt, often on a Yamuna or Ghaggar already in flood from the Shivalik and Himalayan hills, and have put more than 300 mm in a day on Palwal (1875) and Rohtak (1933), as well as for short-duration intensities;
- (d) to design outfalls for the stage of the Yamuna and the Ghaggar and their tributaries, raised by the releases of the Hathnikund barrage and by floods from the Shivalik hills; the levels of the I&WRD drains into which towns discharge, such as Outfall Drain No. 8, which runs from the Rohtak–Jhajjar belt to the Najafgarh drain in Delhi; and the level of the Najafgarh drain itself, which receives the master drains of Gurugram, including the case where the outfall is closed;
- (e) to protect tanks (johads), 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 code issued by the Town and Country Planning Department with memo No. Misc-138-A-Loose/7/5/2006-2TCP of 7 March 2017, and applied by each Competent Authority under its own Act (the Haryana Building Code 2017), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> **Commentary.** Haryana's floods come from three sources, often together. The first is the long, heavy storm on the plains. On 9 September 1875 Palwal recorded 398.8 mm and Ballabgarh 299.7 mm, and on 19 September 1933 the Rohtak rain gauge recorded 484.1 mm, the highest day on record in the State, with 325.1 mm at Jhajjar and 279.4 mm at Beri (IMD, *Climate of Haryana*); on 30 June 1981 Rohtak recorded 297.9 mm and Gurgaon 261.2 mm (IMD). A single day above the 100-year value of the CWC plates has struck the Rohtak–Gurugram–Faridabad belt at least three times in the record. The second source is the rivers, fed from the Shivalik and Himalayan hills and from the Aravallis. The Sahibi flooded in 1957, 1964 and 1977; on 6 August 1977 about 36,000 cusecs passed the Dhansa bund and the Najafgarh jheel was submerged (I&WRD, 2024; I&FC Delhi). The Hathnikund barrage on the Yamuna passed a record 8,28,072 cusecs on 18 August 2019 (as reported). In July 2023 Chandigarh recorded 302.2 mm and Ambala 224.1 mm on 9 July (IMD), Hathnikund passed 3,59,760 cusecs on 11 July (MoJS committee, 2024), and the Ghaggar breached its embankments in Ambala, Kaithal, Fatehabad and Sirsa; the State

reported 1,385 villages affected (as reported). In September 2025 about 3,000 villages were reported affected, in a season 33% above normal over the Haryana, Chandigarh and Delhi sub-division (IMD; as reported). The third source is the city whose drains fail in a fall that is not extreme. On 28 July 2016 the national highway through Gurugram was jammed for more than 18 hours after a fall reported as 46 mm in three hours, the "Gurujam" (as reported); the city flooded again on 19 August 2020, on 31 July 2024, when three people were electrocuted in ponded water near IFFCO Chowk, on 9–10 July 2025, when 103 mm was reported in 90 minutes, and on 1 September 2025, after more than 100 mm in four hours (as reported).

Missing design makes all three worse. The only urban drainage design figure found for the State is second-hand: the NCR Planning Board reports 25 mm/h with a runoff coefficient of 1/8 for the storm water channels of Haryana's urban areas (NCRPB, 2016). Gurugram's master drains carry design discharges on a DTCP drawing of 2012 but no stated return period, and Leg-III, the Badshahpur drain, a storm drain, carried a dry-season flow of 126.53 cusecs in 2021 (Haryana Vidhan Sabha, 2022). In September 2026 the High Court recorded that Gurugram "is facing severe waterlogging during the monsoon season", while the rain that collects is not used to replenish its falling groundwater (*Sunil Singh*, 22 Sep 2026). Objectives (b) to (e) address the storage, outfall and building-level 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 Haryana Building Code 2017 mandate RWH only. Objective (a) is therefore the main new step this Manual takes.

1.2 Stormwater management hierarchy

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

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

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

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

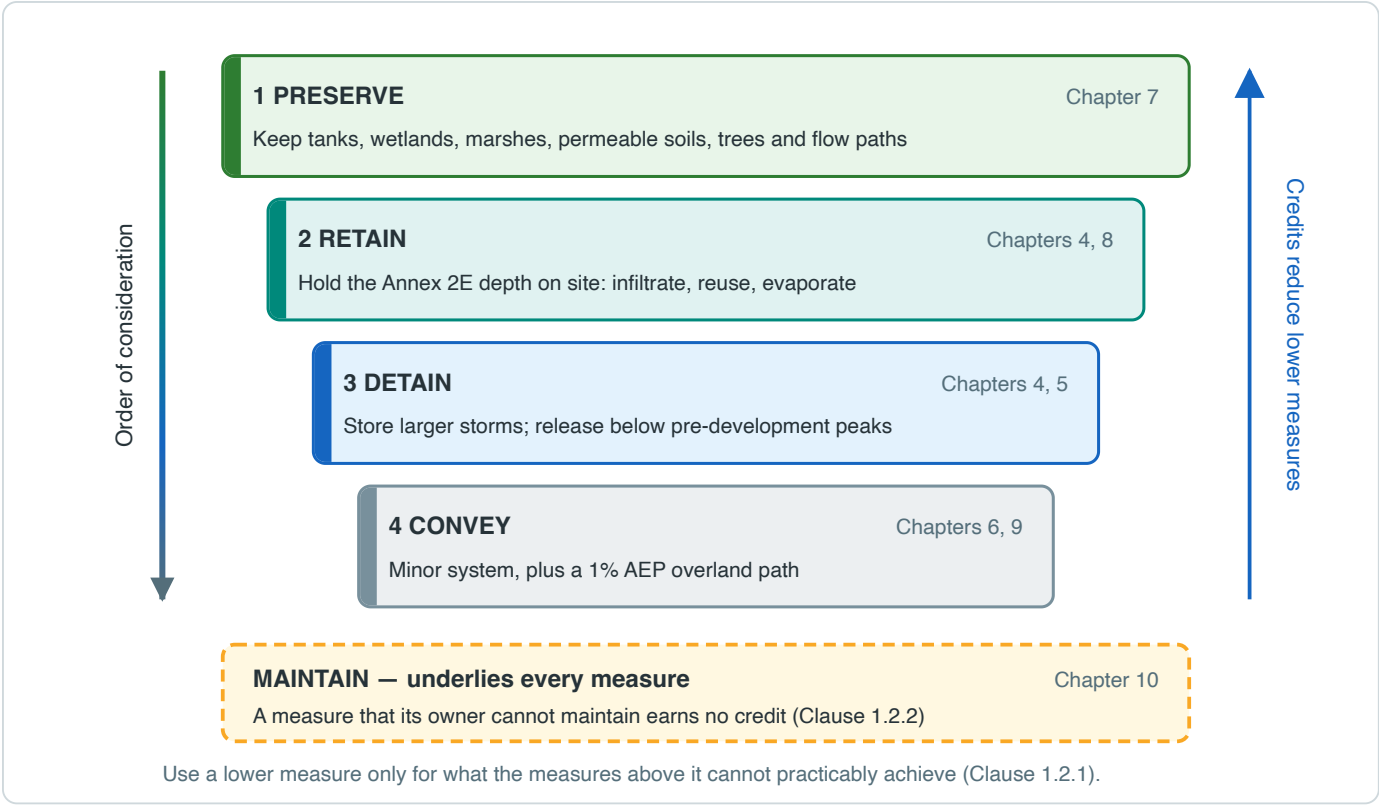

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

Commentary. The order follows the "layers" of Kansas City Metro APWA Section 5600, Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet, 2025). The same logic is behind Georgia's runoff-reduction standard and CSE's "attenuate and infiltrate first" principle (CSE, 2023). For Haryana, the top layer has a particular meaning. The storage that matters is in the State's johads and talabs, of which 19,665 ponds, 18,764 rural and 901 urban, are on the Pond Data Management System of the Haryana Pond and Waste Water Management Authority (HPWWMA, 2024); in the old bunds at the foot of the Aravallis around Gurugram, Ghata, Chakarpur, Jharsa and Wazirabad, built in the late nineteenth century and since made obsolete by building (as reported), of which the Ghata bundh alone ponded 60–100 ha from a catchment of about 12,575 ha (GMDA); in the lakes at Badkhal, Surajkund and Damdama; in the Najafgarh jheel, the depression shared with Delhi into which the Sahibi and Gurugram's drains run; in the khadar of the Yamuna and the Ghaggar; and in the two Ramsar sites, Sultanpur (143 ha) and Bhindawas (412 ha), both designated on 25 May 2021. Losing it has a record: Gurugram's water bodies numbered 641 in the revenue record of 1956, 487 on the Survey of India maps of 1976 and 557 on satellite imagery of 2011–12, with only 123 common to all three (GMDA, report to the NGT). The law protects part of it. The Pond Authority Act of 2018 defines a pond of 0.5 acre or more recorded as talab, johar or tank to include its green belt, peripheral catchment and feeder inlets, and bars construction there, or any obstruction of inflow or outflow, without the Authority's permission (ss.2(k) and 14); public tanks and the land appertaining to them vest in a Municipal Corporation (Haryana Municipal Corporation Act, 1994, s.161); and the Supreme Court has barred construction within 1 km of Badkhal and Surajkund (1996). Ponds under 0.5 acre and ponds on private land, which include many urban depressions, are outside the Act. 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 Haryana through:

- (a) an amendment to the Haryana Building Code 2017 that makes compliance with this Manual a condition of planning permission, building permit, layout approval and completion certificate, for development to which Clause 1.5 applies; and
- (b) bye-laws or standing orders of each urban local body (ULB), adopting the Manual for works executed or approved by that ULB, including the ULB's own drains and roads.

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

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

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

> Commentary. In Haryana the building rules are the Haryana Building Code, 2017 (HBC 2017), one code for the whole State. It is not a Gazette notification made under an Act: the Town and Country Planning Department circulated it with memo No. Misc-138-A-Loose/7/5/2006-2TCP dated 7 March 2017, and it applies to the entire State from 6 January 2017 (Code 1.1(2)); its predecessor, the Haryana Building Code, 2016, replaced the building rules of the separate agencies from 30 June 2016 (Preface). Each Competent Authority applies it under "the respective Act" (Code 1.2(1)(ii)): DTCP, HSVP in its Urban Estates, the Municipal Corporations, Councils and Committees, and HSIIDC in its estates. It is amended by memo in the same way, as on 27 May 2020 and 19 January 2022, each memo forwarded to all departments, boards and corporations "with a request to take necessary action with regard to adoption"; amendments of 8 December 2025 (occupation certificates) and 5 June 2026 (charging points for electric vehicles), and a proposal of November 2026 on purchasable floor area, are reported (as reported; texts not read), and none found touches Code 8.1, 7.3 or 7.16. The Code requires roof rainwater harvesting where the rooftop is 100 m² or more in areas the Competent Authority notifies, and groundwater recharge on all buildings on plots of more than 500 m² (Code 8.1); sets the plinth at 450 mm to 1.5 m, "so located … that proper drainage of the site is assured" (7.3); leaves the drainage of a basement, and its protection from rain, to the owner (7.16(5)(iv)(b)); requires building plans to show "the method of disposal of … storm water" (3.4(2)(vi)); and, for buildings of 5,000–20,000 m² built-up, keeps the inlets and outlets of the natural drainage, at least 20% of the recreational open space unpaved and one recharge bore for each 5,000 m² (12.1). It sets no design storm, return period, release rate or detention volume, no "zero runoff" rule, and no setback from a drain, nala, pond or river. The route of Clause 1.3.1(a) therefore runs through the Town and Country Planning Department, which would issue the amendment by memo as it issues the Code's other amendments, and through each Competent Authority, which would apply it; publication in the Gazette, which Clause 1.3.1 and Annex 1D assume, is this Manual's proposal. This Manual is a draft; neither the Government nor any authority has adopted it. MoHUA told Parliament in July 2026 that urban flooding "falls under the purview of the State Governments and the ULBs" and listed the CPHEEO manual among "advisory guidelines" (Lok Sabha AU1847). The State therefore needs no central approval to adopt higher standards. CPHEEO's Note 2 to Table 4.1 (§4.4.1.4) allows "a high powered committee constituted by State/UT Government through a notification" to adopt higher return periods. Clause 1.3.2 uses that route so that higher standards are on record for centrally funded schemes.

1.4 Definitions

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

Term	Meaning in this Manual
Approving Authority (the Authority)	The body that grants planning permission, building permit or layout approval for a development, or that sanctions a public work: the Competent Authority that approves the building plan, licence or layout for the site under the Haryana Building Code 2017 and its own Act, which is DTCP for licences under the Haryana Development and Regulation of Urban Areas Act, 1975 and for building plans in the controlled areas, HSVP in its Urban Estates, the Municipal Corporation, Municipal Council or Municipal Committee within its limits, or HSIIDC in its industrial estates, including approval by self-certification where the Code allows it, 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 Haryana Building Code 2017 or that is executed as a public work.
Redevelopment	Development on a site where impervious cover already exists.
Land disturbance	Clearing, grading, excavation, filling or paving of land, measured in plan area over the whole of a common plan of development (Clause 1.5.5).
Impervious area	Roofs, paving, compacted gravel, decks and other surfaces that prevent infiltration. Permeable paving designed to Chapter 8 is counted as pervious only for the area it treats.
New or replaced impervious area	Impervious area created, or removed and rebuilt down to the subgrade, by the development. Resurfacing that leaves the base in place is not "replaced".
Retention	Permanent removal of runoff from the drainage system on site, by infiltration, reuse or evapotranspiration (Chapter 4).
Detention	Temporary storage of runoff with a controlled outlet, emptied after the storm (Chapter 4).
Rainwater harvesting (RWH)	Collection of rainfall for supply or recharge under the RWH mandate. RWH storage is not detention unless Chapter 4 allows it.
Minor system	Drains, pipes and inlets designed for the minor-system AEP of Chapter 6.
Major system	The overland and floodway path that carries the 1% AEP (100-yr) flow (Chapter 6).
Pre-development condition	Greenfield: open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted (Chapter 3).
Flood-sensitive catchment	The catchments of Gurugram's master drains, Leg-I, Leg-II and Leg-III (the Badshahpur drain), from the Aravalli slopes through the city to their outfalls into the Najafgarh drain, including the reach past Hero Honda Chowk and Khandsa; the catchment of the Budhiya (Buria) nala and of the city drains that join it through Faridabad, down to its outfall towards the Yamuna; the towns of Rohtak, Jhajjar, Bahadurgarh, Beri and Sampla and the land that drains to Outfall Drain No. 8 there, where the water table is within 3 m of the surface over about half of Rohtak and Jhajjar districts; the land of Panchkula and Ambala that drains to the Ghaggar, the Kaushalya and the Tangri, with the floodplain zone of the Ghaggar notified under section 45 of the Haryana Canal and Drainage Act, 1974; and the floodplain (khadar) of the Yamuna and the land that drains to it through gated or pumped outfalls at Karnal, Panipat and Sonipat, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (johad), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7).
Regional facility	A detention, retention or tank storage facility serving more than one development, built or restored under a basin plan (Chapter 4).
Tier A / Tier B authority	An Approving Authority classed under Clause 1.6.

Term	Meaning in this Manual
Policy supplement	The set of adoptable alternative clauses in Clause 1.7 and Annex 1C.
Drainage report	The preliminary or final report required by Chapter 10.
Registered professional	A person registered under the Haryana Building Code 2017 to prepare and sign the relevant plans, with any further qualification required by Clause 10.6.
Compliance calculator	The State-issued tool for computing and reporting compliance (Clause 10.5).
Maintenance declaration	The registered undertaking by an owner to maintain a stormwater facility (Clause 10.10).
Variance	Approval to depart from a numeric requirement, with equivalent performance shown (Clause 1.10).
Waiver	Approval that a requirement does not apply to a site, on the grounds in Clause 1.10.
Notified	Published by the Government or the State Stormwater Technical Committee in the Haryana Government Gazette.
Competent Authority	The officer or agency authorised under the respective Act to approve building plans and grant occupation certificates under the Haryana Building Code 2017 (Code 1.2(1)(ii) and (xxv)). Where this Manual refers to the Approving Authority for a development, the Competent Authority for the site acts as it.

> **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 Haryana Building Code 2017;
- (b) all drainage, road, bridge, culvert, waterbody and flood-mitigation works executed by a ULB, a State department, a board, or a State undertaking; and
- (c) works executed by Central agencies or their contractors within Haryana, to the extent that the Authority's approval or no-objection is required.

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

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

1.5.3 **RWH.** The existing RWH mandate continues to apply under Code 8.1 of the Haryana Building Code 2017 to buildings whose rooftop is **100 m²** or more in the areas the Competent Authority notifies, and, as groundwater recharge, to all buildings on plots of more than **500 m²** and to parks, parking and other common open spaces, with the occupation certificate withheld until an architect or engineer certifies that the system works; and, in the Urban Estates of HSVP, under its notification of 31 October 2001 to buildings whose rooftop is 100 m² or more, 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.

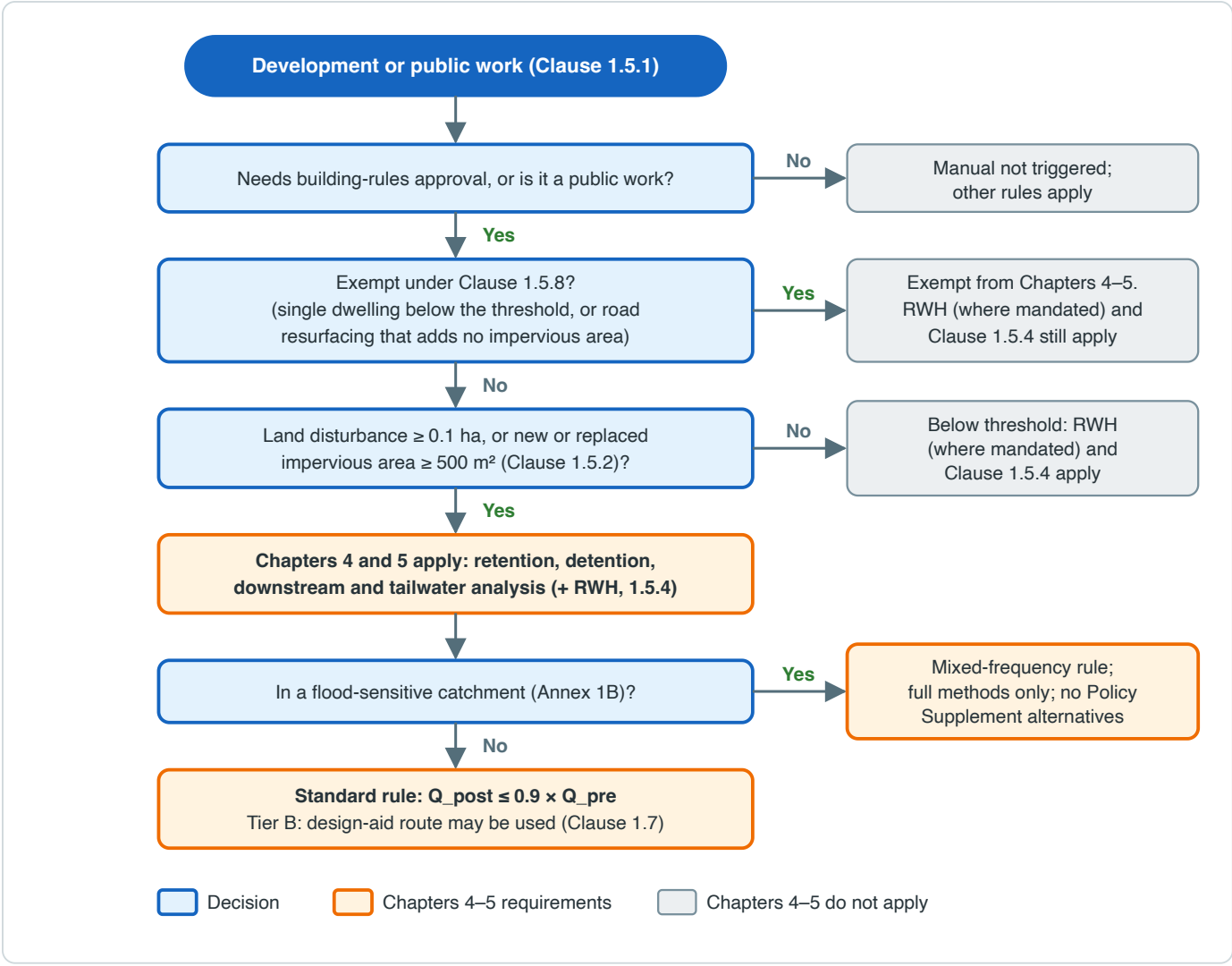

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Haryana plots are small and the cumulative effect of many small plots is what fills Gurugram's drains. For small buildings in Haryana, Code 8.1 of the HBC 2017 requires roof rainwater harvesting only where the rooftop is 100 m² or more and the Competent Authority has notified the area, and groundwater recharge only on plots of more than 500 m², with the occupation certificate withheld until an architect or engineer certifies that the system works; the Code names ten towns where it is "strictly implemented". None of this is sized to a runoff volume, and none of it limits what leaves the plot. A direction of the Chief Minister of 30 June 2026 to extend harvesting to residential plots of more than 250 sq yd in urban areas is reported, but no notification was found (as reported) [TBC]. The plinth of 450 mm to 1.5 m

(Code 7.3) is measured from the street, not from any flood level, and the Code leaves the drainage of a basement to its owner (7.16(5)(iv)(b)), with no entry level for a basement ramp. Clause 1.5.4(b) applies to every building whatever its size for this reason.

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 Municipal Corporation of Gurugram (MCG), and GMDA and every other Approving Authority within the Gurugram Metropolitan Area as notified under the Gurugram Metropolitan Development Authority Act, 2017;
- (b) every other Municipal Corporation constituted under the Haryana Municipal Corporation Act, 1994, as constituted from time to time, among them those of Faridabad and Manesar, with every other Approving Authority within its limits; and
- (c) the Faridabad and Panchkula Metropolitan Development Authorities (FMDA and PMDA), and any metropolitan development authority constituted later by an Act of the State, with every Approving Authority within its notified area; and, wherever they lie, HSVP in its Urban Estates and DTCP for the colonies it licenses under the Haryana Development and Regulation of Urban Areas Act, 1975.

1.6.2 **Tier B authorities.** All other Municipal Councils and Municipal Committees are Tier B.

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

Table 1.1 — Differences between Tier A and Tier B authorities

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

1.6.4 **Moving between tiers.** A Tier B authority may opt into Tier A by council resolution. The Government may notify a Tier B authority as Tier A when it becomes a Corporation, joins the area of a metropolitan development authority (GMDA, FMDA or PMDA) as notified under its Act, 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.** Municipal Corporation of Gurugram, with its engineering wing and, beside it, GMDA for the master drains, and a small Municipal Committee 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 Gurugram.

1.7 Policy supplement: adoptable alternatives

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

1.7.2 The alternatives are:

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

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

1.7.3 **Conditions on adoption.**

- (a) An alternative shall not lower any criterion below the values of this Manual. S-1 and S-2 are simplified methods for meeting the same criterion. They are not lower criteria.
- (b) A Tier B authority adopts an alternative by council resolution, sent to the State Stormwater Technical Committee within 30 days. A Tier A authority needs the Committee's concurrence before adoption.
- (c) The adopted alternatives shall be published on the Authority's website and in the register of Clause 10.17.
- (d) Retention (Annex 2E depth) cannot be replaced by any alternative, except where fee-in-lieu under S-5 funds equivalent retention in the same basin.
- (e) The tables for S-1, S-2 and S-3 shall be issued by the State Stormwater Technical Committee, and reviewed with Chapter 2 (Clause 2.14).

> **Commentary.** The supplement follows the model of the APWA 5600 (2025.01) Policy Supplement, which gives alternatives for the four most contested criteria (applicability, Rational Method limits, stream setback trigger, and Zone 2 setback width). Two of those map onto S-3 and onto the applicability threshold of Clause 1.5.2. Alternative

S-3 copies the APWA answer to the same problem: the 1% AEP extent is not mapped for small drainage areas, so a fixed-width table is offered. S-2 follows the Kansas City 2011 shift from "match existing" to fixed unit-area release rates. Local agencies preferred a set rate because existing conditions were hard to determine consistently (MARC Evolution deck). It also reflects the Sydney Water permissible site discharge (PSD) method. The 2 ha / 0.5 ha limits for S-1 (matching Clause 4.14.1) and the 1 ha limit for S-4 have no direct precedent; they are set by this Manual.

1.8 Relationship with other instruments

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

Table 1.3 — Relationship with other instruments

Instrument	Relationship
Haryana Building Code, 2017 (circulated with memo No. Misc-138-A-Loose/7/5/2006-2TCP of 7 March 2017 and applying statewide from 6 January 2017; amended by memo, as on 27 May 2020 and 19 January 2022, with amendments of 8 December 2025 and 5 June 2026 reported)	Continues. It is a departmental code applied by each Competent Authority under its own Act, not a Gazette notification. It requires building plans to show the disposal of storm water (Code 3.4(2)(vi)); sets the plinth at 450 mm to 1.5 m so that the site drains (7.3); leaves the drainage of a basement to its owner (7.16(5)(iv)(b)); and, for buildings of 5,000–20,000 m² built-up, keeps the inlets and outlets of the natural drainage "with adequate size of channel", at least 20% of the recreational open space unpaved and one recharge bore per 5,000 m² (12.1). It sets no design storm, release rate or detention volume, and no setback from a drain, nala, pond or river. The design criteria of Chapters 2–6 and the hydraulic corridor and setbacks of Chapter 7, whose Zone 1 is at least 15 m, are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the Code, a development plan, a statute or a court order is stricter, it governs (Clause 1.3.3).
Rainwater harvesting: HBC 2017, Code 8.1; HSVP notification of 31 October 2001 in the Urban Estates; Central Ground Water Authority (CGWA), Public Notice No. 1 of 2011 (13 August 2011), which made the whole of Gurgaon district a notified area	Continue unchanged. Code 8.1 requires roof harvesting where the rooftop is 100 m² or more in areas the Competent Authority notifies, and groundwater recharge on all buildings on plots of more than 500 m² and in parks and other common open spaces; places a recharge well at least 10 m from any structure that handles sewage; and ties the occupation certificate to a certificate that the system works, with the owner to maintain it. Since 2020 the Haryana Water Resources Authority issues the groundwater NOCs that CGWA issued before. None of these gives an outlet rule or a storage that is empty when a storm arrives. 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). The State drew 135.96% of its annual extractable groundwater in 2024, and 88 of its 143 blocks were over-exploited (CGWB); yet every block of Rohtak and Jhajjar is safe because the water table there is within 3 m of the surface over about half of each district (HWRA). Recharge structures may count toward retention where they meet Chapters 4 and 8, which make recharge the first choice, with pre-treatment, where the seasonal high water table is deeper than 10 m, give no recharge credit where it is within 3 m, and ask for a hydrogeologist's check in between.
Haryana Development and Regulation of Urban Areas Act, 1975; Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Act, 1963; Haryana Shehri Vikas Pradhikaran Act, 1977	Continue. Colonies are licensed under section 3 of the 1975 Act, and their external development works, executed by HSVP as nodal agency, and internal development works, executed by the colonizer, include storm drains (s.2(g) and (i), as quoted by DTCP); development plans of the controlled areas are made under section 5 of the 1963 Act; and HSVP develops the Urban Estates. Their texts were not read for this Manual [TBC]. This Manual does not decide zoning; the drain reserves and regional facility sites of Chapters 4 and 7 are meant to be shown in those plans and licences.
Haryana Municipal Corporation Act, 1994 (Act 16 of 1994); Haryana Municipal Act, 1973 (Act 24 of 1973)	Continue. Public drains, and drains in or alongside public streets, vest in the Corporation (s.193), with public tanks and the public land appertaining to them (s.161); the Commissioner keeps them in repair and builds new ones (s.194); no premises may be built or occupied without a drain to a Corporation drain within 30 m (s.198); the Commissioner may require distinct drains for sewage and for rain water (s.202), and foul water may not be discharged into a drain for surface water (s.196); and no structure may be built on a municipal drain without the Commissioner's written permission (s.206). Only the section headings of the 1973 Act, which governs the Municipal Councils and Committees, were read [TBC]. This Manual does not change those powers; Chapter 7 treats ponds as drainage assets and Chapter 8 keeps sewage out of storm drains.

Instrument	Relationship
Gurugram Metropolitan Development Authority Act, 2017 (Act 34 of 2017); Faridabad Metropolitan Development Authority Act, 2018; Panchkula Metropolitan Development Authority Act, 2021 (Act 23 of 2021)	Continue. Their "infrastructure development work" includes drainage that connects two or more sectors, municipal colonies or villages, and GMDA's infrastructure development plan must detail storm water drainage (s.17, as read from the Bill of 2017). The Gurugram Metropolitan Area was notified on 12 August 2018. The texts of the GMDA and FMDA Acts as enacted were not read [TBC]. This Manual's master-drain, regional-facility and basin-plan provisions (Chapters 4, 6 and 11) are meant to be carried out through those plans.
Haryana Canal and Drainage Act, 1974 (Act 29 of 1974), ss.2(7) and 45–48	Continues. Where obstruction of a river, stream or drainage channel may cause injury, the State may by notification bar obstruction within defined limits, and the reach so notified becomes a drainage work (s.45), from which an obstruction can be removed (s.46). I&WRD used the section for the Ghaggar floodplain zone in Panchkula, notified on 27 October 2023 on a 100-year flood of 2,933.45 m^3/s computed by Gumbel's method from 54 years of data (I&WRD, replies to the NGT); the NGT questioned whether the procedure had been followed (order of 22 May 2024, as quoted). No section 45 notification was found for the Yamuna or any other river, and no I&WRD rule fixing a distance of no construction from a drain or canal was found. Town sewage works are not drainage works (s.2(7)). Where a section 45 line is wider than the corridor of Chapter 7, it governs (Clause 1.3.3).
Haryana Pond and Waste Water Management Authority Act, 2018 (Act 33 of 2018)	Continues. A "pond" is a tank, lake or other inland water body of 0.5 acre or more, recorded as talab, johar, tank or by any other name, whether it holds water or not, and includes its green belt, peripheral catchment, feeder inlets, bunds, weirs and sluices; ponds under 0.5 acre, on private land, in notified forest or notified as wetlands are excluded (ss.1(3) and 2(k)). No one may build on pond land, its green belt or catchment, or obstruct its inflow or outflow, without the Authority's permission (s.14); the State may notify a protected area around a pond (s.16); and no spatial or development plan covering a pond may be approved without the Authority's prior approval (s.17). No protected-area notification was found [TBC]. Chapter 7 uses the statutory green belt and catchment as the least extent of a pond's protection.
Haryana Water Resources (Conservation, Regulation and Management) Authority Act, 2020 (Act 29 of 2020, amended in 2022)	Continues. The Authority is to encourage rainwater harvesting and recharge "as per geohydrological conditions", its harvesting conditions recommended for building bye-laws bind the agencies that approve building plans, and it is to "discourage and prevent such activities that are likely to lead to potential water logging of land" (s.21(3), (4) and (7)). The recharge rules of Chapters 4 and 8, which depend on the depth to water, are framed to fit that duty.
Punjab Land Preservation Act, 1900, as applied in Haryana; the Aravalli hills	Apply where they bind. The Supreme Court has held that land notified under the Act must be treated as forest (*M.C. Mehta v. Union of India (In re Kant Enclave)*, 11 Sep 2018, as reported; judgment and Act not read [TBC]); its judgment of 20 November 2025 defining the Aravalli hills was stayed on 29 December 2025 (as reported). Earthworks and drainage works on the Aravalli slopes above Gurugram and Faridabad are subject to those orders.
Wetlands (Conservation and Management) Rules, 2017; the Haryana State Wetland Authority; the Ramsar sites of Sultanpur and Bhindawas	Continue. The State Wetland Authority was reconstituted on 12 May 2020. Sultanpur National Park (143 ha) and Bhindawas Wildlife Sanctuary (412 ha) were designated Ramsar sites on 25 May 2021. No wetland notified under the Rules in Haryana was confirmed; the Najafgarh jheel was accepted as a water body in 2017 but had not been notified by March 2024, and 1,881 wetlands were to be ground-truthed under the Supreme Court's orders (as reported). The Union's office memorandum of 8 March 2022 treats the wetlands of the National Wetland Inventory larger than 2.25 ha as protected under rule 4 whether notified or not (as quoted). Where a notification or order is wider than the setback of Chapter 7, it governs (Clause 1.3.3).
Orders of the Supreme Court, the High Court and the National Green Tribunal on lakes, ponds and drains	Apply where they bind. Badkhal and Surajkund: no construction in the green belt or within 1 km of the lakes, with stated exceptions, and the prior approval of CPCB and HSPCB for all plans within 1–5 km (*M.C. Mehta*, I.A. 29 in W.P.(C) 4677/1985, order of 11 Oct 1996). Gurugram's water bodies: unique IDs and restoration for at least 123 water bodies (NGT, O.A. 325/2015, 20 Jul 2018). Master drains: no sewage in dry weather and a BOD of not more than 30 mg/l before the Najafgarh drain (NGT, O.A. 454/2018 and O.A. 6/2012, as reported by GMDA); Najafgarh jheel: the Wetlands Rules to be "strictly followed" (NGT, O.A. 153/2014, 21 Jan 2022, as quoted). Waterlogging: the High Court found Gurugram's water bodies diminished and their channels "largely blocked", and summoned the officers of MCG, HSVP and GMDA (*Sunil Singh v. MoEF*, CWP-20032-2008, order of 22 Sep 2026). The hydraulic corridor and setbacks of Chapter 7, with a Zone 1 of at least 15 m, are this Manual's proposals; where a court's line binds and is wider, it governs.

Instrument	Relationship
Disaster Management Act, 2005; HSDMA; the district flood-control action plans; the Haryana State Drought Relief and Flood Control Board	Continue. Flood-control works are to be finished before 30 June each year under the directions of the Board and the Chief Secretary, and one direction asks for drains to be cleaned before 15 June (as reported). No urban flood plan of HSDMA was found [TBC]. Chapter 10 links its pre-monsoon checks to these dates.
NCR Planning Board, Functional Plan on Drainage for NCR (2016); Sub-Regional Plan for the Haryana Sub-Region of NCR-2021, Chapter 9 (TCP Department)	Superseded for works designed under this Manual. The Functional Plan reports that Haryana's urban storm water channels were designed for 25 mm/h with a runoff coefficient of 1/8, and its rural drains by the Boston Society formula with reduction factors of 1/12 to 1/4; the Sub-Regional Plan asks for rural drains to carry "three days rainfall of five years frequency to be drained in three days" and for urban drains to follow CPHEEO, and sets the policies that rain be retained where it falls and that drains carry only rain water. These are cited as the history of practice and as policy; the return periods of Table 2.1 and the rainfall of Chapter 2 apply instead.
CPHEEO Manual on Storm Water Drainage Systems (2019)	Engineering reference. This Manual sets higher return periods under Clause 1.3.2.
NDMA Guidelines on Management of Urban Flooding (2010) and MoHUA SOP (2017)	This Manual puts into effect the NDMA directives on catchment-based design, detention and retention, waterbody protection and climate-adjusted IDF.
NDMA Urban Flood Risk Management Programme (UFRMP) and AMRUT 2.0	Works funded under these programmes shall comply with this Manual. The development controls of Chapters 4–5 protect the capacity those works create.
IRC:SP:42-2014 and IRC:SP:50-2013	Apply to road drainage only where they do not conflict with Chapter 6.
MBBL 2016, Chapter 9	Model for RWH and for the inspection regime in Chapter 10.

Commentary. RWH in Haryana 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 or August monsoon burst 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.

Haryana is spending on its drains. The Haryana State Drought Relief and Flood Control Board, chaired by the Chief Minister, approves several hundred flood-control schemes a year, 352 schemes worth ₹657.99 crore at its 56th meeting and 388 worth ₹637.25 crore at its 57th (as reported); GMDA desilts the master drains of Gurugram, has begun a fourth, Leg-IV, as an RCC drain whose design is reported to have been checked by IIT Roorkee, and sought a consultant in 2024 for a drainage plan for the city (as reported); and FMDA desilts eight storm drains of Faridabad, among them the Budhiya nala (as reported). None of these works was found with a stated design return period or rainfall. No development-control condition stops new plots in the same catchments from using up the capacity such works create. Linking Chapters 4–5 to approvals closes that gap.

The State's law already holds many of the tools. Public drains vest in a Municipal Corporation, which may require separate drains for sewage and for rain water and bars building over a municipal drain (Haryana Municipal Corporation Act, 1994, ss.193, 202 and 206); the external and internal development works of a licensed colony include its storm drains (Haryana Development and Regulation of Urban Areas Act, 1975, s.2(g) and (i), as quoted by DTCP); section 45 of the Haryana Canal and Drainage Act, 1974 lets the State notify limits along a river or drainage channel within which obstruction is barred; the Pond Authority Act of 2018 protects a pond's green belt and catchment and requires the Authority's approval of any plan that covers it; the Water Resources Authority Act of 2020 tells that Authority to "discourage and prevent such activities that are likely to lead to potential water logging of land" (s.21(7)); and the Building Code asks for storm-water disposal on every building plan and keeps the natural drainage of large sites. What the law lacks is a design standard. None of these instruments says how large a drain must be, which storm it must carry, how wide a nala's corridor must be, or how much storage a filled

johad or a paved plot removes. This Manual's checks are framed as part of the licence, building plan and occupation certificate stages of the Code, not as a separate NOC. It is offered as a technical companion to these instruments, to the orders of the courts and the NGT, and to the drainage works of the cities: it supplies the design storm, detention and buffer numbers they do not set, as a proposal for the Government and the authorities to consider. Neither the Town and Country Planning Department nor any other body has adopted it.

1.9 Roles and responsibilities

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

Table 1.4 — Roles and responsibilities under this Manual

Agency	Role under this Manual
Town and Country Planning Department (DTCP)	Issues the HBC 2017 and its amendments by memo; grants licences for colonies under the Haryana Development and Regulation of Urban Areas Act, 1975, whose external and internal development works include storm drains; prepares the development plans of the controlled areas; and drew the master storm water drainage plan of Gurugram (drawing No. DTP(G) 2104/2012). Would issue the amendment of Clause 1.3.1(a), give regional support to Tier B authorities (Table 1.1) and maintain the empanelled reviewer list (Clause 10.7).
State Stormwater Technical Committee (Clause 1.3.2)	Would adopt higher standards, issue Annexes, tables and the compliance calculator, concur with Tier A alternatives, decide variances referred to it and review the Manual (Clause 1.12).
Urban Local Bodies Department	Oversees the Municipal Corporations under the Haryana Municipal Corporation Act, 1994 and the Municipal Councils and Committees under the Haryana Municipal Act, 1973; in 2026 it pressed a "zero flood" plan on the cities, with 159 waterlogging hotspots listed in Gurugram (as reported). Would issue the model ULB bye-law of Clause 1.3.1(b) and require this Manual in the drainage works of the local bodies.
Municipal Corporation of Gurugram (MCG) and the other Municipal Corporations; Municipal Councils and Municipal Committees	Public drains vest in a Corporation (s.193), and the Commissioner keeps them in repair and builds new ones (s.194), may require a drain before a building is occupied (s.198) and separate drains for sewage and rain water (s.202), and must permit any structure over a municipal drain (s.206). Competent Authorities for building plans within their limits. The High Court summoned the Chief Engineer of MCG in September 2026 over Gurugram's waterlogging (*Sunil Singh*). Would apply this Manual to their works, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15).
Haryana Shehri Vikas Pradhikaran (HSVP, formerly HUDA)	Develops the Urban Estates and their sectors, and is the nodal agency for the external development works, storm drains among them, in those estates (DTCP, report to the NGT, 2022); Competent Authority for building plans in its estates; enforces roof rainwater harvesting there under its notification of 31 October 2001 and a yearly self-declaration (2024), and counted 1,92,700 structures in private plotted buildings by December 2023 (I&WRD, report to the NGT). Would apply this Manual to its sector layouts and drains and hand them over under Clause 10.14.
Gurugram Metropolitan Development Authority (GMDA)	Holds the master drains of Gurugram, Leg-I, Leg-II and Leg-III (the Badshahpur drain), which outfall to the Najafgarh drain, with Leg-IV under construction, and the drains that connect sectors and municipal colonies in the Gurugram Metropolitan Area, whose storm water drainage its infrastructure development plan must detail (GMDA Act, s.17, as read from the Bill text). Nodal agency under the NGT's orders for keeping sewage out of the master drains, whose water must meet a BOD of not more than 30 mg/l before it enters the Najafgarh drain (GMDA, report to the NGT, 2020). Would apply this Manual to the master drains and regional facilities, and agree outfall levels to the Najafgarh drain with I&WRD and the Irrigation and Flood Control Department of Delhi.
Faridabad and Panchkula Metropolitan Development Authorities (FMDA, PMDA)	Infrastructure development in their metropolitan areas, defined in their Acts as in GMDA's; FMDA desilts eight storm drains of Faridabad, among them the Budhiya nala (as reported). Their drainage functions under their Acts were not read for this Manual [TBC]. Would apply this Manual to their drains and regional facilities.

Agency	Role under this Manual
Irrigation and Water Resources Department (I&WRD) and the Haryana State Drought Relief and Flood Control Board	Holds the rivers, embankments and barrages (Hathnikund on the Yamuna, Masani on the Sahibi) and the rural and regional drains, such as Outfall Drain No. 8, Drain No. 2 and the Gaunchi drain; notifies floodplain zones under section 45 of the Haryana Canal and Drainage Act, 1974, as for the Ghaggar in Panchkula (27 October 2023); and prepares the flood-control schemes that the Board, chaired by the Chief Minister, approves. Would provide design river and drain levels, gate and regulator operating rules and release scenarios for Chapter 5, consent to outfalls into its drains, and keep the section 45 lines that Chapter 7 applies.
Haryana Pond and Waste Water Management Authority (HPWWMA)	Regulates ponds of 0.5 acre or more recorded as talab, johar or tank, with their green belts and catchments, under the Act of 2018; its prior approval is needed for any spatial or development plan that covers a pond (s.17), and it keeps the Pond Data Management System. Would certify the boundary, green belt and catchment of a pond for Chapter 7, and consent to a stormwater outlet into a pond.
Haryana Water Resources Authority	Regulates groundwater under the Act of 2020, issues the NOCs for abstraction that CGWA issued before, and has adopted CGWB's block categories of 31 March 2024 for them; it is told to prevent activities that lead to waterlogging (s.21(7)). Would supply depth-to-water data, with CGWB, for the recharge rules of Chapters 4 and 8.
Haryana State Pollution Control Board (HSPCB)	Grants consents, monitors the drains and rivers and the treatment plants that discharge to them; under the Supreme Court's order of 1996, its approval is needed for development plans within 1–5 km of Badkhal and Surajkund. Supports the removal of sewage from storm drains (Chapter 8).
HSDMA and the District Disaster Management Authorities	Approve the State and district disaster management plans; no urban flood plan of HSDMA was found [TBC]. Would recommend flood-sensitive catchments, hold the record of flood-prone locations with the Deputy Commissioners, and lead the post-event review (Clause 10.16).
Haryana State Wetland Authority	Reconstituted on 12 May 2020 under the Wetlands Rules 2017, with the Chief Minister as chairman; keeps the inventory of wetlands, demarcates them and would notify them. Would permit regulated activities in notified wetlands (Chapter 7).
Revenue and Disaster Management Department: the Deputy Commissioners and the tehsil offices	Keep the revenue (khasra) records in which johads, talabs, nalas and khadar land are recorded, run the district flood-control action plans and act against encroachment; the patwaris surveyed the Ghaggar floodplain in Panchkula with I&WRD. Would certify the recorded extent of a nala, pond or johad for Chapter 7.
Public Health Engineering Department (PHED)	Sewerage and sewage treatment in many towns; "strong sewage" reaching ponds is in its scope (HPWWMA, report to the NGT, 2024). Would apply Chapter 8 to the interception of sewage that now flows in storm drains.
Development and Panchayats Department and the Gram Panchayats	Own most village ponds, which the Gram Panchayats de-water and de-silt from their own funds under an order of 24 June 2023 (HPWWMA, report to the NGT, 2024). Would apply Chapter 7 to village ponds that receive town or highway runoff.
Haryana State Industrial and Infrastructure Development Corporation (HSIIDC)	Develops the industrial estates, where it applies the HBC 2017 as Competent Authority. Would apply this Manual in its estates.
Central Water Commission (CWC), a body of the Union	Publishes the Flood Estimation Report for subzone 1(e) used in Chapters 2 and 3, and the river levels at its sites on the Yamuna, such as Karnal and Mawi; it has no flood site in the Ghaggar basin. Would supply river stage records and forecasts for Chapter 5.
Central Ground Water Board (CGWB), a body of the Union	Assesses the groundwater units of the State and their categories, 88 of 143 over-exploited in 2024. Would supply groundwater levels and quality with the Haryana Water Resources Authority.
National Institute of Hydrology (NIH), Roorkee	Runs NIH-DHAARA (Chapter 2).
IMD (Meteorological Centre Chandigarh), and road and rail owners (PWD (B&R), NHAI, Indian Railways)	IMD's stations supply the rainfall records of Chapter 2. Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Agency	Role under this Manual
Irrigation and Flood Control Department, Government of the National Capital Territory of Delhi	Holds the Najafgarh drain in Delhi, into which Gurugram's master drains and Outfall Drain No. 8 discharge. Would be consulted on the outfall levels of those drains (Chapter 5).

Commentary. Stormwater in Haryana is split by tier and by place: between DTCP, through the Building Code, the licences and the development plans; HSVP, through the sectors of its Urban Estates; the metropolitan development authorities, through the master drains of Gurugram, Faridabad and Panchkula; the Municipal Corporations, Councils and Committees, through the drains vested in them; I&WRD, through the rivers, embankments and rural drains and the floodplain zones of section 45; the Pond Authority, through the public ponds and their catchments; and the Revenue and Disaster Management Department, through the revenue records, with the courts and the NGT setting the lines around the lakes and the conditions on the drains. Gurugram shows why the split matters. Its runoff runs off the Aravallis through sector drains built by HSVP and colonizers into master drains held by GMDA, parts of which DTCP's drawing of 2012 marks "to be got constructed by Irrigation Department", and on into the Najafgarh drain, which I&WRD and Delhi's Irrigation and Flood Control Department hold on either side of the boundary; and when the city flooded in 2026 the High Court summoned officers of MCG, HSVP and GMDA together (*Sunil Singh*, 22 Sep 2026). No rule or order found divides the drains of I&WRD from those of the local bodies, HSVP and the metropolitan development authorities [TBC]. Until such a rule is made, this Manual assigns the drainage elements as in Table 1.5. The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Rivers, their floodplains and embankments, the barrages (Hathnikund, Masani) and the floodplain zones notified under section 45	I&WRD
Rural and regional drains, such as Outfall Drain No. 8, Drain No. 2 and the Gaunchi drain, and the Haryana reach of the Najafgarh drain	I&WRD
The master drains of Gurugram (Leg-I to Leg-IV) and the drains that connect sectors, municipal colonies or villages in the Gurugram Metropolitan Area	GMDA
Drains that connect sectors in the Faridabad and Panchkula metropolitan areas	FMDA or PMDA [TBC]
Sector drains in the Urban Estates, until handed over to the local body	HSVP
Drains within a licensed colony, until taken over	The colonizer, as internal development works, under DTCP's licence
Street and public drains within the limits of a local body	The Municipal Corporation, Municipal Council or Municipal Committee
Public ponds of 0.5 acre or more	The Gram Panchayat or local body that owns them, with HPWWMA as regulator
Ponds under 0.5 acre, private ponds and low-lying water collection areas	The local body or the owner, as drainage storage under Chapter 7
Drains within an industrial estate	HSIIDC
Sewers, interceptors and sewage treatment plants	PHED, or the local body or GMDA where it executes the work
Drains of State and national highways	PWD (B&R) or NHAI

Element	Assigned to
Notified wetlands and Ramsar sites	The Haryana State Wetland Authority, with the owner of the land

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

1.10 Variances and waivers

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

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

1.10.2 **Waiver.** The Authority may waive Chapter 4 detention requirements (not retention) where a hydraulic analysis certified under Clause 10.6 shows that the site discharges directly to the sea, or to a tidal reach with no flood-prone property downstream, and that undetained flow does not worsen the outfall-closed condition of Chapter 5. Haryana has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to the Yamuna or the Ghaggar through a flap gate or regulator, to an I&WRD drain whose level is held up, such as Outfall Drain No. 8 above the Dhansa regulator, or only by pumping, as in much of the Rohtak–Jhajjar belt, is in the outfall-closed condition of Chapter 5 whenever the receiving water is high, and detention is not waived for it.

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 Haryana, Gurugram's water bodies numbered 641 in the revenue record of 1956, 487 on the Survey of India maps of 1976 and 557 on satellite imagery of 2011–12, with only 123 common to all three (GMDA,

> report to the NGT in O.A. 325/2015), and the High Court found in 2026 that the city's natural water bodies "have substantially diminished, while the channels that sustained these water bodies remain largely blocked" (*Sunil Singh v. MoEF*, 22 Sep 2026).

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.

References (chapter)

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Municipal Corporations and of the metropolitan development areas
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model HBC 2017 amendment and model ULB bye-law
Form 1-1	Applicability Determination
Form 1-2	Variance / Waiver Request

CHAPTER 2

Design Rainfall and Design Storms

2.1 Purpose and scope

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

2.1.2 It specifies:

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

2.1.3 This chapter applies throughout Haryana. Where a Municipal Corporation, Municipal Council or Municipal Committee, HSVP, GMDA, FMDA or PMDA has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Haryana trace to the rainfall input, not the hydraulics. Haryana shows how. The only design figure found for the State's urban drains is second-hand: the NCR Planning Board reports that Haryana's urban storm water channels were designed for 25 mm/h with a runoff coefficient of 1/8, and that its rural drains were sized by the Boston Society formula $Q = 200 \cdot \sqrt{A}$, cut by reduction factors of 1/12 to 1/4 "on the premise that relatively smaller sections gave better hydraulic performance" (NCRPB, 2016); the underlying order was not found. The 25 mm/h has no stated duration or return period and is about a third of the 50-year 1-hour depth that the CWC plates and ratios give Gurugram. The master drains of Gurugram carry design discharges of 541, 1,305 and 3,702 cusecs on DTCP's drawing of 2012, with no rainfall or return period stated, and no design return period was found for any city in the State. The two published sources that seem to fill the gap do not. The panel for Hissar in IMD Das et al. (2022) repeats a curve that the paper prints for a dozen other cities, and implies a 2-year day of about 170 mm in a district whose annual normal is 396.5 mm; and NIH-DHAARA's reanalysis-based depths are too high in the Shivalik foothills and too low in the south and west (Clause 2.3.6). The CWC ratios, the only regional sub-daily source, understate the short storms of the belt around Delhi, into which Gurugram and Faridabad fall. A city-wide failure in Gurugram on 28 July 2016, after a fall reported as 46–54 mm, points to the capacity and outfall of the drains rather than to an extreme storm (as reported). Fixing one transparent source and method for the whole state is the main purpose of this chapter.

2.2 Definitions

Term	Meaning in this Manual
Annual exceedance probability (AEP)	Probability that a given rainfall depth is equalled or exceeded in any one year. A 1% AEP storm is the "100-year" storm. Both forms are used here: T-year = 1/AEP.
IDF / DDF	Intensity–duration–frequency and depth–duration–frequency relationships for a location.
Point rainfall	Rainfall at a single location, as measured by a rain gauge.
Design storm	A hyetograph (rainfall depth versus time) of stated AEP, duration and temporal pattern.
Critical duration	The storm duration that produces the largest peak flow, water level or storage requirement for the element being designed.
Areal reduction factor (ARF)	Ratio of catchment-average rainfall to point rainfall for the same AEP and duration.
SW monsoon season (JJAS)	June–September. The normal June–September rainfall of the Haryana, Chandigarh and Delhi sub-division is 430.7 mm (IMD, as used in the bulletin of 30 Sep 2025), against an annual mean of 597.4 mm for the sub-division in 1901–1980 (IMD, *Climate of Haryana*). District annual normals of 1901–1980 run from 325.3 mm in Sirsa, 396.5 mm in Hisar and 425.1 mm in Bhiwani to 577.8 mm in Gurgaon, 695.8 mm in Karnal, 988.0 mm in Ambala and 1,073.6 mm at Chandigarh (IMD, *Climate of Haryana*). The normal date of onset is 27 June at Sonepat, 28 June at Ambala and Chandigarh, 30 June at Bhiwani and 3 July at Hissar, and of withdrawal 21 September at Hissar, 23 September at Ambala, Chandigarh and Bhiwani and 25 September at Sonepat (IMD, new normals of 2020). The antecedent moisture rule of Clause 2.11.4 refers to this season; the pre-monsoon deadline of 15 June for desilting and drain works is set ahead of the earliest onset, with pumps, gates and regulators certified ready by 25 June and kept on standby to 30 September (Chapter 10); the State's own directions for flood-control works name 30 June, and one names 15 June (as reported).
Storms outside the season	Large falls come at its edges and outside it. Rohtak recorded 297.9 mm and Gurgaon 261.2 mm on 30 June 1981, before the monsoon had covered the whole State, and Narnaul 160.0 mm on 28 June 2005 (IMD). After it, Punahana recorded 241.3 mm on 2 October 1910 (IMD, *Climate of Haryana*), Ambala 141.6 mm on 5 October 1973, Karnal 130.3 mm on 9 October 1956 and Hissar 128.3 mm on 17 October 1998; in winter and before the monsoon, Ambala recorded 146.8 mm on 11 February 1898 and 135.1 mm on 26 November 1951, Gurgaon 123.4 mm on 16 April 1983 and Hissar 102.2 mm on 15 May 1973 (IMD). On 2 May 2025 Gurugram's block gauges were reported to total more than 246 mm (as reported). Design statistics use annual maxima from all months, and no works deadline or operating rule shall assume that heavy rain is confined to June–September.
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 Haryana this clause is suspended until Annex 2A is published: Clause 2.3.6 sets the interim source.

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

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

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

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

- (a) the IMD isopluvial / IDF values of Das et al. (2022), *MAUSAM* 73(4), for durations of 1–24 h;
- (b) for catchments of 25–5,000 km², the 24-hour point rainfall from the CWC Flood Estimation Report for subzone 1(e) (Upper Indo-Ganga Plains), which covers the State up to the boundary of zone 7 (Western Himalayas), with the Kalka–Pinjore upland beyond that boundary and the Morni and Kalesar hills on it, as applicable.

Where the design value is lower than the CWC 1(e) 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.

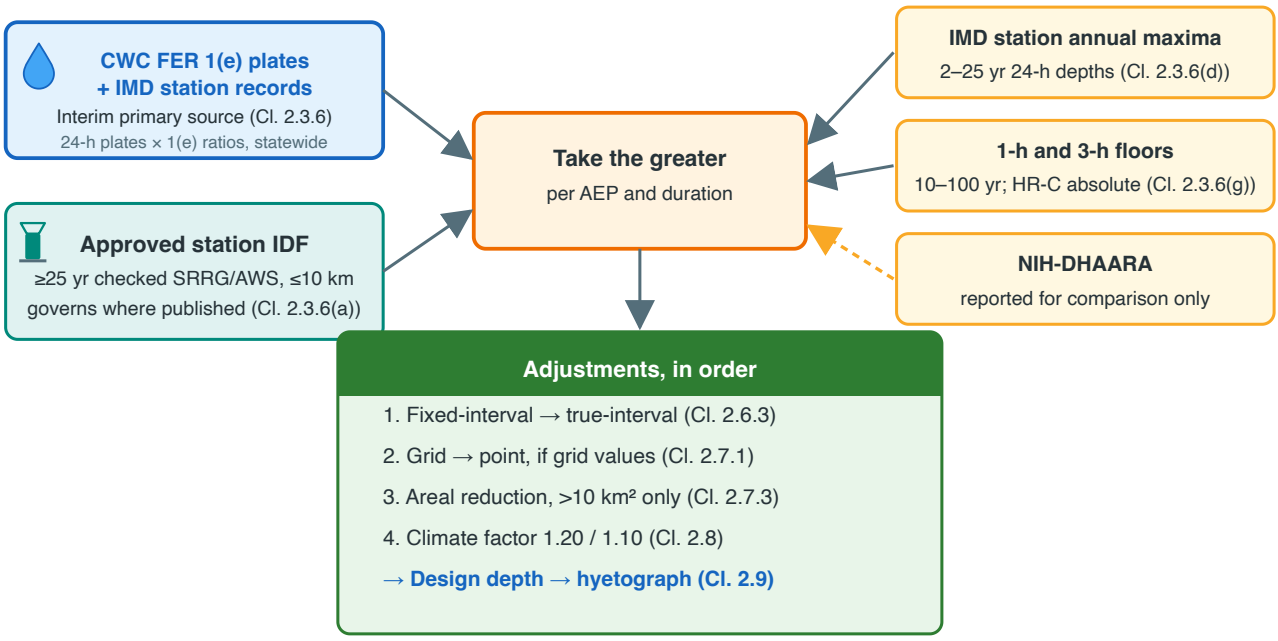

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station, for the durations and AEPs it covers, in place of (f) and (g); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e), and the CWC floor of Clause 2.3.3 still applies. A record is checked when its annual totals and annual maxima have been compared with the IMD normals and station extremes for the station, and every year that disagrees has been explained or removed. An IDF derived from daily data by the one-third rule (Clause 2.6.4) or by any other fixed ratio is not a station IDF. In Haryana Clause 2.3.2(a) is read with 25

years in place of 30 (set by this Manual, so that the recording gauges of the State's long-record stations can qualify once analysed). No IDF has yet been published in Annex 2B, and no station IDF for any station in the State was found in research for this Manual. The first data request is for the IMD stations with the longest records, to be fitted under this paragraph: Ambala, 42103 (daily record 1901–2012), Hissar, 42131 (1914–2012), Karnal, 42137 (1949–2012), Chandigarh, 42105 (1954–2009), Gurgaon, 42178 (1965–2012), Narnaul, 42177 (1966–2012), and Rohtak, 42176 (1967–2012) (IMD); the years of recording-gauge data held at each are to be confirmed [TBC].

- (b) **Subzone.** The whole State is taken in CWC subzone 1(e) (Upper Indo-Ganga Plains, 1984), whose report states that it "covers almost entire Haryana and Punjab" and names Hissar and Rohtak among its towns. On the report's plates the boundary with zone 7 (Western Himalayas) runs just north-east of Chandigarh: Panchkula city and Yamunanagar–Jagadhri lie inside subzone 1(e), the Kalka–Pinjore upland lies beyond the line, and the Morni hills and Kalesar lie on it; the report for zone 7 names Jammu and Kashmir, Punjab, Himachal Pradesh and Uttar Pradesh among its States, but not Haryana. The 1(e) report is used everywhere in the State, including the Kalka–Pinjore upland, the Morni hills and Kalesar (set by this Manual); for a catchment of 25 km² or more that rises in the Shivalik hills or in Himachal Pradesh, such as the Ghaggar above Panchkula, the Kaushalya, the Tangri, the Markanda, the Somb and the Pathrala, the zone 7 report is also run as a sensitivity check under Chapter 3 and the higher result is reported (its plates were not read for this Manual [TBC]). In the south-west, Sirsa and Ellenabad lie about 0.2° of longitude inside the line between subzones 1(a) and 1(e), and no part of the State lies in subzone 1(a) or 1(b). The lines were read by eye from the plates and are to be confirmed on the reports' index maps [TBC]. The rainfall zone and sub-area of the site are those of Annex 2A.

- (c) **24-hour depth, 2% and 1% AEP (50- and 100-yr).** The 24-hour point value at the site read from Plates 9 and 10 of the 1(e) report, the 50- and 100-year isopluvial maps, whatever the catchment area. Where the site lies between two contours, the higher contour value is used; where it lies inside a closed contour with no higher contour within it, the value is that contour plus one contour interval (set by this Manual). Plates are read by the coordinates of the site, not by the town labels. For orientation only, read by eye to about one contour, the 50-year plate gives a spot value of 262 mm at Chandigarh, next to Panchkula, about 250 mm at Ambala, 240–260 mm at Yamunanagar–Jagadhri, 220–240 mm at Karnal, Panipat, Gurugram, Faridabad and Palwal, about 220 mm at Sonipat, 200–240 mm at Kurukshetra and Kaithal, 200–220 mm at Hisar and Jind, about 200 mm at Rohtak, Jhajjar and Rewari, 180–200 mm at Bhiwani and Narnaul, and 160–180 mm at Sirsa and Fatehabad; the readings between Hisar, Rohtak and Rewari, where the contours wind, are of low confidence [TBC]. The 100-year plate gives a spot value of 289 mm at Chandigarh and about 200–280 mm over the rest of the State. The worked example of the 1(e) report, on the Ghaggar at road bridge No. 2 about 7 km west of Ambala City (1,126 km²), reads 25.0 cm at 50 years and gives a 50-year peak of 2,706 m³/s. The station records of the State far exceed the plates: Rohtak 484.1 mm (19 Sep 1933), Dadupur, in the old Ambala district, 444.5 mm (2 Jul 1966; station name to be confirmed [TBC]), Palwal 398.8 mm (9 Sep 1875), Hissar 346.7 mm (16 Aug 1926), Chandigarh 302.2 mm (9 Jul 2023, IMD real-time data), and Rohtak 297.9 mm and Gurgaon 261.2 mm on 30 Jun 1981 (IMD); where the Gumbel estimate of (d) for the station of the site is higher for the same AEP, it governs.

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr).** The report has 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, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3. The station is, for example, Ambala, 42103, for Ambala and Yamunanagar; the higher of Chandigarh, 42105, and Ambala for Panchkula, Pinjore and Kalka; Karnal, 42137, for Karnal, Panipat and Kurukshetra; Hissar, 42131, for Hisar; Rohtak, 42176, for Rohtak and Jhajjar; the higher of Gurgaon, 42178, and New Delhi/Safdarjung, 42182 (daily record from 1901), for Gurugram and Faridabad, which share the plate band and the burst climate of Delhi (set by this Manual); and Narnaul, 42177, for Narnaul, Mahendragarh and Rewari. Bhiwani, 42350 (1992–2012), has fewer than 30 years and is used only as a check. Elsewhere it is the nearest IMD station with 30 or more years of record, from the candidates in Annex 2A. The full record is used, and no year is left out because it is an outlier; the 302.2 mm of 9 July 2023 at Chandigarh, after the end of the record in IMD's station extremes, enters the series once IMD confirms it [TBC].

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

- (f) **Durations of 1 to 24 hours.** The 24-hour depth of (c) or (d) multiplied by the ratios of the 1(e) report in Table 2B.1, at every AEP: 0.34 at 1 hour, 0.475 at 2 hours, 0.56 at 3 hours, 0.607 at 4 hours, 0.647 at 5 hours, 0.68 at 6 hours, 0.77 at 9 hours, 0.84 at 12 hours, 0.89 at 15 hours and 0.93 at 18 hours. Between the tabulated durations the ratio is interpolated on logarithmic axes. The 1-, 2- and 3-hour depths are then subject to (g).

- (g) **Floor for short storms, 10-yr and rarer.** The 1-hour and 3-hour depths shall be not less than (i) 0.35 times (1 hour) and 0.57 times (3 hours) the 24-hour depth of (c) or (d) for the same AEP, everywhere in the State; and, at a site in sub-area HR-C NCR south (Aravalli–Sahibi) of Annex 2A or in a catchment that crosses its boundary, (ii) the following depths, where they are greater, all set by this Manual; the 2-hour depth shall be not less than the value interpolated on logarithmic axes between the 1- and 3-hour values for the same AEP:

Sub-area	Duration	10% (10)	4% (25)	2% (50)	1% (100)
HR-C NCR south (Aravalli–Sahibi)	1-hour depth not less than (mm)	80	95	105	115
HR-C NCR south (Aravalli–Sahibi)	3-hour depth not less than (mm)	115	135	150	165

  The reason is that the ratios of the 1(e) report, derived in 1984 from 5–38 years of recording-gauge data across the subzone, understate the short storms of the belt around Delhi. With the plate values of about 220–240 mm that Gurugram and Faridabad share with Delhi, they give about 75–82 mm in 1 hour and 123–134 mm in 3 hours for the 50-year storm. Both have been exceeded a few kilometres from the State boundary: 148.5 mm fell in 3 hours at Safdarjung between 02:30 and 05:30 on 28 June 2024, and 112.5 mm in 1 hour at the Pragati Maidan automatic weather station on 31 July 2024 (as reported); and in Gurugram 103 mm was reported in 90 minutes on 9–10 July 2025 and more than 100 mm between 15:00 and 19:00 on 1 September 2025 (as reported). The depths of (ii) start from the two Delhi falls. The Safdarjung fall is the largest 3-hour fall known at a gauge with some five decades of recording-gauge record; the largest of n years of record is, on average, about an (n+1)-year event, so the 50-year 3-hour depth is set at not less than 150 mm. The Pragati Maidan fall is the largest 1-hour fall known in a network of a dozen or more stations that have recorded for more than a decade [TBC], so the 100-year 1-hour depth is set at not less than 115 mm. The other AEPs are scaled from these two values in the proportions of the IIT Delhi 15-minute fit at Safdarjung, whose 10-, 25-, 50- and 100-year intensities stand as 0.71 : 0.83 : 0.91 : 1 (IIT Delhi, 2018), and rounded to 5 mm. They are applied in HR-C because Gurugram and Faridabad lie in the same band of the plates as Delhi, adjoin it, and share its burst climate. Elsewhere the ratio floor of (i) applies alone: no short fall above the products of (f) has been documented from hourly data at any gauge outside the NCR belt [TBC], and Annex 2B is to test this first at Chandigarh and Ambala, where the plate values are the highest in the plains. The ratio floor takes the lowest of the 2-year ratios of the 1-hour and 3-hour to the 24-hour depth published for three IMD recording gauges of the Gangetic plain, Lucknow, Kanpur and Bahraich, 0.35–0.38 at 1 hour and 0.57–0.61 at 3 hours (Kathuria, Kaur & Mehra, 1987), which lie just above the 1(e) ratios of 0.34 and 0.56; no such ratio has been published for a gauge in Haryana. The floors are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to them, and the climate factor of Clause 2.8 is. They are interim: the Delhi and Gurugram falls are known from press reports, IMD's hourly data for them have not been read [TBC], and Annex 2B is to replace the floors with frequency analyses of the IMD recording-gauge and automatic weather station records of the State, beginning with the stations of (a).

- (h) **Durations below 1 hour.** No sub-hourly frequency analysis for any station in the State was found in research for this Manual. Until Annex 2B gives one, the ratio of the depth for a duration below 1 hour to the 1-hour design depth is agreed with the Authority, from a published recording-gauge analysis whose source is stated, such as the IIT Delhi fits at Safdarjung and Palam for a site in HR-C (IIT Delhi, 2018), and recorded on Form 2-1 [TBC]; the average intensity for a duration below 1 hour shall be not less than the 1-hour design intensity for the same AEP (set by this Manual).

- (i) **Order of depths.** For the same AEP, no depth shall be less than the depth for a shorter duration.
- (j) **NIH-DHAARA.** Its present-day values at the site are reported on Form 2-1 beside the interim values, for comparison only: in the State they are too high at 24 hours in the Shivalik foothills, too low in the south and west, and below the products of (f) at 1 hour almost everywhere (commentary). 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.
- (k) **IMD Das et al. (2022).** The paper's panel for Hissar repeats the curve that it prints for a dozen other cities, about 60–109 mm/h at 1 hour for 2–100 years; for Hissar that curve implies a 2-year day of about 170 mm, 43% of the district's annual normal of 396.5 mm, and a 100-year day of about 370 mm, above the station's record of 346.7 mm in 1914–2012. The panel is not used as a value, a check or a floor, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available. The paper's range for its North-West region, 6–14 cm at 1 hour and 14–36 cm at 24 hours, is not used either: the paper does not name the stations of the region, and its 24-hour upper bound is below the records of Rohtak (484.1 mm, 1933), Dadupur (444.5 mm, 1966) and Palwal (398.8 mm, 1875).
- (l) **Earlier design values.** The figures found for the State are not a design source. The NCR Planning Board reports that "The intensity of rainfall adopted is 25mm per hour and run off coefficient is 1/8 for designing of storm water drainage channels in Haryana urban area", and that the State's rural drains were sized by the Boston Society formula $Q = 200 \cdot \sqrt{A}$ (Q in cusecs, A in square miles), cut by reduction factors of 1/12 to 1/4 (NCRPB, 2016); the Sub-Regional Plan for the Haryana Sub-Region of NCR sizes rural drains for "three days rainfall of five years frequency to be drained in three days" and urban drains to the CPHEEO manual (TCP Department); and the master drains of Gurugram carry design discharges, Leg-I 541, Leg-II 1,305 and Leg-III (the Badshahpur drain) 3,702 cusecs on DTCP drawing No. DTP(G) 2104/2012 of 9 November 2012, with reach discharges of up to 2,300 cusecs in HUDA's catchment plan for the Badshahpur drain (issued 3 November 2017, revised 24 November 2020), with no return period or rainfall stated anywhere. The return periods of Table 2.1 and the depths of this clause apply instead; the 25 mm/h and the drain discharges are design values carried forward without a stated AEP (Clause 2.3.4(d)), and the 3-day criterion is replaced by the 48- and 72-hour checks of Clause 2.5.2. They are cited as the history of practice.
- (m) **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 Haryana the platform does not yet meet that purpose. Its present-day values there come from IMDAA reanalysis (about 12 km), not from gauges, and they err in both directions. Its 50-year 24-hour depths are above the CWC plates in the Shivalik foothills, 320 mm at Panchkula, 317 mm at Morni and 306 mm at Yamunanagar against about 240–262 mm, and far below the plates and the station records in the south and west: 194 mm at Gurugram, against about 220–240 mm and a record of 282.2 mm; 177 mm at Rohtak, against about 200 mm and records of 297.9 mm (1981) and 484.1 mm (1933); 139 mm at Hisar, against about 200–220 mm and a record of 346.7 mm; and 113–154 mm at Narnaul, Sirsa and Bhiwani, against about 160–200 mm. Its 50-year 1-hour depths, 38–91 mm, are 0.25–0.36 of its 24-hour depths; at Gurugram it gives 58.0 mm, about half the 103 mm reported in 90 minutes there in July 2025 (NIH-DHAARA, queried 7 Nov 2026; IMD; CWC; as reported). A source that errs by these margins cannot be adopted, so Clause 2.3.6 uses the CWC report 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. Haryana is like Delhi in one respect: the CWC sub-daily ratios give less than the short falls recorded in and around Delhi, which is why Clause 2.3.6(g) sets a ratio floor at 1 and 3 hours across the State and, in HR-C, the absolute floors that those falls support. The design figures found for the State are the history of practice, not a design basis: the 25 mm/h

that the NCR Planning Board reports for Haryana's urban storm channels is about a third of the 1-hour depth that the plates and ratios give Gurugram for a 50-year storm, and the capacities of Gurugram's master drains state no return period (Clause 2.3.6(l)). The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the use of the 1(e) report on the zone 7 fringe, the stations for Gurugram and Faridabad, durations below 1 hour and the floors of (g) are set by this Manual. Several points are unresolved. The plate values were read by eye on a scan, to about one contour; the contours between Hisar, Rohtak and Rewari wind, and their reading is of low confidence; and the line of zone 7 across Panchkula, Morni and Kalesar is to be read on the reports' map plates [TBC]. The report's design-office number is not on the scanned pages [TBC]. The name of the station given as Dadupur (444.5 mm, 2 July 1966) is hard to read in the scan of *Climate of Haryana* [TBC]; Chandigarh's 302.2 mm of 9 July 2023 is IMD's real-time value, against 322.2 mm and lower figures in the press [TBC]; and the monthly totals of 701.8 mm at Hissar (October 1991) and 2,231.6 mm at Bhiwani (August 1995) in IMD's station extremes cannot be reconciled with the stations' daily records and are not relied on [TBC]. Gurugram's often-quoted 91.8 mm belongs to a day in July 2021, not to the flood of 28 July 2016, for which 46–54 mm is reported (as reported).

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: Gurugram, Faridabad, Panipat, Ambala and Rohtak 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. Haryana's worst floods have come from long wet spells and multi-day storms. The September storms of 1875, 1911 and 1933 put more than 240 mm in a day on several gauges at once in the Rohtak–Gurugram–Faridabad belt, among them 484.1 mm at Rohtak, 325.1 mm at Jhajjar and 254.0 mm at Panipat on 19 September 1933 (IMD, *Climate of Haryana*). Rohtak received 928.0 mm in August 1995 (IMD). In the waterlogged belt the drains are sized for less than a few days of rain: a study of the Rohtak–Jhajjar drains found that the existing system of about 170 m³/s, with its dead storage, could handle the 1- and 2-day consecutive rainfall of a 5-year return period (*Irrigation and Drainage*, 2006, as summarised), and in the monsoon of 2022 Outfall Drain No. 8 carried 5,000 cusecs at the Dhansa regulator against a capacity of 4,000 (I&WRD, 2024). In July 2023 the rain of 8–10 July over the Shivalik hills, 302.2 mm at Chandigarh and 224.1 mm at Ambala on 9 July (IMD), brought the Ghaggar down on Kaithal, Fatehabad and Sirsa over the following week, where breaches were still open on 18 July (as reported). The 2025 season was 33% above normal over the sub-division (IMD). Where the outfall is held up behind a gate, or the ground is already waterlogged, storage is filled by the whole wet spell, not by its peak hour. A rule based only on critical duration, applied to a small site, picks a 1–2 hour storm and misses this failure mode. That is why the long-duration checks are mandatory.

2.6 Sub-daily rainfall

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

2.6.2 Where only daily (24-hour) depths are available for a duration below 24 hours, the sub-daily depth shall be derived using the **ratio set of Annex 2B**. These are duration-to-24-hour ratios calibrated to Haryana recording gauges. They shall not be lower than the ratios of the CWC Flood Estimation Report for subzone 1(e). The IMD Das et al. (2022) Hissar panel repeats a generic curve and is not used.

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

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

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

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

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

2.7 Point, grid and areal rainfall

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

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

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

- for 25–5,000 km² in subzone 1(e): 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 Hisar (about 12 km) gives a 50-year 24-hour depth of 139 mm, while the Hissar observatory recorded 346.7 mm on 16 August 1926, and the cell at Rohtak gives 177 mm, while the Rohtak rain gauge recorded 484.1 mm on 19 September 1933 (NIH-DHAARA, queried 7 Nov 2026; IMD). In the Shivalik foothills the error runs the other way: the cell at Panchkula gives 320 mm, above the 262 mm of the CWC plate at Chandigarh. Neither error can be corrected without the factors of Annex 2C. Using grid values as point values without correction would make site-level design unsafe.

2.8 Climate factor

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

Table 2.2 — Interim climate factors

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

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

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

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

> **Commentary.** CPHEEO (2019) considers a fixed climate factor "not feasible" nationally and recommends trend testing instead. That leaves designers without a usable number. The 1.20 short-duration factor matches the UK value cited by CPHEEO itself. It is at or below published projections for India: Ali and Mishra (2018) project 3-hourly 100-year maxima rising by about 20% at 1.5 °C and 25% at 2.0 °C of warming. No design uplift factor has been adopted in Haryana. The evidence on trends points different ways. IMD's analysis of 1989–2018 is quoted as finding a significant decrease in annual rainfall at Ambala, Panchkula and Panipat and in monsoon rainfall in six districts, with 3–4 heavy-rain days a year in the north-east and fewer elsewhere (IMD monograph, as quoted in the State Action Plan on Climate Change 2.0; not read [TBC]); a study of IMD gridded data for 1901–2020 finds a significant increase only before the monsoon (Chauhan et al., 2022, summary read); and the State's action plan projects very heavy precipitation events rising by 2.5% by mid-century under RCP 8.5 while the one-day maximum falls marginally, which cannot both be read as design values (Haryana SAPCC 2.0). Recent extremes have not fallen: Rohtak and Gurgaon (1981), Bhiwani (1995) and Ambala (2004) set their highest days after the CWC plates of 1984 were drawn, Chandigarh broke its July record by about 40 mm on 9 July 2023, and the 2025 season was 33% above normal (IMD). As in Delhi, the totals are not rising while the short falls are, so the uplift matters most at the short durations where the 1(e) ratios already understate the bursts (Clause 2.3.6(g)). NIH-DHAARA offers a projection but no historical run of the same model, so no ratio of future to present depths can be formed; under Clause 2.3.6(j) it would serve only as a check. The factors of Table 2.2 are therefore interim values, not Haryana 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.

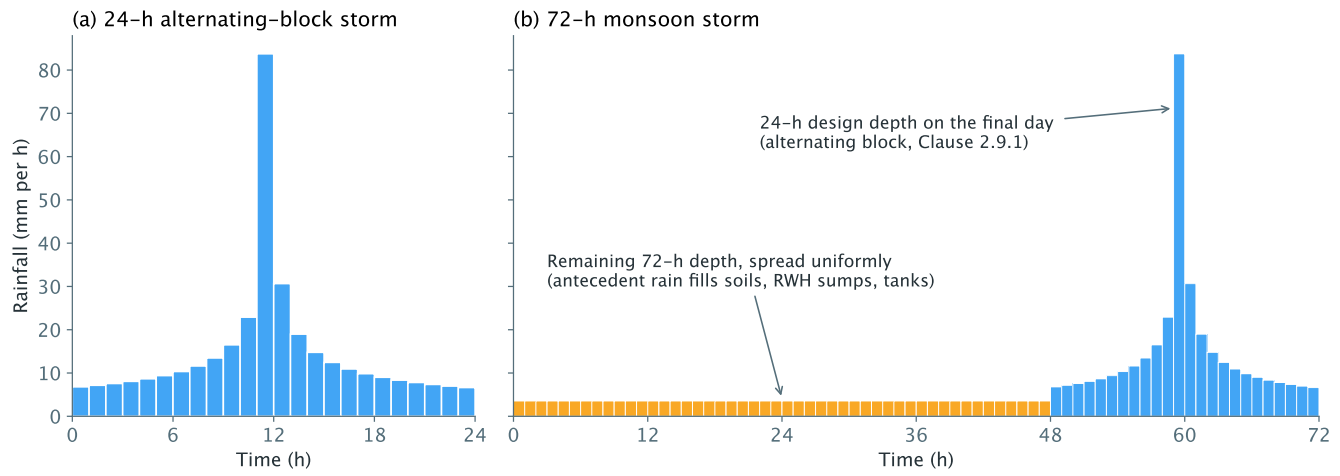

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour SW monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Haryana 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 Haryana monsoon sequence: by the time the largest falls arrive in July–September, the area where the water table stands within 3 m of the surface has grown, from about 2.93 lakh ha in June 2023 to 3.79 lakh ha in October (HWRA), the johads are full, and the Yamuna and the Ghaggar, fed by rain on the Shivalik and Himalayan catchments above Hathnikund and Panchkula, may already be holding up the outfalls. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Haryana 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:

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

2.11.3 **Flood-sensitive catchments** (as listed in Chapter 4: the catchments of Gurugram's Legs I–III and the Badshahpur drain and of the Budhiya nala at Faridabad, the waterlogged towns of Rohtak and Jhajjar, the land of Panchkula and Ambala on the Ghaggar, the Yamuna floodplain at Karnal, Panipat and Sonipat, and any catchment notified by the authority). The **mixed-frequency rule** applies:

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

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

2.11.4 **Antecedent moisture.** Use **AMC III** (wet conditions) for every design storm, whatever its duration, from 1 July to 15 September at a site in sub-area HR-A Shivalik foothills and choes or HR-D Rohtak–Jhajjar–Sonipat waterlogged belt of Annex 2A, or on the floodplain (khadar) of the Yamuna, the Ghaggar or another river anywhere in the State, and in July and August at a site in sub-area HR-B Upper Yamuna–Ghaggar plains or HR-C NCR south (Aravalli–Sahibi). At any other site or time, including every site in sub-areas HR-E Central and south-west dry plains and dunes and HR-F Ahirwal Aravalli south, use AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm. Use AMC II (average conditions) for every other storm. AMC I is not used for design.

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

> **Commentary.** Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that SW monsoon extremes arrive after weeks of rain. In Haryana that holds most strongly where the ground is already wet. In the Rohtak–Jhajjar–Sonipat belt the water table was within 3 m of the surface over about 50% of Rohtak and 43% of Jhajjar district in June 2023, and the area so waterlogged or prone to it grew by about 30% between June and October (HWRA, Atlas 2025); the soils there are saline and sodic. In the Shivalik foothills the normals are the highest in the State, 988.0 mm at Ambala and 1,073.6 mm at Chandigarh, with July and August holding most of it (IMD, *Climate of Haryana*), and the monsoon arrives there by 28 June (IMD). By contrast, Kurukshetra, Mahendragarh and Gurugram had more than half their area with water tables deeper than 30 m in June 2023 (HWRA), and the dune and sandy soils of Hisar, Bhiwani, Sirsa and Mahendragarh take in the first rains fast. This Manual therefore uses AMC III from 1 July to 15 September in HR-A and HR-D and on river floodplains, in July and August in HR-B and

HR-C, and at other sites and times, including the dry south-west, only after a 5-day total of more than 53 mm, the NRCS growing-season threshold for AMC III (Clause 2.11.4). AMC I is not used even in the dry south-west, because the storms that govern there, such as the September storms of 1875, 1911 and 1933, wet the profile over several days. These are interim choices set by this Manual; no study in the State has yet validated AMC classes against observed runoff.

Illustrative scale of the mixed-frequency rule. The values below are not design values. They assume a 2 ha site in a sector draining to the Badshahpur drain in Gurugram 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.

Haryana has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the river into which a town drains, the Yamuna, the Ghaggar and their tributaries; the I&WRD drains that receive town drains; and, for Gurugram and the Rohtak–Jhajjar belt, the Najafgarh drain in Delhi. For an outfall under river or drain backwater, the site storm is combined with the receiving-water level under Clause 5.8.4, which pairs a design event on one side with a 10-yr event on the other in the same way as case (b). On the Yamuna the CWC site at Karnal has a warning level of 248.8 m, a danger level of 249.5 m and a highest flood level (HFL) of 250.07 m (17 June 2013), and the site at Mawi, on the Panipat reach, a danger level of 230.85 m and an HFL of 232.75 m (18 June 2013) (as copied from CWC's list; another source gives 250.01 m on 19 September 2010 for Karnal, and the CWC site sheets were not read [TBC]). Releases at the Hathnikund barrage, whose design flood is 22,000 m³/s and which passed 3,59,760 cusecs on 11 July 2023 (MoJS committee, 2024) and a record 8,28,072 cusecs on 18 August 2019 (as reported), take 35–75 hours to travel the 237 km to Delhi. CWC has no flood site in the Ghaggar basin; the levels of the Ghaggar, the Markanda and the Tangri are those of I&WRD gauges, known for this Manual only from press reports [TBC]. On the Sahibi the Masani barrage has a crest of 240.00 m and bay walls at 242.20 m (I&WRD, 2024), and the HFL at Masani is 242.58 m (2 September 1978) (as copied from CWC's list); below it the river runs as Outfall Drain No. 8, whose capacity of 4,000 cusecs was exceeded by a flow of 5,000 cusecs at the Dhansa regulator in 2022 (I&WRD, 2024), to the Najafgarh drain, into which Gurugram's master drains also discharge. When a river or a receiving drain is high, outfalls are held up behind flap gates and regulators, so storage and pumps are checked for the outfall-closed condition, with the local storm falling before, during or after the high water. No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC], and Chapter 5 sets the interim rule: for a river, a level related to the highest

recorded at the nearest gauge; for an outfall into an I&WRD drain, the drain's design water level, with I&WRD's consent; and for the Najafgarh drain, a level to be agreed with the Irrigation and Flood Control Department of Delhi. Every level is stated on a named datum, as Chapter 5 requires; the datum of the levels quoted here is to be confirmed [TBC].

> Commentary. Haryana has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the stage of the Yamuna, the Ghaggar and the drains that receive the town drains. The coincidence is on record. In July 2023 Chandigarh recorded 302.2 mm and Ambala 224.1 mm on 9 July (IMD), the Hathnikund barrage passed 3,59,760 cusecs on 11 July (MoJS committee, 2024), the Ghaggar carried about 82,400 cusecs at Kaithal on 12 July and breached its embankments there and downstream (as reported), and the Yamuna reached its record level at Delhi on 13 July. Releases from Hathnikund take 35–75 hours to reach Delhi (MoJS committee, 2024), which gives warning of the river but not of a local storm, and the Ghaggar has no CWC flood site at all. In the Rohtak–Jhajjar belt and at Gurugram the receiving water is a drain, Outfall Drain No. 8 and the Najafgarh drain, whose level is set by the regulators at Dhansa and downstream as much as by the rain. 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 (in Haryana, which has no coast, the counterpart of surge is the stage of the Yamuna and the Ghaggar and the level of the drains that receive the town drains, raised by the same monsoon systems that bring the heaviest rain to the towns: on 9 July 2023 Chandigarh recorded 302.2 mm and Ambala 224.1 mm (IMD), the Hathnikund barrage passed 3,59,760 cusecs on 11 July (MoJS committee, 2024), and the Ghaggar breached its embankments in Kaithal, Fatehabad and Sirsa in the week that followed, as reported), they cannot be treated as independent. Case (b) is a simple joint-probability surrogate until a statistical joint analysis is adopted.

2.13 Submittal requirements

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

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

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

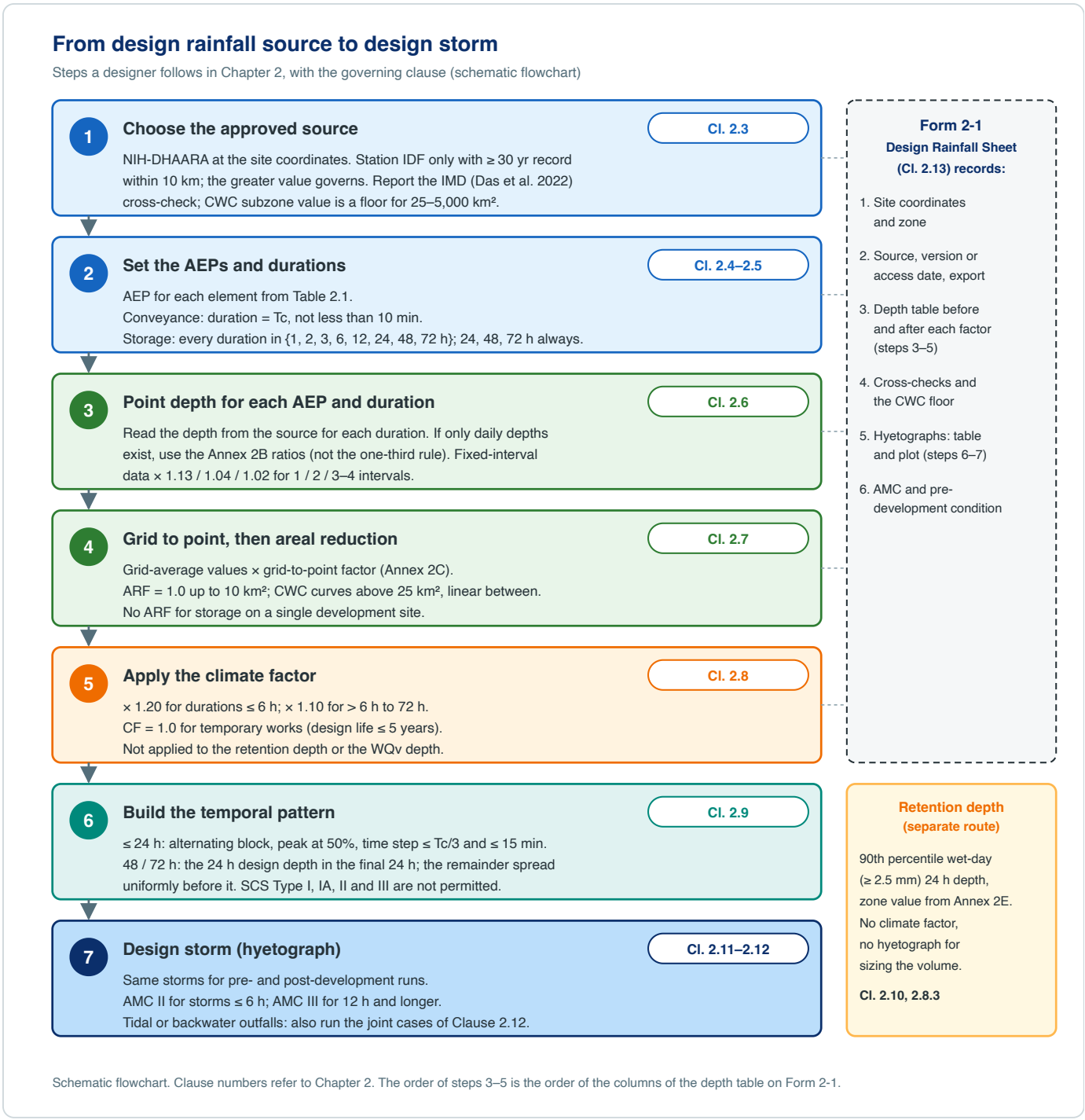

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the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

2.14 Review and update

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

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

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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

Annex	Content
2D	Haryana 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 (johad) 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 (johads) 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 Yamuna and Ghaggar alluvium, Shivalik piedmont gravels, Aravalli rock, dune sands and saline-sodic soils of Haryana, where an HSG A to C jump would be excessive. The 35% minimum imperviousness for unplanned upstream land in 3.3.5(a) is the APWA value (2011, §5602.3E.2). Using the master-plan land use for conveyance follows CPHEEO, which requires C to reflect "ultimate development of the catchment as per the master plan" (CPHEEO 2019, Part A §4.4.1.5).

3.4 Selection of method

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

Table 3.1 — Permitted hydrologic methods

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

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

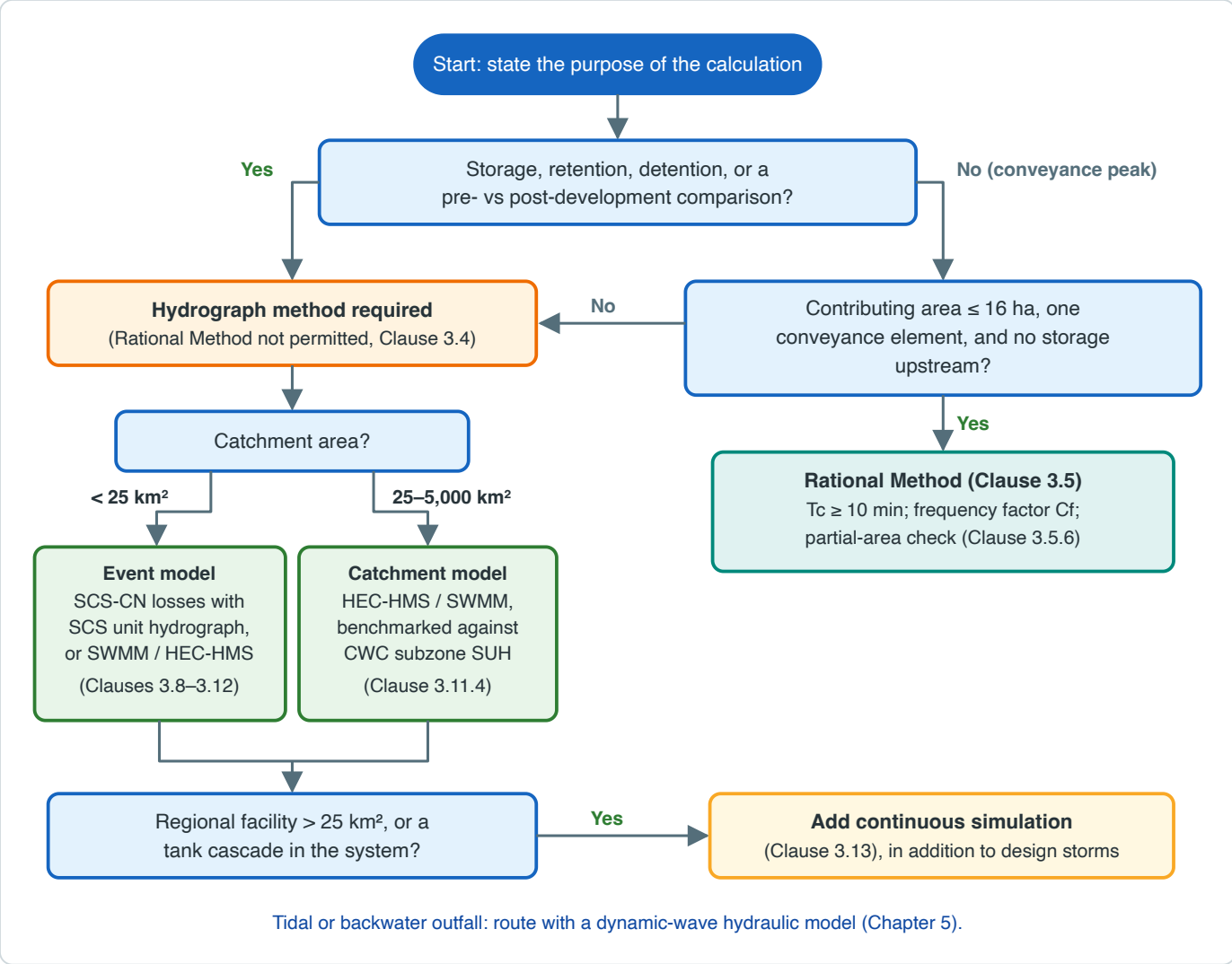

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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 Water Resources Department (I&WRD).

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

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 Haryana'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.

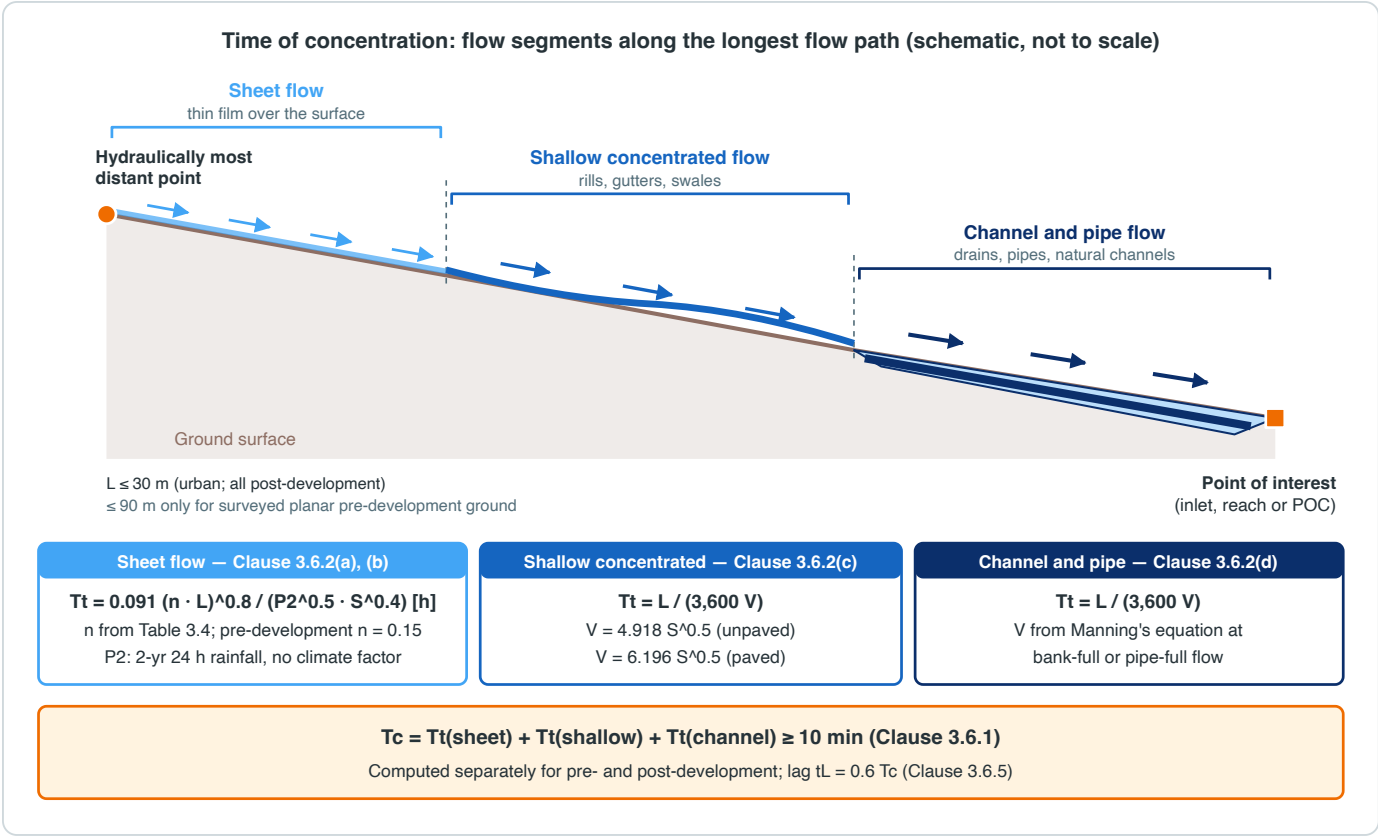

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986), 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 Haryana Space Applications Centre (HARSAC) [TBC], using the soil-series-to-HSG lookup of Annex 3A. The source map and its scale shall be stated.

3.7.2 **Assignment rule.** Where Annex 3A is not yet available for a series, the HSG shall be assigned from the measured saturated hydraulic conductivity and depth to an impermeable layer or water table using the criteria of NEH Part 630, Ch. 7. Until Annex 3A is published, this Manual sets the following interim groups for Haryana: the gravels, coarse sands and boulder beds of the Shivalik piedmont, the belt about 2–4 km wide below the hills at Panchkula, Kalka–Pinjore, Naraingarh, Ambala and Yamunanagar–Jagadhri, and the beds of the choes that cross it, HSG A or B by texture, but HSG C where the boulder bed is cemented or a clay layer lies within 1 m of the surface; the sandstone, clay and mudstone slopes of the Shivalik hills at Morni and Kalesar, HSG C, and HSG D where clay or rock lies within 50 cm; the recent and older alluvium of the Yamuna and Ghaggar plains, HSG B where it is a sandy loam, and HSG C where it is a loam or clay loam, where a kankar layer lies within 1 m or where a field infiltration test gives less than 6 mm/h; the sodic (alkali) soils of Kurukshetra, Kaithal, Karnal and Jind, HSG D for every design storm, whatever their texture; the waterlogged and saline-sodic soils of the Rohtak–Jhajjar–Sonipat belt (sub-area HR-D of Annex 2A), and every other soil in that sub-area where the seasonal high water table is within 3 m of the surface, HSG D for every design storm, whatever a test shows, and no retention practice founded in them earns infiltration credit (Clause 4.4); the rock, scree and thin soils of the Aravalli ridges of Gurugram, Faridabad, Nuh, Rewari and Mahendragarh, HSG D, and HSG C on deep colluvial fans at their foot; the dune sands and loamy sands of Sirsa, Fatehabad, Hisar, Bhiwani, Charkhi Dadri and Mahendragarh, HSG A, except that a sand with a kankar (calcrete) pan within 1 m of the surface is HSG C, and HSG D where the pan lies within 50 cm (NEH Part 630, Ch. 7), and that saline pans and depressions are HSG D; and made ground and fill, HSG C 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, made as a pit or borehole test at the depth of the proposed facility

after pre-wetting and taken through any kankar layer or boulder bed that lies within that depth; on smaller sites, a soil that has not been tested shall be given the less permeable of the groups listed for it. Clause 3.10.1 applies to all of these groups, and on the floodplains of the Yamuna and the Ghaggar the seasonal high water table shall be established (Clause 3.10.2) before any group other than D is used.

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 Shivalik piedmont, where an open gravel that takes in water quickly can be cemented, or capped by clay, within a metre of the surface; in the dry south-west, where a kankar pan a metre down turns a dune sand that takes in water quickly at the surface into a perched soil that ponds; on the Aravalli fringe of Gurugram and Faridabad, where the depth to rock can change from a few centimetres to several metres within one site; and in the Rohtak–Jhajjar–Sonipat belt, where a test made on dry ground in May or June says nothing about a soil whose water table rises to within 1.5–3 m of the surface by October. No statewide HSG map of Haryana, and no statewide area shares of soil texture from NBSS&LUP or HARSAC, were found during research for this Manual [TBC]. The pattern is set out in the CWC report for subzone 1(e): recent alluvial soils on the plains of the Yamuna and the upper Ghaggar, calcareous soils of alluvial origin along the middle Ghaggar, saline and alkaline soils "in some parts of the plains", desert and grey-brown soils near the south-western boundary and brown hill soils along the northern boundary (CWC, 1984, §1.6). The CGWB adds the sand dunes of Bhiwani, Mahendragarh, Hisar and Sirsa, and a piedmont zone "about 2 to 4 km wide, between Siwalik Hills and alluvial plains" of coarse sand, gravels and boulders; about 98% of the State is alluvium and about 2% hard rock (CGWB, *Dynamic Ground Water Resources of Haryana*, 2022 and 2024). About 0.232 million ha, some 5% of the State, is salt-affected (CSSRI, 2016, whose text misprints the share as 0.053%): salinity in Sirsa, Fatehabad, Hisar, Bhiwani, Charkhi Dadri, Rohtak, Jhajjar and Sonipat, and sodicity in Kurukshetra, Kaithal and parts of Karnal and Jind (as reported). In the southern districts CSSRI mapped 85.32 km² of waterlogged saline land and 282.55 km² of hills in the 1,235.16 km² it mapped in Gurugram district, and 190.82 km² of waterlogged saline land in the 1,354.58 km² it mapped in Palwal (CSSRI, 2016, Table 27). Sand covers 46.43% of Charkhi Dadri district (CCSHAU, 2023) and loamy sands and sands 56.4% of a micro-watershed in Nuh (NBSS&LUP), both from search summaries [TBC]. The only measured rates found are 0.45–2.91 cm/h on the soils of the Saraswati palaeochannel, sand to clay loam, and it is not known whether these are basic rates (CCSHAU thesis, 2023, from a search summary [TBC]); no measured basic infiltration rate by soil group from CCSHAU or CSSRI was found [TBC]. The groups of Clause 3.7.2 therefore follow the texture where it is known and the water table where it governs. A sodic soil is placed in group D whatever its texture because its clay disperses when wet and seals the surface, so a sandy loam that is sodic behaves as a clay in a storm. In the Rohtak–Jhajjar–Sonipat belt the water table governs: in June 2023 it was within 3 m of the surface over 49.9% of Rohtak district and 42.6% of Jhajjar district, and the area of the State within 3 m grew from about 2.93 lakh ha in June to about 3.79 lakh ha in October (by NEER's reading of HWRA, *Haryana Water Resources Atlas 2025*); in June 2021 the shallowest well in the State, 0.85 m below ground, was at Kulasi in Jhajjar district (CGWB, *Ground Water Year Book Haryana 2021-22*). There, a soil that has any infiltration capacity in May has little left once the monsoon has raised the water table, and the State's own water law directs that activities likely to lead to waterlogging be discouraged and prevented (Haryana Water Resources (Conservation, Regulation and Management) Authority Act 2020, section 21(7)); infiltration credit there would credit storage that is not available when it is needed and would raise the water table further. The only regional measure of losses is the design loss rate of 3.0 mm/h of CWC subzone 1(e) (Annex 3E). It is a φ-index fitted to the monsoon floods of whole rural catchments, which include the area under standing water and the land beside saturated channels, not the infiltration capacity of any soil, and it shall not be used to assign an HSG or to size an infiltration practice; it is too high for the waterlogged soils of HR-

D and probably too low for the Shivalik gravels and the dune sands. The AMC rule of Clause 3.8.4 follows the same evidence. The monsoon reaches Sonipat by about 27 June, Ambala and Chandigarh by 28 June and Hisar by 3 July, and withdraws from Hisar by about 21 September and from the north and east by 23–25 September (IMD, Pai et al., 2020), so 1 July to 15 September is the part of the monsoon in which the ground is wet in a normal year. AMC III is applied for all of it in HR-A, whose normals are the highest in and beside the State (988.0 mm a year at Ambala and 1,073.6 mm at Chandigarh, with about 285 mm in July and 274 mm in August at Ambala; IMD, *Climate of Haryana*), and in HR-D and on the floodplains, where the water table is shallow; in HR-B and HR-C, whose water tables are deep (97.2% of Kurukshetra district and 51.1% of Gurugram district deeper than 30 m in June 2023, by NEER's reading of the HWRA Atlas), it is applied only in July and August, the wettest months (about 175 mm and 180 mm at Gurgaon against an annual normal of 577.8 mm; IMD, *Climate of Haryana*); and in the sandy, deep-water-table south-west of HR-E and HR-F, with annual normals of 325–518 mm, AMC III follows the 5-day rule alone. AMC I is not used, even on the dune sands, because the State's largest recorded storms, such as those of 9 September 1875 (398.8 mm at Palwal), 28 September 1911 and 19 September 1933 (484.1 mm at Rohtak), fell in September, after two months of monsoon rain (IMD, *Climate of Haryana*). The interim groups of Clause 3.7.2, the 1 m and 50 cm pan, clay and rock rules, the 6 mm/h threshold, the 3 m water-table rule for HR-D, the dates of the AMC rule and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Haryana.

3.8 SCS curve number (SCS-CN) loss method

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

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

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

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

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

Cover type	HSG A	HSG B	HSG C	HSG D
Pre-development reference (Clause 3.3.2): open space, good condition (grass > 75%)	39	61	74	80
Open space, fair condition (grass 50–75%)	49	69	79	84
Open space, poor condition (grass < 50%)	68	79	86	89
Impervious: roofs, paved parking, driveways, paved roads with kerbs and drains	98	98	98	98
Paved roads with open ditches (including right-of-way)	83	89	92	93
Gravel roads (including right-of-way)	76	85	89	91
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

Cover type	HSG A	HSG B	HSG C	HSG D
Meadow (continuous grass, protected from grazing)	30	58	71	78
Brush, good condition	30	48	65	73
Woods, good condition	30	55	70	77
Woods, fair condition	36	60	73	79
Woods, poor condition	45	66	77	83
Water surfaces, tank waterspreads, wet detention basins	Runoff = rainfall (no losses)			

3.8.3 **Use of Table 3.5.**

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

3.8.4 **Antecedent moisture.** AMC shall follow Clause 2.11.4: AMC III for every design storm, whatever its duration, from 1 July to 15 September at a site in sub-area HR-A Shivalik foothills and choes or HR-D Rohtak–Jhajjar–Sonipat waterlogged belt of Annex 2A, or on the floodplain (khadar) of the Yamuna, the Ghaggar or another river anywhere in the State, and in July and August at a site in sub-area HR-B Upper Yamuna–Ghaggar plains or HR-C NCR south (Aravalli–Sahibi); at any other site or time, including every site in sub-areas HR-E and HR-F, AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm; and AMC II for every other storm. CN for AMC I and III shall be obtained from AMC II by:

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

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

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

3.8.5 **Initial abstraction.**

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

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

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

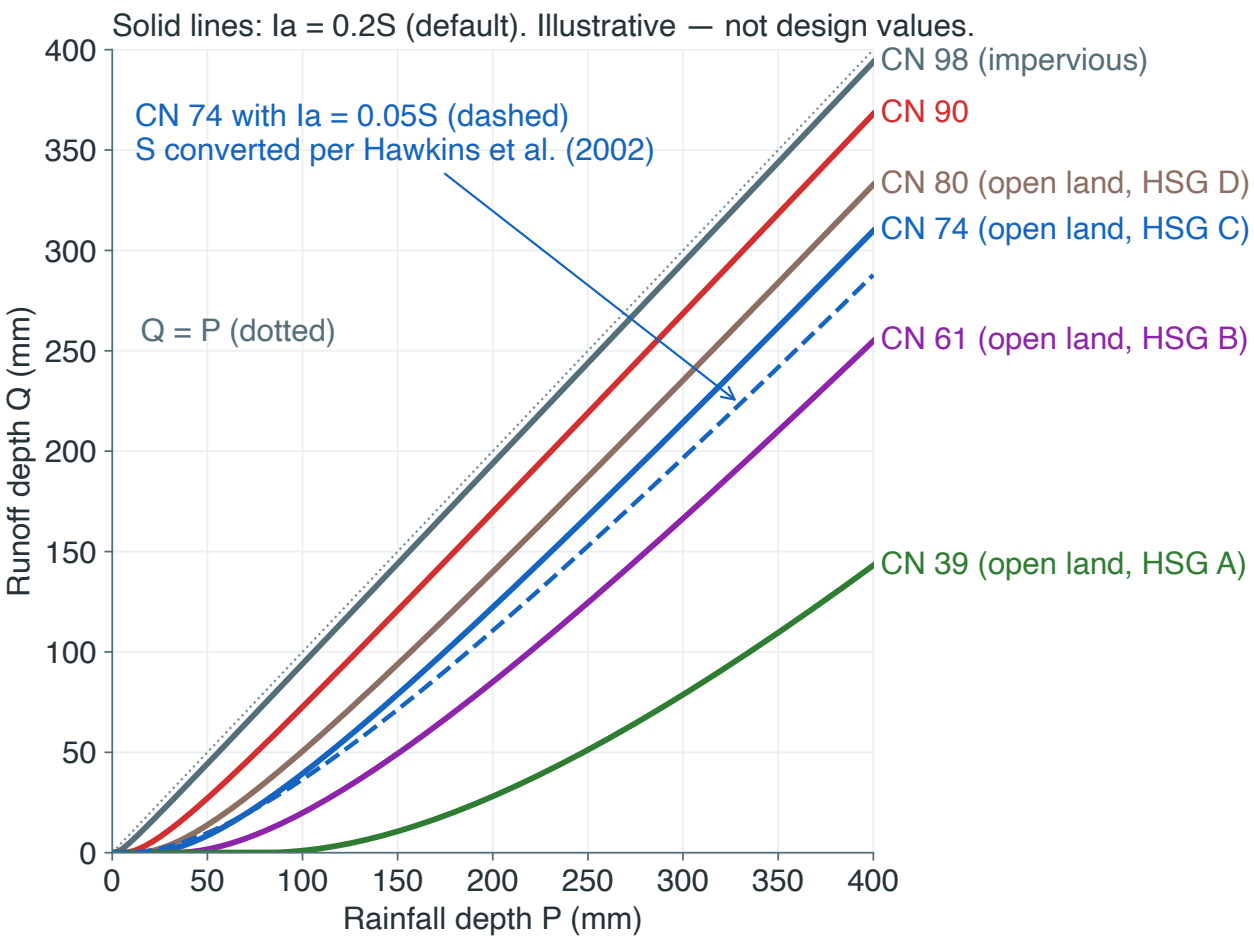

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion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

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

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

3.9 Impervious connectivity

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

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

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

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

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

- for directly connected impervious area: $CN_c = CN_p + (P_{imp} / 100)(98 - CN_p)$;
- where total impervious area is below 30% and part of it is disconnected: $CN_c = CN_p + (P_{imp} / 100)(98 - CN_p)(1 - 0.5\,R)$,

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

> **Commentary.** The composite equations are from TR-55 (USDA SCS, 1986, Ch. 2, Figures 2-3 and 2-4). This Manual prefers separate representation in 3.9.2 because a composite CN spreads the impervious response over the whole area, which suppresses runoff from small storms. For a site that is 50% directly connected impervious on HSG B open space (CN_p 61), 25 mm of rain gives about 9.9 mm of runoff when the two parts are modelled separately, but only about 1.8 mm with the composite CN 79.5. At 200 mm the two methods agree (139.5 mm vs 138.4 mm). *Illustrative — not design values.* The error is largest for the frequent storms that set retention and water-quality volumes. The disconnection criteria of 3.9.3 are set by this Manual, drawing on common practice in US runoff-reduction manuals. Criterion (d) follows the rule of Clause 3.3.3(c) that RWH sumps are full at the start of 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 Haryana Water Resources Authority 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, johad, 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 Rohtak–Jhajjar–Sonipat belt, on the floodplains of the Yamuna and the Ghaggar and on the sodic plains the water table stands close to the surface even before the monsoon, and whatever infiltration capacity the soil has in the dry season is gone when a July–September design storm arrives. In June 2023, before the monsoon, the water table was within 1.5 m of the surface ("waterlogged") under about 20,920 acres of the State and within 1.5–3 m ("prone to waterlogging") under about 703,022 acres; by October 2023 these had grown to about 126,695 and 809,601 acres. Rohtak (about 214,972 acres), Jhajjar (192,954), Hisar (134,531), Jind (64,601) and Sonipat (49,370) held most of the June area, and the land within 3 m was about 49.9% of Rohtak district and 42.6% of Jhajjar district (HWRA, *Haryana Water Resources Atlas 2025*; district shares by NEER's reading of its tables). The CGWB network shows the same pattern: in June 2021 depths ranged from 0.85 m at Kulasi in Jhajjar district to 53.45 m at Ratia in Fatehabad district, with "very shallow (0-2m) water levels … in isolated patches in Jhajjar, Ambala and Rohtak districts", which "indicates water logging conditions" (CGWB, *Ground Water Year Book Haryana 2021-22*). Because the water table is near the surface, every assessment block of Rohtak and Jhajjar districts is classed "safe", while 88 of the State's 143 blocks are over-exploited (CGWB, *Dynamic Ground Water Resources of India* 2024; HWRA public notice of 2024). No monsoon water-table depths for individual town sites were obtained [TBC]; Annex 3A is to supply them. Clause 3.10.4 reflects the receiving waters of this belt, which are drains with little spare capacity and a controlled outfall. The Sahibi enters Outfall Drain No. 8 at RD 17.5 km, and the drain ends at the Dhansa regulator (RD 42.59 km) on the Delhi border and falls into the Najafgarh drain; its capacity is 4,000 cusecs, but "a peak flow of 5000 Cs." was observed at Dhansa in the monsoon of 2022 (I&WRD committee report in NGT O.A. 627/2022). A study of the Rohtak–Jhajjar drainage found that the existing surface drains, of about 170 m³/s, with their dead storage, could handle only the 1- and 2-day consecutive rainfall of 5-year return period (*Irrigation and Drainage*, 2006, from a search summary [TBC]). On the Yamuna the river sets the level: the CWC gauge at Karnal has a danger level of 249.5 m and a highest flood level of 250.07 m (17 June 2013), and Mawi, on the Panipat reach, 230.85 m and 232.75 m (18 June 2013) (CWC site list, as transcribed by SANDRP). On the Ghaggar, CWC has no flood gauge anywhere in the basin, and the levels used in floods are those of I&WRD gauges, known to this Manual only from the press [TBC].

3.11 Unit hydrographs and runoff transformation

3.11.1 **Permitted transforms.**

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

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

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

where qp is the peak flow (m³/s); A is the area (km²); Q is the runoff depth (mm), equal to 1 mm for the unit hydrograph; tp is the time to peak (h); and Δt is the computation interval (h).

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

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

3.11.4 **CWC synthetic unit hydrograph.** For catchments of 25–5,000 km² in CWC subzone 1(e) (Upper Indo-Ganga Plains), which covers the State up to the boundary of zone 7 (Western Himalayas), with the Kalka–Pinjore upland beyond that boundary and the Morni and Kalesar hills on it:

- (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 1984; see Chapter 2). They were derived from natural, mostly rural catchments with data of 1961–1982 that predate the report of 1984, 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 johads and talabs at FTL in 3.12.5 because Haryana's heaviest rain falls in the middle and late monsoon, on water bodies that have taken the earlier rains and are not drawn down for drainage. July and August carry about 355 mm of Gurgaon's annual normal of 577.8 mm and about 560 mm of Ambala's 988.0 mm (IMD, *Climate of Haryana*), and the State's largest recorded days fell in July, August and September: 484.1 mm at Rohtak on 19 September 1933, 444.5 mm at a gauge in Ambala district read as Dadupur on 2 July 1966, 346.7 mm at Hissar on 16 August 1926 and 282.2 mm at Gurgaon on 14 July 1968 (IMD, *Climate of Haryana* and *Extremes*). No johad or talab in Haryana was found to have a documented operating rule or a record of water levels [TBC], and many village ponds receive sewage and grey water from the village drains all year, so that "polluted and overflowing" ponds are one of the priorities of the Authority's annual plans (HPWWMA written statement in NGT O.A. 573/2023, 21 February 2024). The inventory is large and uneven: 19,665 ponds are on the Pond Data Management System of the Haryana Pond and Waste Water Management Authority, 18,764 of them rural and 901 urban (same statement), and in Gurugram the count has run from 641 in the revenue record of 1956 to 487 on the Survey of India sheets of 1976 and 557 on satellite imagery of 2011-12, with only 123 common to all three (GMDA report in NGT O.A. 325/2015). Water bodies should therefore be assumed full from July 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 July to 30 September in Clause 3.13.5(a) is set by this Manual. It starts just after the normal onset of the monsoon, which reaches Sonipat by about 27 June, Ambala and Chandigarh by 28 June and Hisar by 3 July, because the johads are at their lowest

> before the monsoon and the dry days of June would lower the starting level; it ends on 30 September, the date to which this Manual keeps pumps on standby, a week after the normal withdrawal of 21–25 September (IMD, Pai et al., 2020).

3.13 Continuous simulation

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

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

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

3.13.2 **Rainfall input.**

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

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

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

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

- (a) the **starting level of each tank**, taken as the level exceeded on 10% of the days from 1 July to 30 September over the record; and
- (b) the **antecedent soil-moisture condition**, taken from the same days and compared with the AMC rule of Clause 3.8.

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

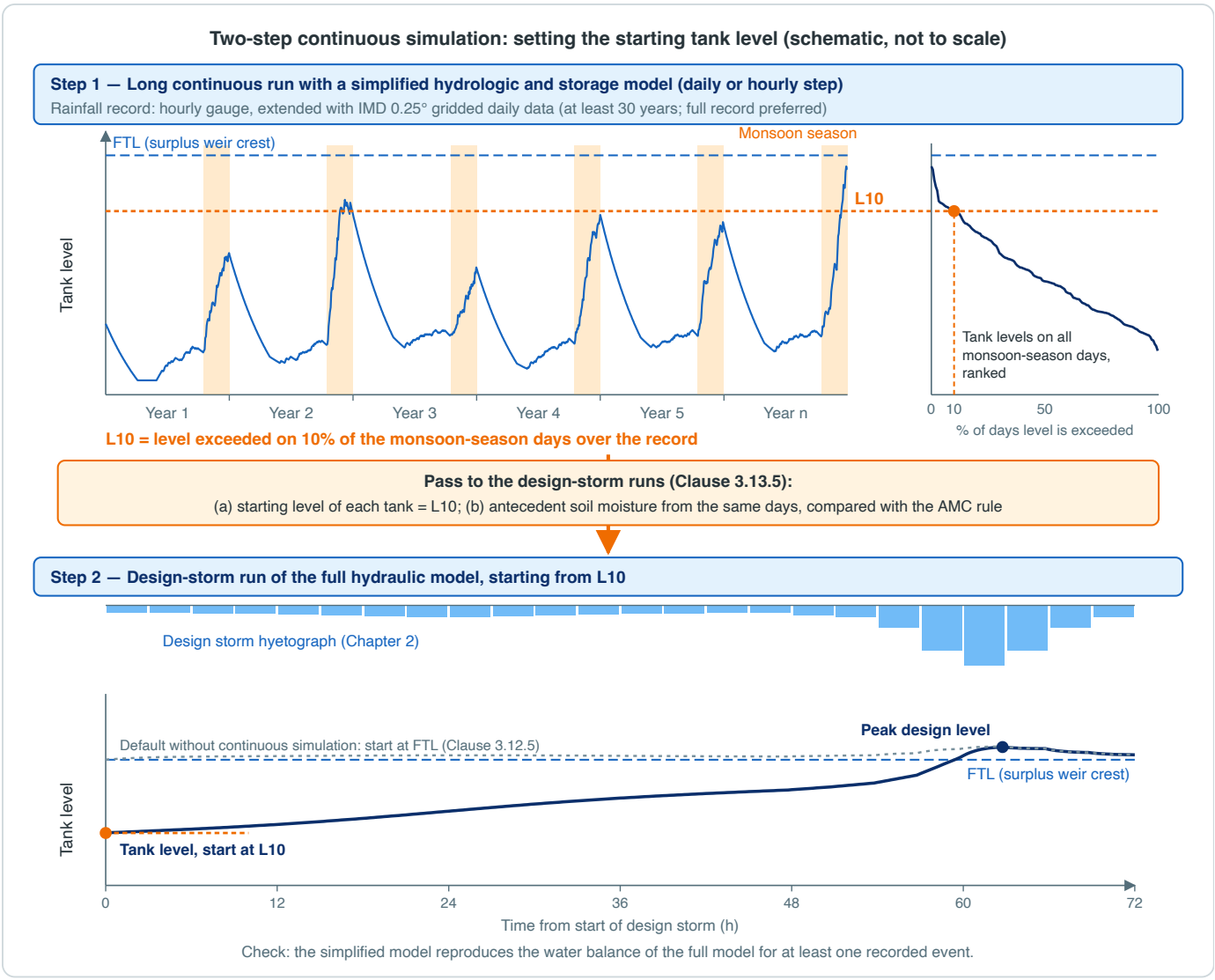

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 July to 30 September (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in 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 Haryana. 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 August and September 1995, when Rohtak recorded 928.0 mm in August (IMD) and the Sahibi filled the Masani barrage in the only monsoon since the late 1980s in which it has reached it (I&WRD).

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.

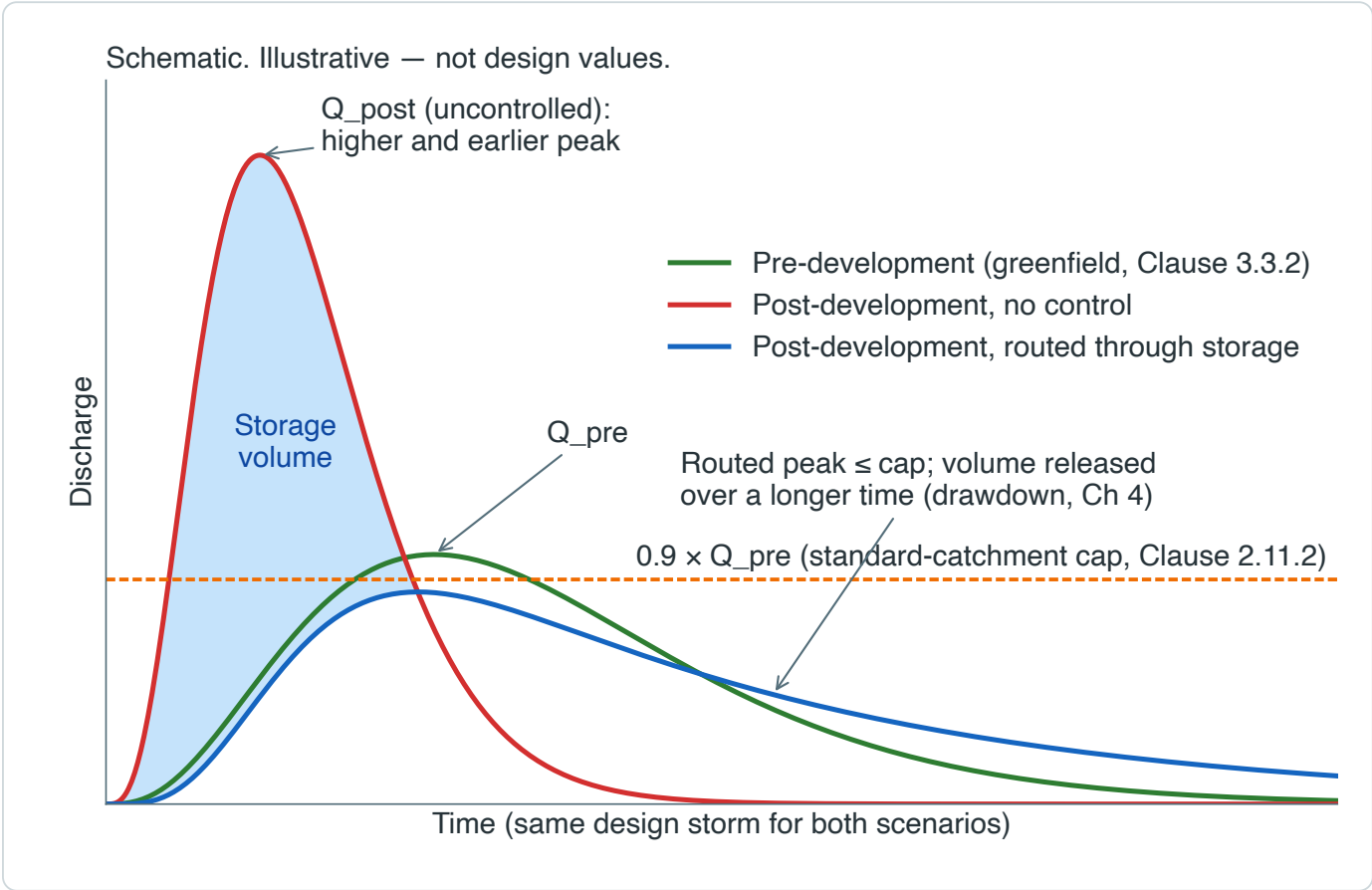

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro 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) ≤ Q_{pre}(10% AEP), and Q_{post}(50% AEP) ≤ Q_{pre}(50% AEP) (Clause 2.11.3).

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

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

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

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

> Commentary. The step sequence follows the standard event-based workflow: delineate; set pre-development CN and Tc; set post-development CN and shorter Tc; run identical storms through a unit hydrograph or kinematic model; compare peaks and volumes; and size storage by modified Puls routing. It adds the Haryana 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&WRD gauging sites, MCG or HSDMA 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 storm of 8–10 July 2023 over Panchkula and Ambala (302.2 mm at Chandigarh and 224.1 mm at Ambala in 24 hours on 9 July, IMD), the storm of 30 June 1981 (297.9 mm at Rohtak and 261.2 mm at Gurgaon in 24 hours, IMD), or the Gurugram storm of 1 September 2025 (more than 100 mm in four hours, as reported), where data exist).

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

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

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

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

3.16 Software acceptance

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

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

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

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

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

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

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

3.17 Documentation

Every hydrologic submittal shall include:

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

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Annexes and forms

Annex / Form	Content
3A	Haryana soil series to HSG lookup; seasonal high water table map
3B	Haryana CN calibration and supplementary land covers (choe beds and Shivalik scrub, Aravalli rock and scree, waterlogged and saline-sodic fields, dune sand, johad and bund beds)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for subzone 1(e), 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 (roof rainwater harvesting by the owner where the rooftop is 100 m² or more, in the areas that the Competent Authority notifies, and groundwater recharge for every building on a plot of more than 500 m², with no occupation certificate until the system is built and certified functional, under Code 8.1 of the Haryana Building Code 2017; and at least one recharge bore for every 5,000 m² of built-up area for buildings of 5,000–20,000 m² under Code 12.1; 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 Haryana rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or "zero run-off". Haryana has one building code for the whole State, the Haryana Building Code 2017, issued by the Town and Country Planning Department with memo No. Misc-138-A-Loose/7/5/2006-2TCP dated 7 March 2017 and applicable to the entire State from 6 January 2017 (Code 1.1(2)); it replaced the Haryana Building Code 2016, which had applied from 30 June 2016. It is a departmental code, not a notification in the Gazette under an Act: each Competent Authority, whether DTCP, HSVP, a municipal body or HSIIDC, applies it under its own Act (Code 1.2(1)(ii)), and it is amended by further memos, of which those of 27 May 2020 and 19 January 2022 were read; amendments of 8 December 2025 (occupation certificates) and 5 June 2026 (charging of electric vehicles) and a proposal of November 2026 on purchasable FAR are reported, none of them touching rainwater harvesting, the plinth or basements (as reported [TBC]). Its drainage provisions protect the building and the drain, not the catchment. The site plan shows the existing drains (Code 3.2); the building plan shows "the method of disposal of waste water, sewage, storm water" (Code 3.4(2)(vi)); the plinth is to be "so located … that proper drainage of the site is assured", at 450 mm to 1.5 m (Code 7.3); rainwater harvesting and recharge are required by Code 8.1 (Commentary to Clause 4.11); and for buildings of 5,000–20,000 m² of built-up area the environmental conditions of Code 12.1 require that "The inlet

and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water", that at least one recharge bore be provided for every 5,000 m² of built-up area, and that "The unpaved area shall be more than or equal to 20% of the recreational open spaces". Its rule of "zero waste water discharge" (Code 11.7) concerns sewage, not storm water. None of these sets a design storm, a release rate, a storage volume or an overflow path, and the Code sets no setback from a drain, nala, canal, pond or river. The Haryana Municipal Corporation Act 1994 allows no premises to be erected or occupied until a drain is made "of such size, materials, and with such fall" as the Commissioner thinks necessary "for the effectual drainage", emptying into a Corporation drain within thirty metres (section 198), forbids any building on a municipal drain without written permission (section 206) and any direct connection to a storm water overflow drain (section 196); none of these sets a design standard either. No instruction of I&WRD forbidding construction within a stated distance of a drain or canal was found. The lines that do exist come from a statute and the courts: the floodplain zone of the Ghaggar in Panchkula, notified on 27 October 2023 under section 45 of the Haryana Canal and Drainage Act 1974, within which any obstruction is prohibited; the pond land, green belt and catchment of every public pond of 0.5 acre or more, on which no structure may be built and no inflow or outflow obstructed without the permission of the Haryana Pond and Waste Water Management Authority (Act 33 of 2018, sections 2(k) and 14); and the green belt round the Badkhal and Surajkund lakes at Faridabad, with no construction within 1 km of them and prior approval of the Central and State Pollution Control Boards for all plans within 1–5 km (Supreme Court, *M.C. Mehta*, order of 11 October 1996). The hydraulic corridor of Chapter 7, with its Zone 1 floor of at least 15 m, and the setback zones of that chapter are this Manual's proposal; the section 45 floodplain, the pond land and the court lines apply where they bind and are wider. The design norms in use are history, to be replaced. The NCR Planning Board reports that "The intensity of rainfall adopted is 25mm per hour and run off coefficient is 1/8 for designing of storm water drainage channels in Haryana urban area", which is about 9 L/s per hectare (by NEER's arithmetic), and that the rural drains were sized by the Boston Society formula, Q = 200·√A (cusecs, A in square miles), cut by reduction factors of 1/12 to 1/4 "on the premise that relatively smaller sections gave better hydraulic performance" (NCR Planning Board, *Functional Plan on Drainage for NCR*, 2016, §5.2.2); the Sub-Regional Plan for the Haryana Sub-Region of the NCR sizes rural drains for "three days rainfall of five years frequency to be drained in three days" and leaves urban drains to the CPHEEO manual; and the master drains of Gurugram have design discharges but no stated return period (Commentary to Clause 4.5). This Manual uses none of these. Basements are regulated, but not for flooding. The roof of a basement may stand 0.9–1.5 m above the average surrounding ground on plots of up to 1,000 m², the open area beside it is to be "effectively drained", and "The responsibility of draining a basement storey and for protecting it from rain shall be that of the owner" (Code 7.16(5)); no rule on the level of a basement ramp or opening, or on basements in low-lying or flood-prone land, was found, and no order on basement flooding in Haryana after 2024 was found [TBC]. In Gurugram, where "Within half an hour of rain, the entire city was waterlogged" on 19 August 2020 (as reported) and the roads become flow paths, a basement whose ramp starts at road level takes the flood first. This Manual therefore adds its own requirements for every basement: no detention storage in a habitable basement (Clause 4.10.1); the crest of every basement ramp and the sill of every basement opening at least 0.5 m above the 1% AEP flood level, with basement drainage pumped to the surface drain through a non-return valve (Clauses 6.11.1 and 6.11.4); and no basement in Zone 2 (Clause 7.5.2). In the flood-sensitive catchments of Clause 4.5.3.2 and in any catchment notified under Clause 4.5.4, it recommends that no basement be permitted where the 1% AEP flood level stands 0.45 m or more above the road in front, because the plinth rule of Code 7.3 then leaves the ground floor and every opening at plinth level below the flood; and in the Rohtak–Jhajjar–Sonipat belt and on the floodplains, where the water table is within 3 m of the surface, that a basement be permitted only as a watertight structure checked against flotation at the design groundwater level (Clauses 4.12.1 and 4.12.3). These are the Manual's proposals, not rules of the Code. This chapter is written so that it can supply, as a technical companion to the Code and the municipal Acts, the sizing for the storm-water disposal that Code 3.4(2)(vi) already requires to be shown on the plans, and the channel size that Code 12.1 leaves open; it has not been adopted for either purpose. In practice the storm drains carry sewage. In 2023 the BOD of Leg-I, Leg-II and Leg-III averaged 48, 63 and 44 mg/l and that of the Budhiya nala 76 mg/l (State of Haryana report in NGT E.A. 35/2023), against the condition of not more than 30 mg/l on which the Gurugram drains may outfall to the Najafgarh drain (GMDA status report in NGT O.A. 454/2018), and the dry-season flow of Leg-III averaged 126.53 cusecs in 2021 (Haryana Vidhan Sabha, starred question 1397, 2022), although the Canal and Drainage Act excludes "works for the removal of sewage from

towns" from its drainage works (section 2(7)) and the Municipal Corporation Act forbids foul water in a drain provided for surface water (section 196). Clause 8.9 deals with that dry-weather flow. Retention and detention apply in full on every site whatever the drain carries: every litre a site releases at the peak of a storm takes up capacity in a drain that is already part-filled with sewage. The CPHEEO (2019) manual describes limiting outflow to the pre-development peak as typical practice, but it uses no "shall" and names no storm frequencies (CPHEEO Part A §8.5.1). This chapter turns that description into a development-control requirement.

4.2 Definitions

Term	Meaning in this Manual
Retention	Permanent removal of runoff from the surface drainage system by infiltration, evapotranspiration or reuse, so that the water never reaches the outfall.
Retention depth	The 90th percentile wet-day 24-hour rainfall depth for the site's zone (Clause 2.10, Annex 2E).
Required retention volume (RRV)	The runoff volume from the retention depth over the post-development site (Clause 4.4.2).
Detention	Temporary storage of runoff, released through a controlled outlet at a rate set by Clause 4.5.
Retention credit	The reduction in required detention storage that results from retention practices, determined by routing under Clause 4.4.6. It is **not** the same as the retained volume.
Permissible site discharge (PSD)	The maximum rate at which a site may discharge for a stated AEP, in L/s or L/s/ha.
Site storage requirement (SSR)	The detention storage required per hectare of site under the simplified method of Clause 4.14.
Multi-stage outlet	An outlet structure with separate openings at different levels, each controlling a different AEP (Figure 4.2).
Drawdown time	Time from the peak stored volume until the stated fraction of that volume has been released.
Emergency spillway	A secondary overflow that passes flows above the primary outlet capacity, or all flow when the primary outlet is blocked, without overtopping the embankment.
Freeboard	Vertical distance between the maximum design water level and the embankment crest or other critical level.
Flood-sensitive catchment	A catchment listed in Clause 4.5.3 or notified under Clause 4.5.4.
Authority	The approving authority under Chapter 1 (the Competent Authority that applies the Haryana Building Code 2017 under its own Act (Code 1.2): DTCP for licensed colonies and controlled areas, HSVP in its Urban Estates, the Municipal Corporation, Municipal Council or Municipal Committee in its area, HSIIDC in its industrial estates, and GMDA, FMDA or PMDA where it grants the approval [TBC], as applicable).

Term	Meaning in this Manual
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Municipal Corporation of Gurugram (MCG), and GMDA and every other approving authority within the Gurugram Metropolitan Area; every other Municipal Corporation constituted under the Haryana Municipal Corporation Act 1994, among them those of Faridabad and Manesar, with every other approving authority within its limits; the Faridabad and Panchkula Metropolitan Development Authorities (FMDA and PMDA), and any metropolitan development authority constituted later by an Act of the State, with every approving authority within its notified area; and, wherever they lie, HSVP in its Urban Estates and DTCP for the colonies it licenses. Tier B: Municipal Councils and Municipal Committees.

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, johads, 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 Haryana, 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) **Gurugram on Legs I–III and the Badshahpur drain**: the catchments of Leg-I, Leg-II and Leg-III (the Badshahpur drain), from the Aravalli foothills to their outfalls to the Najafgarh drain, including the land that drains to the Badshahpur drain at Khandsa and Hero Honda Chowk;

- (b) **Faridabad on the Budhiya nala**: the catchment of the Budhiya (Buria) nala and of the city drains that join it, down to its outfall towards the Yamuna;
- (c) **the Rohtak–Jhajjar waterlogged towns**: Rohtak, Jhajjar, Bahadurgarh, Beri and Sampla, and the land that drains from them to Outfall Drain No. 8 and the other I&WRD drains of sub-area HR-D;
- (d) **Panchkula and Ambala on the Ghaggar**: the land of Panchkula and Ambala that drains to the Ghaggar and its tributaries and choes, among them the Kaushalya and the Tangri, including the Ghaggar floodplain zone notified in Panchkula under section 45 of the Haryana Canal and Drainage Act 1974;
- (e) **the Yamuna floodplain at Karnal, Panipat and Sonipat**: the land of those towns that drains across the floodplain (khadar) of the Yamuna to the river, or to drains that outfall to it, whose outfalls are held up when the Yamuna is high; 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 closed by a regulator or flap gate when the receiving river or drain is high, as on the Yamuna at Yamunanagar, Karnal, Panipat, Sonipat and Faridabad, at the Dhansa regulator on Outfall Drain No. 8 or where the Gurugram drains meet the Najafgarh drain, that depends on pumping, as in much of the Rohtak–Jhajjar–Sonipat waterlogged belt, or that is held up by the Ghaggar or one of its tributaries in flood, for part of the SW monsoon (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and johad 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 Gurugram entry follows the city's drainage and its record. Three master drains, Leg-I, Leg-II and Leg-III (the Badshahpur drain), carry the runoff of the city from the Aravallis to the Najafgarh drain (GMDA status report in NGT O.A. 454/2018, 2 October 2020), across a fall of about 78 m (Lok Sabha reply of 8 August 2025, as reported). DTCP's master storm-water drainage drawing for Gurugram–Manesar 2031 (No. DTP(G) 2104/2012, 9 November 2012) gives them design discharges

of 541, 1,305 and 3,702 cusecs, and HUDA's management plan for the Badshahpur catchment (2017, revised 24 November 2020) gives reach discharges of up to 2,300 cusecs, but neither states a return period or a rainfall intensity; the capacity of the Badshahpur drain has been reported at anything from 500 to 3,800 cusecs, with a bottleneck of about 800 cusecs at Khandsa (as reported). On 28 July 2016 a storm of about 46 mm in three hours (as reported by the Chief Secretary; no IMD reading was found) flooded Hero Honda Chowk and jammed NH-48 for more than 18 hours, and the city flooded again in 2020, 2023, 2024 and 2025, on 9–10 July 2025 after about 103 mm in 90 minutes and on 1 September 2025 after more than 100 mm in four hours (as reported). The Punjab and Haryana High Court recorded on 22 September 2026 that "Gurugram is facing severe waterlogging during the monsoon season" while the channels that fed its water bodies "remain largely blocked", and summoned officers of MCG, HSVP and GMDA (*Sunil Singh*, CWP-20032-2008). The Faridabad entry follows the Budhiya (Buria) nala, which drains the Aravalli side of the city towards the Yamuna; its capacity is reported as having been raised from 280 to 1,700 cusecs (NCR Planning Board, 2016), and it carries sewage, with a BOD of 76 mg/l in 2023 (State of Haryana report in NGT E.A. 35/2023). The Rohtak–Jhajjar entry follows the water table and the outfall: the water table was within 3 m of the surface over 49.9% of Rohtak district and 42.6% of Jhajjar district in June 2023 (HWRA Atlas 2025), the towns drain to Outfall Drain No. 8, whose capacity of 4,000 cusecs was exceeded by a flow of 5,000 cusecs at the Dhansa regulator in 2022 (I&WRD report in NGT O.A. 627/2022), and the Municipal Corporation of Rohtak lists 16 waterlogging-prone areas (as reported). The belt holds the State's largest recorded day, 484.1 mm at Rohtak on 19 September 1933 (IMD, *Climate of Haryana*). The Panchkula–Ambala entry follows July 2023. On 9 July 2023 Chandigarh recorded 302.2 mm and Ambala 224.1 mm in 24 hours (IMD, July 2023 summary, from real-time data); the Ghaggar breached near Ambala and the breach was closed with the help of the Army, while the Municipal Corporation used 19 pump sets and I&WRD inventory pumps of 962 cusecs in the city (Haryana Vidhan Sabha, starred question 16, September 2023). The Ghaggar floodplain zone in Panchkula was notified under section 45 of the Haryana Canal and Drainage Act 1974 on 27 October 2023, on a 100-year flood of 2,933.45 m³/s computed by Gumbel's method from 54 years of data (I&WRD replies in NGT O.A. 421/2022); the CWC report's own example, on the Ghaggar near Ambala, gives a 50-year peak of 2,706 m³/s (Annex 3E). The Yamuna entry follows the river: Hathnikund passed its highest flow since it was commissioned, about 8.28 lakh cusecs, on 18 August 2019, and about 3.59 lakh cusecs in July 2023 (as reported); the river has reached 250.07 m at the CWC gauge at Karnal (danger level 249.5 m) and 232.75 m at Mawi (danger level 230.85 m), both in June 2013 (CWC site list, as transcribed by SANDRP); and no floodplain notification under section 45 for the Yamuna in Haryana was found. The Ghaggar towns downstream, Kaithal, Fatehabad and Sirsa, where the river breached its banks in July 2023, Yamunanagar–Jagadhri on the Somb and Pathrala, Shahabad on the Markanda, the towns of Palwal and Hisar, and Rewari on the Sahibi below the Masani barrage, 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 johad 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&WRD agreement.

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

Commentary. Greenfield is the target for all redevelopment, because a dense city only reduces its runoff as it rebuilds. On small, fully built plots in areas such as the old cores of Rohtak, Panipat, Hisar, Ambala and Sonipat, the old town of Faridabad, or the village abadis (abadi deh) inside the sectors of Gurugram, there is often no space for the full greenfield storage. A rule that cannot be met invites variances and non-compliance, which help

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

4.6 Detention sizing procedure

4.6.1 Method

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

4.6.2 Steps

1. Delineate the site and sub-areas. Map HSG and confirm by testing (Chapter 3).
2. Extract design rainfall for 50%, 10% and 1% AEP and every duration in Clause 2.5.2, with the climate factor (Chapter 2, Form 2-1).
3. Build design hyetographs: alternating block for ≤ 24 h; the "peak day last" pattern for 48 and 72 h (Clause 2.9).
4. Compute pre-development hydrographs (greenfield CN; AMC III for storms of every duration from 1 July to 15 September in sub-areas HR-A and HR-D and on river floodplains, and in July–August in HR-B and HR-C, and at other sites and times after a 5-day total of more than 53 mm, AMC II otherwise).
5. Compute the release caps for each AEP and duration under Clause 4.5.2 or 4.5.3.
6. Compute post-development hydrographs with the same storms and AMC, including retention practices (Clause 4.4.6).
7. Choose a trial facility geometry (stage–storage) and a multi-stage outlet (Clause 4.6.5).
8. Route every storm and duration. Use a time step of no more than **5 minutes**, and no more than Tc/3 of the post-development catchment.
9. Check every release against its cap, and check drawdown (Clause 4.7). Adjust the outlet and storage and repeat.
10. Check the tailwater condition of Clause 4.6.6 and the downstream analysis of Chapter 5.
11. Size the emergency spillway and set freeboard (Clause 4.9).
12. Report the governing storm for storage, for each outlet stage, and for the spillway (Clause 4.17).

4.6.3 Storms to be routed

Every facility shall be routed for the full matrix:

Table 4.1 — Design storms to be routed for detention sizing

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

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

4.6.4 Initial conditions

Each run shall start with:

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

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

4.6.5 Multi-stage outlet design

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

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

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

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

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

4.6.6 Tailwater on the outlet

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

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

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

4.6.7 Illustrative example

Illustrative — not design values. This example shows the procedure and the sizes it produces. The inputs are invented to be plausible for a sector draining to the Badshahpur drain in Gurugram. 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.

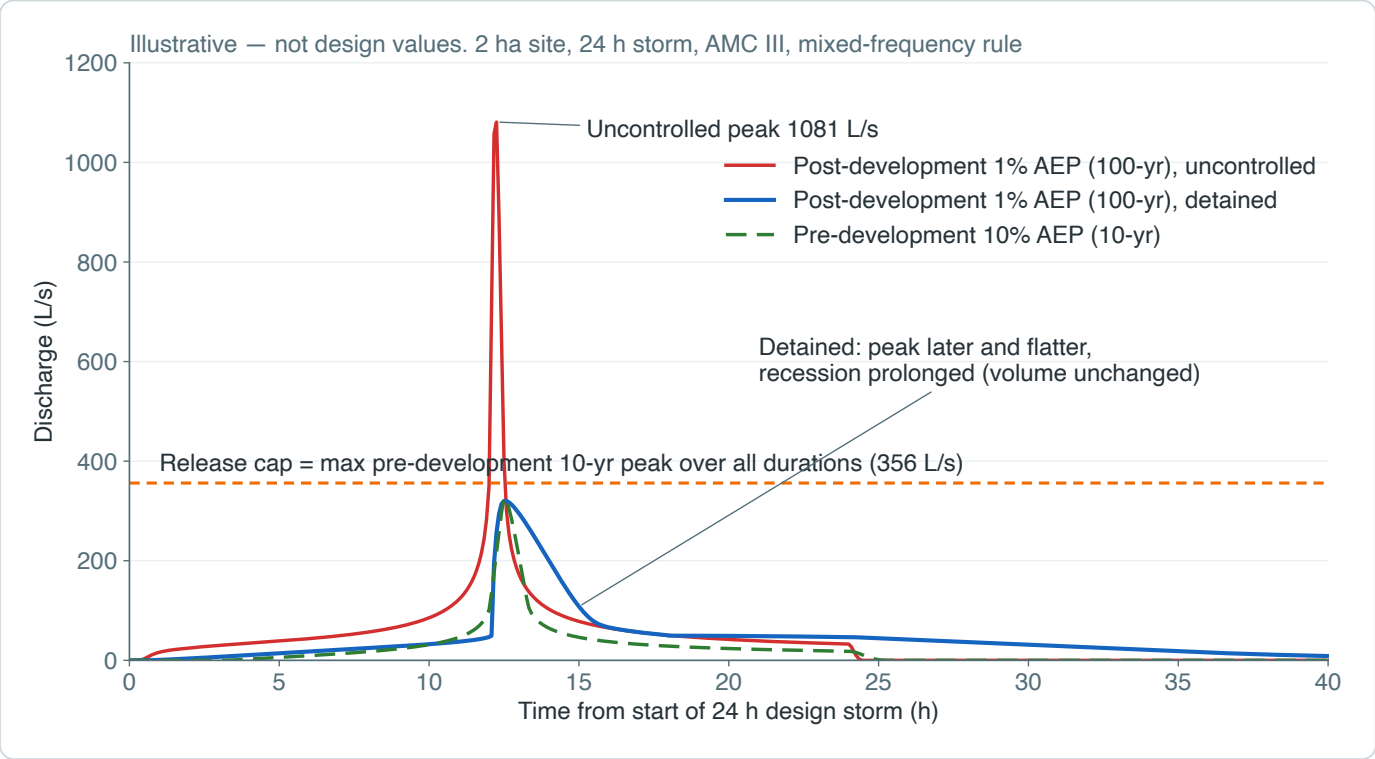


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA 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 Haryana 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 August–September 1995 at Bhiwani (197.4 mm in 24 hours on 28 August and 246.6 mm on 4 September, IMD) followed within days.

4.8 Outlet structures

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

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

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

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

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

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

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

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

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

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

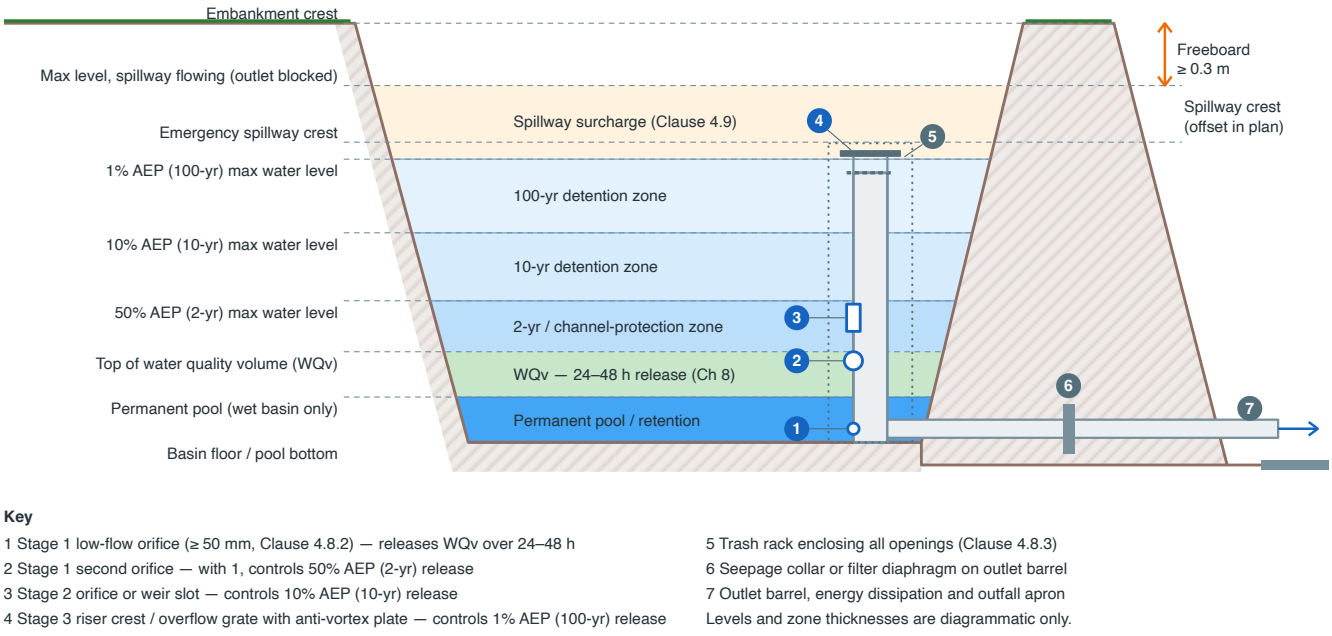


Figure 4.2 — Detention storage stack (permanent pool, WQv, 2-yr, 10-yr and 100-yr zones, spillway surcharge and freeboard) and multi-stage riser outlet. Schematic, not to scale. Original drawing for this Manual, adapted from the multi-stage outlet and storage-zone concepts in MARC/KC APWA Section 5600 (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 Haryana Building Code 2017, under which at least 20% of the recreational open space of a building of 5,000–20,000 m² of built-up area is to be unpaved (Code 12.1) and groundwater recharge is mandatory "for open spaces like parks, parking, plazas, playgrounds and other common areas" (Code 8.1(2)(ii)). It also fits the policy of the Sub-Regional Plan for the Haryana Sub-Region of the NCR, which asks for "retention of rain water where it is received as much as possible, by ponding, retardation dams, grass waterways", and GMDA's finding that the "natural low lying water collection areas" of Gurugram "need to be preserved through appropriate legal mechanisms" (GMDA report in NGT O.A. 325/2015). A detention area graded into the open space below the level of the road keeps it pervious and usable, which is what 4.10.6 requires. Two kinds of land are not open space for this purpose. A johad or talab on the land, with its green belt and catchment where the Haryana Pond and Waste Water Management Authority Act 2018 applies, 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, only as Chapter 7 allows and only with the Authority's permission. And land within the Ghaggar floodplain zone notified under section 45 of the Haryana Canal and Drainage Act 1974, the green belt round the Badkhal and Surajkund lakes (Supreme Court, 1996), a municipal drain on which no structure may be built without permission (Haryana Municipal Corporation Act 1994, section 206), and land in the hydraulic corridor of a drain or water body under Chapter 7 are corridor or flood land already: water reaches them first, so they are not counted as detention for the development beside them (Chapter 7).

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 Code 8.1 and the environmental conditions of Code 12.1 of the Haryana Building Code 2017, the notification of HSVP (then HUDA) of 31 October 2001 for its Urban Estates, any condition of a licence, building plan or occupation certificate, the conditions of the Central Ground Water Authority or the Haryana Water Resources Authority for the area notified in Gurugram district, or any rainwater harvesting rule or direction of an approving authority.

Commentary. RWH in Haryana is required by Code 8.1 of the Haryana Building Code 2017, with two thresholds on different bases. In the areas that the Competent Authority specifies by notification, the owner shall arrange roof rainwater harvesting where "the area of the rooftop is 100 square metres or more" (Code 8.1(1)); and "Recharging of ground water shall be mandatory … for all types of buildings, including Group Housing Societies having a plot area more than 500 square metres", and for parks, parking, plazas, playgrounds and other common areas (Code 8.1(2)). The system shall let only clear water in, with the first shower segregated and filtered; a recharge well shall be "not less than 10 metres away from any structure handling sewage or industrial waste water", though not from leak-proof manholes and sewers; an architect or engineer certifies that the system is functional, and without it "no occupation certificate shall be issued"; and the owner shall keep it in good repair (Code 8.1(3)). The Code names ten towns where it is to be "strictly implemented": Panchkula, Kurukshetra, Shahabad, Karnal, Panipat, Sonipat, Gohana, Faridabad, Yamunanagar and Gurugram (Code 8.1(4)). Buildings of 5,000–20,000 m² of built-up area shall also keep the natural drain inlets and outlets, leave at least 20% of the recreational open space unpaved, and provide at least one recharge bore for every 5,000 m² of built-up area, with the harvested water stored for reuse and the excess led to the tube well bore after filtration (Code 12.1). The predecessor rule is the notification of

HSVP (then HUDA) of 31 October 2001, which made roof harvesting mandatory in its Urban Estates where the roof is 100 m² or more, and by December 2023 HSVP counted 460 systems in its open spaces and 1,92,700 in private plotted buildings (I&WRD report in NGT O.A. 694/2023); since 2024 HSVP asks its allottees for an undertaking that the recharge well on their plot works (HSVP Chief Engineer's memo of 2024). The whole of Gurugram district was declared a "notified area" by the Central Ground Water Authority (public notice of 13 August 2011, from a search summary; the sources differ on its number [TBC]), and since 2020 the Haryana Water Resources Authority issues the groundwater permissions, with power to direct rainwater harvesting and recharge "as per geohydrological conditions" (HWRA Act 2020, section 21). A direction of the Chief Minister of 30 June 2026 to extend RWH to residential plots of more than 250 square yards is reported, but no notification was found [TBC]. None of these rules sets a storage volume, a design storm, an infiltration test or a depth to the water table, so the functionality certificate of Code 8.1(3) has no stated standard; the tests of Clauses 4.4.3 and 4.11.4 can supply one. This Manual credits these structures against its own retention requirement (Clause 4.4) as follows:

- An RWH storage tank or sump, including the reuse tank of Code 12.1, 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). 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. Where recharge earns no credit (below), reuse is the practical way to earn retention.
- Recharge pits, trenches, shafts, wells and bores, including the recharge wells of Code 8.1 and the recharge bores of Code 12.1, count as retention only where they meet Clause 4.11.4: they are credited only to the extent that they drain within 72 hours at half the rate measured in a site test (Clauses 4.4.3 and 4.4.5), with their base at least 1.0 m above the seasonal high water table, and the credit is found by routing under Clause 4.4.6, not by deducting their volume.
- **Recharge depends on the depth to water.** Haryana has both extremes. The State draws more groundwater than is recharged, at a stage of extraction of 135.96% in 2024, with 88 of its 143 assessment blocks over-exploited (CGWB, *Dynamic Ground Water Resources of India* 2024); in June 2023 the water table was deeper than 30 m under 97.2% of Kurukshetra district, 85.3% of Mahendragarh and 51.1% of Gurugram. Yet it was within 3 m of the surface under 49.9% of Rohtak district and 42.6% of Jhajjar, where every block is "safe" because the water is near the surface and much of the land is waterlogged and saline-sodic (HWRA Atlas 2025; shares by NEER's reading of its tables). The credit for recharge therefore follows the seasonal high (post-monsoon, October–November) water table at the site, from Clause 3.10.2 or Clause 4.12.1:
    - (a) **deeper than 10 m below ground: recharge first.** Retention shall be provided by recharge before reuse or detention wherever site tests allow, as in Gurugram, Faridabad, Kurukshetra, Kaithal, Karnal, Panipat, Mahendragarh and Rewari, and every pit, shaft, bore or well shall have pre-treatment ahead of it: a silt trap, a filter and a first-flush diverter, as Code 8.1(3) already requires;
    - (b) **within 3 m of the ground: no recharge credit.** In sub-area HR-D, on most of the floodplains of the Yamuna and the Ghaggar, within the Ghaggar floodplain zone notified under section 45 and on the land of a pond under the Haryana Pond and Waste Water Management Authority Act 2018, no recharge or infiltration practice earns retention credit, whatever a test shows; detention, conveyance and reuse govern there, and a recharge structure that the Code requires is built as the Code requires but is not counted. This follows the State's own water law, which directs that activities likely to lead to waterlogging be discouraged and prevented (HWRA Act 2020, section 21(7));
    - (c) **3–10 m below ground:** recharge earns credit only after a check by a hydrogeologist shows that the practice will not raise the water table to within 3 m of the surface at the site or its neighbours, and that the groundwater below is not saline, as it is over much of Sirsa, Fatehabad, Hisar, Jind, Jhajjar, Bhiwani, Nuh, Mahendragarh, Rewari and Faridabad districts (CGWB, *Ground Water Year Book Haryana 2021-22*); and
    - (d) **everywhere,** road and parking runoff shall be recharged only through a surface infiltration practice with a filter, such as a vegetated basin or trench, never directly into a bore or well, and runoff from a drain that carries sewage, such as the Gurugram Legs or the Budhiya nala, shall not be recharged at

all. In the area notified by the Central Ground Water Authority in Gurugram district, the conditions of the CGWA and of the Haryana Water Resources Authority apply in addition.

- On the Aravalli rock of Gurugram, Faridabad and Nuh, a recharge bore or shaft earns credit only on a borehole test at its own depth, in a fractured zone that the test proves.
- The unpaved area of Code 12.1 and the pervious open space of a layout are pervious area. They enter the post-development run as pervious land under Clause 3.9.2 and get no further credit as retention or detention unless they are built and tested as an infiltration practice.

In the Rohtak–Jhajjar–Sonipat belt and on the floodplains, a recharge pit drains slowly or not at all in the SW monsoon, and a sump is full after the first heavy rain. Treating RWH as detention would therefore credit storage that does not exist when it is needed. That is why this Manual assumes RWH 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. The depth-to-water rule, its 10 m and 3 m thresholds, the hydrogeologist's check in between, the borehole test on rock and the pre-treatment and road-runoff rules are set by this Manual; no Haryana rule on where recharge may or may not be credited was found.

4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the Rohtak–Jhajjar–Sonipat waterlogged belt (sub-area HR-D of Annex 2A) and the waterlogged parts of Hisar, Jind and Ambala districts, the floodplains (khadar) of the Yamuna and the Ghaggar and of their tributaries, including the Ghaggar floodplain zone notified in Panchkula, and the beds and green belts of johads and talabs, 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 Haryana Water Resources Authority record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, drain or johad.

For the flotation check of 4.12.3 at sites in the Rohtak–Jhajjar–Sonipat waterlogged belt and the Yamuna and Ghaggar floodplains, 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. Haryana is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3, do not apply in the State. The exposure provisions of 4.12.5 apply where groundwater at a site is saline or brackish, which over much of the State it is: the conductivity of groundwater ranged from 99 µS/cm at Kami in Sonipat district to 24,060 µS/cm at Nagina in Nuh district, 21.89% of samples exceeded 3,000 µS/cm, and the groundwater of the southern, western and central districts, Sirsa, Fatehabad, Hisar, Jind, Jhajjar, Bhiwani, Nuh, Mahendragarh, Rewari and Faridabad, is "mostly saline" (CGWB, *Ground Water Year Book Haryana 2021-22*). The State's groundwater runs to both extremes. Depths ranged from 0.85 m to 53.45 m below ground in June 2021 and from 0.63 m to 76.50 m in October–November 2021 (same source); in June 2023 the water table was within 3 m of the surface over 49.9% of Rohtak district and 42.6% of Jhajjar district, and deeper than 30 m over 97.2% of Kurukshetra district and 51.1% of Gurugram district (HWRA Atlas 2025; shares by NEER's reading of its tables). Where it is deep, infiltration is the best retention and should be used, subject to the depth-to-water rule of the Commentary to Clause 4.11, the 1.0 m separation of Clause 4.4.3 and Chapter 8. The Rohtak–Jhajjar–Sonipat belt and the floodplains are the opposite case. There the water table is within a few metres of the surface before the monsoon and rises through it, so an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when the Yamuna or the Ghaggar is high and the river raises the water table of the floodplain beside it. The design groundwater level of 4.12.1(b) therefore takes the design flood level of the adjacent river, drain or johad where that is higher than the well record, and in the Rohtak–Jhajjar–Sonipat belt and on the floodplains the flotation check takes ground level unless piezometers show otherwise. 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: the area of the State with the water table within 3 m grew from about 2.93 lakh ha in June 2023 to about 3.79 lakh ha in October 2023 (by NEER's reading of the HWRA Atlas), so a reading taken in June understates the design level. No monsoon water-table depths for individual town sites in Gurugram, Faridabad, Rohtak or Jhajjar were obtained [TBC]. The factor of 1.2, the 0.5 m allowance and the "ground level" default for the waterlogged belt and the floodplains have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Haryana 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 johad 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.

Haryana has a pond Act but no working tank cascade. Its regional storage is of three kinds: the johads and talabs regulated by the Haryana Pond and Waste Water Management Authority, the old flood-detention bunds of the Aravalli foot at Gurugram, and the drains and regulators of I&WRD. The Haryana Pond and Waste Water Management Authority Act 2018 (Act 33 of 2018) defines a pond as a tank, lake or other inland water body of 0.5 acre or more, "whether it contains water or not", recorded in the revenue records "as talab, johar, tank or by any other name", including its green belt, peripheral catchment, feeder inlets, bunds, weirs and sluices, but not a notified wetland, a pond in a notified forest or a pond on private land (sections 1(3) and 2(k)); no structure may be built on pond land, its green belt or its catchment, and no inflow or outflow obstructed, without the Authority's permission (section 14), and no spatial or development plan of an area that includes a pond may be approved without the Authority's prior approval (section 17). No protected area under section 16 was found to have been notified [TBC]. Three points follow:

- A pond on a list may not exist, or may be private. The Authority's Pond Data Management System holds 19,665 ponds (HPWWMA written statement in NGT O.A. 573/2023, 21 February 2024); in Gurugram, GMDA's committee checked 826 features in 242 villages and inventoried 644 water bodies of about 1,142 acres, of which about 35% by number are privately owned, and only 123 appear in all of the revenue record of 1956, the Survey of India sheets of 1976 and the imagery of 2011-12 (GMDA report in NGT O.A. 325/2015). A johad is credited only after a survey shows its bed, bund and outlet, only for the storage above its full level, and only with the Authority's permission where the Act applies.
- The old bunds were regional detention, and most no longer work. The Ghata bundh, about 1.25 km long and 5 m high, closes a gap of about 1.5 km in the Quaderpur–Mehrauli ridge where the Li, Kausat and Dhulaint nalas converge, and once held a pondage of about 60 ha below 240 m and 100 ha up to 245 m from a catchment of about 12,575 ha, of which about 3,500 ha is in Haryana (GMDA report in NGT O.A. 325/2015);

the Chakarpur, Jharsa, Wazirabad and Ghata bunds of the late nineteenth century were described to Parliament in 2025 as made obsolete by urbanisation (as reported). Restoring such pondage is the kind of regional storage that Clause 4.13 can credit, once it is identified in a basin master plan (Chapter 11), surveyed, and given an operating rule under Chapter 7.

- A drain of I&WRD, or a floodplain, is not regional storage. Outfall Drain No. 8 has already carried more than its capacity (5,000 cusecs against 4,000 at the Dhansa regulator in 2022; I&WRD report in NGT O.A. 627/2022), the Gurugram Legs and Outfall Drain No. 8 end in the Najafgarh drain in Delhi, whose level the State does not control, and the Ghaggar floodplain zone notified under section 45 of the Haryana Canal and Drainage Act 1974 is the river's own flood land. Storm water spilled to any of them uses capacity that the drain or river needs for its whole basin; it can be relied on only with the written agreement of I&WRD, for a stated flow and level, and for the Najafgarh drain in coordination with the Irrigation and Flood Control Department of Delhi (Chapter 5).

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

4.14 Simplified methods for small sites

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

4.14.2 **Method.**

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
HR-Z1 Shivalik foothills: HR-A Shivalik foothills and choes	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HR-Z2 Northern, NCR and central plains: HR-B Upper Yamuna–Ghaggar plains	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HR-Z2 Northern, NCR and central plains: HR-C NCR south (Aravalli–Sahibi)	B / 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
HR-Z2 Northern, NCR and central plains: HR-D Rohtak–Jhajjar–Sonipat waterlogged belt	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HR-Z3 Dry south-west: HR-E Central and south-west dry plains and dunes	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HR-Z3 Dry south-west: HR-F Ahirwal Aravalli south	A / B / 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):

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

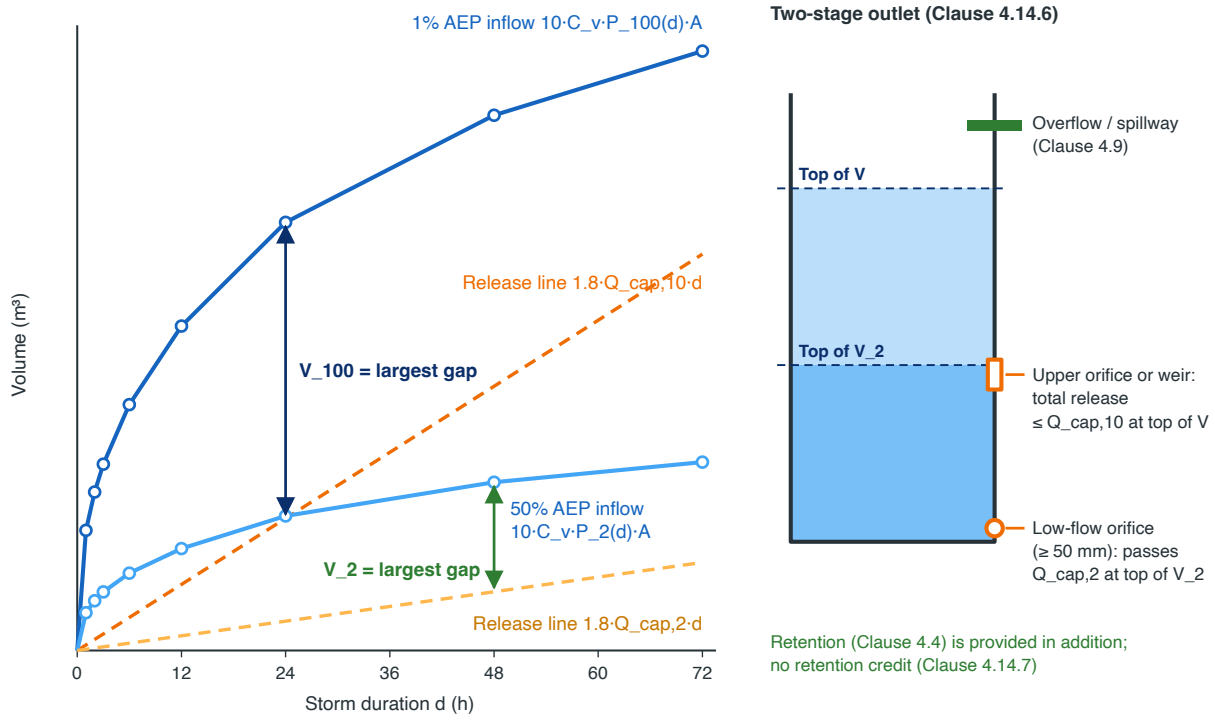
$V_2 = \max_d [\, 10 \times C_v \times P_2(d) \times A - 1.8 \times Q_{cap,2} \times d \,]$

where $P_{100}(d)$ and $P_2(d)$ are the 1% and 50% AEP rainfall depths (mm) for duration d (hours), with the climate factor; and C_v is the post-development volumetric coefficient: the composite C of Table 3.2 (upper half of each range), multiplied by Cf of Table 3.3 for the 1% AEP. For durations of 12 hours or more, C for every pervious surface shall be taken as not less than **0.50**. The factor 1.8 assumes an average release of half the cap over the storm (3.6 × 0.5).

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

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

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



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

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

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

$V = \max(V_{100}, V_2)$; $V_T = \max$ over d of $[\ 10 \times C_v \times P_T(d) \times A - 1.8 \times Q_{cap} \times d\ ]$ (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 Gurugram plain, rounded down. They are therefore **provisional**. The State Stormwater Technical Committee shall confirm or revise them against NIH-DHAARA values for each zone when it issues Annex 4B.

The route is deliberately **stricter** than the full method, so that simplicity costs the developer storage rather than costing the people downstream. The 100-yr release is held to about the greenfield 10-yr peak everywhere, which is the flood-sensitive rule of Clause 4.5.3; the storage assumes the outlet releases only half the cap on average; pervious ground is assumed wet in long storms; and no retention credit is taken. A designer who wants a smaller tank can use the full method of Clause 4.6. The storage formula is the rainfall-mass (inflow minus outflow)

method. Clause 3.4.2 otherwise forbids rainfall-based peak methods for storage, because they ignore the shape of the hydrograph; this route is a stated exception because its conservative assumptions cover that error for small sites, and the 24- to 72-hour durations are always checked.

4.15 Safety, fencing and multi-use

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

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

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

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

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

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

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

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

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

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

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

4.16 Basis: why peak matching alone fails

Commentary. This section has no requirements. It records why this chapter requires release **below** pre-development rates, retention, long-duration checks and a downstream analysis, rather than simple peak matching.

1. **Timing.** Detention lowers a site's peak but stretches its hydrograph (Figure 4.1). Downstream, the stretched releases from many sites overlap with each other and with the main-stem peak. In Denver's study, ten basins each releasing 100% of the historic 100-yr peak produced 106% of the historic peak at the outlet. Only releasing 90% at each site brought it to 97% (UDFCD memo, 2012). A Colorado State University thesis found that location-blind on-site detention "can actually increase peak flows above post-development peaks". An optimisation study found that a downstream pond performed worse than upstream ponds because its outflow synchronised with the main stem (Water 2016, 8(7):290).
2. **Volume.** Detention does not remove volume. In the illustrative example, the post-development 100-yr storm produces about three times the runoff volume of the pre-development 10-yr storm (Clause 2.11). Only retention, or storage that empties to somewhere other than the receiving drain, reduces volume.
3. **Scale.** Kansas City modelling (McEnroe, 2005) found that uniform 3 cfs/ac control reduced Q100 by 36% in a 200-ac watershed. With the same control everywhere, Q100 still rose by 40% at 14 sq mi, and the benefit faded beyond about 1–2 sq mi. The KC committee concluded that "'match existing' can harm streams" (MARC Evolution deck). Georgia makes a ten-percent downstream analysis mandatory for the same reason: "Due to peak flow timing and runoff volume effects, some structural practices fail to reduce discharge peaks to pre-development levels downstream" (GSMM 2016).
4. **Design-storm dependence.** An Australian study of 20 real on-site detention systems found that designs using even ten temporal patterns "cannot reliably produce an OSD system design that will always be effective" under real rainfall (Water Science and Engineering, 2019). This is why Clause 4.6.3 routes the full duration matrix rather than one critical storm.
5. **Closed outfalls.** In Haryana, the governing failure is volume with no outlet when the receiving water is high. Gurugram's master drains end in the Najafgarh drain, which is held up by its own flood from the Sahibi and Outfall Drain No. 8 and, at its outfall in Delhi, by the Yamuna; GMDA describes the city's drainage as three master drains "having outfall into Najafgarh Drain" (GMDA status report in NGT O.A. 454/2018), and the capacity actually available at the Khandsa bottleneck of the Badshahpur drain has been reported as about 800 cusecs (as reported). Outfall Drain No. 8 ends at the Dhansa regulator on the Delhi border; its capacity is 4,000 cusecs, but 5,000 cusecs was observed there in 2022 (I&WRD report in NGT O.A. 627/2022), and in the Sahibi flood of 6 August 1977 the water stood at 213.575 m above Dhansa against a bund top of 214 m (Delhi I&FC). The towns of the Yamuna bank outfall through gates that are closed when the river rises: Hathnikund passed about 8.28 lakh cusecs on 18 August 2019 and about 3.59 lakh cusecs in July 2023, and the river has reached 250.07 m at Karnal, 0.57 m above its danger level (CWC; as reported). Releases from Hathnikund take about 35–75 hours to reach Delhi, 237 km downstream (MoJS committee interim report, January 2024), which gives warning of the river but none of a local burst, and the two can come together: Chandigarh recorded 302.2 mm and Ambala 224.1 mm on 9 July 2023, two days before the Hathnikund peak of 11 July (IMD; MoJS committee). On the Ghaggar there is no CWC flood gauge, and the river breached its banks near Ambala and in Kaithal, Fatehabad and Sirsa in July 2023 (as reported). In the Rohtak–Jhajjar–Sonipat belt much of the land drains only by pumping, to drains that could carry only the 1- and 2-day rainfall of 5-year return period when they were studied (*Irrigation and Drainage*, 2006, from a search summary [TBC]). 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 johad system (Clause 4.13); and

- check downstream and at the outfall (Chapter 5).

Kansas City's own history shows the price. On a test site, peak matching needed 3.0 ac-ft of storage and the 2011 comprehensive criteria needed 4.9 ac-ft (MARC Evolution deck). Over-detention costs more storage. That is the cost of protecting the catchment rather than only the site boundary.

4.17 Submittal requirements

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

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

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

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Annexes and forms

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

CHAPTER 5

Downstream and Tailwater Analysis

5.1 Purpose and scope

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

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

5.1.2 This chapter applies to:

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

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

5.1.4 **No tidal outfalls in Haryana.** Haryana is landlocked: it has no coast, no tide and no Coastal Regulation Zone. No outfall in the State discharges to the sea, a tidal creek or an estuary, so the provisions of this chapter that depend on tide, storm surge, sea-level rise or a river mouth do not apply in Haryana: Clause 5.7 and Annex 5A, cases J1 to J3 of Table 5.2, the tidal lock windows of Clause 5.10.3, the seawater requirement of Clause 5.11.3(a) (gates and seats shall still be of corrosion-resistant materials), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Haryana the receiving water is one of three kinds: a drain of I&WRD, such as Outfall Drain No. 8, or a master drain of GMDA, FMDA or a Municipal Corporation that leads to one, many of which end in the Najafgarh drain, which runs on into Delhi; a river, the Yamuna, the Ghaggar and its tributaries and choes, or the Sahibi, reached directly, through a gate in an embankment or bund, or through a pumping station, whose level is often set by the releases of the Hathnikund barrage or of the dams and weirs upstream; or a johad, a bund or a depression, which may have no outlet at all, as in parts of the dry south-west, or may be emptied only by pumping, as in the Rohtak–Jhajjar–Sonipat waterlogged belt, and:

- (a) its tailwater is set by Clauses 5.6 and 5.8, including Clause 5.8.5;
- (b) where Clauses 5.10 to 5.12, Form 5-1 or Chapter 6 refer to the J1 tailwater or the J1 tidal curve, the minor-system tailwater of Clause 5.6.2 or 5.8.5 applies, as a time series where the receiving level varies; where they refer to the J2 tailwater or to HAT + surge + SLA, the major-system tailwater applies: the design-AEP river level of Clause 5.8.4(b), or the major-system tailwater of Clause 5.8.5, whichever is higher at the outfall;
- (c) the outfall-closed check of Clause 5.10 applies where an outfall is closed by a river, a receiving drain, a johad or a pumped sump, with the river lock of Clause 5.8.5(b), the drain lock of Clause 5.8.5(a) and the closures of Clause 5.8.5(e) and (f) in place of the tidal lock windows; and
- (d) where there is no defined outfall, Clause 5.8.5(d) applies: the outfall is treated as closed for the whole storm and after it (Clause 5.9.4), and the downstream analysis ends at the storage or at the depression that receives it.

Commentary. The drains of Haryana's cities fail in places that site design does not see, and in three different ways. The first is the receiving drain. Gurugram's three master drains, Leg-I, Leg-II and Leg-III (the Badshahpur drain), outfall into the Najafgarh drain (GMDA, 2020); Outfall Drain No. 8, which takes the Sahibi and the drains of the Rohtak–Jhajjar belt, ends at the Dhansa regulator and falls into the Najafgarh drain in Delhi, and it carried a peak of 5,000 cusec at Dhansa in the monsoon of 2022 against a capacity of 4,000 cusec (I&WRD, report to the NGT, 2024). The capacity of Leg-III is reported anywhere from 500 to 3,800 cusec (as reported), and no design return period is stated for any of these drains. The second is the river. The Yamuna at the Hathnikund barrage passed a reported 8.28 lakh cusec on 18 August 2019 (as reported), and its releases take 35 to 75 hours to reach Delhi past the towns of the State (MoJS committee, 2024). The Ghaggar, the Markanda and the Tangri come down from the Shivaliks, and in July 2023 the Ghaggar's bunds breached at Ambala, in Kaithal, in Fatehabad and in Sirsa (Haryana Vidhan Sabha, 2023; as reported); CWC has no flood gauge in the Ghaggar basin, so the only levels are those of the State's gauges, read in the press. The third is the land with nowhere to drain to. In the dry south-west a johad or a low patch of ground may be the end of the drainage, and in the Rohtak–Jhajjar–Sonipat belt the water table stands within 3 m of the surface over about half of Rohtak district and 43% of Jhajjar (HWRA, 2025), so the land drains only by pumping to the I&WRD drains. The outfalls also belong to one body while the drains above them belong to others: the rivers, embankments and drainage works are held by I&WRD, the master drains by GMDA or FMDA, the sector drains by HSVP, the street drains by the Municipal Corporations and the ponds by the Gram Panchayats and local bodies, and no rule divides them (Chapter 6, Clause 6.9). A detention basin that meets every release rate in Chapter 4 still fails if the drain below it is already full, if the river it drains to stands above its outfall for days, or if there is nowhere for the water to go. This chapter makes all three failure modes part of the design. Haryana has no tidal outfall, so Clause 5.1.4 says which of the chapter's coastal provisions fall away and what takes their place.

5.2 Definitions

Term	Meaning in this Manual
Analysis point	A location on the downstream system where pre- and post-project conditions are compared (Clause 5.3.3).
Contributing catchment	The whole area draining to an analysis point, on and off site.
Major drain	A channel listed as a major drain in the basin plan or Annex 5B, or any river, I&WRD canal, Outfall Drain No. 8 and the Najafgarh drain into which it falls at the Dhansa regulator, the Leg-I, Leg-II and Leg-III (Badshahpur) master drains and Leg-IV of Gurugram, the Budhiya (Buria) nala of Faridabad, the Gaunchi drain of Faridabad and Palwal, Drain No. 2 of Panipat, any drain of I&WRD, any drain maintained by GMDA, FMDA, PMDA, HSVP, HSIIDC, a Municipal Corporation, a Municipal Council or a Municipal Committee, or a licensed colonizer, with an internal width of 1.0 m or more, 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.

Term	Meaning in this Manual
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, johad** 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 johad 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, MCG, HSDMA or I&WRD; and
- (e) each building or road segment lying within the 1% AEP flood extent along the route. Representative points may be used where buildings are closely spaced.

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

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

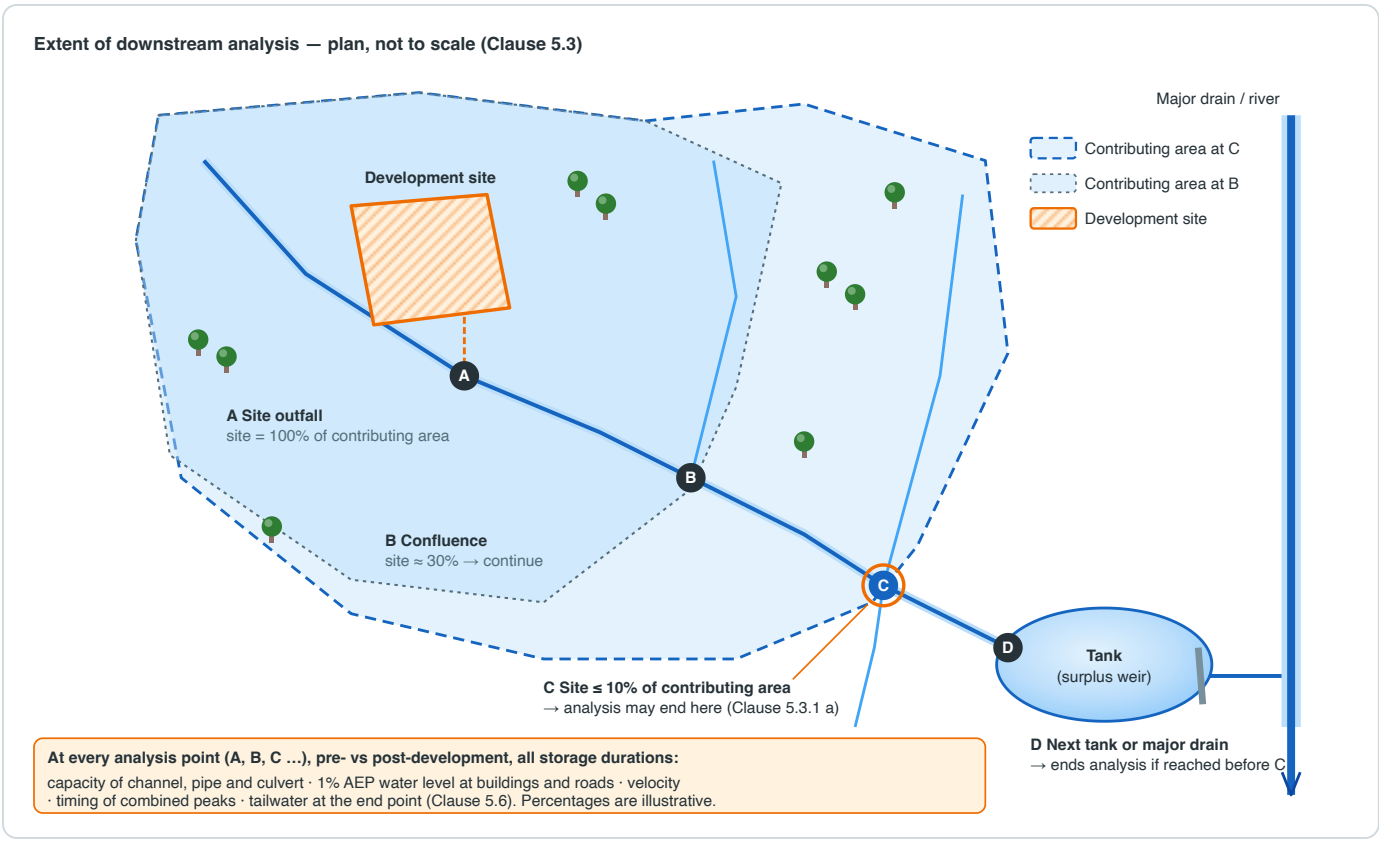

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next johad or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Haryana. In Gurugram, where the city's drains fall about 78 m from the Aravalli ridge to the Najafgarh drain (MoHUA reply in the Lok Sabha, 2025, as reported) through the Leg-I, Leg-II and Leg-III (Badshahpur) master drains, reported as about 12, 16 and 26 km long (as reported), with the Ghata and other bunds across them, and in the Rohtak–Jhajjar belt and the Sahibi basin, where the drains join Outfall Drain No. 8, which runs to the Dhansa regulator at its RD 42.59 km before it falls into the Najafgarh drain in Delhi (I&WRD, 2024), the 10% point can lie many kilometres downstream, across several tanks. A tank with a working surplus weir changes the hydrograph completely, so the analysis is better ended there and the tank level reported. Clause 5.3.2 prevents that end point from hiding a rise in the tank level. The small-site statement (5.3.4) and its 500 m distance have no direct precedent and are set by this Manual.

5.4 What the analysis must check

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

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

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

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

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

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

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

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

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

5.4.4 **Method.** The analysis shall:

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

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

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

> **Commentary.** Clause 5.4.2(d) exists because detention changes when the site's water arrives, not only how much arrives (Clause 4.16). A Colorado State University thesis and a *Water* (2016) optimisation study both found that delayed site releases can coincide with the main-stem peak and raise it. Georgia's manual states the result directly: some structural practices "fail to reduce discharge peaks to pre-development levels downstream" because of "peak flow timing and runoff volume effects" (GSMM 2016). The duration-of-inundation check (5.4.2(e)) matters in the river towns and the waterlogged belt of Haryana: in September 2025 the flow at the Hathnikund barrage stayed above 1 lakh cusec for about 129 hours (SANDRP, from CWC data); in July 2023 six breaches of the Ghaggar bund and the Hansi–Butana canal in Kaithal district were still open on 18 July, six days after the river passed 82,400 cusec there (as reported); and in the Rohtak–Jhajjar belt, where the water table stands within 3 m of the surface over about half of Rohtak district and 43% of Jhajjar (HWRA, 2025), the low ground drains only by pumping to the drains of I&WRD. Detention that prolongs releases can lengthen that time even when it lowers the peak.

5.5 Acceptance criteria

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

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

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

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

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

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

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

> **Commentary.** The 10 mm tolerance (5.5.1(a)) has no direct precedent. It is meant to be at or below the numerical precision of a typical one-dimensional model, so that "no increase" can be tested without arguing over rounding. The 10% velocity tolerance is likewise set by this Manual. The timing exception in 5.5.4 follows the Georgia manual, where the downstream analysis can show "that peak controls are not needed" and allow them to be waived (GSMM 2016, Standard #8). It is limited here to sites low in the catchment, which is where synchronisation with the main-stem peak is most likely (*Water* 2016, 8(7):290). It is not available above that, because the evidence on scale (Clause 4.16) shows that early release from many upstream sites raises peaks.

5.6 Tailwater: general and non-tidal outfalls

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

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

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

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

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

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

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

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

Table 5.1 — Design tailwater levels for tidal outfalls

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

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

5.7.2 **Sources and datums.**

- (a) **Tidal levels.** MHWS, HAT and MSL shall be taken from the current edition of the Indian tide tables published by the National Hydrographic Office (NHO) or by the Survey of India, for the nearest standard or secondary port, or from the port authority's published tidal levels. The edition and port shall be stated.
- (b) **Datum conversion.** Tide-table heights are referred to chart datum. They shall be converted to the project datum through a documented connection between chart datum, the tide gauge zero and a Survey of India benchmark. The offset and its source shall be stated on Form 5-1.
- (c) **Estuaries, creeks and canals.** For outfalls inside estuaries, creeks, backwaters or tidal canals (for example the estuaries of the coastal States; there is none in Haryana, Clause 5.1.4), tidal levels may differ from the open coast. Open-coast levels shall be used unless measured levels over at least one spring–neap cycle, or a calibrated hydrodynamic model, justify a different value. No reduction below open-coast levels shall be taken without such evidence.
- (d) **Interim.** Until Annex 5A is published, the designer shall obtain the values directly from the sources in (a) and record them.

5.7.3 **Storm surge.**

- (a) **Major-system and storage design.** The surge term in "HAT + surge" is the **10% AEP (10-yr) storm surge** for the coastal segment, given in Annex 5A. The 1% AEP surge is used only in the joint case of Clause 2.12(b), with the 10-yr 48-hour storm. That keeps the two cases symmetric, so that a rare rainfall is never paired with a rare surge.
- (b) **Joint case.** The 1% AEP still-water level for Clause 2.12(b) is taken from Annex 5A.
- (c) Until Annex 5A is published, both values shall be taken from a site-specific study using INCOIS, IMD or NCCR surge hindcasts or return-level analyses. The study shall state its source, method and record length.

- (d) Wave set-up shall be added where the outfall faces the open sea without a protected entrance.

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

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

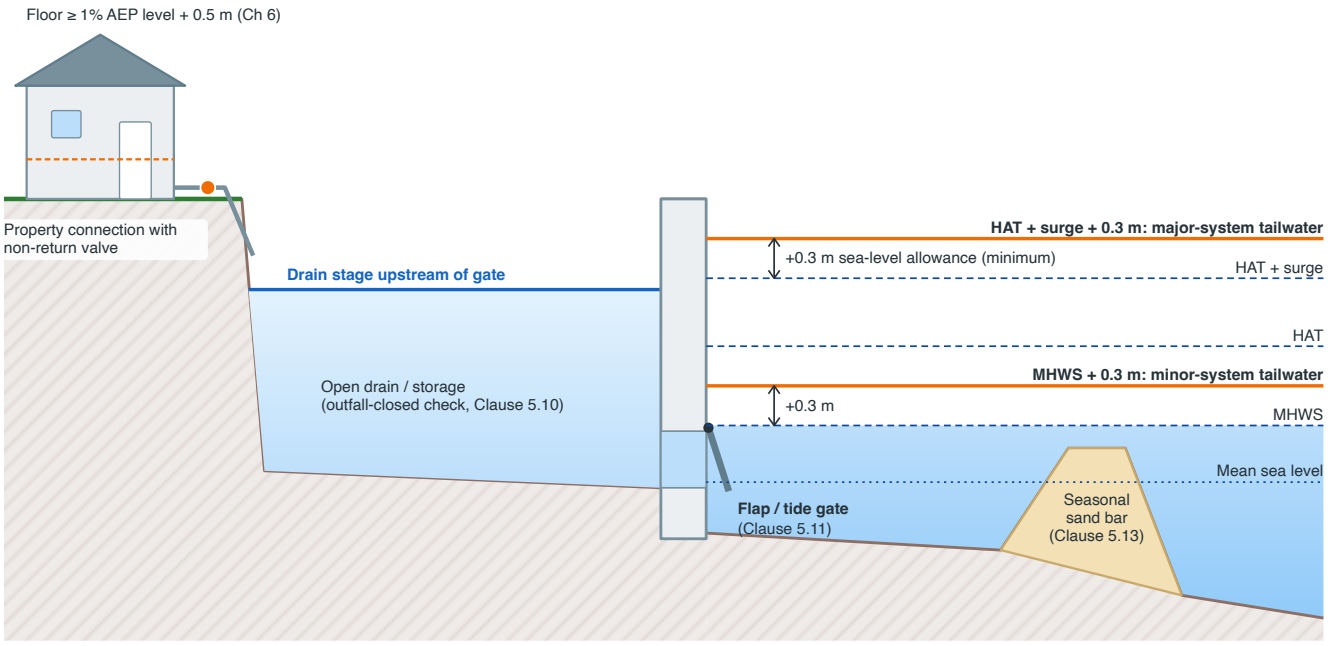

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater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

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

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

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

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

5.8 Riverine backwater

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

- the **Yamuna** from the **Hathnikund** barrage past **Yamunanagar**, **Karnal**, **Panipat** and **Sonipat** to the boundary with Delhi, and below Delhi along **Faridabad** and **Palwal**, with the releases of Hathnikund, and the drains that lead to it, among them the **Budhiya** (Buria) nala of Faridabad, the **Gaunchi** drain of Faridabad and Palwal and **Drain No. 2** of Panipat (Clauses 5.8.3 and 5.8.5(b) and (c));
- the **Somb** and the **Maskara** in Yamunanagar district (Clause 5.8.5(b));
- the **Ghaggar** at **Panchkula**, including the floodplain zone notified there under section 45 of the Haryana Canal and Drainage Act 1974, with the **Kaushalya** dam above it, and on through **Ambala**, **Kaithal**, **Fatehabad** and **Sirsa** to the **Ottu** weir, with its tributaries and choes, the **Tangri** at **Ambala** and the **Markanda** at **Shahabad**, for which no CWC gauge level exists (Clauses 5.8.3 and 5.8.5(b));
- the **Sahibi** at the **Masani** barrage in **Rewari** and at **Dadri** in **Jhajjar** district (Clauses 5.8.3 and 5.8.5(b));
- **Outfall Drain No. 8** to the **Dhansa** regulator and the **Najafgarh drain** beyond it, the **Leg-I**, **Leg-II** and **Leg-III** (**Badshahpur**) master drains of **Gurugram**, which outfall to the Najafgarh drain, and **Leg-IV**, and the other drains of I&WRD (Clause 5.8.5(a));
- the pumped drains of **Rohtak**, **Jhajjar**, **Bahadurgarh** and the other towns of the **Rohtak–Jhajjar–Sonipat** waterlogged belt, and the **johads**, bunds and lakes that receive storm water, among them the **Ghata** bundh in Gurugram, **Damdama** lake near Sohna, **Badkhal** and **Surajkund** at Faridabad, and the **Najafgarh jheel** (Clause 5.8.5(e) and (f));
- the **Western Yamuna Canal** and its branches, the **Agra canal**, and any other irrigation canal or channel of I&WRD that receives storm water (Clause 5.8.5(g)); and
- elsewhere: any river or I&WRD channel listed in Annex 5B.

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

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

5.8.3 **Reservoir and tank releases.** Where a reservoir or tank upstream can release to the river (for example the Hathnikund barrage on the Yamuna, whose releases take about 35–75 hours to pass the State's towns on their way to Delhi, the Kaushalya dam at Pinjore on a tributary of the Ghaggar, the Ottu weir on the Ghaggar in Sirsa, and the ungated Masani barrage on the Sahibi), 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 **I&WRD drains and the Najafgarh drain, river-locked outfalls, the Yamuna below the Hathnikund barrage, catchments with no outfall, pumped outfalls in the waterlogged belt, johads, bunds and lakes, and discharges to I&WRD channels and canals.**

- (a) **I&WRD drains and the Najafgarh drain.** For an outfall to a drain of I&WRD, such as Outfall Drain No. 8, to a master drain of GMDA, FMDA, PMDA or a Municipal Corporation that leads to one, such as Legs I to IV and the Badshahpur drain of Gurugram or the Budhiya (Buria) nala of Faridabad, or to a drain that ends in any of them:
  - **Consent.** Storm water shall not be discharged to a drain of I&WRD without the written consent of I&WRD, or to another body's drain without the written consent of that body; the procedure for I&WRD's consent was not found during research [TBC]. The discharge shall not exceed the rate the consent allows.
  - **Design water level.** The tailwater is the higher of the drain's design water level as I&WRD or the owner states it in writing and its level in the coincident case of Clause 5.8.4, computed from all the storm water it receives, including the drains of other bodies, with its downstream boundary at the level of the drain, river or regulator it ends in. Until a design water level is published for a drain, the computed level governs [TBC].
  - **Present condition and capacity.** The drain shall be taken in its present condition, net of silt, encroachment, solid waste and obstruction by crossing services and culverts, and with its narrowest section as surveyed, such as the reaches of the Badshahpur drain at Khandsa and Hero Honda Chowk. Where the owner's records give different capacities for the same reach, the lowest applies until the owner confirms the capacity in writing (set by this Manual): the capacity of Leg-III is reported as 3,702 cusec (DTCP drawing, 2012) and 3,800 cusec (GMDA, as reported), but as 800 cusec at the bottleneck at Khandsa (GMDA, 2021, as reported) and 500 cusec near Hero Honda Chowk (as reported) [TBC]. A widening, lining, remodelling or new drain that has been proposed but not completed, including Leg-IV until it is commissioned and the works of a drainage master plan that are not yet built, shall not be counted.
  - **Drain lock.** Where the drain is at or above its design water level, or at bank-full, in the coincident case, the outfall-closed check of Clause 5.10 applies with a single lock for as long as the drain stays above the outfall invert, taken from the drain model and not less than **72 hours**, covering the whole of the 48- and 72-hour storms of Clause 5.10.2 (set by this Manual). A drain shall not be taken to run below its design water level because its stated capacity has not been reached: Outfall Drain No. 8 carried 5,000 cusec at the Dhansa regulator in 2022 against a capacity of 4,000 cusec (I&WRD, 2024).
  - **The Najafgarh drain.** For a drain that ends in the Najafgarh drain, directly or through Outfall Drain No. 8 and the Dhansa regulator, the downstream boundary shall be the level of the Najafgarh drain at the junction in the coincident case, computed with the inflow of Outfall Drain No. 8 at the largest recorded flow (5,000 cusec, 2022) or from a hydrograph method for its catchment (Chapter 3), whichever is greater, the Dhansa regulator and any regulator below it as operated in the largest recorded event, and no storage credited in the Najafgarh jheel or any other depression along the drain unless the operator's records show it available at the start of a storm. The level shall be not less than **213.58 m**, the highest level recorded at the Dhansa gauge (6 August 1977, CWC site list, as copied by SANDRP; 213.575 m upstream of the Dhansa bund in the records of Delhi's Irrigation and Flood Control Department), transferred to the junction under item (b); at a junction upstream of Dhansa, no outfall shall be designed without a profile (set by this Manual) [TBC]. The Najafgarh drain runs from Dhansa into Delhi, where it is held by the Irrigation and Flood Control Department of the Government of NCT of Delhi (I&FC), and the operator of the Dhansa regulator was not confirmed during research [TBC]. The level at an outfall to it therefore cannot be set by a Haryana body alone: the designer shall obtain it through I&WRD, which shall coordinate it with I&FC, and shall state on Form 5-1 the level used, its source and whether I&FC has confirmed it; until a level is agreed, the computed level of this item, not less than 213.58 m transferred, governs (set by this Manual).
  - **Water quality.** A drain that reaches the Najafgarh drain is also subject to the condition that the water in it shall not exceed a BOD of 30 mg/l (GMDA, 2020, citing the NGT and CPCB), which is the subject of Clause 8.9, not of this clause.

    - **Flap gate.** The outfall shall have a flap gate (Clause 5.11) where the design water level or the computed level is above the outfall invert.
- (b) **River-locked outfalls.** For an outfall to a river directly, through a gate or sluice in an embankment or bund, or through a pumping station, or into a drain that itself discharges in one of those ways, the designer shall identify the body that operates each gate, sluice and pumping station, and obtain the sill of each gate, the crest of the embankment or bund, the installed pumping capacity and the operating levels, including the river level at which each gate is closed. Every level shall state its datum and its connection to the gauge datum of the nearest CWC or I&WRD gauge.
    - **Design river level.** The river level of Clause 5.8.2 at the outfall shall be, for the major-system cases (Clause 5.8.4(b)), the **1% AEP river level at the outfall**: the 100-year level of a flood-frequency study or floodplain delineation that gives a level at the outfall, including the levels I&WRD computed for a floodplain zone notified under section 45 of the Haryana Canal and Drainage Act 1974, or a level from a hydraulic model under Clause 5.8.2(b), with the releases of item (c). In the Ghaggar floodplain zone notified in Panchkula on 27 October 2023, the model shall carry not less than the 100-year flood of **2,933.45 m³/s** (103,594 cusec) on which I&WRD based the zone (I&WRD replies to the NGT in OA 421/2022); the levels computed for the zone were not found during research [TBC]. The level shall in no case be less than the **highest recorded level** at the nearest CWC or I&WRD gauge on the same river, transferred to the outfall. The highest levels found during research (Table 5B.1), from a 2022 copy of the CWC site list and the MoJS committee report of 2024, none read in a CWC site sheet [TBC], are: the Yamuna at Kalanaur **268.66 m** (9 September 2010; a gauge on the Uttar Pradesh bank opposite Yamunanagar), at Karnal **250.07 m** (17 June 2013; 250.01 m on 19 September 2010 in a CWC document of 2018), at Mawi **232.75 m** (18 June 2013; on the Uttar Pradesh bank opposite Panipat), at Palla **212.8 m** (8 September 1995; 213.275 m, of 1988, on the gauge's notice board), at Manjhawali **193.96 m** (21 August 2019), at Mohna **193.13 m** (6 September 1978; now listed by CWC as 192.43 m, 9 September 1995) and at Palwal (Rahimpur) **182.25 m** (22 August 2019, since removed from the list); the Somb at Fatehgarh **276.35 m** and the Maskara at Ghodopipli **271.25 m** (both 18 August 2019); and the Sahibi at Masani **242.58 m** (2 September 1978) and at Dadri **214.98 m** (26 August 2008). Where two values are reported for the same gauge, or a level has been removed from the list, the higher, or the removed level, applies until CWC confirms the level (set by this Manual). Where a later flood has exceeded the listed level, the later level governs. The recorded level shall be transferred along the river with the water-surface slope of the flood that set it, from the CWC and I&WRD gauge records, or from the model. Until either is available, the recorded level of the nearest gauge upstream applies unchanged at the outfall, except that where the outfall lies between two gauges on the same river, with no tributary joining between them, the level may be interpolated linearly by river distance between the highest recorded levels of the two gauges (set by this Manual).
    - **Rivers with no CWC gauge. CWC has no flood gauge in the Ghaggar basin** (SANDRP, 2018), so no CWC level exists for the Ghaggar, its choes, the Kaushalya, the Tangri or the Markanda; the gauges at Chandimandir, Guhla, Chandpur, Ottu and the other sites belong to I&WRD or to Punjab, and their levels appear only in the press, in feet on a gauge whose zero was not found, such as a danger mark of 748 ft at Khanauri on the Punjab border, crossed by about 6 ft on 15 July 2023 (as reported). On such a reach, and for an outfall upstream of every gauge on its reach, the river level shall be the higher of the level from a model under Clause 5.8.2(b) and the highest flood level surveyed at the outfall from flood marks, including those of July 2023, and from the records of I&WRD, the local body or the Deputy Commissioner, with its source stated. Where a level is known only as a gauge reading, the designer shall tie the gauge zero to the project datum and a Survey of India benchmark by levelling, with I&WRD's confirmation of the reading. No outfall shall be designed on such a reach without one of these levels (set by this Manual).
    - **10% AEP level.** For the cases with the river at its 10% AEP level (Clause 5.8.4(a)), the level shall be taken from the same model or a frequency analysis of the gauge record, and not less than the **danger level** at the nearest gauge, transferred in the same way: **249.5 m** at Karnal, **230.85 m** at Mawi and **212.44 m** at Dhansa (CWC site list, as copied by SANDRP). Where no danger level has been found, as at the other gauges listed above and on the Ghaggar system, the 10% AEP case shall use the design river level of this item until a frequency analysis is accepted (all set by this Manual). The datum of every level is to be confirmed for each gauge [TBC].

    - **Tailwater.** The tailwater at the outfall shall be the higher of that river level beyond the gate or embankment, and the maximum level in the drain behind it, computed by routing the drain as a closed storage for as long as the river stands above the level behind it, with the inflow of the whole catchment that drains to it, its storage as surveyed in its present condition, net of silt, sand, 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 of the permanent pumps less the largest pump (set by this Manual), with gravity discharge through the gate only while the river is lower than the level behind it. Pumps shall deliver against the design river level of this item, and every pump, panel and control shall remain operable with the river at that level (Clause 5.12.5).
    - **River lock.** Portable dewatering pumps brought in for an event, inventory pumps lent for a flood, and capacity that has been sanctioned or proposed but not commissioned, shall not be counted. The outfall-closed check of Clause 5.10 applies with a single lock that lasts for as long as the river stays above the outfall invert, or above the level at which its gate is closed if that is lower, taken from the river model or from the stage record of the nearest CWC or I&WRD gauge in the flood that set the highest recorded level or in a comparable flood, with the releases of item (c), and not less than: **7 days (168 hours)** on the Yamuna, on the Sahibi and on the Ghaggar below Guhla (Kaithal, Fatehabad and Sirsa); and **72 hours** on the Ghaggar and its choes in Panchkula and Ambala districts, the Tangri, the Markanda, the Somb and the Maskara (set by this Manual). Either lock covers the whole of the 48- and 72-hour storms of Clause 5.10.2, so that storage and pumping handle the full storm volume (Clause 5.9.4) and the drawdown of Clause 5.10.5 is met by pumping until the lock ends. A shorter lock may be used only where the outfall invert is above the 1% AEP river level of this item, or where a gauge analysis under Clause 5.10.6, including the releases of the barrage and dams above, shows it and the Authority approves it.
    - **Gate failure and breach.** Floor levels and pumped outfalls behind a gate, embankment or bund shall also be checked for the failure of the gate and for a breach of the embankment or bund, with the land and drains behind it filled to the river level beyond it.
- (c) **The Yamuna below the Hathnikund barrage, and rivers below dams and weirs.** For an outfall to the Yamuna, or to a river below a dam or weir such as the Ghaggar below the Kaushalya dam and the Ottu weir, or the Sahibi below the Masani barrage:
    - in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) shall be run with the river at the level that results from the largest recorded release of the barrage, dam or weir above, routed to the outfall, with the flow of the catchment below it as it occurred in the same event (set by this Manual), until I&WRD publishes an operating rule that bounds the release [TBC]. For the Yamuna the largest reported release at Hathnikund is about **8.28 lakh cusec** (about 23,400 m³/s) on 18 August 2019 (as reported, from I&WRD records), above the barrage's design flood of 22,000 m³/s (MoJS committee, 2024); it applies until I&WRD gives the record (set by this Manual);
    - a release, or a release rule, alone shall not be taken to bound the river level: the highest level of the Yamuna at Delhi came on 13 July 2023 from a peak at Hathnikund of 3,59,760 cusec (MoJS committee, 2024), less than half the release of 2019, so the level shall also be checked for the largest recorded event at the nearest gauge, with the local inflows and the downstream conditions as they occurred;
    - the river level shall not be reduced on the ground that the flood comes from rain that falls outside the town or outside the State, or that the site storm is small, and the release shall be placed before, during and after the site storm; the travel time of the release from Hathnikund to the outfall, from the committee's travel times by reach, may be used to place it, but not to lower it; and
    - no barrage, dam or weir gate shall be assumed to open earlier or wider than the operator's records show, and the Western and Eastern Yamuna canals shall be taken as closed in a flood, as reported above 1 lakh cusec at Hathnikund, so that no flood water is credited to them.
- (d) **Catchments with no outfall.** Where a site, or the catchment it drains to, has no defined outfall to a river, a drain or a waterbody that carries water away from it, as where the drains of a town or village of the dry south-west (sub-areas HR-E and HR-F of Annex 2A) end in a johad or a depression with no outlet:
    - there is no receiving water and no tailwater. The outfall is treated as closed for the whole storm and after it (Clause 5.9.4): the storage shall hold, below the level of its overflow, the runoff volume of the 1% AEP 72-hour design storm of Clause 2.9.2, with the climate factor of Clause 2.8, from the whole area draining to it,

computed by Clause 3.8 for the post-development condition, and shall be emptied only by infiltration at the verified rate of Clause 4.4.3, by evaporation or by reuse, within 7 days of the end of the 10% AEP 72-hour storm, with no gravity or pumped discharge credited to a drain, nala or road (set by this Manual);
    - where the site drains to a public basin, johad or depression that also receives other land, the downstream analysis of Clauses 5.3 to 5.5 shall end at that basin, johad or depression, and shall report its maximum water level in the 1% AEP 72-hour storm, with the whole area that drains to it at its present land use, with and without the project; Clause 5.5.1 applies at every building, road and plot around it. The basin, johad or depression shall start the storm at the level that the 10% AEP 72-hour storm leaves in it 7 days after that storm ends, or higher where its flood marks or the records of the local body, the Gram Panchayat or the Deputy Commissioner show it, and a johad that receives dry-weather flow shall start full (set by this Manual);
    - the overflow path shall be traced to where it ends, with its depth and velocity on every road and plot it crosses, within the limits of Table 6.3; it shall not end on a neighbour's land or in another catchment, and a pump or a pipe that moves the water onto a road, a neighbour's land or another catchment is not an outfall; and
    - where the depression is a pond under the Haryana Pond and Waste Water Management Authority Act 2018 or a wetland, item (f) also applies.
- (e) **Pumped outfalls in the waterlogged belt.** In the Rohtak–Jhajjar–Sonipat waterlogged belt (sub-area HR-D of Annex 2A), and elsewhere where the seasonal high water table is within 3 m of the ground and a town's drains reach an I&WRD drain only by pumping, as at Rohtak, Jhajjar and Bahadurgarh:
    - the tailwater of a drain or sump that is pumped to an I&WRD drain shall be its routed level under item (b), with the permanent pumps less the largest one and no portable pumps, with the receiving drain at the level of item (a), and with pumping credited only at the rate that I&WRD's consent allows while the receiving drain is at that level; where the consent provides for pumping to stop when the receiving drain is full, no pumping shall be credited for that period (set by this Manual);
    - mobile pumping from one drain into another shall not be counted, and a project's pumped discharge into another drain shall be included in that drain's level (Clause 5.12.3);
    - no infiltration shall be credited in the routing, and the ground and any storage shall be taken as saturated, with the design groundwater level at the seasonal high level after the monsoon (Clause 4.12.1), because the area of the State with the water table within 3 m grew from about 7.2 lakh acres in June 2023 to about 9.4 lakh acres in October 2023 (HWRA, 2025); and
    - low ground, fields and depressions around the town shall not be credited as storage unless their owner and the local body have agreed in writing to receive the water and the depth and duration of ponding on them are reported.
- (f) **Johads, ponds, bunds and lakes.** For an outfall to a johad, talab or other pond, a bund or a lake, directly or through a drain that ends in it, such as the Ghata bundh and the other bunds of Gurugram, Damdama lake, Badkhal and Surajkund lakes, the Najafgarh jheel and the village johads that receive town drains:
    - **Consent.** Storm water shall not be discharged to a pond without the written consent of its owner, the Gram Panchayat or the local body, and, where the pond is a pond under the Haryana Pond and Waste Water Management Authority Act 2018 (a tank, lake or other inland water body of 0.5 acre or more recorded as talab, johar or tank, including its green belt, peripheral catchment, feeder inlets, bunds, weirs and sluices), any permission that the Authority requires under ss.14, 16 and 17 shall be obtained. Where it is a Ramsar site (Sultanpur or Bhindawas) or a wetland under the Wetlands (Conservation and Management) Rules 2017, any permission that the Wetland Authority of Haryana requires shall be obtained; at Badkhal and Surajkund the Supreme Court's lines apply (Chapter 7). An outfall that carries dry-weather flow is dealt with under Clause 8.9.
    - **Design level.** The tailwater for the major-system and storage cases shall be the level at which the johad, pond, bund or lake spills to the next drain or onto land, from its overflow sill or, where it has none, the lowest point of its rim, plus the head over that point needed to pass the 1% AEP inflow with the project's discharge included (Clauses 5.3.2 and 5.12.3); for a gated bund or lake with a published full level and no published maximum level, it is the full level plus the design-flood surcharge, and **full level + 0.5 m** where no surcharge has been computed (set by this Manual) [TBC]. In every case it shall be not less than the highest

level recorded at the waterbody, from its flood marks and the records of its owner (set by this Manual). For the Ghata bundh, whose pondage GMDA reports as about 60 ha below 240 m and about 100 ha up to 245 m above MSL (GMDA, report to the NGT in OA 325/2015), the tailwater shall be not less than **245 m** until a survey gives the level of its spill (set by this Manual) [TBC].

    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall shall be treated as closed for the whole storm (Clause 5.9.4), with storage and pumping handling the full storm volume. Every johad, pond, bund and lake starts every design storm at its spill level, or at its full level (Clause 7.7.3). No storage shall be credited in the Najafgarh jheel, in a dry lake bed such as Badkhal, or in the shrinking water area of Damdama lake (reported to fall from about 80 to about 35 acres within a month of the monsoon), unless its owner's records show the storage available at the start of comparable storms and the Authority accepts it.

- (g) **I&WRD consent, section 45 and court lines; canals.** No outfall structure, gate, pumping station or drain shall be built in the bed, bank or floodplain of a river, or in a drain, embankment or canal of I&WRD, without the consent of I&WRD. Within the limits of a notification under section 45 of the Haryana Canal and Drainage Act 1974, which make the reach a drainage-work in which an obstruction is prohibited and may be removed (ss.45 and 46), an outfall shall not be built without I&WRD's written permission. The State has told the NGT that construction on river floodplains is banned under section 45 (State report in EA 35/2023), but the only notification found is the Ghaggar floodplain zone in Panchkula [TBC]; the designer shall state whether the outfall lies in a notified zone. The designer shall also check the outfall against the lines that courts have set, as they stand at the time of design (Chapter 7): the green belt and the 1 km and 1–5 km zones around Badkhal and Surajkund lakes (Supreme Court, *M.C. Mehta*, order of 11 October 1996). Whether a drain outfall is permitted within each line is to be confirmed with the authority concerned before design [TBC]. Storm water shall not be discharged to the Western Yamuna Canal, its branches and distributaries, the Agra canal or another irrigation or supply canal without the written consent of I&WRD or the canal's owner; a supply canal is not a drainage outfall (set by this Manual). Where consent is given, the tailwater is the higher of the canal's design water level and its level in the coincident case of Clause 5.8.4, the discharge shall not exceed the rate the consent allows, and the outfall shall have a flap gate (Clause 5.11) where that level is above the outfall invert.

No pump, gate, sluice, regulator, barrage or dam operation that helps drainage, such as pumping a drain down before a storm, lowering a johad or lake before a storm, closing a gate late or opening barrage gates early, shall be assumed unless the operator's written records show it. Where the outfall invert is below the tailwater of this clause, the outfall shall have its own flap gate (Clause 5.11) and, where the outfall-closed check requires it, pumping (Clause 5.12), with the pumped volume included in the routing of the drain, the johad or the river (Clause 5.12.3). Pumping shall not be used to move water out of a catchment with no outfall (item (d)).

> **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. Haryana's rivers break that assumption, because the monsoon spells that fill them fall on the Shivaliks and on the towns of the plains together. On 9 July 2023 Chandigarh recorded 302.2 mm and Ambala 224.1 mm in 24 hours (IMD), the Ghaggar, the Markanda and the Tangri rose the same week, and the Yamuna peaked at Hathnikund on 11 July (MoJS committee, 2024). On 18 August 2019, the day of the largest reported release at Hathnikund, the Somb at Fatehgarh and the Maskara at Ghodopipli in Yamunanagar district also set their highest recorded levels (CWC site list, as copied by SANDRP). On the Sahibi, the highest level at Masani, 242.58 m, was set on 2 September 1978 (CWC site list), in the same week as the Yamuna's record of 1978 at Delhi. The two cannot be treated as independent, and a local storm can fall before, during or after the river peak. Clause 5.8.4 therefore pairs a design event on one side with a 10-yr event on the other, in the same way as Clause 2.12(b). This pairing has no direct precedent. It is more severe than an independence assumption would give.
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> Clause 5.8.3 reflects the barrage, dams and weirs above the State's towns. The Hathnikund barrage on the Yamuna was built by I&WRD in 1999, with a design flood of 22,000 m³/s (1 in 100 years), a highest flood level of 342.35 m, a pond level of 334.32 m and 18 gates, and its operating rule opens all the gates fully once the inflow reaches 6,094 m³/s (2,15,400 cusec) (MoJS committee, 2024). Its largest reported releases are 8,06,464 cusec

on 17 June 2013 and about 8.28 lakh cusec (8,28,072 cusec in I&WRD records, as reported) on 18 August 2019, about 23,400 m³/s, which is above the design flood (SANDRP; as reported); in July 2023 it passed 3,59,760 cusec on 11 July (MoJS committee, 2024), and in September 2025 a reported 3,29,313 cusec on 1 September (SANDRP). The Western and Eastern Yamuna canals are reported to be closed once the inflow passes 1 lakh cusec (SANDRP, citing I&WRD), so the whole flood goes down the river. The releases take about 12–24 hours to reach Karnal, 19–40 hours to reach the Mawi gauge opposite Panipat and 35–75 hours to reach Delhi (summed from the travel times by reach of the MoJS committee, 2024), which gives warning to close gates and move pumps but does not lower the river. On the Ghaggar system, the Kaushalya dam at Pinjore was reported releasing about 4,000 cusec on 9 July 2023 (600 cusec in another report), and its danger level is reported as 478 m (as reported); the Ottu weir in Sirsa is reported to pass about 40,000 cusec (as reported). On the Sahibi, the Masani barrage was left without gates when work stopped in 1986, and its weir storage is held by walls at 242.20 m on a crest of 240.00 m (I&WRD, 2024), so it spills without control. No operating rule or release record for the Kaushalya dam, the Ottu weir or the Dhansa regulator was obtained during research, and no hourly stage record for any gauge in the State was obtained other than those published by the committee and SANDRP [TBC]. Until they are, the largest recorded release applies, with the flow of the catchment below it as it occurred in the same event (Clause 5.8.5(c)).

Clause 5.8.5 is set by this Manual. In Haryana the tailwater at a town outfall is set not by the tide but by a drain of I&WRD or a master drain that may already be full, by a river held high for days by its own flood and the releases above it, or by a johad, a depression or a pumped sump with nowhere else to go. No document found during research gives a design water level for any of them. The Haryana Municipal Corporation Act 1994 requires the drain of new premises to empty into a Corporation drain within thirty metres, or else into a cesspool (s.198(2)), but it does not say against which level; the Haryana Building Code 2017 requires a large project to keep "the inlet and outlet point of natural drain system" with a channel of adequate size (Code 12.1), with no level either.

The first is the receiving drain. Haryana's drains were not designed to carry the peak. Its rural drains were sized by an empirical formula cut by reduction factors of 1/12 to 1/4, and its urban channels for 25 mm/h (NCRPB, 2016; Chapter 6), and the Sub-Regional Plan sizes rural drains for "three days rainfall of five years frequency to be drained in three days" (TCP Department, SRP-NCR 2021). Gurugram's master drains have stated discharges, 541, 1,305 and 3,702 cusec for Legs I to III (DTCP drawing, 2012), but no return period (GMDA, report to the NGT in OA 523/2019), and the capacity of Leg-III is reported as anything from 500 to 3,800 cusec, with a bottleneck of 800 cusec at Khandsa (as reported). Outfall Drain No. 8 carried 5,000 cusec at Dhansa in 2022 against a capacity of 4,000 cusec (I&WRD, 2024). A drain built that way stands at or above its design water level in the storms this Manual designs for, so item (a) computes its level from all the water it receives, takes the lowest reported capacity until the owner confirms one, and adds a drain lock. The 72-hour floor of the drain lock covers the longest design storm, and the SRP's own criterion, a 3-day storm drained in 3 days, is a drain that stands high for about three days. Gurugram's master drains and Outfall Drain No. 8 end in the Najafgarh drain, which runs from Dhansa into Delhi. In 1977 the Sahibi raised the level upstream of the Dhansa bund to 213.575 m against a bund top of 214 m, about 36,000 cusec passed through the bund, and the Jhatikara bund breached (Delhi I&FC); the drain's capacity is now reported as 8,000 cusec from Dhansa to Kakraula (Delhi planning document, seen as an extract). The level of the drain at the boundary is therefore decided as much in Delhi as in Haryana, which is why item (a) makes I&WRD coordinate it with Delhi's I&FC and, until a level is agreed, uses the record at Dhansa as a floor.

The second is the river lock. The Yamuna's levels along the State are measured by CWC at gauges several of which stand on the Uttar Pradesh bank, and the site list has been revised: the Mohna level of 1978 was replaced by a lower one of 1995, and the Palwal level of 2019 was removed (SANDRP, 2022). Item (b) keeps the higher value until CWC explains the change, because a level that the river reached is not made lower by being taken off a list. The danger level is used as the floor of the 10% AEP level because the river has crossed it in recent floods: at Mawi the river reached 232.75 m in 2013, 232.30 m in 2023 and 232.1 m in 2025 against a danger level of 230.85 m, and at Karnal it passed 249.5 m in 2010 and 2013 (CWC; MoJS committee, 2024; SANDRP), so a level reached about once in ten years is unlikely to lie below it; it is to be replaced by a frequency analysis of the CWC record [TBC]. A Yamuna flood lasts. In September 2025 the flow at Hathnikund stayed above 1 lakh cusec for about 129

hours, from 1 September to 5 September (SANDRP, from CWC data), and the flood wave then takes another 35 to 75 hours to pass the reach to Delhi (MoJS committee, 2024), so a town on the river can see it high for a week; the 7-day lock covers that and matches the lock that the Delhi and Uttar Pradesh editions of this Manual set on the same river. The Ghaggar system is different above and below. In the Shivalik foothills its choes, the Tangri and the Markanda rise and fall within hours to days, and the 72-hour lock covers the whole of the longest design storm of Clause 2.5.2. Below Guhla the river spreads, breaches and returns slowly: in July 2023 the flood passed Kaithal district on 12 July, six breaches there were still open on 18 July, and the Ottu weir was still passing about 38,400 cusec on 21 July (as reported), so the lower Ghaggar takes the 7-day lock. The Sahibi takes it as well, because in 1977 the Najafgarh drain below it ran at "about 6000-6500 cusecs for number of days" (Delhi I&FC). Neither lock is a substitute for the stage record of the flood that set the highest level, from which each is to be lengthened. **CWC has no flood gauge anywhere in the Ghaggar basin** (SANDRP, 2018); the State's gauges are reported in feet, as at Khanauri, where the river was about 6 ft above its danger mark of 748 ft on 15 July 2023, and at Ottu, whose danger mark is reported as 17 ft (as reported), with no gauge zero found. That is why item (b) requires a modelled or surveyed level, and a levelled tie for any gauge reading, before an outfall to those rivers is designed. The Panchkula floodplain zone rests on a 100-year flood computed by Gumbel's method from 54 years of data (I&WRD replies to the NGT in OA 421/2022), the State's own precedent for a 1% AEP river, although the NGT has questioned whether the procedure for the notification was followed (order of 22 May 2024, as quoted). Item (b) counts only the permanent pumps less the largest one, for the same reason that Clause 5.12.2(b) requires a standby pump; the inventory pumps that I&WRD lent at Ambala in July 2023 (Haryana Vidhan Sabha, 2023) are not a design capacity. The breach check follows the Ghaggar breaches of July 2023.

The third is the barrage release. Item (c) runs the design storm with the river at the largest recorded release because the rain that raises the Yamuna at Hathnikund and the rain on the towns below come from the same monsoon spell (see the Commentary to Clause 5.8.4). The largest reported release, about 8.28 lakh cusec in August 2019, is above the barrage's own design flood, so the design flood does not bound the release. The release does not bound the river either: the record level of the Yamuna at Delhi in July 2023 came from less than half the release of 2019, with local rain, the inflows below the barrage and the conditions downstream (MoJS committee, 2024; SANDRP). The Kaushalya dam, the Ottu weir and the Masani barrage have no operating rule that was found, and Masani has no gates at all.

The fourth is the land with no outfall, or with a pumped one. In the dry south-west a town's drains may end in a johad or a low patch of ground; the Sahibi below the Masani barrage "does not exist on ground" for about 11 km and is cultivated (I&WRD, 2024). In such a catchment the governing failure is the volume of a multi-day storm, and the State's largest storms are multi-day September storms such as those of 9 September 1875 and 19 September 1933, which brought 398.8 mm to Palwal and 484.1 mm to Rohtak in a day (IMD, *Climate of Haryana*). Item (d) therefore applies the 72-hour design volume, treats the outfall as closed for the whole storm and after it, and makes the overflow path end on public land. In the Rohtak–Jhajjar–Sonipat belt the problem is the opposite: the water table is high, not deep. In June 2023 about 2.15 lakh acres of Rohtak district and 1.93 lakh acres of Jhajjar had the water table within 3 m, about half and 43% of the two districts, and the area of the State within 3 m grew by about 30% between June and October (HWRA, *Haryana Water Resources Atlas 2025*). The land drains only by pumping to the I&WRD drains, and the Haryana Water Resources Authority is required to "discourage and prevent such activities that are likely to lead to potential water logging of land" (HWRA Act 2020, s.21(7)). Item (e) gives no infiltration credit, counts only permanent pumps, and limits the credited pumping to what I&WRD's consent allows when its drain is full, because a pump that discharges into a full drain only moves the flood downstream.

The fifth is the johad and the bund. Haryana has 19,665 ponds on the Pond Authority's data system, 18,764 rural and 901 urban (HPWWMA, written statement to the NGT, 2024), and many of them receive the drains of the villages and towns around them, sewage included: a joint committee found "discharge of untreated effluent in the water bodies" at Kharkhara in Rewari (NGT, OA 573/2023). A johad that receives dry-weather flow is full before the storm, which is why items (d) and (f) start it full. The Pond Authority Act protects a pond's green belt, catchment, inlets and outlets (ss.2, 14 and 17), so an outfall to a pond needs its permission as well as the owner's consent. The bunds of Gurugram, Ghata, Chakarpur, Jharsa and Wazirabad, were built in the late nineteenth century to hold flood water (MoHUA, Lok Sabha reply, 2025, as reported); of the 12,575 ha that drain to the Ghata bundh, 9,075 ha

lie in Delhi (GMDA, report to the NGT in OA 325/2015), so its level, like that of the Najafgarh drain, depends on land across the State boundary. No full level, maximum level or surcharge was found for any johad, bund or lake in the State [TBC], which is why item (f) uses the spill level and the head over it, and full level + 0.5 m for a gated bund or lake: 0.5 m is the freeboard that this Manual uses for floor levels (Clause 6.11.1), and it is a floor, not an estimate of the surcharge. The Najafgarh jheel was accepted by the State as a water body in 2017 but had not been notified by March 2024, and most of it is reported to be privately owned (as reported), so no storage is credited in it.

The sixth is the body that owns the receiving water. The rivers, embankments, drainage works and canals are I&WRD's; the master drains are GMDA's or FMDA's; the street drains vest in the Municipal Corporation (HMC Act 1994, s.193); the ponds belong to the Gram Panchayat or the local body, with the Pond Authority as regulator; and no rule dividing the drains of I&WRD from the others was found (Chapter 6, Clause 6.9). Items (a), (f) and (g) ask for the owner's consent and design level because a design that discharges to a channel or a pond cannot be checked without them. The Western Yamuna Canal and its branches carry supply water and are closed when the Yamuna is in flood (as reported), so storm water put into them goes where the operator does not expect it. Section 45 of the Canal and Drainage Act lets the State notify a reach of a river, stream or drainage channel within which obstruction is barred; only the Ghaggar zone in Panchkula has been found, and item (g) asks the designer to state whether the outfall lies in a notified zone. The court lines of item (g) decide where an outfall can be built, not its level; their status is set out in Chapter 7.

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.

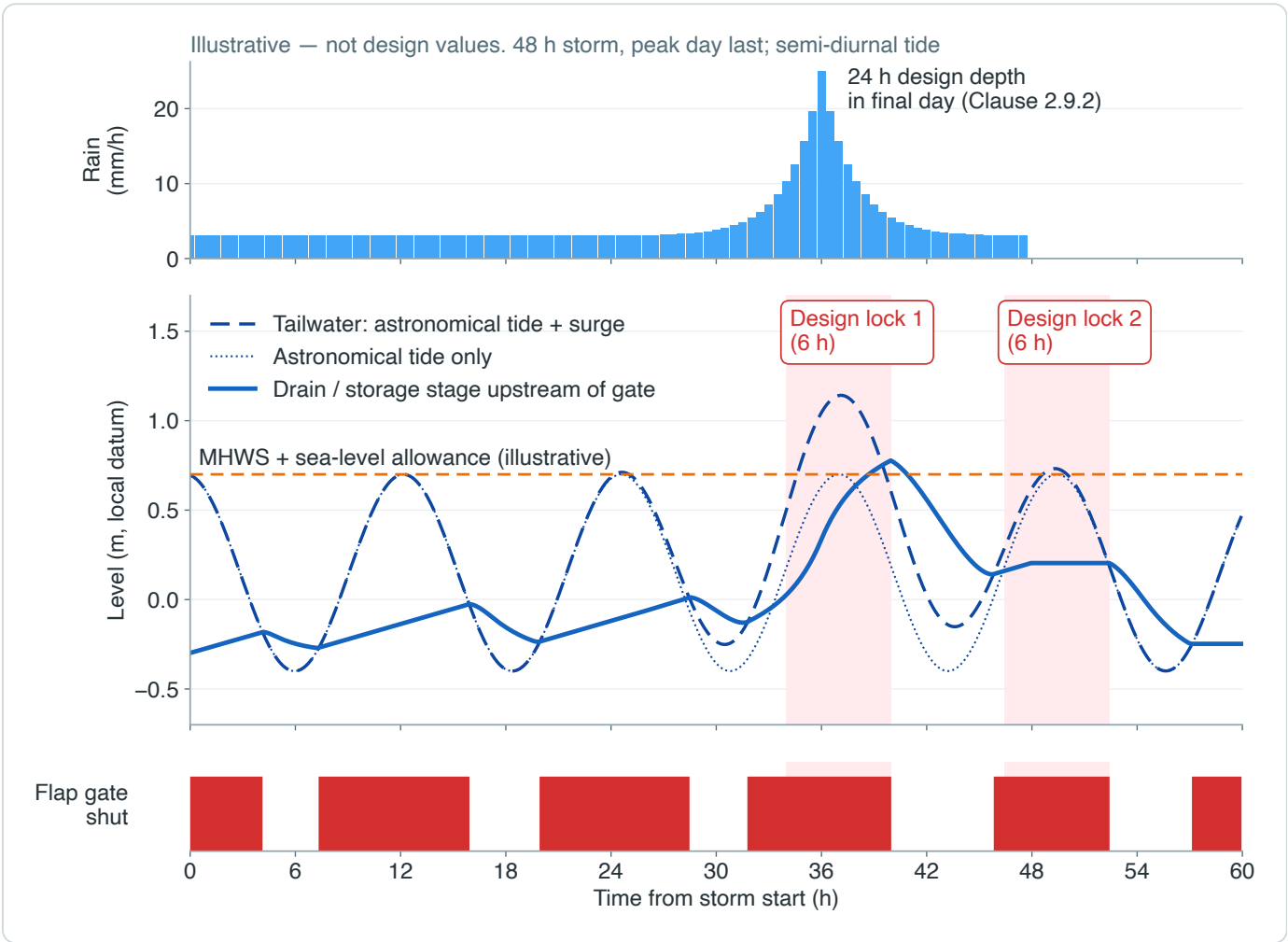

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal 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 Haryana requirement in this Manual. In Haryana it applies where an outfall is shut not by the tide but by a river that stays high for days, by a receiving drain that is already full, or by a depression with no outlet. In September 2025 the flow at the Hathnikund barrage stayed above 1 lakh cusec for about 129 hours (SANDRP, from CWC data). In July 2023 the Ghaggar passed a reported 82,400 cusec in Kaithal district on 12 July, and six breaches there were still open on 18 July (as reported). Outfall Drain No. 8 carried 5,000 cusec at the Dhansa regulator in 2022, a quarter more than its capacity of 4,000 cusec (I&WRD, 2024), and in the Rohtak–Jhajjar–Sonipat belt the low ground drains only by pumping. A river in flood stays high for as long as the flood lasts, a drain beyond its capacity backs up into every drain that joins it, a depression or johad with no outlet empties only by infiltration and evaporation, and the low ground of the waterlogged belt only by pumping, which is why Clause 5.8.5 replaces the two 6-hour windows described below with a single river lock of at least 72 hours, or 7 days on the Yamuna, the Sahibi and the lower Ghaggar, with a drain lock where the receiving drain is full, and with a closure for the whole storm where there is no outfall. A rate rule cannot help when there is no outlet: an orificed basin behind a closed gate simply fills.

The default of two consecutive 6-hour locks has no direct precedent. It represents gravity outfalls failing to discharge for about half of each tidal cycle around the two high tides nearest the storm peak. Figure 5.3 shows why both windows matter. The first lock catches the storm peak. The second arrives before the storage has drained, so the stage rises again.

Placing the first window on the rainfall peak is deliberately unfavourable. Cyclone rainfall and surge share a cause, and Clause 2.12 already treats them as dependent. The check replaces neither the J2 and J3 level checks nor the downstream analysis; it adds a test of timing and volume.

5.11 Flap gates, tide gates and non-return valves

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

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

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

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

5.11.3 **Construction.**

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

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

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

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

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

- before **25 June** each year;
- after every event in which they closed against a storm flow; and
- as set in the maintenance plan (Chapter 10).

> Commentary. The requirement for gates below the 1% still-water level is set by this Manual. The construction details follow common coastal-drainage practice. A gate that is jammed open by debris lets the tide into the drain. A gate held shut by a sand bank turns a gravity outfall into a dead end. In Haryana the outfalls do not cross a beach, but many of them pass through a gate in an embankment or bund, or end in a drain closed by a regulator, and the bunds breach. In July 2023 the Ghaggar breached its bunds at Ambala, where a major breach was plugged with the help of the Army and the Municipal Corporation ran 19 pump sets with inventory pumps of 962 cusec from I&WRD (Haryana Vidhan Sabha, 2023), and in Kaithal, Fatehabad and Sirsa, where breaches of the Ghaggar bund, the Hansi–Butana canal and the Chandpura siphon bund flooded villages, some 80 of them in Fatehabad district (as reported). In August 1977 the Sahibi rose upstream of the Dhansa bund to 213.575 m against a bund top of 214 m, about 36,000 cusec passed through the bund, and the Jhatikara bund breached and the Najafgarh jheel was submerged (Irrigation and Flood Control Department, Delhi). A gate that is jammed or left open lets the river or the receiving drain back into the drains behind it, and a bund that breaches fills the land behind it to the river level. The embankments, bunds and regulators are held by I&WRD, or, at Dhansa, by an operator not confirmed during research, while the drains that reach them belong to the Municipal Corporations, HSVP, GMDA, FMDA or a colonizer, and no rule linking the operation of any of these gates to the levels of the drains was found during research [TBC], so a gate and the drains behind it can belong to different bodies. The 25 June inspection date is set ahead of the SW monsoon.

5.12 Pumped outfalls

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

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

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

5.12.2 **Capacity.**

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

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

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

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

Changeover shall be automatic.

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

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

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

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

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

The arrangement shall prevent back-siphoning.

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

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

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

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

5.12.9 **Testing.** Every pumped outfall shall be test-run at full duty, including on standby power, before **25 June** each year. Private pumped systems shall be covered by a registered maintenance declaration (Chapter 10).

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

5.13 Sand-bar closure of river mouths

5.13.1 **Where it applies.** This clause applies to outfalls into any river or creek whose mouth is subject to seasonal sand-bar closure. That includes the mouths of the coastal States (there is none in Haryana: Clause 5.1.4), and any other mouth listed in Annex 5B.

5.13.2 **Assumption at the start of the SW monsoon.** The mouth shall be assumed **closed** by a bar at the start of the June–September season, at the crest level of the most recent pre-monsoon survey. This applies unless I&WRD 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&WRD 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. Haryana has no coast and no river mouth, so Clause 5.13 does not apply in the State (Clause 5.1.4). Its nearest inland counterparts are the silt, sand and boulders that the Yamuna and the Shivalik streams leave at an outfall, and the debris and dumped material that block the drains below them. The Yamuna is heavily silted at Hathnikund, where the canal head regulators are closed once the silt reaches 2,500 ppm (MoJS committee, 2024), the choes of the Ghaggar system carry sand and boulders in flash floods, and construction and demolition waste has been found dumped on the banks of the Ghaggar in Panchkula (NGT, OA 421/2022). A flap gate held open or shut by silt, or a regulator whose gates cannot be moved, turns a designed outfall into a dead end or a back-flow path. No written gate-operation rule for the Dhansa regulator, for the gates on the drains that outfall to the Yamuna or the Ghaggar, or for any johad or bund outlet was found during research [TBC]. Clause 5.8.5 deals with both by giving no credit for a gate operation or a storage that the operator's records do not show. Clause 5.13.2 has no direct precedent. It puts the burden of proof on showing that the mouth is open rather than assuming it.

5.14 Documentation

Every project subject to this chapter shall submit a **Downstream and Tailwater Report** (Form 5-1). It shall contain:

1. a plan of the analysis extent showing:
    - the site;
    - each analysis point with its contributing catchment area and the site's percentage of it; and
    - the end point and the reason it was chosen (Clause 5.3);
2. the model description:
    - software and version;
    - the network schematic, with survey sources for the drains and crossings;
    - land use and CN for off-site areas;
    - any upstream detention included; and
    - calibration or validation evidence where available;
3. for each analysis point, AEP and duration, the existing and with-project:
    - peak flow;
    - time to peak;
    - maximum water level and velocity; and
    - duration of inundation (Clause 5.4);
4. the comparison against Clause 5.5, with each failure identified and the remedy adopted;
5. the tailwater derivation:
    - tide-table edition and port;
    - MHWS, HAT and MSL relative to chart datum;
    - the datum connection to the Survey of India benchmark and the project datum;

    - surge source and value;
    - SLA; and
    - river levels and their sources (Clauses 5.6 to 5.8);
6. the joint-case table of Clause 5.9 with results;
7. the outfall-closed check (Clause 5.10):
    - storm and lock alignment;
    - stage hydrographs; and
    - the volume balance for each lock window;
8. a schedule of flap gates, tide gates and non-return valves, with certified head–discharge data (Clause 5.11);
9. pumped outfall design, power supply, flood immunity and controls, where provided (Clause 5.12);
10. the sand-bar assumption and supporting I&WRD certification, where relevant (Clause 5.13); and
11. inspection and maintenance requirements for Chapter 10.

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

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Annexes and forms

Annex / Form	Content
5A	Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment
5B	Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map
5C	Worked example: outfall-closed check for a site on a tributary of the Badshahpur drain in Gurugram
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) Haryana 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.** Haryana's drains have been designed with a low stated level of service and no plan for floods larger than the drain. The only design criteria for the State's drains found during research are those reported by the National Capital Region Planning Board: "The intensity of rainfall adopted is 25mm per hour and run off coefficient is 1/8 for designing of storm water drainage channels in Haryana urban area", and the rural drains were sized by an empirical formula and then reduced, by factors of 1/12 to 1/4, "on the premise that relatively smaller sections gave better hydraulic performance than those designed for peak discharge" (NCRPB, *Functional Plan on Drainage for NCR*, 2016, §5.2.2). The Sub-Regional Plan for the Haryana Sub-Region of NCR says only that urban drains should follow the CPHEEO manual (TCP Department). Gurugram's master drainage drawing gives Legs I to III discharges of 541, 1,305 and 3,702 cusec (DTCP drawing DTP(G) 2104/2012), and HUDA's catchment plan for the Badshahpur drain reach discharges of up to 2,300 cusec, but neither states a return period, and no approved drainage master plan with a design return period was found for any city in the State. A design intensity of 25 mm/h is about the average rate at which Gurugram received rain over four hours on 1 September 2025, when more than 100 mm fell between 3 pm and 7 pm (as reported), and on 9–10 July 2025 the city was reported to have received 133 mm in 12 hours, 103 mm of it in 90 minutes (as reported). The city's failures have come from storms far smaller than that: on 28 July 2016 a fall reported by the Chief Secretary as 46 mm in three hours left NH-48 jammed between Rajiv Chowk and Hero Honda Chowk for more than 18 hours (as reported). Where the drains overflow, the water runs along the roads and collects at the chowks and underpasses, because the roads are the only path left: Gurugram's highest 24-hour rainfall on record, 282.2 mm on 14 July 1968, and the 261.2 mm

of 30 June 1981 (IMD), fell before most of the present city was built. The natural channels that should carry the overflow have been lost: in September 2026 the Punjab and Haryana High Court found that "the existing natural water bodies have substantially diminished, while the channels that sustained these water bodies remain largely blocked", and summoned officers of MCG, HSVP and GMDA (*Sunil Singh v. MoEF*, CWP-20032-2008, order of 22 September 2026). The drains are also divided among owners: the Municipal Corporations, HSVP, GMDA, FMDA, PMDA, licensed colonizers, HSIIDC and I&WRD all build or hold drains and receiving waters in the same city, and no rule divides them (see the Commentary to Clause 6.9). Fixing the rainfall (Chapter 2) is only half the answer. The other half is a second, surface-level system that carries the flows the pipes cannot, without flooding buildings. That is the dual drainage concept of this chapter, taken from Kansas City Metro APWA Section 5600 (5601.8, Levels of Service), which requires every element to have a 1% AEP overflow path.

6.2 Definitions

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

6.3 The dual drainage concept

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

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

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

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

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

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

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

> **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 Gurugram 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.

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: Gurugram, Faridabad, Panipat, Ambala and Rohtak core and other high-density areas	10% (10-yr)	1% (100-yr) overland path	This Manual (see Commentary)
Minor system: other Class I areas	20% (5-yr)	1% overland path	This Manual; CPHEEO Table 4.1
Minor system: other areas	50% (2-yr)	1% overland path	This Manual; CPHEEO Table 4.1
Arterial road drainage and crossings	2% (50-yr) for arterials that are notified evacuation or emergency routes; 4% (25-yr) for other arterials	Next higher AEP: 1% for a 2% design; 2% for a 4% design	This Manual (25–50-yr); split set by this Manual
Collector road drainage and crossings	4% (25-yr)	2% (50-yr)	This Manual

Element	Design AEP (return period)	Check event	Basis
Local road drainage and crossings	10% (10-yr)	4% (25-yr)	This Manual
Road underpasses and other trapped sags on public roads	2% (50-yr)	1% (100-yr)	This Manual (Clause 6.10.5)
Airports, railway stations, power stations and other critical infrastructure	1% (100-yr) in Class I areas; 2% (50-yr) elsewhere	—	CPHEEO 2019 Table 4.1
Major (overland) system, every element	1% (100-yr)	—	This Manual
Building floor levels	1% level + 0.5 m freeboard	—	This Manual (Clause 6.11)

6.4.2 **Check events.** At the check event of Table 6.1, the combined minor and major system shall carry the check-event flow within the 1% AEP limits of Table 6.2 and without water entering any building. The 1% overland path requirement of Clause 6.3.2 applies in addition to the check event.

6.4.3 **Higher standards.** An approving authority may adopt a rarer AEP for any element, including through the high-powered committee route in Note 2 of CPHEEO Table 4.1. It shall not adopt a more frequent AEP than Table 6.1.

6.4.4 **High-density areas.** The approving authority shall notify, by map, the high-density areas to which the 10% AEP minor-system standard applies. Until it does, the 10% AEP standard applies to:

- (a) the old towns of Gurugram, Faridabad, Panipat, Ambala and Rohtak: the older, densely built area within each Municipal Corporation that the applicable development plan identifies as the old town, existing town, core or central business district, outside the sectors planned under the development plan, with the boundary of each to be confirmed by the Municipal Corporation and DTCP [TBC];
- (b) in every other Municipal Corporation, Municipal Council or Municipal Committee, the area that the applicable development plan identifies as the old town, existing town or central business district, and the abadi deh (lal dora) of the villages that have been taken into the built-up area; and
- (c) any area in a Tier A body where the master plan permits a floor space index above the base value for the zone.

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

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

6.5 Street hydraulics: spread, depth and flow hazard

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

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

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

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

Table 6.2 — Street flow limits

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

Class	Description	D·V limit (m²/s)	Depth limit D (m)	Velocity limit V (m/s)
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.

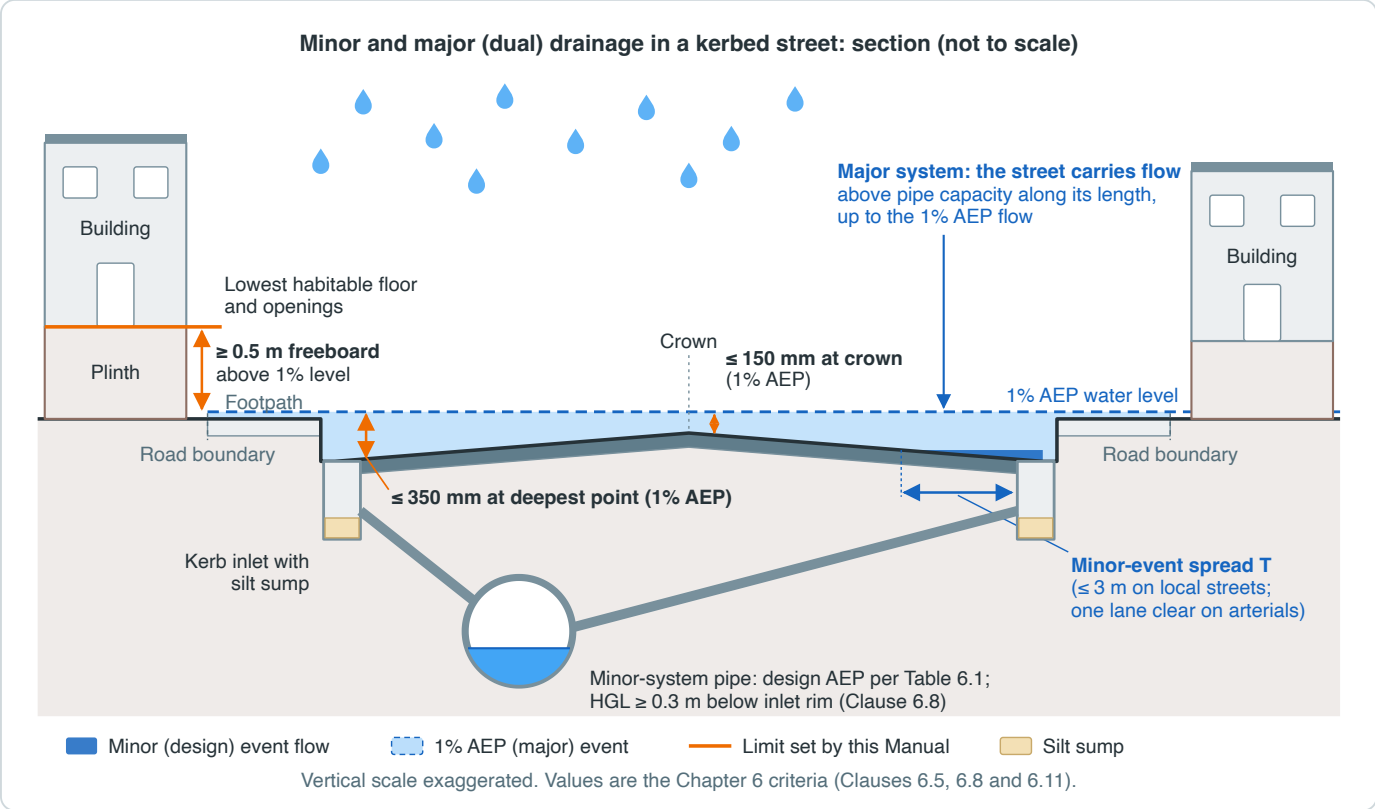


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

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 Haryana 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.

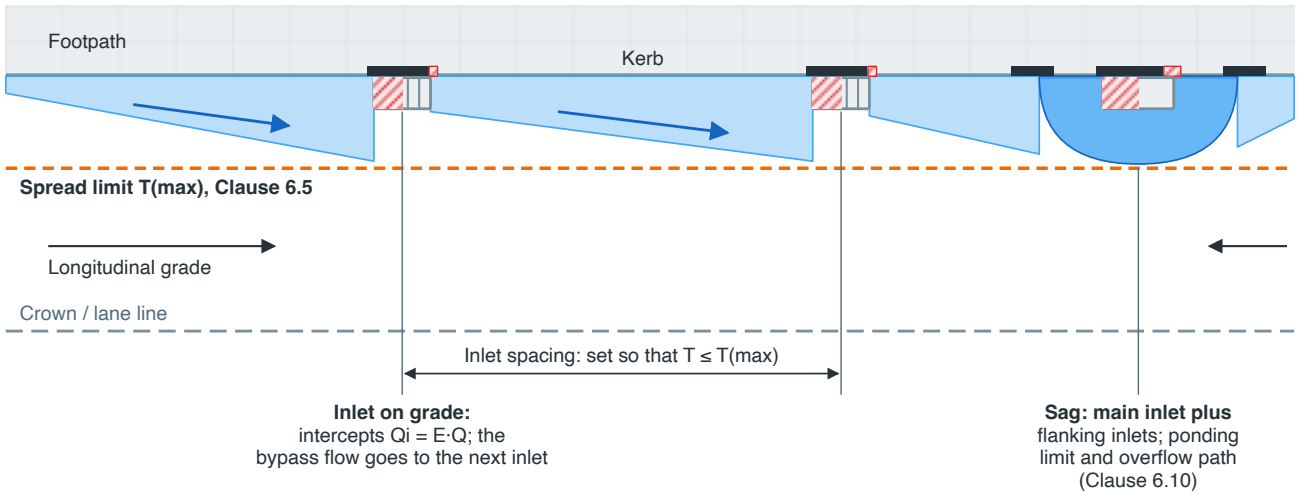
6.6.5 **Sag inlets.** At a sag on a kerbed road:

- (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.

Gutter spread, inlet interception and clogging: plan (not to scale)



Clogging factors (share of clean capacity lost), Clause 6.6

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

Gutter flow spread (minor event)
Ponding at sag
Assumed clogged portion
Kerb opening

Figure 6.2 — Gutter spread, inlet interception and clogging. Original drawing for this Manual, adapted from FHWA, HEC-22 Urban Drainage Design Manual (3rd ed., 2009; 4th ed., 2024) and CPHEEO, Manual on Storm Water Drainage Systems (2019).

> **Commentary.** The clogging factors are more severe than the APWA 5600 (2006, 5604.2) rating of sump inlets at 80% of theoretical capacity (a 20% reduction), because grates in Haryana 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. A fixed cap stops a single blocked inlet from leaving a long dry gutter run. The 300 mm silt sump is set by this Manual. It matches the 0.3 m sump shown on the CPHEEO catch-basin detail (CPHEEO 2019, Figure 5.9).

6.7 Pipes and open and covered drains

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

> V = (1/n) · R^(2/3) · S^(1/2); Q = A · V

where V is the mean velocity (m/s), n is the Manning roughness (Table 6.6), R is the hydraulic radius (m), S is the friction slope (m/m), A is the flow area (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 Panchkula, Pinjore, Kalka and Morni in the Shivalik foothills and other hill towns with the approving authority's agreement;
- (c) maximum velocity in unlined and vegetated channels: Chapter 9, Table 9.2;
- (d) the Froude number of flow in open and covered drains shall not exceed 0.8 at the design flow, unless the drain is designed for supercritical flow under Chapter 9.

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

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

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

6.7.6 **Minimum sizes.**

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

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

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

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

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

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

Table 6.7 — Minimum freeboard in open and covered drains

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

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

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

6.7.10 **Bends and junctions.**

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

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

Table 6.8 — Maximum spacing of manholes on straight pipe runs

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

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

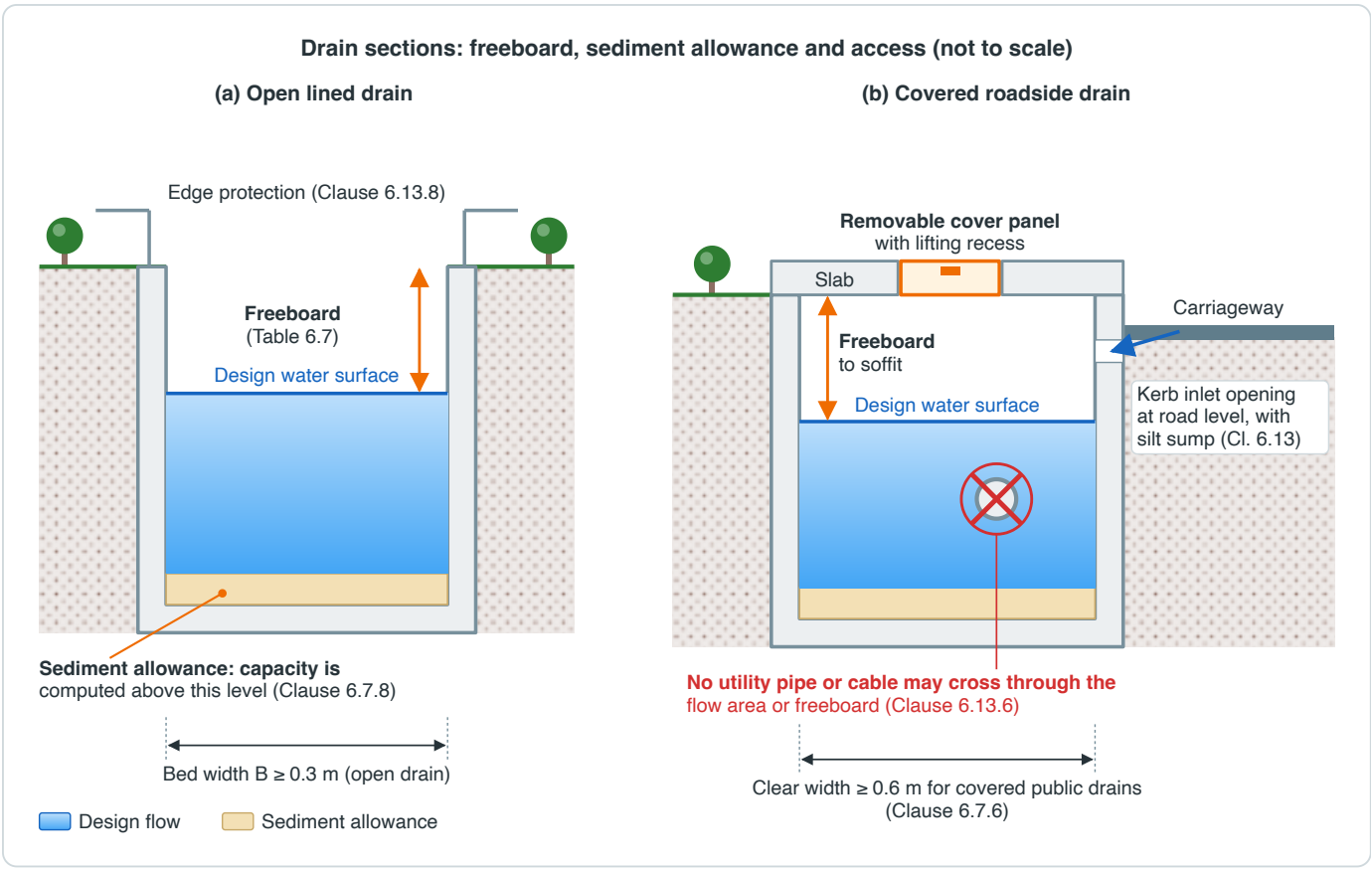


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

Commentary. The n values are those of CPHEEO (2019) Table 5.1. The higher minimum design values have no direct precedent; this Manual sets them because CPHEEO notes that the 0.011 value for spun pipes "may be taken as given by the manufacturer". That is a clean-pipe value, and Haryana 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 Gurugram's floods of 2016 to 2025; about 18 km of the 29 km Badshahpur drain was reported in 2021 to have been concreted by HSVP (as reported), and in September 2026 the Punjab and Haryana High Court found that the channels that sustained the city's water bodies "remain largely blocked" (*Sunil Singh v. MoEF*, CWP-20032-2008, order of 22 September 2026). The 0.6 m minimum cover is the value used in the CPHEEO (2019) worked pipe-design computation sheet (Part A, Chapter 5). The 0.9 m cover under carriageways is set by this Manual.

The sediment allowance values (75 mm or 10% for drains, 5% for large pipes) are set by this Manual. No Indian standard sets a sediment allowance for design. Gurugram'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 Haryana most town drains end in a drain of I&WRD or a master drain that is already full in a large storm, in a river held high for days, or in a pumped sump (Clause 5.8.5). In Gurugram the sector drains end in Legs I to III, whose level is set by the Najafgarh drain at their outfall and by their own narrow reaches, such as the bottleneck of the Badshahpur drain at Khandsa, reported as 800 cusec against a total of 2,300 cusec upstream (GMDA, 2021, as reported). In the Rohtak–Jhajjar belt the drains end in Outfall Drain No. 8, which carried 5,000 cusec at Dhansa in 2022 against a capacity of 4,000 cusec (I&WRD, 2024), and in the Yamuna towns in a river whose level is set by the Hathnikund releases. A drain whose HGL is started from a free outfall, or computed one length at a time without the receiving drain, the bottleneck or the river level, fails in exactly that way. An HGL computed from the outfall, with the tidal tailwater of Chapter 5, exposes those errors at design stage. The MHWS plus 0.3 m starting level is from CPHEEO (2019) Table 6.2. The access-hole method is described in HEC-22 from the 2009 edition onward.

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

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

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

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

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

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

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

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

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

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

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

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

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

6.9.8 **Use and protection.**

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

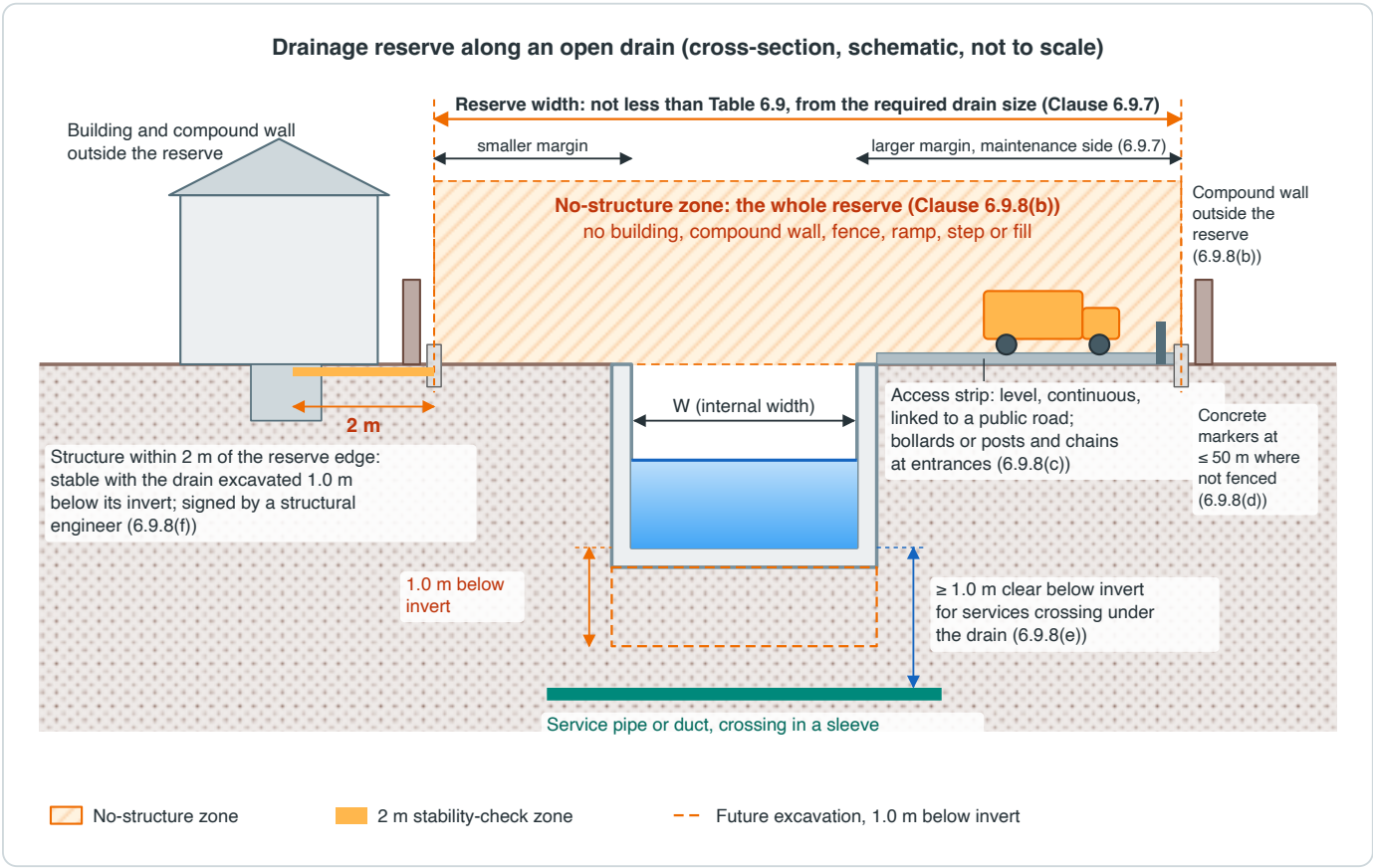


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Haryana, 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. Haryana has no statutory reserve width along a drain or nala. The Haryana Building Code 2017 sets no setback from a drain, canal, nala, pond or river; it requires the site plan to show existing features "such as well, drains" (Code 3.2) and the building plan the method of disposal of storm water (Code 3.4), and, for a building of 5,000–20,000 m² of built-up area, only that "The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water" (Code 12.1). No instruction of I&WRD setting a distance from a drain or canal within which construction is barred was found during research [TBC]. The Haryana Municipal Corporation Act 1994 vests in the Corporation "All public drains, all drains in, along side or under any public street" (s.193(1)) and the adjacent land, not being private property, appertaining to any public tank (s.161(1)(b)); it provides that "without the written permission of the Commissioner … no building, wall, fence or other structure shall be erected on any municipal drain", and lets the Commissioner remove it (s.206); and it bars the erection or occupation of premises until a drain has been built "of such size, materials, and with such fall" as the Commissioner finds "necessary for the effectual drainage" of them (s.198). Section 206 protects the drain itself, not a strip beside it. The only instrument found that draws a line along a channel is section 45 of the Haryana Canal and Drainage Act 1974, under which the State may notify limits along "any river, stream or drainage channel" within which an obstruction is prohibited, and the reach so notified "shall be held to be a drainage-work". It has been used for the floodplain zone of the Ghaggar in Panchkula, notified on 27 October 2023 village-wise by khasra number on a 100-year flood of 2,933.45 cumecs computed by I&WRD (I&WRD replies to the NGT in OA 421/2022), and no other notification under it was found [TBC]. The State has told the NGT that "All the construction activities are banned on river Flood Plains and no encroachment on any river is allowed as per section 45" (State report in EA 35/2023), but without a notification that statement draws no line on the ground. The Supreme Court has barred construction in the green belt and within 1 km of Badkhal and Surajkund lakes, with exceptions, and required the prior approval of the pollution control boards for development plans from 1 km to 5 km (*M.C. Mehta v. Union of India*, order of 11 October 1996), and the Haryana Pond and Waste Water Management Authority Act 2018 protects a pond of 0.5 acre or more recorded as talab, johar or tank together with its green belt, peripheral catchment, feeder inlets and outlets (ss.2 and 14), without a distance. None of these gives a reserve width along a drain. This Manual therefore gives the reserve a width, as its own proposal and not as a statutory width: a **hydraulic corridor** made up of the reserve of Table 6.9, based on the drain size needed to carry the design flow (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along a natural drain or a drain of I&WRD that drains 8 ha or more, the setbacks of Clause 7.4 measured from its top of bank, with a Zone 1 of at least 15 m; where a 1% AEP flood extent has been mapped, it governs Zone 2, and where a notification under section 45 or a court has set a wider line, such as the Ghaggar floodplain zone in Panchkula or the green belt and 1 km zone around Badkhal and Surajkund, that line applies for as long as it binds (Chapter 7). For this Manual, every nala and choe that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whoever maintains it and whether or not it is lined, piped or covered, and land recorded in the revenue records as a nala, johad or pond is part of the channel or waterbody whatever its present use (set by this Manual). The corridor is set by this Manual. It should be shown in the development plans of DTCP, the sector plans of HSVP, the infrastructure development plans of GMDA, FMDA and PMDA and the layout plans of licensed colonies, with the revenue (khasra) map overlaid, rather than made a new NOC.

The reserve matters because the drains of Haryana's cities are divided among owners, and no rule divides them. The Municipal Corporations hold the public drains and street drains (HMC Act 1994, s.193); HSVP builds the sector drains of its Urban Estates as external development works, as the "nodal agency for execution of all such development works in the Urban Estates of Haryana" (DTCP, report to the NGT in OA 661/2018); a colonizer licensed under the Haryana Development and Regulation of Urban Areas Act 1975 builds the "sewers and drains both for storm and sullage water" of its colony as internal development works (s.2(i), as quoted by DTCP); GMDA plans the drainage "which connects two or more sectors, municipal colonies or villages" (GMDA Act 2017, from the Bill) and reports Legs I to III as the master storm water drainage system of Gurugram (GMDA, 2020), although a part of the Badshahpur drain is shown "to be got constructed by Irrigation Department" (DTCP drawing DTP(G)

2104/2012) and about 18 km of its 29 km was reported to have been concreted by HSVP (as reported, 2021); FMDA desilts the Budhiya nala and seven other drains of Faridabad (as reported); I&WRD holds the drainage works under the Canal and Drainage Act, among them Outfall Drain No. 8, with the rivers, embankments and canals; HSIIDC builds the drains of its industrial estates; and the ponds belong to the Gram Panchayat or the local body, with the Pond Authority as their regulator. The Canal and Drainage Act excludes from a "drainage work" any "works for the removal of sewage from towns" (s.2(7)). No rule dividing the drains of I&WRD from those of the Municipal Corporations, HSVP, GMDA or FMDA was found during research. For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: rivers, embankments, regulators, canals and the drains that I&WRD maintains as drainage works, including Outfall Drain No. 8 and every reach notified under section 45, to I&WRD; the master drains that connect two or more sectors, municipal colonies or villages within the Gurugram, Faridabad and Panchkula metropolitan areas, including Legs I to IV and the Budhiya nala, to GMDA, FMDA or PMDA; the sector drains of an Urban Estate to HSVP until they are handed over to the local body; the internal drains of a licensed colony to the colonizer until they are taken over; the public drains and street drains within a Municipal Corporation, Municipal Council or Municipal Committee to that body; the drains of an industrial estate to HSIIDC; highway drains to PWD (B&R) or NHAI; and a pond to the Gram Panchayat or local body that owns it, under the regulation of the Pond Authority (set by this Manual). Under Clause 6.9.8(a), the reserve along an I&WRD drain is transferred to I&WRD. Where a channel's status is disputed, the corridor follows the channel and not its name: the Badshahpur drain is both a natural nala from the Aravalli and the trunk drain of Gurugram. No design return period was found for any drain in the State: Gurugram's master drainage drawing gives discharges of 541, 1,305 and 3,702 cusec for Legs I to III without one (DTCP, 2012), and the State's drains were sized by a formula reduced by factors of 1/12 to 1/4 and its urban channels for 25 mm/h (NCRPB, 2016). Until a Basin Stormwater Master Plan is adopted (Clause 6.9.6(b)), the required drain size of Clause 6.9.7 is the size computed by the designer under this chapter. This Manual does not prescribe a lined or an unlined section. It requires the section to meet the velocity limits of Clause 6.7.3 and Chapter 9, and a reserve wide enough for an unlined or vegetated section is a reserve that keeps both options open.

Commentary. Requirements 6.9.2(b)–(e), 6.9.3 and 6.9.4 have no direct precedent and are set by this Manual. Compound walls around individual plots are almost universal in Haryana 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. In Gurugram the chowks and underpasses of NH-48 are where the city's floods stop traffic: on 28 July 2016 NH-48 was jammed between Rajiv Chowk and Hero Honda Chowk for more than 18 hours and prohibitory orders were imposed near Hero Honda Chowk (as reported); on 19 August 2020 the expressway underpasses and Hero Honda Chowk were flooded, and the city was reported waterlogged within half an hour of the rain (as reported); and on 9–10 July 2025 the highway was jammed for about 8 km between Narsinghpur and Rajokri (as reported). The same failure kills: on 31 July 2024 three people were electrocuted near the IFFCO Chowk metro station when a live cable fell into ponded water (as reported). Clause 6.10.5(d) links the 150 mm crown depth limit of Table 6.2 to the point at which traffic should stop.

6.11 Building floor levels

6.11.1 The lowest habitable floor, and every opening through which water could enter a building (doors, ventilators, basement ramps, lift pits and service entries), shall be at least **0.5 m above the 1% AEP flood level**.

6.11.2 The 1% AEP flood level is the highest of:

- (a) the 1% AEP major-system water level in the street or overland flow path next to the building (Clauses 6.9 and 6.10, including the fully-blocked check at sags);
- (b) the 1% AEP flood level of any river, channel, tank or waterbody (Chapter 7); and
- (c) the 1% AEP level with the tailwater of Chapter 5; and
- (d) where the Approving Authority has adopted a 1% AEP flood depth map under Clause 7.3.4, the ground level at the plot plus the mapped 1% AEP depth.

6.11.3 **Default where no level has been computed.** For a plot below the Chapter 1 thresholds, or where no 1% AEP level has been computed for the plot, the lowest habitable floor and openings shall be at least the higher of:

- (a) **0.65 m above the highest crown level of the road on which the plot fronts**; and
- (b) where an adopted 1% AEP flood depth map covers the plot, **the ground level plus the mapped 1% AEP depth plus 0.5 m**.

The Approving Authority may adopt a regional map, such as a State-approved map or a published national map of modelled 1% AEP flood depth (for example the India Flood Atlas), until a local study replaces it. A map that does not model storm surge shall not be used in place of Clause 6.11.6.

6.11.4 **Basements.** The crest of every basement ramp and the sill of every basement opening shall meet Clause 6.11.1. Basement drainage shall be pumped to the surface drain through a non-return valve.

6.11.5 **Services.** Electrical panels, transformers, standby generators, lift machinery and pumps that serve a building shall meet Clause 6.11.1.

6.11.6 **Coastal band.** The coastal band is the land within **500 m** landward of the High Tide Line along the sea front, as defined by the CRZ Notification, 2019, with the High Tide Line as demarcated in the approved Coastal Zone Management Plan. Where the Survey of India Hazard Line lies further inland than 500 m, the band extends to the Hazard Line. Within the coastal band, in addition to Clauses 6.11.1 to 6.11.5:

- (a) the lowest habitable floor and every opening shall also be at least **0.5 m above the coastal flood level**, which is the 1% AEP still-water level (Clause 5.7.3(b), Annex 5A) plus **twice** the sea-level allowance of Clause 5.7.4 (so at least 0.6 m), because buildings have a design life of more than 50 years (Clause 5.7.4(c));
- (b) where the plot fronts the open beach, the coastal flood level shall include wave set-up from a site study;
- (c) no habitable room, electrical service room or plant listed in Clause 6.11.5 shall be placed in a basement; and
- (d) every basement opening, ramp crest and ventilation opening shall meet Clause 6.11.6(a).

Clause 6.11.6 does not authorise any construction that the CRZ Notification prohibits. Where both apply, the stricter governs.

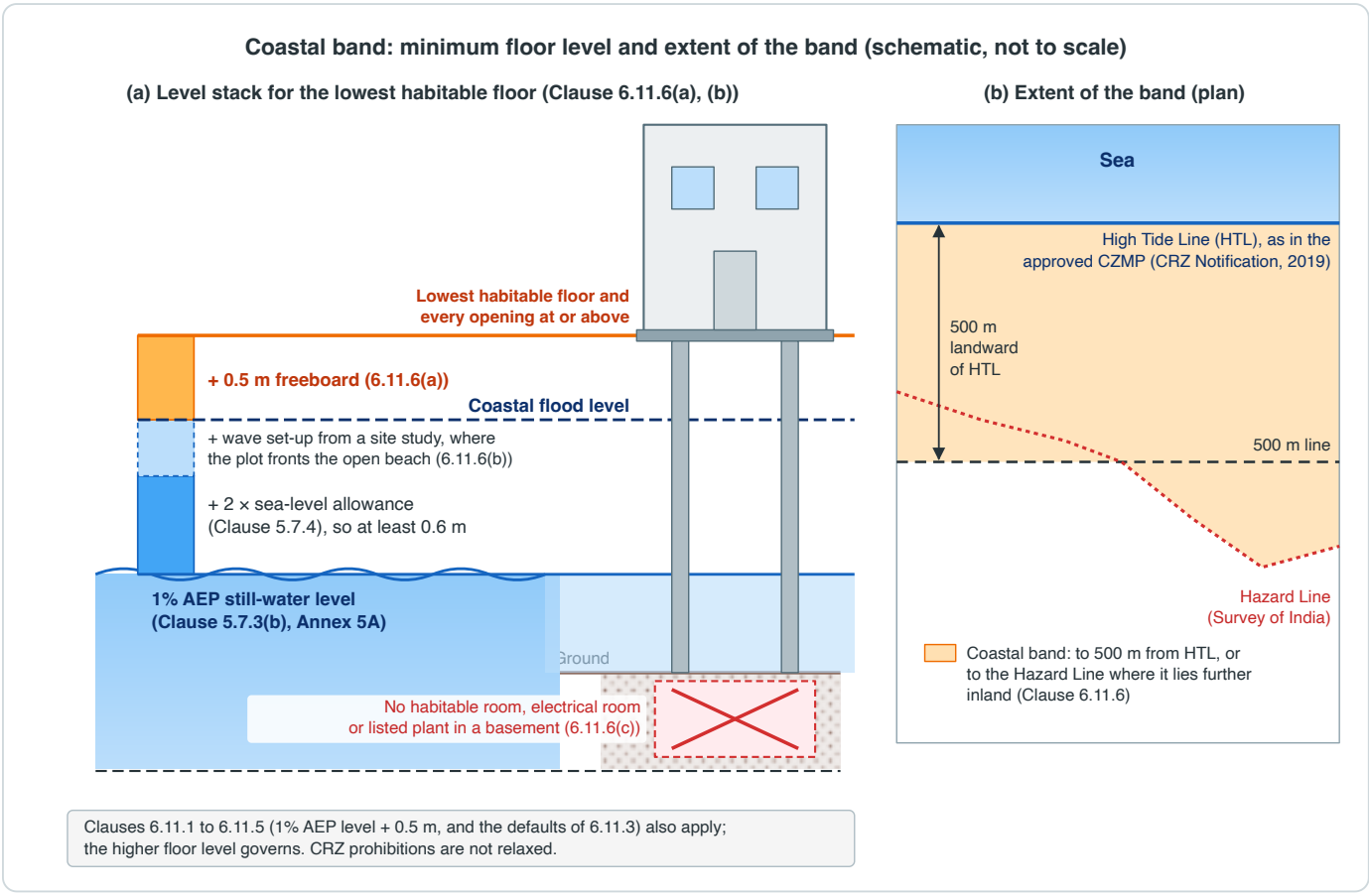


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further inland (Clause 6.11.6). Original drawing for this Manual, adapted from the CRZ Notification, 2019 (para 1(i) and Annexure IV) and PUB Singapore, Code of Practice on Surface Water Drainage (7th ed.), cl. 2.1.1.

Commentary. The 0.5 m freeboard above the 1% AEP level follows the DID Malaysia 2008 checklist (platform and lowest floor at 100-yr ARI + 0.5 m). It is more than the APWA 5600 (2006, 5601.8 A2) requirement of 1 ft (about 0.3 m) above the 1% stage. The 0.65 m default in Clause 6.11.3 is derived from the other limits of this chapter, not separately sourced: the 1% water level at the crown may be up to 150 mm (Table 6.2), plus the 0.5 m freeboard. It has no direct precedent and applies to plots where no flood level exists. URDPFI (2015) also links minimum plinth levels to flood frequency in its flood-plain zoning, which is covered in Chapter 7.

Clause 6.11.3(b) lets a small plot use a mapped 1% AEP depth where no local study exists, instead of guessing from the road level alone. Modelled national maps are coarse (about 30 m), and most model rainfall and river flooding but not storm surge, which is why 6.11.3 keeps the road-crown check and Clause 6.11.6 sets a separate coastal rule.

The coastal band of Clause 6.11.6 uses the 500 m line of the CRZ Notification, 2019 (G.S.R. 37(E), para 1(i): "the land area from High Tide Line ... to 500 meters on the landward side"), because every coastal authority already maps it and it needs no new survey. The Hazard Line, demarcated by the Survey of India to show the extent of flooding and shoreline change, extends the band where it lies further inland (CRZ Notification, 2019, Annexure IV). The band takes the coastal level from the joint-case still-water level of Chapter 5 rather than from the rainfall map. The higher standard reflects the setting: a coastal flood rises with the sea, cannot be drained while the tide is up, and will rise further with the sea. Singapore takes the same approach with a fixed minimum platform level of 4.0 m above datum on its southern coast and 4.5 m on its northern coast, whatever the rainfall flood level (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 2.1.1). Each coastal State's tide and surge levels vary too much along its coast for one fixed level, so this Manual uses the computed still-water level instead. Using twice the sea-level allowance applies the sensitivity case of Clause 5.7.4(c) as the design case, because a building, unlike a drain, cannot easily be raised later. The basement restriction in 6.11.6(c) is set by this Manual: a basement in the coastal band fills from the sea as well as from rain, and cannot be pumped out to a tide-locked outfall. Haryana has no coast, no High Tide Line and no Coastal Regulation Zone, so the coastal band is empty in the State and Clause 6.11.6 does not apply there. Clauses 6.11.3 and 6.11.4 matter instead. The Haryana Building Code 2017 requires the plinth to be between 450 mm and 1.5 m high, "so located … that proper drainage of the site is assured" (Code 7.3), with the plinth shown on the plans with reference to the mean street level (Code 3.4); it sets the roof of a basement between 0.9 m and 1.5 m above the average ground level, and provides that "The responsibility of draining a basement storey and for protecting it from rain shall be that of the owner" (Code 7.16). No clause on keeping surface water out of a basement, and no restriction on basements in flood-prone or waterlogged areas, was found in the Code, and no amendment touching Codes 7.3 or 7.16 was found [TBC]. Clause 6.11.3, which sets the lowest habitable floor and every opening 0.65 m above the road crown where no flood level has been computed, and Clause 6.11.4, which applies the same level, or 0.5 m above the 1% AEP flood level, to the crest of every basement ramp and the sill of every basement opening, are set by this Manual and are stricter than the Code; 0.65 m lies within the plinth of 450 mm to 1.5 m that the Code allows, so the two can be met together. In the Rohtak–Jhajjar–Sonipat belt a basement also lies in the groundwater, and the flotation check of Clause 4.12.3 applies to it. Within a floodplain zone notified under section 45 of the Haryana Canal and Drainage Act 1974, on the land of a pond and its green belt and catchment under the Haryana Pond and Waste Water Management Authority Act 2018, and around Badkhal and Surajkund lakes, the lines of Chapter 7 also apply.

6.12 Culverts and road crossings

6.12.1 **Design AEP.** A culvert or bridge that carries a road over a drain or waterway shall pass the design AEP flow of Table 6.1 for that road class without overtopping the road, and with the headwater limits of Chapter 9, Clause 9.4. Where the waterway is a State highway or national highway crossing, the design AEP shall also be not less than that of IRC:SP:42-2014 §7.1.4 for the span. The rarer AEP governs.

6.12.2 **Check event and 1% AEP.** At the check event and at the 1% AEP event, the crossing and the road together shall pass the flow:

- (a) with overtopping depth ≤ 150 mm at the road crown and ≤ 350 mm at the deepest point of the road;
- (b) within the hazard limits of Table 6.3;
- (c) with no overtopping at all of arterial roads that are notified evacuation routes; and
- (d) without raising the 1% AEP flood level at any upstream building or property boundary above the level for the existing condition, unless the affected owners and the approving authority agree.

6.12.3 **Where overtopping is not permitted.** Overtopping in the 1% AEP event is permitted only where the structure span is less than 6 m **and** the 1% AEP peak flow is not more than 7 m³/s, unless a guard rail is installed downstream of the overtopping section. Otherwise, the crossing shall pass the 1% AEP flow without overtopping.

6.12.4 **Blockage check.** The 1% AEP check shall be repeated with a blocked inlet:

- (a) 50% of the inlet area blocked for culverts with a span or diameter below 1.5 m; and
- (b) 20% blocked for larger culverts.

The results of this check shall meet Clause 6.12.2(a) and (d).

6.12.5 **Minimum size.** Culverts under public roads shall be at least 900 mm in diameter, or 900 mm × 900 mm for box culverts.

6.12.6 **Hydraulic design.** Culvert hydraulics, including inlet and outlet control, tailwater, road overtopping and outlet protection, shall follow Chapter 9, Clauses 9.4 and 9.6.

> Commentary. The design AEPs are those of Table 6.1. The overtopping limits are the street-depth limits of Table 6.2. The span and flow threshold in Clause 6.12.3 is the SI conversion of APWA 5600 (2006): overtopping allowed only where the structure span is under 20 ft and the 1% peak is 250 cfs or less, unless a downstream guard fence is installed. IRC:SP:42-2014 (§7.1.4) sets 25-yr for NH/SH culverts up to 2 m span and 50-yr for 2–6 m spans. The blockage percentages in Clause 6.12.4 and the 900 mm minimum size have no direct precedent and are set by this Manual. The 50% value matches the grate clogging factor.

6.13 Haryana 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 Haryana 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 Haryana the south-west monsoon normally sets in at Sonipat on 27 June, at Ambala and Chandigarh on 28 June, at Bhiwani on 30 June and at Hisar on 3 July, and normally withdraws from Hisar on 21 September, from Ambala, Chandigarh and Bhiwani on 23 September and from Sonipat on 25 September (IMD, new normals). So Clause 6.13.10 refers to the south-west monsoon, and Chapter 10 requires desilting and drain works to be complete by 15 June; the gates, regulators, flap gates, pumps and standby generators are certified ready and test-run by 25 June (Clauses 5.11.5 and 5.12.9), before the normal onset everywhere in the State; and pumps and gates stay on standby until 30 September, after the last normal withdrawal. The State's own directions are later: the Haryana State Drought Relief and Flood Control Board was reported to have required its short-term schemes and pump purchases to be completed before 30 June, and the Chief Secretary to have directed that all flood control works be completed by the same date, although a direction of the Chief Minister to clean the drains before 15 June has also been reported (as reported). Large storms fall before 30 June: on 30 June 1981 Rohtak recorded 297.9 mm and Gurgaon 261.2 mm in a day, and before the monsoon Gurgaon recorded 123.4 mm on 16 April 1983 and Hissar 102.2 mm on 15 May 1973 (IMD), which is why the drain works are not left later than 15 June. No desilting order of GMDA or of a Municipal Corporation with a completion date was found during research [TBC]: GMDA's desilting of Legs I to III is reported without dates. These dates are therefore set by this Manual.

The Haryana Building Code 2017 requires the inlet and outlet points of the natural drainage of a large project to be "maintained with adequate size of channel for ensuring unrestricted flow of water" (Code 12.1), and the Haryana Municipal Corporation Act 1994 bars any "building, wall, fence or other structure" on a municipal drain without the Commissioner's written permission (s.206) and requires a drain for "the effectual drainage" of premises before they are erected or occupied (s.198). Natural drains and the drains of I&WRD are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over; within a reach notified under section 45 of the Haryana Canal and Drainage Act 1974 the Divisional Canal Officer may order an obstruction removed, remove it himself and recover the cost as land revenue (s.46). Where a drain is covered, Clause 6.13.2 applies to it in full.

Clause 6.13.7 is not yet the practice. Gurugram's master drains carry sewage: in 2020 GMDA reported that 51.30 MLD of untreated discharge to Legs I to III still had to be diverted (GMDA, report to the NGT in OA 454/2018), and in 2023 their average BOD was 48, 63 and 44 mg/l against the condition of 30 mg/l for drains that reach the Najafgarh drain, and that of the Budhiya nala in Faridabad 76 mg/l (State of Haryana, report to the NGT in EA 35/2023). The Haryana Municipal Corporation Act 1994 already allows the Commissioner to require separate drains for sewage and rain water (s.202) and bars foul water from a drain provided for surface water (s.196). Clause 8.9 sets how dry-weather flow in storm drains is surveyed and intercepted until the connections are removed, including the rule that interception shall not reduce the capacity of the drain (Clause 8.9.5(b)).

The 10 m and 30 m spacings and the ±15 mm tolerance have no direct precedent and are set by this Manual. Clause 6.13.6 responds to the common sight of water mains and cables running through drains. Each one traps debris and reduces the section. Mechanical cleaning through cover openings, rather than manual entry, is assumed throughout, consistent with the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013.

6.14 Outfalls

6.14.1 Outfalls shall be designed for the tailwater conditions of Chapter 5. Outfalls below the 1% AEP still-water level shall have flap or tide gates or non-return valves (Chapter 5 and Chapter 9, Clause 9.10).

6.14.2 Outfall protection and energy dissipation shall be designed under Chapter 9, Clause 9.6. Outfalls to tanks and waterbodies shall also meet Chapters 7 and 8.

6.15 Submittal requirements

Every conveyance submittal shall include a **Conveyance Design Report** (Form 6-1) containing:

1. a catchment plan showing sub-catchments, the minor system, inlet locations and the major-system overland flow paths for the 1% AEP event (Clause 6.3.2);
2. the land-use and road-class AEP adopted for each element (Table 6.1), and the high-density area status;
3. design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3;
4. gutter spread, depth and D·V checks for the minor, check and 1% events (Tables 6.2 and 6.3);
5. an inlet schedule with clean capacity, clogging factor, design capacity and bypass flow (Clause 6.6);
6. pipe and drain design tables with n, velocity, sediment allowance and freeboard (Clause 6.7);
7. HGL profiles for the minor and check events, with the tailwater used (Clause 6.8);
8. sag ponding levels, including the fully-blocked check (Clause 6.10);
9. a floor-level schedule for every building (Clause 6.11);
10. culvert and crossing calculations (Clause 6.12 and Chapter 9); and
11. a utilities-crossing schedule and access-opening layout for covered drains (Clause 6.13).

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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Haryana with capacity curves (on grade and sag)
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Form 6-1	Conveyance Design Report checklist

CHAPTER 7

Waterbodies, Johads (Ponds) and Setbacks

7.1 Purpose and scope

7.1.1 This chapter treats waterbodies as part of the drainage system. It sets the rules for:

- (a) identifying and mapping every waterbody that a development or public work affects;
- (b) the setback zones around waterbodies, and the uses allowed in each zone;
- (c) fill in flood-prone land, and the compensatory storage needed where fill is allowed;
- (d) counting tank (johad) storage, including tank cascades, as design storage;
- (e) restoring and desilting tanks and ponds;
- (f) protecting supply channels, surplus courses, inlets and outlets;
- (g) wetlands, marshes and estuaries, which in Haryana, with no coast and no tidal water, means the two Ramsar sites (Sultanpur National Park and Bhindawas Wildlife Sanctuary), any wetland that the Haryana State Wetland Authority notifies or lists under the 2017 Rules, the wetlands of the national atlas that the State is ground-truthing, the Haryana side of the Najafgarh jheel, lakes and jhils such as Badkhal, Surajkund and Damdama, bandh pondages such as that of the Ghata bandh, the floodplain wetlands and depressions (khadar) of the Yamuna and the Ghaggar, and the johads and talabs recorded in the Revenue records;
- (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 Haryana Pond and Waste Water Management Authority Act, 2018, the Haryana Canal and Drainage Act, 1974 (section 45), the Haryana Municipal Corporation Act, 1994, the Haryana Municipal Act, 1973, the Punjab Village Common Lands (Regulation) Act, 1961, the Punjab Land Preservation Act, 1900, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Haryana has a pond Act, and its definition of a pond already takes in the catchment. The **Haryana Pond and Waste Water Management Authority Act, 2018** (Haryana Act No. 33 of 2018; Gazette of 23 October 2018) defines a "pond" as "a tank or lake or any other inland water body having an area of 0.5 acre or more, whether it contains water or not, and mentioned in revenue records as talab, johar, tank or by any other name", which "includes green belt and the peripheral catchments areas, main feeder inlet and other inlets, bunds, weirs, sluices etc" but not a notified wetland (s. 2(k)). The Act does not apply to a pond of less than 0.5 acre, to one in a notified forest, or to one on private land (s. 1(3)). It forbids anyone, without the Authority's permission, to "construct any structure on pond land, green belt and catchment area", or to "cause any obstruction in the natural or normal course of inflow or outflow of water into or from the pond on the upstream or down-stream", to discharge untreated municipal waste or industrial effluent into a pond, or to breach a bund or alter a waste weir

(s. 14); it lets the State notify a protected area around a pond (s. 16); and it requires that the Authority be consulted on "spatial or development plan of any area comprising a pond or protected area", no such plan to be approved or enforced without its prior approval (s. 17(1)). The Authority is chaired by the Chief Minister. By February 2024 it had entered 19,665 ponds, 18,764 of them rural and 901 urban, in its Pond Data Management System, each with a unique ID (Authority's written statement to the National Green Tribunal, 21 February 2024). No protected-area notification under section 16 was found for this Manual. In the Municipal Corporations, the adjacent land, not being private property, "appertaining to any public tank" vests in the Corporation, with the public drains and the drains along the streets (Haryana Municipal Corporation Act, 1994, ss. 161 and 193); in the villages most johads stand on shamlat deh, the common land of the village, which includes land kept "for the benefit of the community including … drinking wells or ponds" (Haryana Municipal Act, 1973, s. 2(22B)(iv), as indexed). The rivers and the I&WRD's drains have their own tool: under section 45 of the Haryana Canal and Drainage Act, 1974, the State may notify limits along a river, stream or drainage channel within which no obstruction may be formed, and the notified reach is then "held to be a drainage-work" (Clause 7.4, Disclosure).

The courts have read the catchment into the protection of a lake. In the Badkhal and Surajkund case the Supreme Court relied on NEERI's finding that "The natural drainage pattern of the surrounding hill areas feed these water bodies during rainy season", and that large-scale construction nearby "may disturb the rain water drains which in turn may badly affect the water level as well as the water quality" of the lakes; it barred construction in the green belt and, with exceptions, within 1 km of the lakes, and made all plans within 1 to 5 km subject to the prior approval of the Central and Haryana Pollution Control Boards (*M.C. Mehta (Badkhal and Surajkund Lakes)*, I.A. 29 in W.P.(C) 4677/1985, order of 11 October 1996). Badkhal is now dry (as reported). The application before the National Green Tribunal in *Oberoi* (O.A. 325/2015) sought "not to grant development permission over water bodies and their catchment areas in Gurugram and Faridabad districts", and in 2018 the Tribunal directed unique IDs and restoration for at least 123 water bodies in Gurugram and the same exercise across the State. In 2026 the Punjab and Haryana High Court recorded that in Gurugram "the existing natural water bodies have substantially diminished, while the channels that sustained these water bodies remain largely blocked", and that the rain that waterlogs the city "is not being effectively utilized for the purpose of replenishing the depleting groundwater levels" (*Sunil Singh v. MoEF*, CWP-20032-2008, order of 22 September 2026).

This Manual treats every recorded johad, talab and other pond, with its catchment and the flow paths that feed it, as drainage infrastructure. The Pond Act already says that a pond includes its green belt, its peripheral catchment and its feeder inlets, and forbids building on them or obstructing the inflow without the Authority's permission; it does not say how the catchment is to be found on the ground, which flow paths count, or what a development inside it must do. The catchment and flow-path rules of this chapter (see "Recorded johad" and "Catchment and flow paths" in the definitions after Clause 7.2, the setbacks of Clause 7.4 and Figure 7.3) are offered as a technical method for those questions: the catchment delineated from the terrain under Chapter 3, every flow path that drains 8 ha or more treated as a natural channel with its setback, no flow path blocked except by a crossing that meets Clause 7.10.3, and the runoff not retained on a site returned, after treatment, to the path it used before. **They are this Manual's proposal. The Haryana Pond and Waste Water Management Authority has not adopted or endorsed them**, and the Act, the Authority's permissions and approvals, and any protected area it notifies govern wherever they say more. The same rules apply, as this Manual's own standard, to the ponds the Act does not reach: those of less than 0.5 acre, those on private land (about 35% of the water bodies inventoried in Gurugram are privately owned, GMDA), and the natural low-lying collection areas that GMDA's inventory says "need to be preserved through appropriate legal mechanisms". No design under this Manual shall assume or rely on the filling of a recorded johad, or on the blocking or diversion of a flow path that feeds it, unless a drainage assessment under Chapters 3 to 5 shows where the storage and the flow go, and the lost storage is replaced under Clause 7.6.4. The Haryana Building Code 2017 sets no setback from water; its nearest provision is the environmental condition for buildings of 5,000 to 20,000 m² built-up area that "The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water" (Code 12.1). This chapter gives the design rules that protect waterbody storage and conveyance. It does not replace the revenue, municipal, pond, drainage and wetland procedures that record and protect waterbodies in law, or the directions of the Supreme Court, the High Court and the National Green Tribunal.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river or seasonal stream (such as the Yamuna, the Ghaggar, the Markanda, the Tangri and the Sahibi, and the seasonal hill streams, or choes, of the Shivalik foothills), natural drain or nala, I&WRD drain (such as Outfall Drain No. 8, Drain No. 2 at Panipat and the Gurugram Leg drains), canal, lake or jhil (such as Badkhal, Surajkund and Damdama, and the Najafgarh jheel), pond (johad, johar, talab, pokhar), whether or not it is a "pond" under the Haryana Pond and Waste Water Management Authority Act, 2018, bandh pondage (the water held behind an old earthen bandh, such as the Ghata bandh), marsh or low wet land (dabar), floodplain wetland or depression (khadar), abandoned quarry or mine pit, supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (johad)	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, waste weir or escape) 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&WRD 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 inlet, nala or canal)	A channel that brings water from a river, anicut or upstream tank into a tank.
Surplus course	The channel that carries the overflow of a surplus weir to the next tank, a river, a drain or the sea.
Sluice (sluice, regulator or outlet gate)	A controlled outlet through a tank bund, usually to an irrigation channel.
Top of bank	For a channel, the break in slope at the edge of the channel. Where it cannot be identified, the edge of the water surface at the 50% AEP (2-yr) flow.
1% AEP flood extent	The land flooded by the 1% AEP (100-yr) flood with the climate factor of Clause 2.8, from a hydraulic model that meets Chapter 3 and Chapter 5, or from a map adopted by the Authority under Clause 7.3.4.
Floodway	The waterbody and the adjoining land that must be kept free of obstruction to pass the 1% AEP flood without raising the 1% AEP water level by more than **0.1 m** at any point (Clause 7.6.1). For a tank, all land below MWL.
Flood fringe	The part of the 1% AEP flood extent outside the floodway.
Zone 1 (waterbody protection zone)	The inner setback zone defined in Clause 7.4.3.
Zone 2 (flood fringe setback)	The outer setback zone defined in Clause 7.4.4.
Setback	Zone 1 and Zone 2 together.

Term	Meaning in this Manual
Compensatory storage	Excavated storage that replaces flood storage lost to fill, under Clause 7.6.4.
Flood cushion	Storage below FTL kept empty, under a documented operating rule, to absorb a flood (Clause 7.8).

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

Term	Meaning in this Manual
Johad (जोहड़; talab)	A natural or excavated depression, usually with an earthen bund, that stores rainfall runoff from its own catchment: in the Shabdasagara, "कच्चा तालाब", an unlined (earthen) tank (Annex 7E). Johar is the spelling of the Pond Act ("talab, johar, tank", s. 2(k)), and talab the plain Hindi word; both mean the same thing for this chapter. A johad is a tank or pond under Clause 7.2, not a check dam. Most johads have no surplus weir or sluice, only a low point in the rim or bund over which they spill; where a johad has none, its FTL is the level at which it spills to the village nala, a drain or low ground, found by survey. A johad need not hold water to be a johad: one that is dry, or kept full only by sullage, keeps its bed, its bund, its catchment and its flow paths.
Pond (Pond Act)	A pond as defined in section 2(k) of the Haryana Pond and Waste Water Management Authority Act, 2018: 0.5 acre or more, recorded as talab, johar, tank or by another name, with its green belt, peripheral catchment, feeder inlets, bunds, weirs and sluices; not a notified wetland, a pond in a notified forest or a pond on private land (s. 1(3)). Every such pond is a recorded johad for this chapter, and the Authority's permission and approval (ss. 14 and 17) are needed in addition to this Manual's requirements.
Recorded johad	A johad, talab or other pond shown in the Revenue records, the Pond Data Management System of the Pond Authority, GMDA's inventory of water bodies, a Municipal Corporation's records, a development plan or master drainage drawing, or a survey made under a court's or the Tribunal's directions, whether or not it is a pond under the Pond Act. A recorded johad is part of the drainage system for this Manual. Where it is proposed to be filled or built on, in whole or part, a drainage assessment under Chapters 3 to 5 shall show the storage and flow paths lost and their effect upstream and downstream, and the lost storage shall be replaced under Clause 7.6.4 before any design relying on the filling is approved. This definition and rule are set by this Manual; they do not override the Pond Act, a court order or another statute that forbids the filling.
Catchment and flow paths	The catchment of a johad is the land that drains to it, and its flow paths are the nalas, channels, feeder inlets and depressions by which that runoff reaches it, recorded or not. For a pond under the Pond Act they are the "peripheral catchments areas, main feeder inlet and other inlets" of section 2(k). The catchment shall be delineated from the terrain under Chapter 3, or taken from the Revenue records or a court-ordered survey where it is recorded, and shown on the Waterbody Sheet (Form 7-1), and in it: (a) every flow path draining 8 ha or more is a natural channel under Clause 7.4.1(b), with its setback, whether or not it is recorded; (b) no flow path shall be blocked, filled, diverted or built across except by a crossing that meets Clause 7.10.3; (c) the runoff of a development that is not retained on site under Chapter 4 shall leave it, after treatment under Chapter 8, by the flow path it used before development, so that the johad keeps its inflow; and (d) the catchment boundary shall be marked on the approved layout plan. This is this Manual's proposed technical method for the catchment that the Pond Act protects; it has not been adopted by the Pond Authority, and the Authority's permissions, approvals and any protected area notified under section 16 govern where they say more.
Monsoon water line	The outer edge of a johad's, lake's or wetland's water in the monsoon: the largest of the edge shown by dated imagery of the monsoon and the month after it (July to October) in the years of record, which shall cover at least 20 years so as to include wet years, the edge recorded in the Revenue records, and the spill level (FTL) contour; where none is available, the MWL contour. The boundary of a johad or lake under Clauses 7.3.3 and 7.13.1 is the largest of its Revenue record boundary, its surveyed FTL and its monsoon water line, and setbacks are measured from that boundary. A dry year's edge never sets the boundary. This definition, and the 20 years, are set by this Manual.
Bandh pondage	The water held behind an old earthen bandh (embankment) across a nala at the foot of the Aravallis, such as the Ghata bandh at Gurugram, about 1.25 km long and 5 m high, behind which water stood over about 60 ha below 240 m and up to about 100 ha below 245 m above mean sea level (GMDA, report to the Tribunal); the Chakarpur, Jharsa and Wazirabad bandhs are of the same kind (as reported). A bandh pondage is a tank under Clause 7.2, whether or not it now holds water, and its bandh is a tank bund for Clause 7.14.
Jhil (jheel); dabar	A jhil is a pool, shallow lake or marsh, such as the Najafgarh jheel; a dabar is low or hollow ground where water collects (Annex 7E). A jhil is a lake or marsh under Clause 7.2 and, where Clause 7.12.1 lists it, a wetland. A dabar is a marsh or low wet land; where it is one of GMDA's "natural low lying water collection areas", it is a recorded johad for this chapter.

Term	Meaning in this Manual
Khadar; bangar	Khadar is the low land along a river or lake where rainwater stands for long, the floodplains of the Yamuna and the Ghaggar; bangar is the upland that is not flooded (Annex 7E). Land recorded or mapped as khadar is within the 1% AEP extent until a hydraulic study under Clause 7.3.4 shows otherwise.
Nala; nali	A nala is a watercourse or drain, natural or cut, such as the Badshahpur nala and the Budhiya nala; a nali is a small street or house drain (Annex 7E). Every nala that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whoever maintains it and whether or not it is lined, piped or covered.
I&WRD drain; section 45 reach	An I&WRD drain is a drainage work of the I&WRD under the Haryana Canal and Drainage Act, 1974, such as Outfall Drain No. 8; a section 45 reach is a river, stream or drainage channel within limits notified under section 45, which is then a drainage work, such as the Ghaggar floodplain in Panchkula. Each is a waterbody under Clause 7.3; a section 45 limit governs where it is wider than the setback of Clause 7.4 (Clause 7.4.5).
Sullage-fed johad	A johad that receives the sullage (grey water) of a village or colony, by its drains or nalis, in addition to rainfall runoff. It remains a waterbody under this chapter, not a treatment unit for a development; the sullage is intercepted under Clause 8.9.5 ahead of the johad, and its starting level for Clause 7.7.3 is FTL in every season.

7.3 Inventory and mapping of waterbodies

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

- (a) its type (Clause 7.2), name and survey numbers;
- (b) its custodian (a Municipal Corporation, Council or Committee (in which public drains, and drains in, alongside or under a public street, vest under section 193 of the Haryana Municipal Corporation Act, 1994, with the adjacent land, not being private property, appertaining to a public tank under section 161), GMDA, FMDA or the Panchkula Metropolitan Development Authority (for the master drains and the waterbodies they manage), HSVP (for the sector drains and ponds of its Urban Estates until they are transferred), a licensed colonizer (for the drains within a licensed colony until they are taken over), the I&WRD (for its drains, rivers, embankments, canals and regulators, and the reaches notified under section 45 of the Haryana Canal and Drainage Act, 1974), the Gram Panchayat (for village ponds and other shamlat land), the Haryana Pond and Waste Water Management Authority (as the regulator of every pond of 0.5 acre or more under its Act of 2018), the Haryana State Wetland Authority and the Forests and Wildlife Department (for a notified wetland and the Ramsar sites), HSIIDC (for the drains and ponds of its industrial estates), a private owner, or another body);
- (c) its boundary as recorded in Revenue records;
- (d) for tanks: FTL, MWL, TBL, the surplus weir crest length and type, sluices, the supply channel and the surplus course, each with its datum;
- (e) its position in any tank cascade, with the upstream and downstream tanks;
- (f) the 1% AEP flood extent, where mapped; and
- (g) known encroachments, with the date recorded.

7.3.2 **Project mapping.** Every drainage report shall include a Waterbody Sheet (Form 7-1) showing all waterbodies:

- (a) within the site;
- (b) within 100 m of the site boundary; and
- (c) downstream, to the extent of the downstream analysis of Chapter 5.

The sheet shall show, on a plan at a scale of 1:1,000 or larger for (a) and (b):

- the Revenue record boundary;
- the surveyed FTL or top of bank;
- the MWL contour (tanks) and the 1% AEP flood extent;
- Zone 1 and Zone 2 (Clause 7.4); and

- every supply channel, surplus course, sluice and surplus weir.

7.3.3 **Sources.** Waterbodies shall be identified from all of the following. Where they conflict, the larger waterbody extent governs:

- (a) Revenue records and khasra maps of the Revenue Department, in which johads, talabs and other ponds are entered as talab, johar, tank or by another name (the record on which a "pond" is defined in section 2(k) of the Haryana Pond and Waste Water Management Authority Act, 2018), with village ponds on shamlat deh, nalas, khadar land and land recorded as jhord; the Pond Data Management System of the Haryana Pond and Waste Water Management Authority, in which 19,665 ponds had been entered by February 2024, each with a unique ID; the inventory of 644 water bodies in Gurugram, with unique IDs, made by GMDA under the directions of the National Green Tribunal; the reaches and khasra lists notified under section 45 of the Haryana Canal and Drainage Act, 1974, such as the Ghaggar floodplain in Panchkula (Gazette of 27 October 2023); the public tanks, drains and watercourses vested in a Municipal Corporation under sections 161 and 193 of the Haryana Municipal Corporation Act, 1994; the waterbodies, drains and green belts shown in development plans and in the master storm-water drainage drawings of DTCP, HSVP and GMDA; the green belts of Badkhal and Surajkund lakes under the Supreme Court's order of 1996; the boundaries of the two Ramsar sites and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was confirmed for this Manual); and the wetlands of the national atlas that the State is ground-truthing;
- (b) I&WRD and Gram Panchayat tank registers and records of FTL and MWL;
- (c) the Authority's inventory (Clause 7.3.1) and any list published under court directions;
- (d) historical topographic maps and satellite imagery, including the ISRO National Wetland Inventory and Assessment; and
- (e) a site survey by a licensed surveyor, levelled to the datum stated in Clause 7.3.5.

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

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

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

7.3.5 **Datum.** All levels in this chapter shall be stated to one datum, stated on every drawing. Where I&WRD 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 Haryana city was found, and no design return period was found for any of the State's urban drains: DTCP's master storm-water drainage drawing for Gurugram (No. DTP(G) 2104/2012 of 9 November 2012) gives Leg I 541, Leg II 1,305 and Leg III (the Badshahpur drain) 3,702 cusecs, and HUDA's catchment plan for the Badshahpur drain (Rev. 2 of 24 November 2020) gives reach discharges up to 2,300 cusecs, but neither states the storm they were sized for. The only flood line found that has been notified is the Ghaggar floodplain in Panchkula district, notified by the I&WRD under section 45 of the Haryana Canal and Drainage Act, 1974 (Gazette of 27 October 2023), village by village and khasra by khasra, on a 100-year flood of 2,933.45 m³/s (103,594 cusecs) computed by Gumbel's method from 54 years of data (I&WRD, replies to the National Green Tribunal in O.A. 421/2022); the Tribunal observed in May 2024 that "the requisite procedure for declaration of the Flood Plain Zone of River Ghaggar has not been followed", and the boundary pillars were reported complete in February 2025. The State has told the Tribunal that "All the construction activities are banned on river Flood Plains and no encroachment on any river is allowed as per section 45", but no notification for the Yamuna or any other river in Haryana was found, and this Manual does not read one into that statement. On the Sahibi, the I&WRD found that for about 11 km downstream of the Masani barrage "there is no land,

particularly, marked for Sahibi River in Revenue Record" (committee report in O.A. 627/2022, 2024). The records of the ponds are better than those of the rivers: the Pond Authority's Pond Data Management System gives every pond a unique ID, and GMDA's committee checked 826 features in 242 villages and inventoried 644 water bodies of about 1,142 acres in Gurugram, against counts of 641 in the Revenue record of 1956, 487 on the Survey of India maps of 1976 and 557 on imagery of 2011–12 (GMDA, report to the Tribunal in O.A. 325/2015). The counts differ because ponds have been lost and because each source defines a pond differently; Clause 7.3.3 makes the larger extent govern. Every site plan under this Manual shall overlay the khasra map and show each johad, johar, talab and tank, each parcel recorded as jhord, each nala and each khadar parcel, with its pond UID where one exists, on the Waterbody Sheet (Form 7-1); the Haryana Building Code 2017 already requires the site plan to show "any existing physical features such as well, drains" (Code 3.2). Levels shall be stated to one datum (Clause 7.3.5): the levels published for the State's structures and pondages, such as the crest of the Masani barrage (240.00 m) and the Ghata pondage (240 to 245 m above mean sea level), shall be tied to a surveyed datum before use [TBC]. Clause 7.3.4 lets the Authority adopt flood maps once they are issued; until then the Applicant must produce the 1% AEP extent for larger and flood-sensitive sites, and a section 45 limit, where one has been notified, is a minimum that the 1% AEP extent of this Manual, with the climate factor, may exceed but never reduce. 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 statute, rule or building code read for this Manual sets a distance in metres from a drain, nala, johad, lake or river in Haryana; 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 approval of the I&WRD for a work on or next to one of its drains, rivers, embankments, canals or regulators, or within limits notified under section 45 of the Haryana Canal and Drainage Act, 1974 (such as the Ghaggar floodplain in Panchkula), the prior approval of the Haryana Pond and Waste Water Management Authority for a spatial or development plan of an area comprising a pond or protected area, or its permission for a structure on pond land, green belt or catchment area or in a protected area (Haryana Pond and Waste Water Management Authority Act, 2018, ss. 14 and 17), the permission of the Haryana State Wetland Authority for a regulated activity in a notified wetland, or a direction of the Supreme Court, the Punjab and Haryana High Court or the National Green Tribunal (such as the Badkhal and Surajkund lines listed in the Disclosure to Clause 7.4) sets a setback wider than Zone 1 or Zone 2, the wider setback governs for the uses it restricts.

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

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

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

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

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

> **Commentary.** The 15 m minimum is set by this Manual. Haryana has no general statutory distance from water: the Haryana Building Code 2017 sets no setback from a drain, nala, pond, canal or river, and no instruction of the I&WRD barring construction within a stated distance of a drain or canal was found. The lines that exist are tied to a notification, to a pond or to one waterbody: within limits notified under section 45 of the Haryana Canal and Drainage Act, 1974, no obstruction may be formed, and the notified reach becomes a drainage work (used for the Ghaggar floodplain in Panchkula, notified on 27 October 2023 on a 100-year flood of 2,933.45 m³/s); on a pond's land, green belt and catchment area no structure may be built, and no inflow or outflow obstructed, without the permission of the Haryana Pond and Waste Water Management Authority (Haryana Pond and Waste Water Management Authority Act, 2018, s. 14), but the Act sets no distance; around Badkhal and Surajkund lakes there is to be no construction in the green belt or, with exceptions, within 1 km (Supreme Court, 1996); and around a notified wetland no permanent construction is permitted within 50 m of the mean high flood level (Wetlands Rules, 2017, r. 4(2)(vi)). This Manual's 15 m gives every johad, nala and drain a hydraulic corridor where nothing wider binds, and is this Manual's proposal, not a statutory width (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 Haryana flood maps are mostly coarser than US maps, the Yamuna and Ghaggar alluvial plains, the Rohtak–Jhajjar–Sonipat waterlogged belt and the depressions of the Sahibi and the Najafgarh jheel are very flat (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).

Haryana's building code gives no distance in metres from water. The Haryana Building Code 2017 was searched for drain, nala, pond, river, canal and flood, and sets no setback from any of them; its only distances near water concern sewage: a septic tank is not to be "within 60 (sixty) metres from any percolation well, watercourse or stream used or likely to be used for drinking or domestic purposes" (Code 11.4), and a recharge well is to be at least 10 m from any structure handling sewage or industrial waste water (Code 8.1(3)(v)). No instruction of the I&WRD barring construction within a stated distance of a drain or canal was found. The Haryana Municipal Corporation Act, 1994 adds no width: no building, wall, fence or other structure may be erected on a municipal drain without the Commissioner's written permission (s. 206), and the adjacent land appertaining to a public tank, not being private property, vests in the Corporation (s. 161), but no strip is set around either. A municipal bye-law restricting certain acts "within a radius of thirty metres of a tank, pond, well or Baoli" was seen only in a search summary; the bye-law and the acts it restricts were not identified, and this Manual does not rely on it. The lines that exist are tied to a notification, to a pond or to one waterbody: within the limits of a section 45 notification under the Haryana Canal and Drainage Act, 1974, no obstruction may be formed and any obstruction may be ordered removed (ss. 45 and 46; the Ghaggar floodplain in Panchkula, 2023); on a pond's land, green belt and catchment area no structure, and no obstruction of the inflow or outflow, without the Pond Authority's permission, and in a protected area, once notified, no construction without its prior permission (Pond Act, 2018, ss. 14, 16 and 17; no distance is set in the Act, and no protected area was found notified); around Badkhal and Surajkund lakes at Faridabad, no construction in the green belt, none outside it within 1 km of the lakes except on plots sold before 10 May 1996 and owners' houses of up to 2½ storeys, and prior approval of the Central and Haryana Pollution Control Boards for all plans from 1 km to 5 km (Supreme Court, order of 11 October 1996); and around a notified wetland, no permanent construction within 50 m of the mean high flood level (Wetlands Rules, 2017, r. 4(2)(vi)), none of the State's wetlands having been confirmed as notified under the Rules for this Manual. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

Disclosure. Haryana has **no statutory setback in metres from a drain, nala, johad, lake or river**: no statute, rule or building code read for this Manual sets one, and **the only floodplain notified under the State's drainage law that was found is the Ghaggar floodplain in Panchkula**. 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, and so are the catchment and flow-path rules for johads and the reading of the monsoon water line (definitions after Clause 7.2). The Pond Act already protects a pond's green belt and peripheral catchment; this Manual's catchment and flow-path rules are offered as a **technical method for applying that protection**, but they are **this Manual's proposal, not a statutory width or rule**, and neither the Haryana Pond and Waste Water Management Authority nor any other government body has adopted or endorsed them. The setback is applied as **the larger of the corridor and any statutory or court line**, so the Manual is **stricter than statute** along drains, nalas and johads, and no less strict anywhere. The 1% AEP extent of this Manual, with the climate factor, governs Zone 2 wherever it is wider than a notified or court line. What does exist, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **Rivers and drains (section 45).** Limits notified under section 45 of the Haryana Canal and Drainage Act, 1974, within which no obstruction may be formed and any obstruction may be removed, the notified reach becoming a drainage work: the Ghaggar floodplain in Panchkula district (Gazette of 27 October 2023; 100-year flood of 2,933.45 m³/s). No section 45 notification for the Yamuna or another river was found.
- **Ponds.** The pond land, green belt, peripheral catchment and feeder inlets of every pond of 0.5 acre or more recorded as talab, johar or tank, on which no structure may be built, and no inflow or outflow obstructed, without the Pond Authority's permission; any protected area notified around a pond; and the Authority's

prior approval of any spatial or development plan of an area comprising a pond (Pond Act, 2018, ss. 2(k), 14, 16 and 17). The Act sets no distance, and no protected area was found notified.

- **Lakes.** Around Badkhal and Surajkund lakes, no construction in the green belt, none within 1 km of the lakes except as the Court allowed, and prior approval of the Central and Haryana Pollution Control Boards for all development schemes and plans from 1 km to 5 km (Supreme Court, 1996).
- **Wetlands.** No permanent construction within 50 m of the mean high flood level of a notified wetland (Wetlands Rules, 2017, r. 4(2)(vi)); the two Ramsar sites, Sultanpur and Bhindawas, to their designated boundaries; and the directions of the National Green Tribunal on the Najafgarh jheel (Clause 7.12, Commentary).
- **Municipal drains and public tanks.** No building on a municipal drain without the Commissioner's permission (Haryana Municipal Corporation Act, 1994, s. 206), and the adjacent land of a public tank vested in the Corporation (s. 161). These protect the waterbody, not a flood corridor; the whole recorded and monsoon extent is a waterbody for this chapter.
- **I&WRD drains, embankments, canals and regulators.** Works on or next to them need the I&WRD's approval.

This Manual sets 15 m as the floor because no width exists in Haryana for drains, nalas or johads; because 15 m 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 the drains need. The reasons for the corridor and the catchment rules are the record: the High Court found in 2026 that Gurugram's natural water bodies "have substantially diminished, while the channels that sustained these water bodies remain largely blocked"; the HARSAC action plan for Gurugram found 47 ponds of 2 to 8 acres in and around the city "either dried up or filled with municipal waste" (2021); DTCP's master drainage drawing for Gurugram marks reaches of the drains as "Land under stay/litigation/encroachment"; and a reach of the Badshahpur drain is reported to narrow from a capacity of 2,200 cusecs to 700 cusecs (as reported). Until a statute, rule, notification, development plan or the Pond Authority adopts them, the 15 m minimum and the catchment rules are this Manual's recommended standard, and the statutory and court controls above remain the only legal minimum. Approving authorities should state in each approval which was applied.

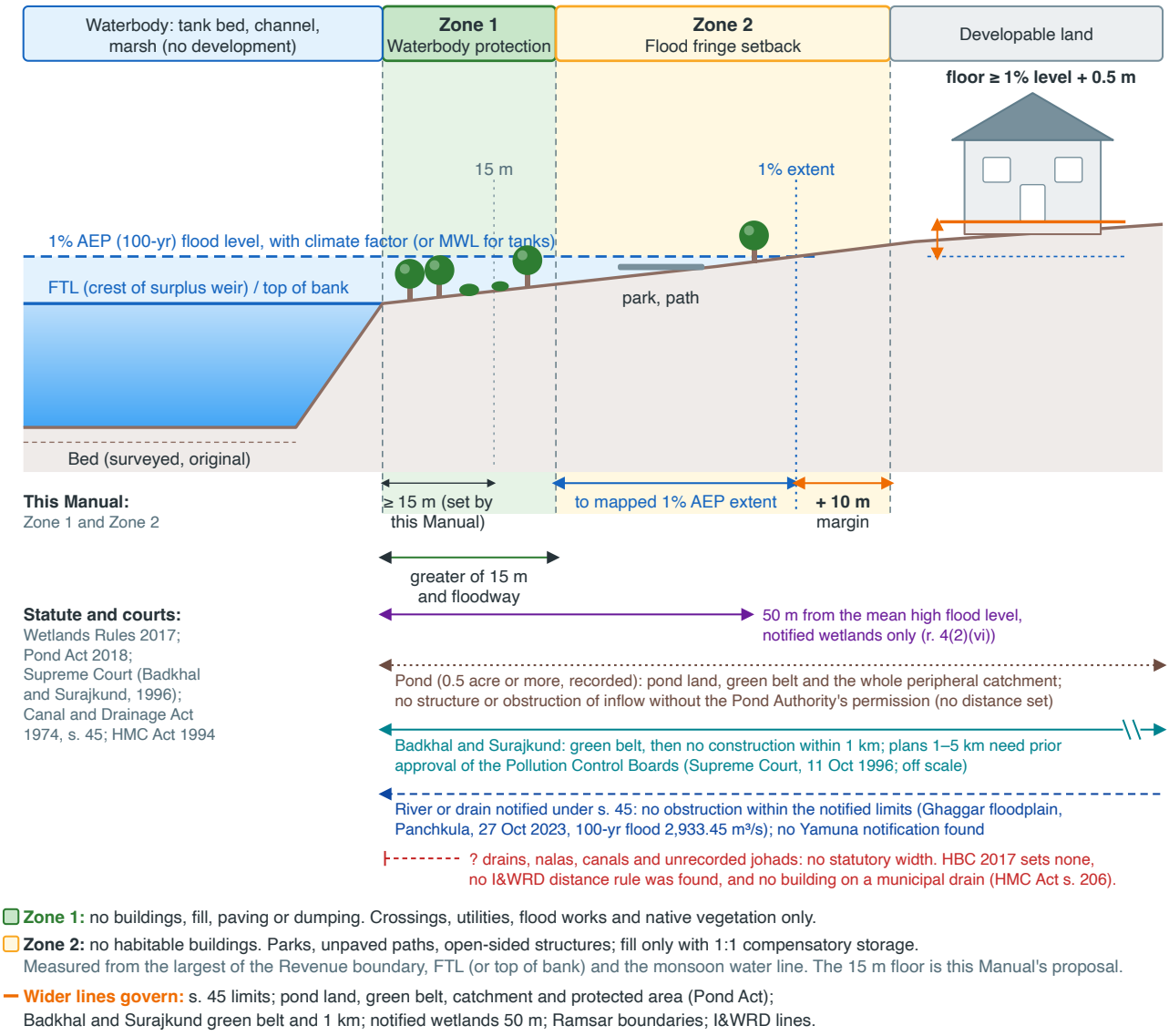

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 open space required by the Haryana Building Code 2017, where the Authority agrees. Zone 1 land shall be handed over to the custodian or kept free of private use, as the Authority decides.

> Commentary. The permitted uses follow APWA 2025.01: in Zone 1, only utility and road crossings; in Zone 2, linear utilities, trails and open-sided structures; no clearing, grading, fill or paving in either zone without approval (MARC Supplement, 2025). Clause 7.5.2 adds parks and playgrounds, the uses URDPFI (2015) allows in the 10-year flood zone. The ban on walls in Clauses 7.5.1 and 7.5.3 responds to urban Haryana 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 Yamuna and Ghaggar alluvial plains, the Rohtak–Jhajjar–Sonipat waterlogged belt and the depressions of the Sahibi and the Najafgarh jheel, where runoff spreads and stands, are flat, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Haryana the lines around waterbodies are measured from a high level, not from the dry-season water line: the Wetlands Rules, 2017 measure their 50 m from the mean high flood level, and the Pond Act defines a pond "whether it contains water or not", with its green belt and peripheral catchment (s. 2(k)). The difference matters because many of the State's johads, jhils and pondages fill only in the monsoon. The Damdama lake near Sohna is reported to shrink from about 80 acres to about 35 acres within a month of the monsoon's end (as reported), and behind the Ghata bandh at Gurugram, where water stood over 60 to 100 ha up to 245 m above mean sea level, GMDA found "no perennial waterbody … except a comparatively small waterbody of about 2 ha" (report to the Tribunal). A line drawn from the edge of the dry months would leave the foreshore that the monsoon floods, and that the johad or pondage needs in order to store it, open to building. This Manual gives the same rule a level for every johad, jhil and pondage: its monsoon water line, read over at least 20 years, and its FTL are part of its boundary (definitions after Clause 7.2), and the foreshore up to MWL is its flood storage. Treating all land below MWL as floodway (Clause 7.6.1) means that no new building or fill is approved in a tank foreshore.
>
> The developed-fringe mechanism of Clause 7.6.6 is set by this Manual. Large parts of the colonies and sectors of Gurugram along the Badshahpur drain and in the low ground below the Aravallis that the city's drains flooded in July 2016 and in most monsoons since, the low parts of Ambala flooded when the Ghaggar breached in July 2023, and the waterlogging-prone wards of Rohtak and the other towns of the Rohtak–Jhajjar–Sonipat belt (all as reported) already lie within the 1% AEP extent. A blanket Zone 2 ban on redevelopment there would stop the

replacement of older, lower buildings with buildings raised above flood level. The mechanism follows the URDPFI (2015) approach for the 25-year flood zone (stilts, minimum plinth, no basements), applied here to the 1% AEP extent.

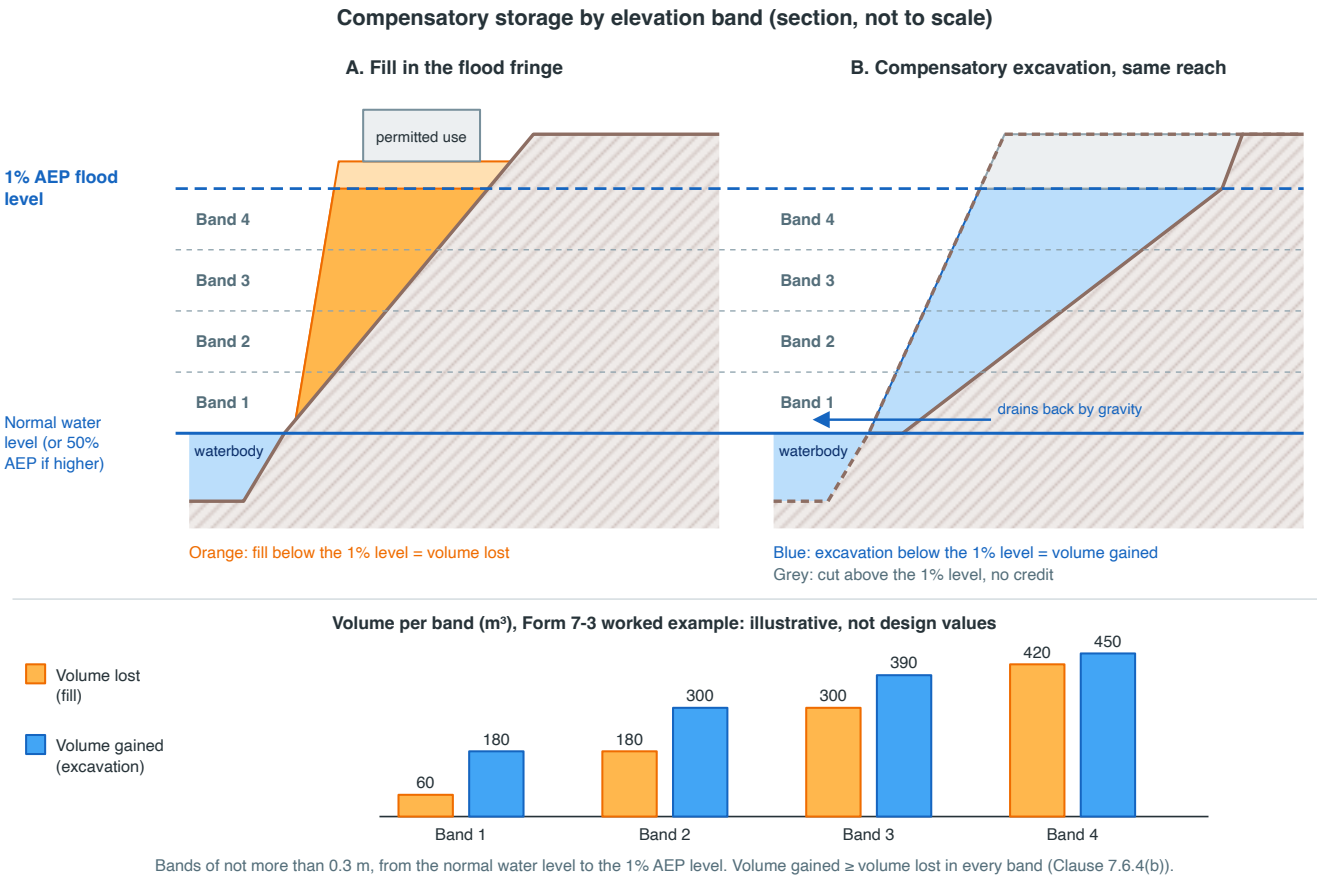

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation draining back to the waterbody by gravity. Band-by-band calculation on Form 7-3. Original drawing for this Manual, illustrating the method of Clause 7.6.4, which is set by this Manual.

7.7 Tank cascades as design storage

Haryana has a pond Act but no tank Act, and its storages range from the village johad to the barrages of the I&WRD. The storages that matter for urban drainage are of six kinds. The first is the village and urban johad or talab of 0.5 acre or more, recorded as talab, johar or tank and regulated by the Pond Authority under the Pond Act, 2018, usually with no outlet structure, standing on shamlat land or vested in a Municipal Corporation, and often fed by village sullage as well as by its catchment; 19,665 were on the Authority's register in February 2024. The second is the johad or pond that the Act does not reach because it is smaller than 0.5 acre or on private land, and the natural low-lying collection areas, which in Gurugram are a large share of what remains (GMDA). The third is the bandh pondages at the foot of the Aravallis, such as those of the Ghata, Chakarpur, Jharsa and Wazirabad bandhs, built in the late nineteenth century to hold the runoff of the hill nalas and reported to have been made obsolete by urbanisation (Lok Sabha reply, August 2025, as reported); they are the tanks for which Clauses 7.7 and 7.8 matter most in Gurugram, and no operating rule or level record for any of them was found. The fourth is the lakes, Badkhal and Surajkund at Faridabad, under the Supreme Court's order of 1996, and Damdama near Sohna. The fifth is the I&WRD's barrages and regulators, such as the

Hathnikund barrage on the Yamuna, the Masani barrage on the Sahibi, whose weir was left without gates when work stopped in 1986, and the Dhansa regulator at the end of Outfall Drain No. 8; they are not tanks for these clauses, and their releases and levels enter a design as inflow and tailwater (Chapter 5). The sixth is the wetlands, the Najafgarh jheel, which receives the Sahibi and the Gurugram drains, and the Ramsar sites of Sultanpur and Bhindawas, which are wetlands under Clause 7.12. Clauses 7.7 and 7.8 apply to any of these whose storage is counted; any bandh pondage or lake whose storage is to be counted is subject to Clause 7.7.1 in full, with the I&WRD, GMDA, the Municipal Corporation, the Gram Panchayat or other custodian, and the custodian of each bandh and lake shall be confirmed for the inventory (Annex 7A), because it was not established for this Manual.

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&WRD, or the other custodian, concurs in writing.

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

7.7.2 **Modelling.** Tank cascades shall be modelled under Clause 3.12.5 (level-pool routing of each tank, with surplus weir and sluice ratings) and Clause 3.13 (continuous simulation). The whole cascade, from the uppermost tank whose surplus can reach the site or facility to the next river, major drain or sea outfall, shall be modelled together, including the catchment of each johad and the flow paths that feed it, the johad with its FTL and its overflow to the village nala or an I&WRD drain, and, where that drain carries the overflow on to a regulated outfall such as the Dhansa regulator of Outfall Drain No. 8 and the Najafgarh drain, the drain and the outfall, with the drain's design water level as the tailwater of the johad's overflow (Chapter 5), as shown in Figure 7.3.

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

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

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

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

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

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

- (a) routes the cascade under Clause 7.7.2;
- (b) shows the effect on flood levels in the foreshore and upstream, and on flows in the surplus course and downstream; and
- (c) checks the bund under Clause 7.14.

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

The FTL starting level follows Clause 3.12.5. Haryana's johads and depressions are fullest, and its water table highest, when its worst storms come. In the waterlogged belt the area with the water table within 3 m of the ground grew from about 2.93 lakh ha in June 2023 to about 3.79 lakh ha in October (Haryana Water Resources Atlas, 2025), so that at the end of the monsoon a johad there can be full, with its bed in the groundwater and the fields around it wet; the State's largest recorded daily falls came in that season, 484.1 mm at Rohtak on 19 September 1933 and 398.8 mm at Palwal on 9 September 1875 (IMD). The I&WRD drains that take the overflow run full at the same time: Outfall Drain No. 8, built for 4,000 cusecs, carried 5,000 cusecs at the Dhansa regulator in the monsoon of 2022 (I&WRD, report to the Tribunal), and Gurugram's Leg drains outfall to the Najafgarh drain, whose level in a wet spell is their tailwater (Chapter 5). Many village johads are also fed by sullage, and the Pond Authority's annual plans give priority to polluted and overflowing ponds (statement to the Tribunal, 2024): a johad fed in this way can stand at or near FTL in every season. No record of how long Haryana's johads and pondages stay at or above FTL in a wet spell was obtained for this Manual. An empty johad at the start of the season is not a design assumption: in a wet spell it fills, and while it is full it stores nothing more below FTL, its feeder nalas discharge against a high level, and its overflow joins a drain that is already running full. A tank cascade passes floods from one tank to the next, so a design that counts storage in one tank and ignores the surplus arriving from the tank above it will overstate the benefit. That is why Clause 7.7.2 requires the whole cascade to be modelled.

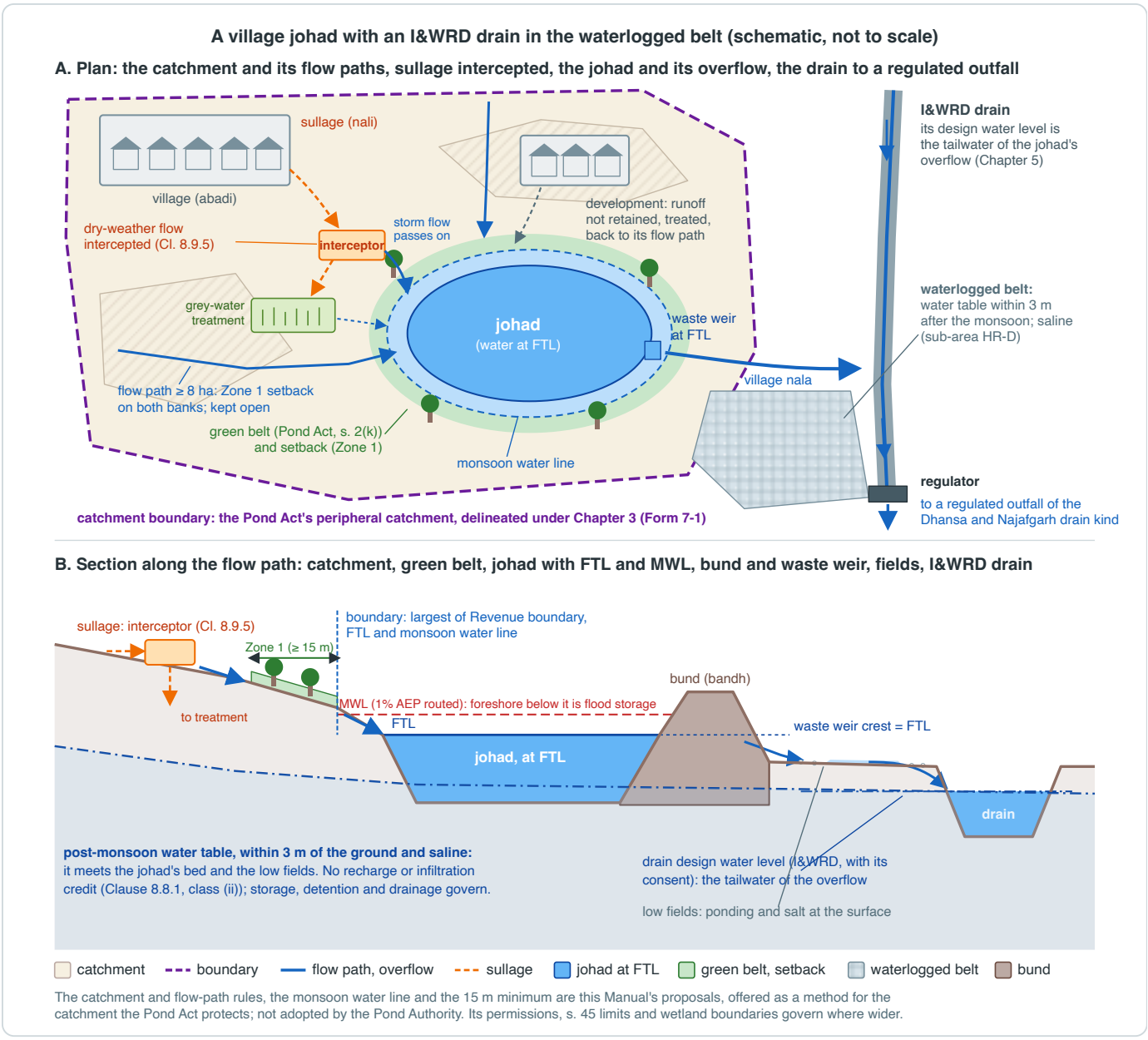

Figure 7.3 — A village johad with an I&WRD drain in the waterlogged belt (schematic, not to scale; no particular johad is shown). A: in plan, the johad's catchment drains along its flow paths and feeder inlets to the johad, which is a "pond" with its green belt and peripheral catchment under the Pond Act (s. 2(k)) where it is recorded and of 0.5 acre or more; the village's sullage is intercepted ahead of the johad (Clause 8.9.5) and treated before it reaches the water; the johad spills at its FTL over its waste weir to the village nala, which joins an I&WRD drain that runs to a regulated outfall of the kind of the Dhansa regulator and the Najafgarh drain. The catchment, the flow paths, the johad and its overflow are one waterbody system for this Manual (definitions after Clause 7.2): a development in the catchment keeps its flow paths open, with the setback of Clause 7.4 on every path draining 8 ha or more, and sends the runoff it does not retain on site, after treatment (Chapter 8), down the path it used before. B: in section, the johad holds water up to its FTL and its foreshore up to MWL is its flood storage; its overflow discharges against the design water level of the I&WRD drain, which sets its tailwater (Chapter 5); the post-monsoon water table, within 3 m of the ground and saline, meets the johad's bed and the low fields, so that no recharge or infiltration is credited (Clause 8.8.1, class (ii)) and storage, detention and drainage carry the design. The catchment and flow-path rules, the monsoon water line and the 15 m minimum are this Manual's proposals, offered as a technical method for the catchment that the Pond Act protects and not adopted by the Pond Authority; the Authority's permission and approval, a protected area notified under section 16, a section 45 limit or a notified wetland boundary governs where it says more. Original drawing for this Manual.

7.8 Operating rules and pre-monsoon flood cushion

7.8.1 **Operating rule content.** Every tank whose storage is counted under Clause 7.7 shall have a written operating rule, agreed by the custodian and kept with the O&M plan (Chapter 10). It shall state:

- (a) the levels and dates for filling, holding and drawdown through the year;
- (b) the sluice and regulator settings at each level;
- (c) who operates the sluices and regulators, and who may order a release;
- (d) the maximum release rate, set so that the release, added to the flow from the downstream catchment, does not cause flooding of buildings downstream;
- (e) the forecast and warning triggers (IMD district warnings, HSDMA 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&WRD control, the operating rule shall be I&WRD's rule. This Manual does not authorise any other body to operate a I&WRD tank.

> **Commentary.** No operating rule for a Haryana johad, bandh pondage or lake that keeps a flood cushion was found, and most johads have no controllable outlet, so Clause 7.8.3 applies to them. The controlled flows that matter in the State are those of the I&WRD's barrages and regulators: the releases of the Hathnikund barrage, which passed a record of about 8.28 lakh cusecs on 18 August 2019 (as reported) and take some 35 to 75 hours to reach Delhi (MoJS committee, 2024); the Dhansa regulator at the end of Outfall Drain No. 8, through which the drain passes to the Najafgarh drain; and the Masani barrage on the Sahibi, whose weir was left without gates when work stopped in 1986 and so cannot be operated at all (I&WRD, 2024). No HSDMA plan for urban flooding was found, and no warning protocol tied to a regulator setting or a pondage release was found. Without an agreed rule with dates, levels, release rates and a named operator, storage in a johad or pondage cannot be relied on, and a release made without warning to the colonies and fields downstream is itself a flood. Clause 7.8.2 turns that principle into a rule that can be checked, with a reliability test, because a cushion that is usually refilled by the early monsoon rain gives no protection in a July or August monsoon burst. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.
>
> Many johads have other users. A village johad on shamlat land is kept for the common purposes of the village, a use the courts have protected (*Jagpal Singh v. State of Punjab*, Supreme Court, 2011, as reported), and the Pond Authority restores ponds for the water-stressed villages first (statement to the Tribunal, 2024). Drawing a johad down before a storm has a cost to those who use it, which is why Clause 7.8.2(d) requires the custodian to accept it.

7.9 Restoration, desilting and deepening

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

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

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

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

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

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

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

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

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

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

> Commentary. The State's own deadline for flood-control works and drain cleaning has usually been 30 June, set at the meetings of the Haryana State Drought Relief and Flood Control Board and by the Chief Secretary's orders to the Deputy Commissioners, with one directive of 15 June (all as reported); no order of the Urban Local Bodies Department, GMDA or HSVP fixing a date for the desilting of drains or ponds was found. The date of 15 June in this Manual is set by this Manual: it comes before the monsoon's normal onset in the State, from about 27 June at Sonipat and 28 June at Ambala to about 3 July at Hisar (IMD, new normal dates, 2020), whereas 30 June comes after it in the north and east. Village johads are de-watered and de-silted by the Gram Panchayats from their own funds, under an order of the Development and Panchayats Department of 24 June 2023 (Pond Authority, statement to the Tribunal, 2024), and johads are also renewed under the Amrit Sarovar mission, under which 1,627 were reported completed in Haryana, though an Assembly reply gives smaller numbers (as reported; the figures conflict). No published measure of their effect on storage or recharge was found. Excavation to "increase capacity" is governed by Clause 7.9.3, and in the waterlogged belt deepening that cuts into the groundwater gives no storage at all. The 15 June 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 Haryana precedent.

7.10 Supply channels, surplus courses, inlets and outlets

7.10.1 **Part of the major system.** Supply channels and surplus courses are part of the major drainage system (Chapter 6). They shall be protected as waterbodies, with Zone 1 and Zone 2 setbacks under Clause 7.4.

7.10.2 **No closure or covering.** No supply channel or surplus course shall be closed, filled, diverted, covered, culverted along its length, or converted into a road or a closed drain, except under a design approved by the custodian that keeps or increases its 1% AEP capacity and its access for maintenance.

7.10.3 **Crossings.** Every road, rail, utility or access crossing of a waterbody, supply channel or surplus course shall:

- (a) pass the 1% AEP flow (with the climate factor), or the surplus of the upstream tank at its MWL, whichever is greater, with the freeboard required by Chapter 9;
- (b) not reduce the waterway width at the crossing below the full channel width as recorded in Revenue records or as surveyed, whichever is greater;
- (c) keep the channel bed level and grade; and
- (d) not raise the 1% AEP water level by more than the limit in Clause 7.6.2.

7.10.4 **Capacity.** The design capacity of a surplus course shall be the greater of the surplus weir discharge at MWL and the 1% AEP flow from its own catchment, combined as the cascade model (Clause 7.7.2) shows.

7.10.5 **Protection at structures.** Outlets of surplus weirs and sluices, and drain outfalls into waterbodies, shall have energy dissipation and scour protection designed under Chapter 9, so that the flow leaving them does not erode the bund, the bank or the channel bed.

7.10.6 **Drain outfalls into waterbodies.** A storm drain outfall into a tank, channel or wetland shall:

- (a) have its invert at or above the normal water level of the receiving waterbody, unless the drain is designed for submerged outfall under Chapter 5;
- (b) be located and aligned so that it does not cut through or weaken a tank bund;
- (c) have a gross pollutant trap and first-flush treatment (Chapter 8); and
- (d) not carry sewage or dry-weather flow (Chapter 8).

Commentary. This Manual protects supply channels and surplus courses as part of the major system. In urban areas they are often the first to be lost. Surplus courses are narrowed by culverts and compound walls, and supply channels are covered and turned into roads, which cuts the tank off from its source or leaves its surplus with nowhere to go. In Haryana the drains of the streets vest in the Municipal Corporations, the drainage works and rivers lie with the I&WRD, and the master drains of Gurugram with GMDA, but the split between them has not been written down. The Haryana Municipal Corporation Act, 1994 vests in the Corporation "All public drains, all drains in, along side or under any public street, and all sewage disposal works" (s. 193(1)), puts their maintenance and the construction of new drains on the Commissioner (s. 194(2)), and bars any building, wall, fence or other structure on a municipal drain without the Commissioner's written permission (s. 206). The Haryana Canal and Drainage Act, 1974 covers the I&WRD's drainage works, "escape channels from canals, dams, weirs, embankments, sluices, groins and other works for the protection of lands from flood or from erosion", but not "works for the removal of sewage from towns" (s. 2(7)), and makes any river, stream or drainage channel notified

under section 45 a drainage work. The GMDA Act, 2017 gives GMDA the drainage "which connects two or more sectors, municipal colonies or villages", leaving that within a sector, colony or abadi deh to the local body or licensee (as read from the Bill); the sector drains of an HSVP Urban Estate are external development works of HSVP, and the drains within a licensed colony internal development works of the colonizer, until they are handed over (Haryana Development and Regulation of Urban Areas Act, 1975, s. 2, as quoted by DTCP). No rule or order dividing the I&WRD's drains from the drains of the Municipal Corporations, HSVP or GMDA was found for this Manual. This Manual's working assignment, not a statement of law, is: rural and regional drains, Outfall Drain No. 8, the Haryana reach of the Najafgarh drain, rivers and embankments with the I&WRD; the Gurugram master drains (Legs I to IV) and the drains along the master and sector-dividing roads with GMDA; sector drains with HSVP until transfer; drains in licensed colonies with the colonizer until taken over; street and public drains in a Corporation with the Corporation; the drains of industrial estates with HSIIDC; and village ponds with the Gram Panchayat or Municipality as owner and the Pond Authority as regulator. Gurugram shows what is lost when the natural channels are treated as spare land: the High Court found in 2026 that "the channels that sustained these water bodies remain largely blocked"; DTCP's drawing of 2012 marks the Badshahpur drain across Khandsa village as "upgraded for enhanced capacity (work in progress)" and other reaches as "Katcha drain running" on land being made available; and a narrow reach is reported to cut the drain's capacity from 2,200 to 700 cusecs (as reported). The only existing rule on channel width is the Haryana Building Code's condition, for buildings of 5,000 to 20,000 m² built-up area, that the inlet and outlet of the natural drain system be kept "with adequate size of channel for ensuring unrestricted flow of water" (Code 12.1), with no width or design flow; Clauses 7.10.2 and 7.10.3 give it both. 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 johad 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 Haryana no shared form of storage is required by the building code: the rainwater harvesting of the Haryana Building Code 2017 is plot-level (Code 8.1), the large-project conditions ask for recharge bores and unpaved open space (Code 12.1), and the Code has no detention, peak-flow or "zero runoff" rule. The nearest existing forms of shared storage are the johads restored by the Pond Authority and renewed under the Amrit Sarovar mission, the old bandh pondages of Gurugram, the revival of the 18-acre Wazirabad lake

at Gurugram in 2022 (as reported), and the proposals of HUDA's catchment plan for the Badshahpur drain for "creation of check dam in Non-urbanizable area" and recharge wells along the drain (2017, revised 2020); the State's sub-regional plan for the NCR asks for "retention of rain water where it is received … by ponding, retardation dams" as policy. 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 Haryana State Wetland Authority;
- (b) the two Ramsar sites of Haryana (Sultanpur National Park and Bhindawas Wildlife Sanctuary, both designated on 25 May 2021), each to its boundary as designated, any wetland notified under the 2017 Rules, and the wetlands of the national atlas that the State is ground-truthing, until each is found not to be a wetland;
- (c) the Haryana side of the Najafgarh jheel and the depression of the Sahibi, the bandh pondages such as that of the Ghata bandh, the lakes of Badkhal, Surajkund and Damdama, and the marshy low land (dabar) and depressions of the floodplains (khadar) of the Yamuna and the Ghaggar, within the 1% AEP extent of Clause 7.3.4 or any limit notified under section 45 of the Haryana Canal and Drainage Act, 1974, whichever is larger (the river channel itself is a waterbody under the rest of this chapter); and
- (d) any other marsh, wetland, jhil or johad 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. Haryana's wetlands are the concern of the Haryana State Wetland Authority (the Wetland Authority of Haryana, reconstituted by the Environment and Climate Change Department on 12 May 2020), chaired by the Chief Minister, with the Secretaries of the Urban Local Bodies and Irrigation Departments among its members and the Director of Environment as Member Secretary. No wetland notified by it under the Wetlands (Conservation and Management) Rules, 2017 was confirmed for this Manual. The State has two Ramsar sites, both designated on 25 May 2021: Sultanpur National Park in Gurugram district, of 143 ha, and Bhindawas Wildlife Sanctuary in Jhajjar district, of 412 ha (Rajya Sabha reply, 13 February 2025; the Ramsar Information Sheets were not read). The Supreme Court, which is overseeing the ground-truthing and demarcation of the wetlands of the national atlas, named Haryana in August 2025 among the States with the least progress (*M.K. Balakrishnan v. Union of India*, W.P.(C) 230/2001, order of 19 August 2025, as quoted), and in October 2025 the State directed its Deputy Commissioners to verify 1,881 wetlands (as reported); the Union Ministry has said that the wetlands of the national atlas larger than 2.25 ha are protected under rule 4 of the 2017 Rules whether or not they are notified (office memorandum of 8 March 2022, as quoted). The Najafgarh jheel, which lies across the boundary with Delhi and receives the Sahibi and the Gurugram drains, is reported to have been accepted by Haryana as a water body in 2017 but never notified, and in March 2024 the State sought six weeks to designate it a transboundary wetland; most of it is reported to be privately owned (as reported). The National Green Tribunal directed in January 2022 that, until an integrated plan is made, the environment management plans of Haryana and Delhi be enforced and the 2017 Rules "be strictly followed", that the jheel's water be "at least Class 'C'", and that its outlet "should remain free from sewage" (O.A. 153/2014, as quoted by the Wetland Authority). A drain outfall, desilting, diversion or regulator operation in or near a Ramsar site, a notified wetland or the Najafgarh jheel therefore needs the Wetland Authority's permission where the notification or the Rules regulate it, and compliance with the Tribunal's directions, as well as compliance with this chapter; for the johads, jhils and depressions that are not notified, this chapter, the Pond Act and the revenue and municipal law are the only controls. Clause 7.12.2 targets a specific risk: drains built to relieve flooding next to a marsh can drain the marsh itself, and once it is dry it is encroached. Sewage reaches Haryana's johads, drains and wetlands through the storm drains (Clause 8.9, Commentary). Gurugram's Legs I to III carried about 138 MLD of untreated sewage to the Najafgarh drain in 2020, of which 51.30 MLD had still to be diverted or treated (GMDA), and a proposed 400 MLD treatment wetland near Najafgarh for Leg III was "not considered being not financially viable" (GMDA, action taken report, 2021); to keep treated water out of the drain, the State raised the capacity of the channel taking Gurugram's treated sewage to Jhajjar for irrigation from 188 to 550 MLD (Wetland Authority, report to the Tribunal, 2022). In the villages, a joint committee of the Tribunal found "discharge of untreated effluent in the water bodies" at Kharkhara in Rewari district (O.A. 573/2023), and the Pond Act forbids the discharge of untreated municipal waste into a pond (s. 14(iii)). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by many existing outfalls. In Haryana they apply in full to every new outfall, and every existing outfall to a johad, lake, wetland, river or I&WRD drain that carries dry-weather flow comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed.

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. Haryana's main controls on filling and building in johads, drains and their catchments are the Pond Act, the drainage and municipal law and the courts. The Pond Act forbids building on pond land, green belt and catchment area, and obstructing the inflow or outflow, without permission (s. 14), lets the Authority direct the Gram Panchayat or Municipality to remove any building or obstruction within a protected area and pond land (s. 15(2)), and punishes a contravention with a fine of up to ₹25,000 or imprisonment of up to three months, or both (s. 20). Within a section 45 reach, the Divisional Canal Officer may order an obstruction removed, remove it himself and recover the cost as arrears of land revenue (Haryana Canal and Drainage Act, 1974, s. 46), and in a Municipal Corporation the Commissioner may remove a structure built on a municipal drain (Haryana Municipal Corporation Act, 1994, s. 206(2)). Village ponds on shamlat land are commons: the Supreme Court refused to interfere with a High Court order that a village pond be used for the common purposes of the villagers (*Jagpal Singh v. State of Punjab*, 2011, as reported), and the High Court has ordered filled common ponds in Haryana restored under the Punjab Village Common Lands (Regulation) Act, 1961 (as reported). The National Green Tribunal directed in 2018 that unique IDs be given to, and restoration made of, at least 123 water bodies in Gurugram, and the exercise repeated across the State (O.A. 325/2015, order of 20 July 2018); MCG has pursued litigation over the common land of the Ghata bandh (GMDA, report to the Tribunal). In the Aravalli districts, the Supreme Court held in 2018 that land notified under the Punjab Land Preservation Act, 1900 is "forest" and ordered constructions in Kant Enclave at Faridabad made after 18 August 1992 demolished (*M.C. Mehta v. Union of India (Kant Enclave)*, 11 September 2018, as reported; the judgment was not read). A complaint before the Tribunal in 2025 concerns a pond in Sector 7, Ambala City, "recorded as a Jhord (water-holding area) in the revenue records", said to be being filled (O.A. 351/2025, CPCB reply). This Manual treats a recorded johad, with its catchment and flow paths, as drainage infrastructure (definitions after Clause 7.2), and land recorded as a johad, talab or jhord as a waterbody under Clause 7.3 whatever its present state. The Pond Authority's rules, if any, the Punjab Village Common Lands (Regulation) Act, 1961, the Punjab Land Preservation Act, 1900 and the encroachment provisions of the development authority Acts were not read for this Manual. 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 June) 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 bunds of most johads are low and are not expected to make them specified dams, but each shall be screened under Clause 7.14.1. The old bandhs of Gurugram are higher: the Ghata bandh is about 1.25 km long and about 5 m high (GMDA), and the heights of the Chakarpur, Jharsa and Wazirabad bandhs were not found; each shall be screened. The I&WRD's barrages, such as Hathnikund and Masani, are not tanks under this chapter (Clause 7.7, scope note). Where the storage of a johad, bandh pondage or lake is counted under Clause 7.7, its bund or bandh is a tank bund for Clause 7.14.2 unless the Act applies. Whether a tank bund that is not across a river or tributary is a "dam" under the Act is not clear from its text. In Haryana the embankments that matter to the towns are the I&WRD's river embankments and the bunds of its drains, and the old bandhs of Gurugram that now stand among buildings. In July 2023 the Ghaggar breached its embankments: a major breach at Ambala was plugged with the help of the Army, and the Municipal Corporation pumped the flooded parts of the city (Vidhan Sabha reply, September 2023); in Fatehabad the Chandpura embankment and the Rangoi nullah breached and some 50 to 80 villages were flooded (reports differ), and breaches were also reported in Kaithal and Sirsa districts (as reported). No breach map or emergency action plan for a johad bund, a bandh or a drain embankment was found. A failed or overtopped bund floods the colonies and fields below it, and an unannounced release floods them too, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments. The hazard classes, the breach analysis and the emergency action plan for high-hazard tanks are set by this Manual. They extend the Chapter 4 requirement for detention basins (1% AEP spillway with outlet blocked, 0.2% AEP for high-hazard basins) to tanks that are counted as design storage.

7.15 Submittal requirements

Every drainage report for a development or work under Clause 7.1.2 shall include:

1. the **Waterbody Sheet (Form 7-1)** under Clause 7.3.2, with the setback zones and their basis (mapped extent, hydraulic study or fixed width);
2. the hydraulic study of the 1% AEP extent and floodway, where Clause 7.3.4 requires it;
3. the **Compensatory Storage Calculation (Form 7-3)**, by elevation band, where fill is proposed in the flood fringe;
4. for any tank storage counted: the **Tank Storage Credit Sheet (Form 7-2)**, with the survey, stage–storage curve, operating rule, cascade model results and custodian concurrence of Clause 7.7.1;
5. for any crossing, outfall or work in Zone 1: the custodian's NOC and the hydraulic analysis of Clause 7.6.2 or 7.10.3;
6. for restoration or desilting: the pre-works survey, silt tests and hydrogeological report of Clause 7.9; and
7. for any embankment: the Dam Safety Act screening and hazard class of Clause 7.14.

7.16 Review and update

7.16.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). The fixed-width table of Clause 7.4.6 shall also be reviewed within 2 years of the Authority adopting 1% AEP flood maps for its area.

7.16.2 Where the Authority adopts new 1% AEP flood maps, they apply to new submittals **6 months** after adoption, unless the Authority notifies otherwise.

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Annexes and forms

Annex / Form	Content
7A	Statewide waterbody GIS layer and inventory fields

Annex / Form	Content
7B	Fixed-width setback table (alternative S-3, with Annex 1C)
7C	Template tank operating rule, with flood cushion
7D	Desilting and restoration specification
7E	Glossary of Hindi and Urdu 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 Haryana 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 Haryana 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 Haryana, and because no treatment BMP works for long if they are not removed. CPHEEO (2019) notes that Indian drains carry night soil, urine and food waste (Part A §9.5). In its WSUD procedure it lists TSS, total nitrogen, total phosphorus and gross pollutants as the key pollutants (Part A Ch. 10). AMRUT 2.0 funds the harvesting of rainwater "through storm water drains into water body (which is not receiving sewage/effluent)" (Lok Sabha unstarred question AU1419), which only works if sewage is first kept out of the drains.

8.4 Water quality volume and design flow

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

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

where:

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

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

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

where:

- WQv is in m^3;
- A = the contributing area, m^2;
- $Rv = 0.05 + 0.009 \cdot I$; and
- I = the impervious percentage of the contributing area (0–100), after the connectivity rules of Clause 3.9.

The Rv form above may be used only for sites under 0.5 ha and under the Tier B simplified method (Clause 4.14). This is the same limit as for the retention volume (Clause 4.4.2). For all other sites the WQv shall be computed with the SCS-CN method, as the retention volume is: WQv (m^3) = 10 × Q_{wq} × A, where Q_{wq} (mm) is the SCS-CN runoff from P_{wq} for each sub-area and A is in ha.

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

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

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

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

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

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

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

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

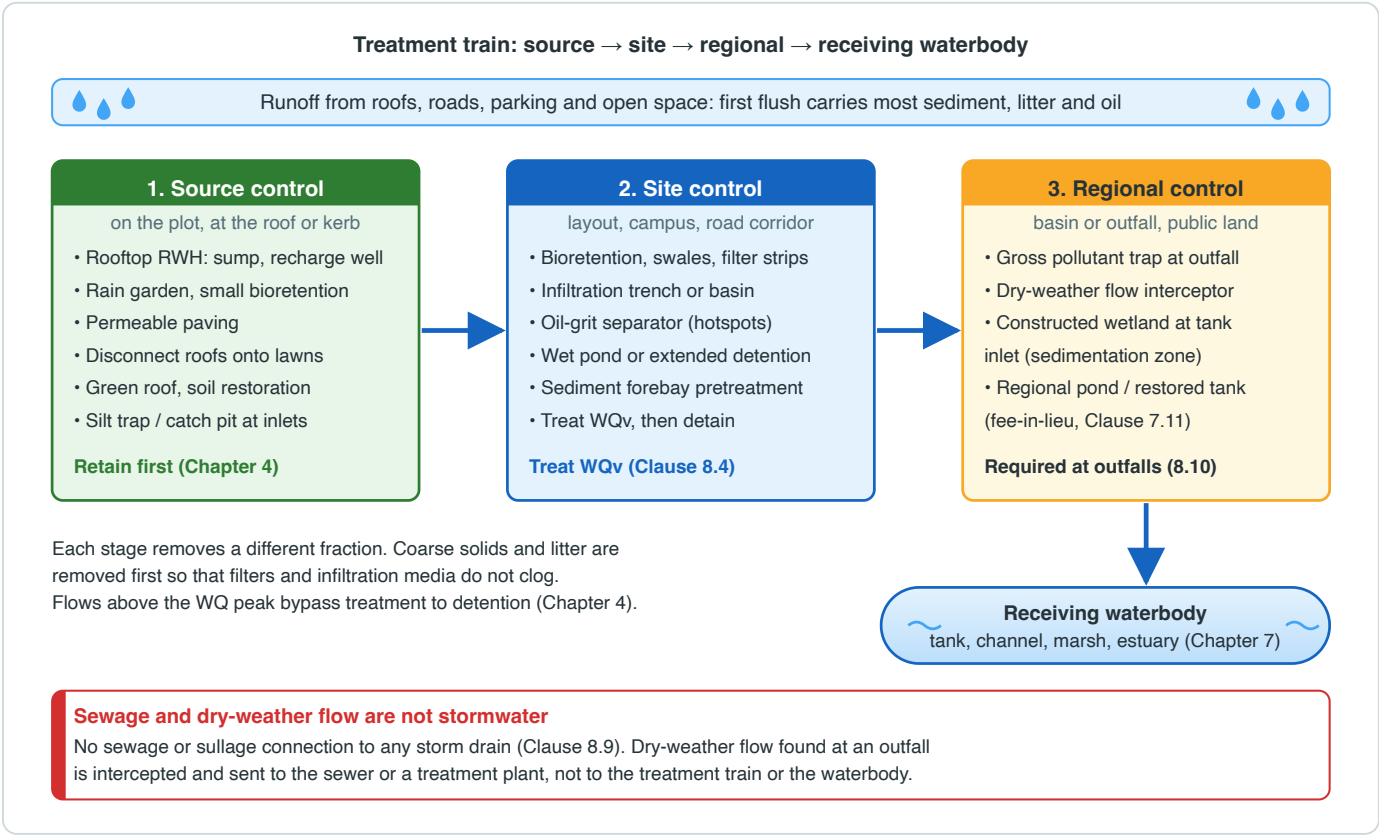


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater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

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Dune sands, alluvium and piedmont gravels	Laterite / hard rock	Sodic and saline-sodic soils / water table within 3 m	Haryana 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	Dune sands, alluvium and piedmont gravels	Laterite / hard rock	Sodic and saline-sodic soils / water table within 3 m	Haryana 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 Haryana 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. Haryana 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.**

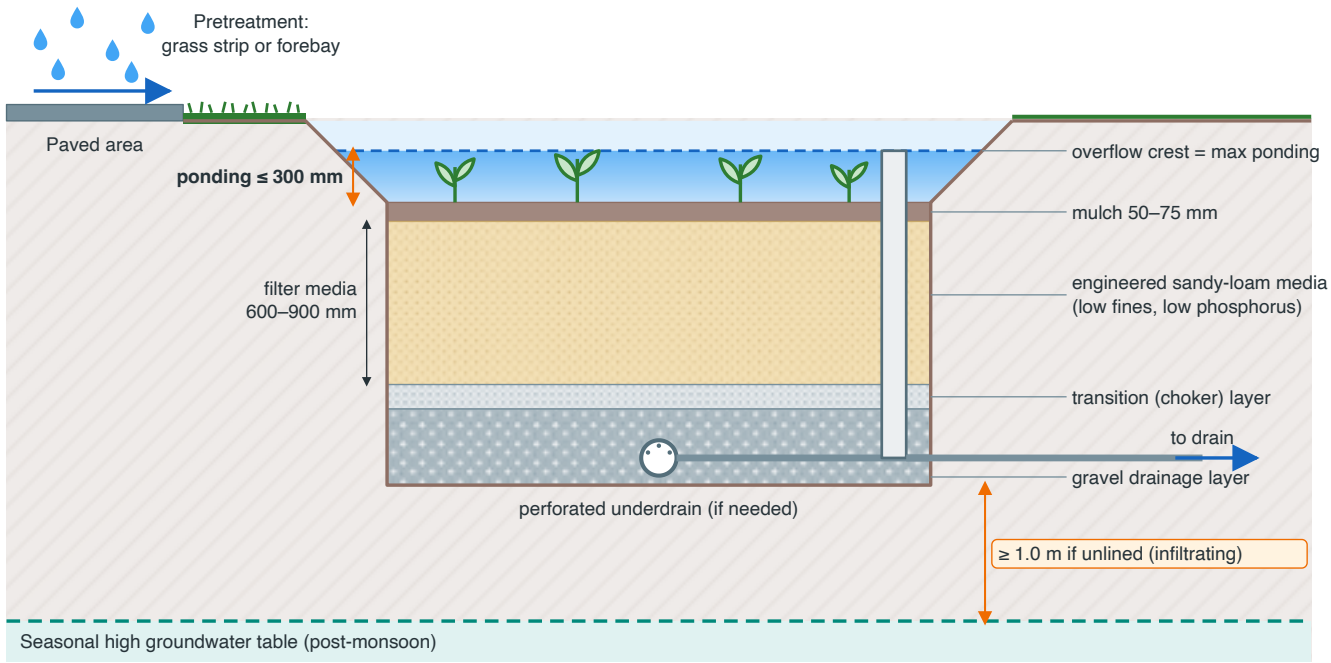
- (a) At every inlet that receives runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody.
- (b) A sump at least 300 mm below the outlet invert.
- (c) Silt traps are pretreatment only and earn no VR.

> **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 Haryana. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Haryana. Surface ponding in bioretention and rain gardens must drain within 48 hours (Clause 8.7.2(b)), well inside the time mosquito larvae need to develop. This is consistent with the 24–48 hour WQv drawdown of Clause 8.4.7.
> - **Dry seasons.** Most of Haryana's rain falls in the south-west monsoon, and the State is wet in the north-east and dry in the south-west: the district normals range from 325.3 mm a year at Sirsa and 396.5 mm at Hisar to 577.8 mm at Gurgaon, 988.0 mm at Ambala and 1,073.6 mm at Chandigarh (IMD, *Climate of Haryana*

and Union Territories of Delhi and Chandigarh, 1991, normals of 1901–1980), and July and August alone bring 354.7 mm of Gurgaon's 577.8 mm. The monsoon now sets in at Sonipat on about 27 June, at Ambala on about 28 June and at Hisar on about 3 July, and withdraws from Hisar by about 21 September and from Sonipat by about 25 September (IMD, new normal dates, 2020). For eight or nine months of the year johads and jhils fall or dry out unless they are fed, and in the villages and towns the feed is often sullage or sewage (Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool through the dry months on its own catchment's runoff is not to be used; in the dry south-west (sub-areas HR-E and HR-F) the dry forms of Clause 8.7 (bioretention, swales, infiltration where Clause 8.8.1 allows it, and extended dry detention) are the practical choice, and in the waterlogged belt (sub-area HR-D) lined and surface forms that do not infiltrate. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; johads, talabs, jhils and bandh pondages are waterbodies under Chapter 7 and are not to be used as treatment for a development, even where the Pond Authority treats the grey water reaching a village pond in a constructed wetland of its own. 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 Haryana drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

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



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

Dimensions as set in Clause 8.7.2.

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

8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Haryana, which has no coastal sand areas (Clause 8.8.9). **Depth to water decides.** Haryana's groundwater runs to both extremes: the stage of extraction was 135.96% in 2024, with 88 of the 143 assessment units over-exploited, yet every block of Rohtak and Jhajjar was "safe", because there the water table is near the surface (CGWB). For this Clause the seasonal high groundwater table is the post-monsoon level (October and November), not the pre-monsoon level, and each site falls in one of three classes. (i) **Deeper than 10 m** (as over most of Gurugram, Faridabad, Kurukshetra, Kaithal, Karnal, Panipat, Mahendragarh and Rewari): recharge, with pretreatment, is the first means of meeting retention wherever this Clause is met. (ii) **Within 3 m** (the land that the Haryana Water Resources Atlas maps as waterlogged (0 to 1.5 m) or prone to waterlogging (1.5 to 3 m), which in June 2023 was about half of Rohtak district and two-fifths of Jhajjar, with parts of Hisar, Jind and Sonipat; sub-area HR-D generally; the floodplains of the Yamuna and the Ghaggar; the beds and foreshores of johads, talabs and jhils; and the reaches notified under section 45 of the Haryana Canal and Drainage Act, 1974): no infiltration facility, recharge pit, recharge well or recharge shaft shall receive runoff of any kind, the exception for roof water in Clause 8.11.3(c) does not apply, and no infiltration or recharge is credited toward retention or the WQv; retention there is met by storage for use, by evaporation from shallow lined storage and by detention under Chapter 4, and drainage governs the design. (iii) **Between 3 m and 10 m**: infiltration or recharge is credited only on a hydrogeologist's report of the seasonal high water table and its trend over at least the past five years that shows that this Clause is met, that the water table is not rising, and that the mound below the facility will not reach a foundation, a basement or the root zone of adjoining saline land. The Haryana Water Resources Authority is to "discourage and prevent such activities that are likely to lead to potential water logging of land" (Haryana Water Resources (Conservation, Regulation and Management) Authority Act, 2020, s. 21(7)), and class (ii) is this Manual's means of not adding to it. **Quality.** The groundwater of the south, west and centre of the State is mostly saline (Sirsa, Fatehabad, Hisar, Jind, Jhajjar, Bhiwani, Nuh, Mahendragarh, Rewari and Faridabad districts, CGWB), and in 2024 fluoride exceeded 1.5 mg/L in 23.66% of the samples tested. In those districts recharge does not make the groundwater fit to drink: a recharge well is used only after a check of the groundwater quality and the water-table trend at the site, water drawn back from a recharged aquifer is tested before any drinking use, and no industrial or sewage-laden runoff is led to any recharge structure. Road runoff reaches the ground only through a filtered surface infiltration facility (Clause 8.11.3(b)). The classes, the 3 m and 10 m limits and the post-monsoon reading are 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.** This Clause applies only to coastal sand aquifers. Haryana has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The dune sands of Sirsa, Hisar, Bhiwani and Mahendragarh and the sands of the Yamuna and Ghaggar beds and floodplains (khadar) are not coastal sand areas: Clause 8.8.1 applies there in full, and the reduced separation of item (d) does not. In coastal sand areas:

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

8.8.10 **Laterite and hard-rock areas.** In laterite and hard-rock terrain (for example the Aravalli rock and scree of the ridges of Gurugram, Faridabad and Nuh and of the hills of Mahendragarh and Rewari, where groundwater is held mainly in the weathered and fractured zone, and the Shivalik hill slopes of Morni and Kalesar):

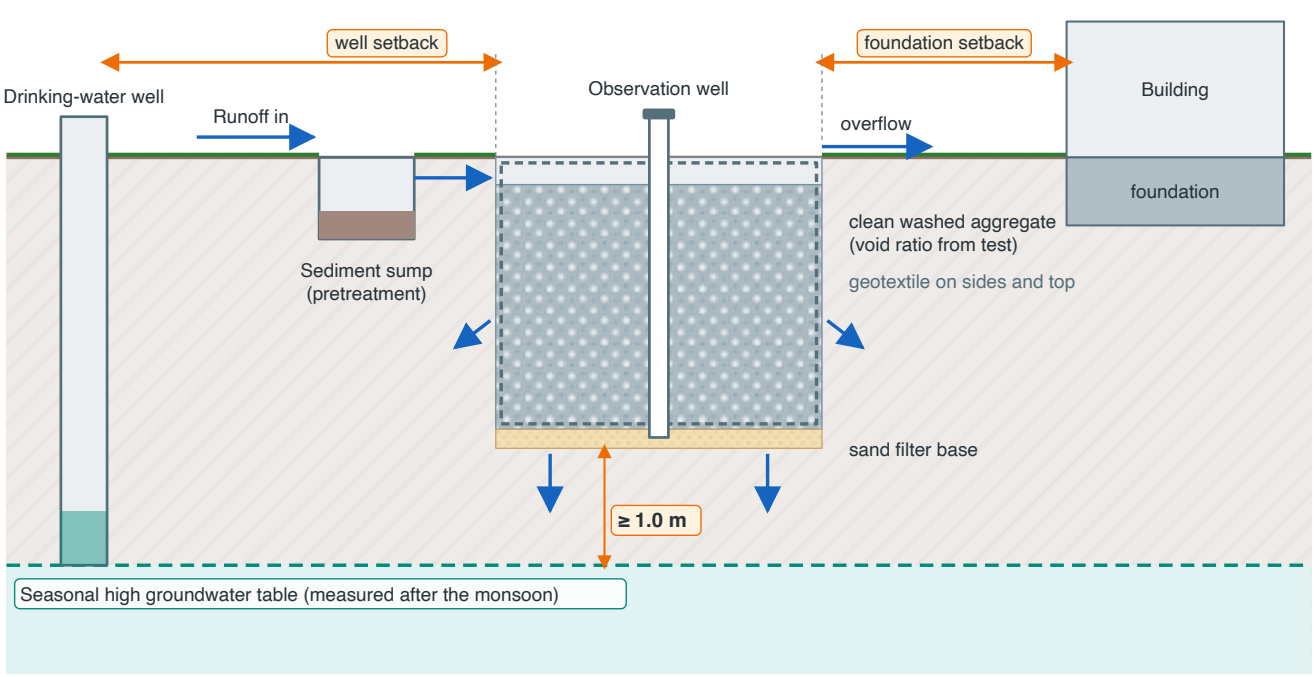
- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes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

8.8.11 **Delta clays and black cotton soils.** In the silted beds of johads, talabs and jhils, the clay of the Najafgarh jheel and other inland depressions, the saline-sodic soils of the Rohtak–Jhajjar–Sonipat belt (sub-area HR-D), the sodic soils of Kurukshetra, Kaithal and Karnal, the Shivalik clays, ground where a kankar pan or a cemented boulder bed lies within about 1 m of the surface, 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 Haryana precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Haryana RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.
>
> No statewide map of hydrologic soil groups for Haryana was found, and no measured basic infiltration rates by soil group; every infiltration design needs the tests of Clause 8.8.3. The State's ground is about 98% alluvium and 2% hard rock (CGWB), and falls into six broad kinds. Along the Shivalik foothills a piedmont belt about 2 to 4 km wide of coarse sand, gravel and boulders (CGWB) takes water fast, but the Shivalik clays and cemented boulder beds do not. The recent alluvium of the Yamuna and the Ghaggar, sandy loams in the Karnal, Panipat, Kurukshetra and Yamunanagar plains, is open; the older alluvium of the Gurugram and Faridabad plains, Sonipat and Jind, loams and clay loams with kankar, is slower. The sodic soils of Kurukshetra, Kaithal and parts of Karnal and Jind seal at the surface, and the saline and saline-sodic soils of the Rohtak–Jhajjar–Sonipat belt lie over a water table that is within 3 m of the ground over much of the belt (salinity and sodicity by district as reported by CSSRI; water table from the Haryana Water Resources Atlas, 2025). The Aravalli rock and scree of Gurugram, Faridabad, Nuh and Mahendragarh, mapped as "hill area" over about 17 to 23% of those districts (CSSRI, 2016), sheds water, though deep colluvial fans take some; and the dune sands of Sirsa, Hisar, Bhiwani and Mahendragarh take water fast except where a kankar or saline pan lies near the surface. This Manual's interim soil groups follow from these: Shivalik piedmont gravels A or B, but C or D on Shivalik clays and cemented boulder beds; Yamuna and Ghaggar alluvium B or C; sodic soils D; the saline-sodic soils of the waterlogged belt D, with no infiltration credit; Aravalli rock and scree D, and C on deep colluvium; dune sands A, and C or D on kankar and saline pans; and made ground C unless tested. **Groundwater runs to both extremes.** In the assessment of 2024 the stage of groundwater extraction for the State was 135.96%, and of 143 assessment units 88 were over-exploited, 11 critical, 8 semi-critical and 36 safe (CGWB); every block of Gurugram, Kaithal, Karnal, Kurukshetra and Panipat was over-exploited, and every block of Rohtak and Jhajjar safe, the latter because the water is close to the surface. In June 2023 the water table was deeper than 30 m over about 97% of Kurukshetra district, 85% of Mahendragarh and 51% of Gurugram, and within 3 m of the ground, waterlogged or prone to it, over about half of Rohtak district and two-fifths of Jhajjar (Haryana Water Resources Atlas, 2025, this Manual's reading of its tables); the area within 3 m grew from about 2.93 lakh ha in June to about 3.79 lakh ha in October. Pre-monsoon depths in the CGWB's wells ranged from 0.85 m at Kulasi in Jhajjar to 53.45 m in Fatehabad in June 2021, with very shallow water "in isolated patches in Jhajjar, Ambala and Rohtak districts" and a groundwater trough in Panipat and Sonipat along the Ambala–Delhi highway (CGWB, Ground Water Year Book 2021–22). The quality of the groundwater is poor in the south, west and centre: of 879 samples tested in 2024, 21.05% had an electrical conductivity above 3,000 µS/cm, 23.66% fluoride above 1.5 mg/L and 14.56% nitrate above 45 mg/L (CGWB), and

the water of Sirsa, Fatehabad, Hisar, Jind, Jhajjar, Bhiwani, Nuh, Mahendragarh, Rewari and Faridabad districts is "mostly saline" (CGWB, 2021–22). The Haryana Water Resources Authority regulates groundwater under its Act of 2020 and has classified villages by their water level; the Central Ground Water Authority declared the whole of Gurgaon district a notified area in 2011 (as quoted; since 2020 groundwater NOCs in Haryana are issued by the State Authority). **The State therefore needs recharge in some places and must avoid it in others.** Where the post-monsoon water table is deeper than 10 m, recharge comes first, with pretreatment; where it is within 3 m, in the waterlogged belt, the floodplains and the beds of johads and jhils, no recharge or infiltration is credited, and storage, detention and drainage carry the design; in between, a hydrogeologist decides (Clause 8.8.1). Everywhere, runoff from roads goes to surface systems and never directly to a recharge well, borewell or shaft (Clause 8.11.3(b)), and water drawn back from a recharged aquifer for drinking should be tested for fluoride, nitrate and salinity. Clause 8.8.9 has no effect in Haryana, which has no coast.



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

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

8.9 Sewage cross-connections and dry-weather flow

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

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

8.9.3 **Where no sewer exists.** Where no sewer is available, sewage and sullage shall go to an approved on-site or decentralised treatment system. The treated effluent of such a system may be discharged to a storm drain only with the written consent of the Haryana State Pollution Control Board (HSPCB) 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 Haryana. 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 Haryana the law already separates the two. In a Municipal Corporation the Commissioner may require "one drain for filth and polluted water and an entirely distinct drain for rain water and unpolluted sub-soil water" (Haryana Municipal Corporation Act, 1994, s. 202), and no one may discharge foul water into a Corporation drain provided for surface water, or have a drain made to communicate directly with a storm water overflow drain (s. 196); a "drainage work" of the I&WRD "does not include works for the removal of sewage from towns" (Haryana Canal and Drainage Act, 1974, s. 2(7)); and no one may discharge untreated municipal waste or industrial effluent into a pond (Haryana Pond and Waste Water Management Authority Act, 2018, s. 14(iii)). In practice the drains carry sewage: the State's own sub-regional plan for the NCR records that "drains actually act as combined system both for sewage and drainage". In Gurugram the three master drains, Legs I, II and III (the Badshahpur drain), outfall to the Najafgarh drain, and the National Green Tribunal has made it a condition of that discharge that the water in them have a BOD of not more than 30 mg/l (as GMDA reported to the Tribunal in 2020). In 2020 the three Legs carried about 138 MLD of untreated sewage, of which 51.30 MLD had still to be diverted or treated (GMDA); their average BOD in 2023 was 48, 63 and 44 mg/l, and that of the Budhiya nala at Faridabad, before it reaches the Yamuna, 76 mg/l (State of Haryana, report to the Tribunal, 2024); and in the dry season of 2021 Leg III carried an

average of 126.53 cusecs (Vidhan Sabha reply, 2022). In the villages the drains carry sullage to the johads, and a joint committee of the Tribunal found untreated effluent reaching the johad of Kharkhara in Rewari district; the Pond Authority treats the grey water reaching ponds in constructed wetlands, while "strong sewage" is for the Public Health Engineering Department (Pond Authority, statement to the Tribunal, 21 February 2024). The diversions on the Legs, and the interception of village sullage ahead of a johad, are DWF interceptors under Clause 8.9.5, and Clause 8.9.5(b) applies to them in full: each is sized from the measured dry-weather flow, does not reduce the drain's capacity for the minor and major events, and sends the storm flow above its capacity on down the drain or over the johad's overflow, never to the treatment plant or back into the village.

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 Haryana 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 Haryana Building Code 2017 (Code 8.1, under which roof rainwater harvesting is required, in the areas the Competent Authority notifies, where the rooftop is 100 m² or more, groundwater recharge is mandatory for all buildings on plots of more than 500 m² and for parks, parking, plazas and other common areas, the recharge well is kept at least 10 m from any structure handling sewage or

industrial waste water, and no occupation certificate is issued until an architect or engineer certifies the system functional, with strict implementation in ten named towns; and the environmental conditions of Code 12.1 for buildings of 5,000 to 20,000 m² built-up area, of at least one recharge bore per 5,000 m² and an unpaved area of at least 20% of the recreational open space) continues to apply, subject to the limits of Clause 8.8.1 (Chapter 1). This Clause sets how RWH structures are counted under this Manual.

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

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

8.11.3 **Recharge structures.**

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

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

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

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

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

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

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

> Commentary. The rule that RWH storage does not count as detention is set in Chapter 4. Haryana's building code makes rainwater harvesting and recharge mandatory, but sets no detention rule. Under the Haryana Building Code 2017, roof rainwater harvesting is required "In the areas specified by the Competent Authority, through a notification", where "the area of the rooftop is 100 square metres or more" (Code 8.1(1)); groundwater recharge "shall be mandatory not only for residential buildings but for all types of buildings, including Group Housing Societies having a plot area more than 500 square metres and above", and for "open spaces like parks, parking, plazas, playgrounds and other common areas" (Code 8.1(2)); only clear water may enter, the first shower is to be segregated, and the recharge well is to be "not less than 10 metres away from any structure handling sewage or industrial waste water" (Code 8.1(3)); an architect or engineer certifies the system functional, and without it no occupation certificate is issued (Code 8.1(3)(vii) and (ix)); and the rule is to be "strictly implemented" in Panchkula, Kurukshetra, Shahabad, Karnal, Panipat, Sonepat, Gohana, Faridabad, Yamuna Nagar and Gurgaon (Code 8.1(4)). The two thresholds use different bases, 100 m² of rooftop for harvesting and 500 m² of plot for recharge; one State action plan reads them as a single 500 m² rule with 100 m² "recommended" (HARSAC, 2021),

which misstates the Code. For buildings of 5,000 to 20,000 m² built-up area, the environmental conditions ask for recharge bores, "minimum one per 5000 sqm of built-up area", reuse of the stored water and "unpaved area … more than or equal to 20% of the recreational open spaces" (Code 12.1). The Code's predecessor in the Urban Estates was HUDA's notification of 31 October 2001, for buildings with a rooftop of 100 m² or more; HSVP counted 460 harvesting structures in its open spaces and 1,92,700 in private plotted buildings by December 2023, and in 2024 asked its allottees for an undertaking that their structures are functional (I&WRD, report to the Tribunal; HSVP, 2024). A direction of the Chief Minister of 30 June 2026 that harvesting be mandatory in government buildings and urban residential plots of more than 250 square yards was reported, but no notification was seen. The amendments to the Code read or reported to 2026 do not touch Code 8.1. The Haryana Water Resources Authority, which issues groundwater NOCs and is to "encourage rainwater harvesting and catchment conservation as per geohydrological conditions" (Haryana Water Resources (Conservation, Regulation and Management) Authority Act, 2020, s. 21(3)), sets no building-level volume either. The Code sets no sizing method, storage to be empty before a storm or peak-flow limit. Because Haryana's water table is either very deep or very shallow (Clause 8.8.1), the function of harvesting depends on where the building is: recharge is its main function where the post-monsoon water table is deeper than 10 m, as over most of Gurugram, Faridabad and the Kurukshetra–Karnal–Panipat belt (Clause 8.11.2(b)); in the waterlogged belt and on the floodplains, where it is within 3 m, the Code's recharge duty can be met only by storage for use, and recharge structures earn no credit under this Manual. RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a July or August monsoon burst 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 June**; and
- (c) any area exposed between 15 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 Haryana'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 June stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 15 June 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 Haryana it settles in the johads and bandh pondages that the nalas and flow paths feed, and in the I&WRD drains that take their overflow (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 Haryana 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	Haryana BMP performance calibration
8D	BMP design sheets, media specification, plant lists
8E	Erosion and sediment control standard details
Form 8-1	Water Quality Sheet
Form 8-2	Infiltration Test Record

CHAPTER 9

Hydraulic Design of Structures

9.1 Purpose and scope

9.1.1 This chapter sets the hydraulic design methods for the structures used in the minor and major systems (Chapter 6), in retention and detention facilities (Chapter 4), at outfalls (Chapter 5) and at waterbodies (Chapter 7). It covers:

- (a) pipes and box drains (Clause 9.3);
- (b) culverts (Clause 9.4);
- (c) open channels (Clause 9.5);
- (d) energy dissipators, outlet protection and drop structures (Clause 9.6);
- (e) detention outlet structures (Clause 9.7);
- (f) trash racks and screens (Clause 9.8);
- (g) pumps and sumps (Clause 9.9);
- (h) tide gates, flap gates and non-return valves (Clause 9.10);
- (i) inlets and gratings (Clause 9.11);
- (j) manholes, junction chambers and access (Clause 9.12); and
- (k) materials and durability, including coastal and saline exposure (Clause 9.13).

9.1.2 **Structural design is outside the scope of this Manual.** Structures shall be designed structurally to the applicable Indian Standards and IRC codes, for example IS 456 (plain and reinforced concrete), IS 458 (concrete pipes), IRC:SP:13 (small bridges and culverts) and the IRC bridge codes. Where this chapter refers to a structural standard, it does so only for durability (Clause 9.13) or hydraulic performance.

9.1.3 Design flows, design AEPs and level-of-service limits come from Chapters 2 to 7. This chapter does not change them.

> **Commentary.** APWA Section 5600 places most structure hydraulics in its sections on inlets and manholes (5604), enclosed pipe systems (5606), engineered channels (5607) and detention (5608). CPHEEO (2019) spreads them across Chapters 5, 6, 8 and 11. This chapter gathers them in one place and points to the US Federal Highway Administration (FHWA) hydraulic circulars for methods that Indian codes do not cover in enough detail: HDS-5 for culverts, HEC-14 for energy dissipators, HEC-22 for inlets and access holes, and HEC-24 for pump stations. The FHWA editions cited are those listed in the FHWA hydraulics library as of October 2026.

9.2 General requirements

9.2.1 **Tailwater.** Every structure that discharges to a river, to a drain of I&WRD, to the Najafgarh drain or to a johad or pond whose level can rise above the outfall invert shall be analysed with the tailwater conditions of Chapter 5: the non-tidal tailwater of Clause 5.6 for minor- and major-system design; the riverine backwater of Clause 5.8, including the flood released from Hathnikund barrage on the Yamuna and from the Kaushalya dam on the Ghaggar near Pinjore, and the flood from the Shivalik choes; the outfall-closed check of Clause 5.10 wherever the receiving water can rise above

the outfall invert, which is the case for the town drains that outfall to the Yamuna, from Yamunanagar to Palwal, and to the Ghaggar, the Tangri and the Markanda, from Panchkula and Ambala to Kaithal, Fatehabad and Sirsa, for the drains that outfall to I&WRD drains, among them Outfall Drain No. 8, which ends at the Dhansa regulator on the Delhi border, and for Gurugram's master drains, Legs I to III, which outfall to the Najafgarh drain; for an outfall to an I&WRD drain, the design water level of that drain at the outfall, with I&WRD's consent, or, where none is published, the level of the drain running at its design capacity (set by this Manual); for an outfall to the Najafgarh drain, its level at the outfall at its design flow, which is to be agreed with Delhi's Irrigation and Flood Control Department through I&WRD [TBC], because the drain runs on through Delhi, whose regulators set its level; the level held in a drain by any regulator, sluice, bundh, barrage or pumping station downstream of the outfall, taken as a fixed control at its gate-closed level, its weir or bund crest or the start level of its pumps; and the joint case of Clause 2.12. Where a catchment has no outfall and ends in a johad or depression, the tailwater is the level reached in that storage when it holds the 72-hour design volume with no outflow other than infiltration and evaporation (Clause 4.12.7). No document found sets a design river or drain level at any outfall in Haryana; until one is published, the levels of Chapter 5 apply.

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

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

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

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

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

9.3 Pipes and box drains

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

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

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

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

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

9.3.5 **Changes of size and direction.**

- (a) Pipe size shall not decrease downstream.
- (b) Pipes shall join only at manholes or junction chambers, except that inlet connections may join pipes of 1,200 mm or more through a factory-made junction.

- (c) Changes of direction greater than 90° in a single structure are not permitted.

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

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

9.4 Culverts

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

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

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

> HWo = ho + H − L·S

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

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

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

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

Barrel and inlet	ke
Concrete pipe, projecting from fill, socket (groove) end	0.2
Concrete pipe, projecting from fill, square-cut end	0.5
Concrete pipe, headwall or headwall with wingwalls, socket end	0.2
Concrete pipe, headwall or headwall with wingwalls, square edge	0.5
Concrete pipe, headwall, rounded entrance (radius = D/12)	0.2
Concrete pipe, mitred to conform to fill slope	0.7
Concrete pipe, bevelled edges	0.2

Barrel and inlet	ke
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.

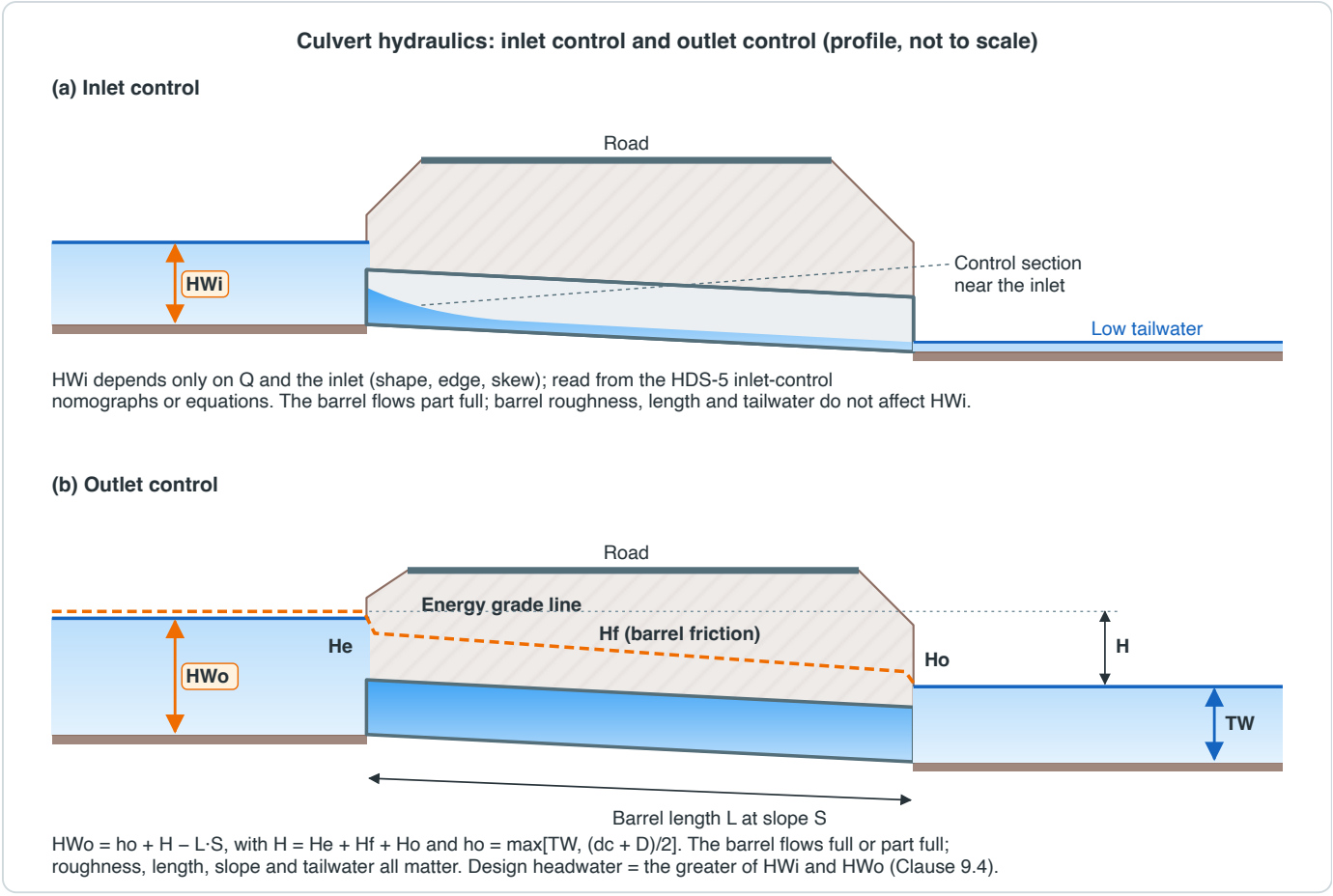

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

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

9.5 Open channels

9.5.1 **Flow computation.** Open channels shall be designed by Manning's equation for uniform flow, with the n of Table 6.6. Water levels shall be computed by gradually varied flow (standard step) analysis where tailwater, bridges, culverts, bends or changes of section affect them, which on the town drains that outfall to the Yamuna and the Ghaggar, whose levels releases from Hathnikund barrage and the floods of the Shivalik choes set, on Gurugram's master drains, which outfall to the Najafgarh drain through reaches that narrow at Khandsa and Hero Honda Chowk (as reported), on drains that end at an I&WRD drain or regulator, such as Outfall Drain No. 8 and the Dhansa regulator, and on the flat drains of the waterlogged Rohtak–Jhajjar–Sonipat belt, 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 Haryana (the recent alluvium of the Yamuna and Ghaggar plains, the older alluvium with kankar of the NCR plains, the sodic soils of the Kurukshetra–Kaithal–Karnal plains, the saline-sodic soils of the waterlogged Rohtak–Jhajjar–Sonipat belt, the dune and sandy soils of the south-west, the boulder and gravel beds of the Shivalik piedmont, and the rock and scree of the Aravallis). 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 Haryana 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.

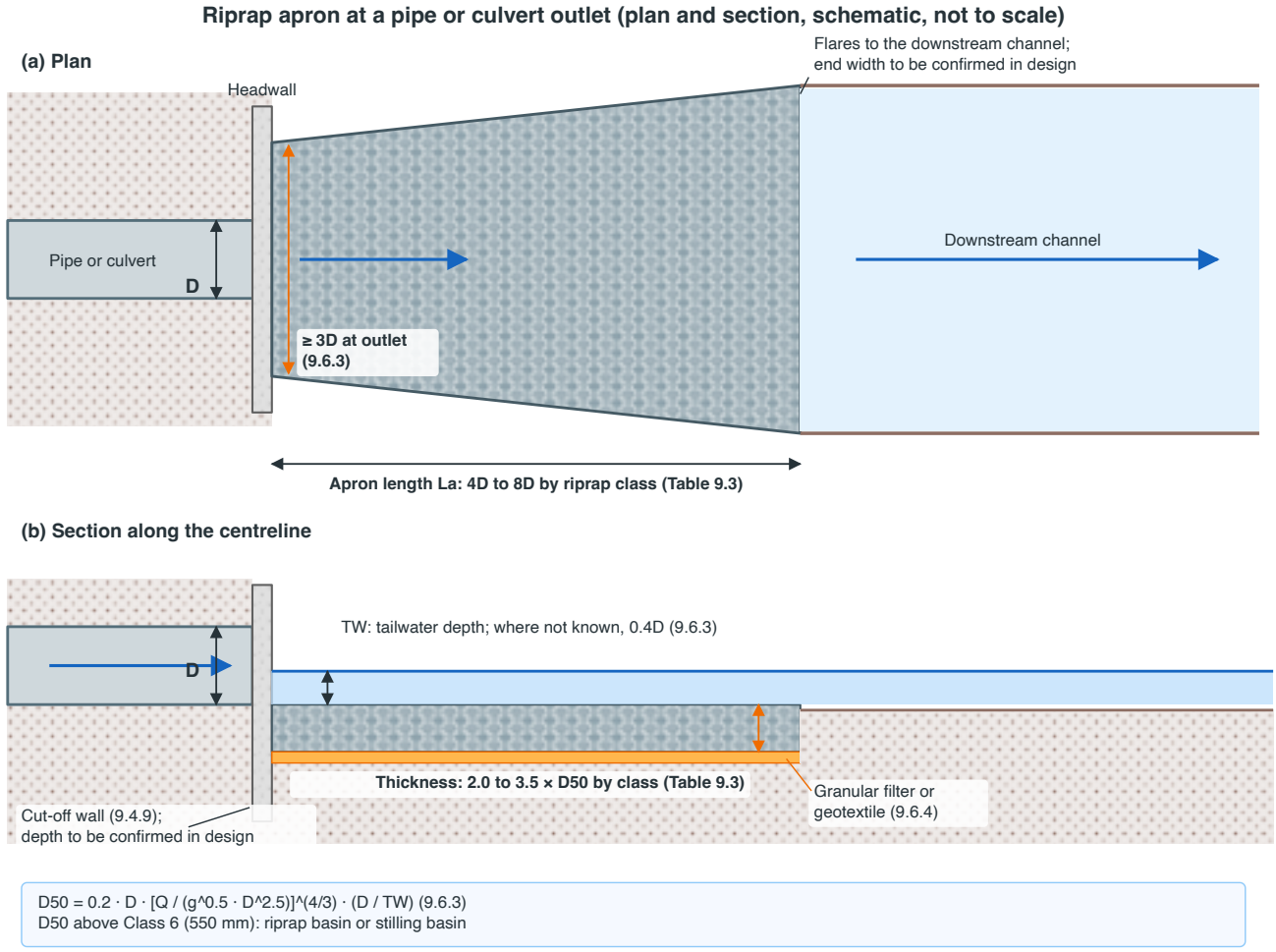

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design 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 (m^2/s) and h is the drop height (m). The pool geometry shall be set from the Rand (1955) relationships: drop length Ld/h = 4.30 D^0.27; pool depth Yp/h = 1.00 D^0.22; sequent depths y1/h = 0.54 D^0.425 and y2/h = 1.66 D^0.27.
- (b) Baffled chutes and stepped drops shall be designed by HEC-14 or US Bureau of Reclamation methods.
- (c) The height of a single vertical drop in a public drain shall not exceed 1.5 m. Drops shall have edge protection under Chapter 6, Clause 6.13.8.

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

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

9.7 Detention outlet structures

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

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

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

> Q = Cd · 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 m³/s.

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

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

9.9 Pumps and sumps

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

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

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

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

- (a) where variable-speed drives and automatic controls are installed, 5 minutes of the minimum inflow (CPHEEO 2019, §8.3.3);
- (b) otherwise, 10 to 15 minutes of the peak inflow, or the volume needed for the pump manufacturer's minimum cycle time, from $V = Q \cdot t$ (CPHEEO 2019, Eq. 8.1); and
- (c) for constant-speed pumps, the volume $V = \Theta \cdot q / 4$ for each pump, where Θ is the minimum cycle time recommended by the motor manufacturer and q is the pump capacity (FHWA HEC-24, 2001).

9.9.4 **Duty and standby.**

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

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

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

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

9.9.8 **Controls and monitoring.**

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

9.9.9 **Power supply.**

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

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

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

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

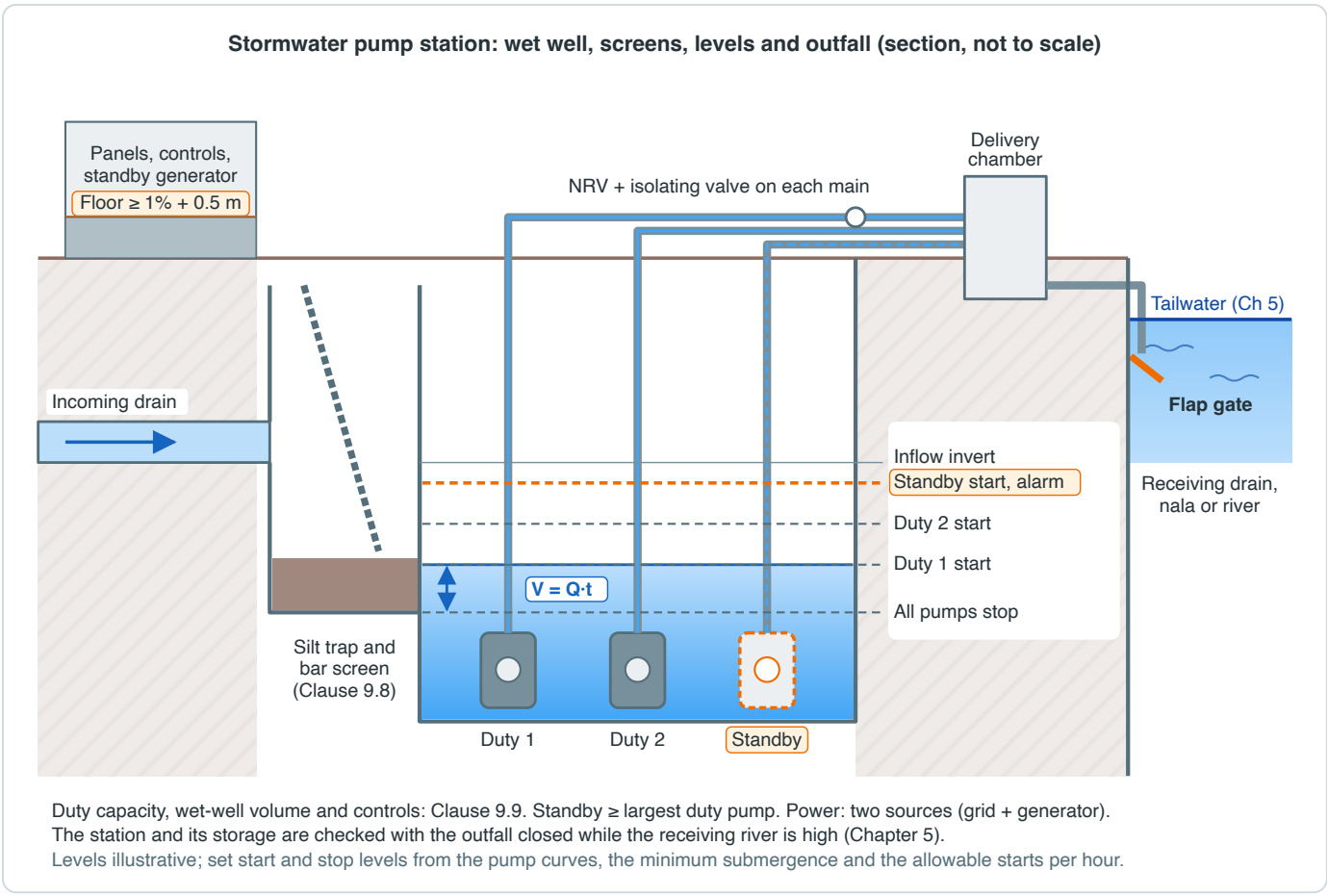

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

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

9.10 Tide gates, flap gates and non-return valves

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

9.10.2 **Types.** Acceptable devices are:

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

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

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

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

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

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

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

> Commentary. CPHEEO (2019, §6.3.10.1) describes flap gates and flood gates at outfalls to tidal waters. It notes that "adequate storage may be necessary if pumping is to be avoided during the closure of the gate" and that hinge pins and links "should be of corrosion-resistant materials". Haryana has no coast, so no outfall in the State is closed by the tide, and the beach, estuary and tidal provisions of Clauses 9.6.7, 9.9.2(b) and 9.10.5, and the coastal and tidal rows of Table 9.5, do not arise; in Clause 9.9.2(c) the highest tailwater is the highest river or drain level of Chapter 5. The saline-groundwater row of Table 9.5 applies wherever groundwater or soil is saline, and the tests of Clause 9.13.3 and the metalwork of Clause 9.13.6 should be used there too: CGWB describes the groundwater of the southern, western and central districts as mostly saline, has measured electrical conductivity of up to 24,060 µS/cm (Nagina, Nuh district) and found 21.89% of its samples above 3,000 µS/cm (2021–22), and the waterlogged soils of the Rohtak–Jhajjar–Sonipat belt are saline-sodic. Gates are still required below the 1% still-water level, because the State's town drains outfall to rivers and drains that rise above their inverts. On the Yamuna, Hathnikund barrage passed 8.28 lakh cusecs on 18 August 2019 (as reported) and 3,59,760 cusecs on 11 July 2023 (MoJS committee, 2024), and the CWC gauge at Karnal has a danger level of 249.5 m against a high flood level of 250.07 m (2013), and that at Mawi 230.85 m against 232.75 m (as reported); releases take 35–75 hours to travel from Hathnikund to Delhi, which gives the towns below some warning, but a local storm gives none. On the Ghaggar CWC has no flood sites at all, and in July 2023 the river and its choes breached their banks at Ambala, Kaithal, Fatehabad and Sirsa, with 82,400 cusecs reported at Kaithal on 12 July (as reported); the Municipal Corporation of Ambala ran 19 pump sets and I&WRD deployed inventory pumps of 962 cusecs (Haryana Vidhan Sabha reply, 2023). Outfall Drain No. 8, which takes the Sahibi and the drainage of the Rohtak–Jhajjar belt to the Dhansa regulator and on to the Najafgarh drain in Delhi, has a capacity of 4,000 cusecs and carried 5,000 cusecs at Dhansa in 2022 (I&WRD); in August 1977 the Sahibi stood at 213.575 m upstream of Dhansa against a bund top of 214 m (Delhi's Irrigation and Flood Control Department). Gurugram's three master drains, Legs I, II and III (Badshahpur), outfall to the Najafgarh drain; they were drawn for 541, 1,305 and 3,702 cusecs in DTCP's master drainage drawing of 2012, but reaches at Khandsa and near Hero Honda Chowk have been reported to carry far less (as reported), so a drain that joins them above such a reach is throttled as if its outfall were partly closed, and its storage or pumping is checked under Clause 9.10.7 and Chapter 5. Pumping stations are the normal answer at Gurugram's underpasses, which flooded on 19 August 2020 (as reported); the Union Ministry of Housing and Urban Affairs reported 141 pumps and 77 suction tankers deployed in the city (Lok Sabha, 2025, as reported); and on 31 July 2024 three people were electrocuted near IFFCO Chowk when a live cable fell into ponded water (as reported), which is why Clause 9.9.10 keeps electrical rooms, generators and transformers above the 1% AEP flood level. In the Rohtak–Jhajjar–Sonipat belt the water table stands within 3 m of the surface over about half of Rohtak and 43% of Jhajjar district (HWRA, June 2023), the land is flat, and a study of the rural drains there found that a system of about 170 m³/s could handle the 1- and 2-day but not the 3-day 5-year rainfall (*Irrigation and Drainage*, 2006); the town drains of Rohtak, Jhajjar and Bahadurgarh therefore

need storage and pumped outfalls sized under Clause 9.9 and the outfall-closed check of Chapter 5, with no infiltration credited. Screens matter as much as gates, because the drains carry silt, construction debris and solid waste: 544 km of Gurugram's drains were desilted before the 2025 monsoon (Lok Sabha, 2025, as reported), HARSAC found 47 ponds of 2–8 acres in and around Gurugram dried up or filled with municipal waste (2021), and the National Green Tribunal has heard complaints of construction debris dumped on the banks of the Ghaggar at Panchkula (OA 421/2022). Bunds and barrages across drains fix the level upstream: Gurugram's Ghata, Chakarpur, Jharsa and Wazirabad bundhs, built in the late nineteenth century to hold back the runoff from the Aravallis (as reported), the Ghata bundh being about 1.25 km long and 5 m high with a catchment of about 12,575 ha, most of it in Delhi (GMDA), and the Masani barrage on the Sahibi, whose weir, crest 240.00 m, was left without gates in 1986 (I&WRD); each is taken as a fixed control in Clause 9.2.1 at its crest, and its effect on storm capacity is checked under Clause 8.9.5 and the HGL of Chapter 6. No inventory of the regulators, sluices, flap gates and pumping stations on the drains of any Haryana town, with their capacities and operating rules, no published operating rule for the Dhansa regulator or for the outfalls of Gurugram's master drains, and no design river or drain level at any outfall was found in the public domain. Clauses 9.10.3 and 9.10.5 are set by this Manual because a flap gate, sluice or regulator that fails, or is jammed open by silt, solid waste or debris, lets a river or drain in flood back into the town network, and one jammed shut blocks it. The town drains of Haryana carry silt, solid waste and sewage to their outfalls: in 2023 Gurugram's Legs I, II and III averaged a BOD of 48, 63 and 44 mg/l and Faridabad's Budhiya nala 76 mg/l, against the 30 mg/l required of the drains that reach the Najafgarh drain, and Leg-III carried 126.53 cusecs in the dry season of 2021 (State of Haryana and GMDA reports to the National Green Tribunal; Haryana Vidhan Sabha reply), so a gate, its screen and the sewage interception beside it are exposed to the same debris and must be kept clear together; and because the Yamuna can stay high for days below Hathnikund barrage, which passed 8.28 lakh cusecs on 18 August 2019 (as reported), and Outfall Drain No. 8 has carried 5,000 cusecs at the Dhansa regulator against its capacity of 4,000 cusecs (2022, I&WRD), a gate that leaks or jams can be exposed for the whole of a flood.

9.11 Inlets and gratings

9.11.1 **Hydraulics.** Inlet capacity, spacing and clogging shall follow Chapter 6, Clause 6.6.

9.11.2 **Load class.** Gratings, covers and frames shall be rated for the traffic at their location. Load classes shall be those of IS 1726 (cast iron manhole covers and frames) or EN 124 (gully tops and manhole tops), at least:

- (a) carriageways and medians: EN 124 class D400 or the equivalent heavy-duty IS class;
- (b) kerb-side channel inlets within 0.5 m of the kerb: class C250 or equivalent; and
- (c) footpaths and cycle tracks: class B125 or equivalent.

9.11.3 **Grate pattern.**

- (a) Grates in carriageways, cycle tracks and footpaths shall not have openings parallel to the direction of travel wider than 25 mm.
- (b) Grate types without tested capacity data shall be rated by the weir and orifice methods of FHWA HEC-22 (2024), with the clogging factors of Chapter 6.

9.11.4 **Kerb openings.** Kerb-opening inlets shall have a clear opening height of at least 100 mm and a length of at least 1.0 m. Where a kerb inlet discharges through the wall of a covered drain (Chapter 6, Clause 6.13.1), the opening shall be at road level.

9.11.5 **Security.** Gratings and covers on public land shall be hinged or locked to their frames, so that they cannot be removed without a tool.

9.11.6 **Inlet chambers.** Inlet chambers shall have the silt sump of Chapter 6, Clause 6.6.7, and shall be sized so that the sump can be emptied by a suction or grab machine.

> **Commentary.** NDMA (2010, §4.13) cites IS 5961 for cast-iron gratings for drainage inlets. The load classes are based on the EN 124 classes used internationally. The 25 mm limit on parallel openings is set for cyclist and pedestrian safety. APWA 5600 (2006, 5604.2) requires kerb openings of at least 4 ft (about 1.2 m) long and 6 in (about 150 mm) clear height. Clause 9.11.4 sets smaller minimums suited to the narrower roads and lower kerbs common in Haryana 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 Haryana 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 Haryana 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 Haryana locations to exposure classes, the sulphide-corrosion requirement and the ban on new masonry drains in

> Tier A bodies have no direct precedent and are set by this Manual. Drains that receive sewage cross-connections (a common condition, Chapter 8) generate hydrogen sulphide, which attacks unprotected concrete above the water line.

9.14 Submittal requirements

Every structure design shall be submitted with a **Hydraulic Structures Report** (Form 9-1) containing, as applicable:

1. culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check;
2. channel water-surface profiles, velocities, Froude numbers and freeboard;
3. outlet protection and dissipator design, with riprap sizing;
4. detention outlet stage–discharge tables and the emergency spillway check;
5. screen and rack design with the 50% blocked check;
6. a pump station design report: inflow hydrograph, storage, pump curves and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check;
7. gate and valve selection with head-loss data;
8. inlet, grate and cover load classes; and
9. an exposure class and materials statement (Clause 9.13).

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Annexes and forms

Annex / Form	Content
9A	HDS-5 inlet-control coefficients and worked culvert example in SI units
9B	Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers
9C	Pump station design checklist and standard control philosophy

Annex / Form	Content
Form 9-1	Hydraulic Structures Report checklist

CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

10.1 Purpose and scope

10.1.1 This chapter sets out how compliance with this Manual is shown, checked, built, kept working and enforced. It covers:

- (a) the submittal stages and their contents (Clauses 10.3–10.4);
- (b) the compliance calculator (Clause 10.5);
- (c) professional certification and review (Clauses 10.6–10.7);
- (d) construction inspection and as-built certification (Clauses 10.8–10.9);
- (e) maintenance declarations, O&M plans, inspection and access (Clauses 10.10–10.13);
- (f) handover of public assets (Clause 10.14);
- (g) enforcement (Clause 10.15); and
- (h) monitoring, post-event review and data publication (Clauses 10.16–10.17).

10.1.2 This chapter applies to every development and public work to which Chapters 4 and 5 apply under Clause 1.5.2. Clauses 10.3.1 (Stage 0), 10.15 and 10.17 also apply to development that is subject only to Clause 1.5.4.

Commentary. A criterion that is not checked at approval, built as approved, and maintained afterwards has no effect. In Haryana the failure is one of missing criteria and of conditions checked only for rainwater harvesting. No document of DTCP, HSVP, the Urban Local Bodies Department, a Municipal Corporation, GMDA or FMDA stating a design return period for urban storm drains was found; the only urban figure on record is the 25 mm/h and runoff coefficient of 1/8 that the NCR Planning Board reports for Haryana's urban channels (2016). The approval route shapes this chapter. The Haryana Building Code 2017 is a departmental code, not a Gazette notification: it was circulated by the Town and Country Planning Department under memo No. Misc-138-A-Loose/7/5/2006-2TCP of 7 March 2017, applies to the whole State from 6 January 2017 (Code 1.1(2)), and is applied by each Competent Authority under its own Act (Code 1.2(1)(ii)), that is by DTCP for colonies licensed under the Haryana Development and Regulation of Urban Areas Act 1975, by HSVP in its sectors under the HSVP (HUDA) Act 1977, and by the Municipal Corporations, Councils and Committees under the Haryana Municipal Corporation Act 1994 and the Haryana Municipal Act 1973; it is amended by further memos (27 May 2020 and 19 January 2022 read; 8 December 2025 and 5 June 2026 reported; no amendment to its rainwater harvesting, plinth or basement clauses was found). Under it the site plan must show existing drains (Code 3.2), the building plan must show "the method of disposal of … storm water" and the rainwater harvesting system (Code 3.4(2)(vi)–(vii)), the plinth must be 450 mm to 1.5 m high so that "proper drainage of the site is assured" (Code 7.3), and basement drainage is the owner's responsibility (Code 7.16(5)(iv)); an architect or engineer certifies that the rainwater harvesting system works, and the occupation certificate is withheld until it is built (Code 8.1(3)(vii) and (ix)); and for 5,000–20,000 m² built-up the natural drainage inlets and outlets must be kept and at least 20% of the recreational open space left unpaved, certified with the occupation certificate application (Code 12.1). The licence for a colony includes its storm drains, as internal development works built by the colonizer and as external development works executed by HSVP (HDRUA Act 1975, s.2, as quoted by DTCP). In a Municipal Corporation no premises may be built or occupied until a drain is made "of such size, materials, and with such fall" as effectual

drainage needs, to a Corporation drain within 30 m (HMC Act 1994, s.198), no drain may communicate directly with a storm water overflow drain (s.196), and nothing may be built on a municipal drain without the Commissioner's written permission (s.206). A spatial or development plan that covers a pond needs the prior approval of the Haryana Pond and Waste Water Management Authority (Pond Authority Act 2018, s.17); an obstruction within the limits notified under s.45 of the Haryana Canal and Drainage Act 1974, as on the Ghaggar floodplain in Panchkula, needs I&WRD's permission; an outfall to an I&WRD drain needs I&WRD's consent; and in Gurgaon district, a CGWA notified area since 2011, the groundwater rules apply. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a setback from a drain, river or pond, and no I&WRD rule barring construction within a set distance of a drain or canal was found. Every stormwater item in this chapter is therefore written so that the architect or engineer on record can certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the Authority can check it with the building plan, with the licence and at the occupation certificate. 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 Haryana Building Code 2017 (Table 10.1):

Table 10.1 — Submittal stages and linked approvals

Stage	Submittal	When	Linked approval
0	**Pre-application** meeting and **Form 1-1** (Applicability Determination)	Before the planning permission or layout application	None (advisory record)
1	**Preliminary drainage report**	With the planning permission or layout application	Planning permission / layout approval
2	**Final drainage design**	Before building permit, or before commencement where the permit is issued with the planning permission	Building permit / commencement

Stage	Submittal	When	Linked approval
3	**Construction inspections** at hold points	During construction	None (records filed)
4	**As-built certificate** and verification tests	Before the completion certificate	Completion / occupancy certificate
5	**Maintenance declaration** registered, or **handover** of public assets	Before or with the completion certificate	Completion certificate; asset acceptance
6	**Annual declarations** and inspection reports	Every year after completion	Continuing compliance

10.3.2 **Stage 0 is mandatory** for:

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

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

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

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

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

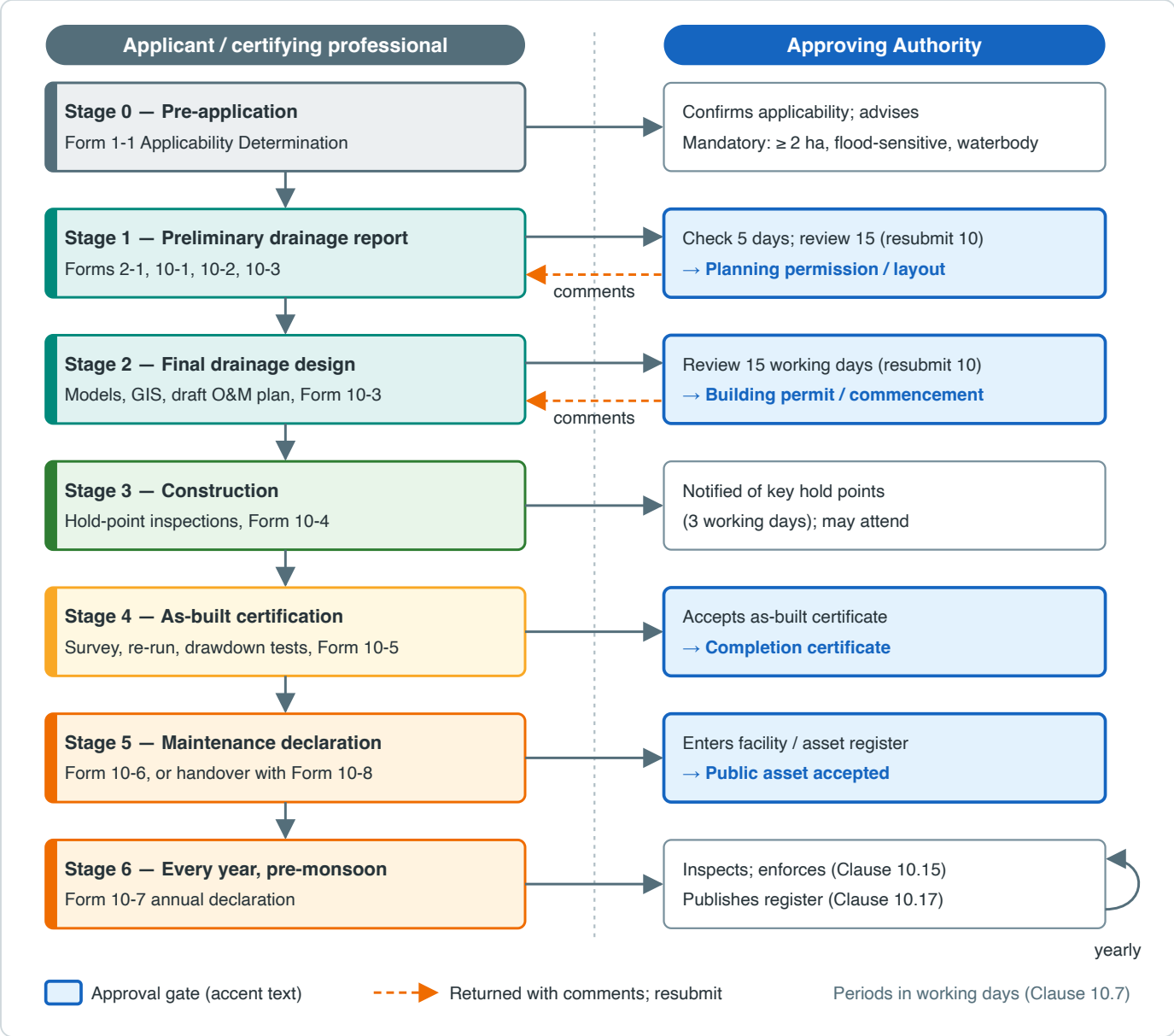

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **Commentary.** The stages follow the APWA 5600 sequence of preliminary and final stormwater studies, construction inspection and maintenance agreements (APWA 5600, 2006, §5608 and §5609), mapped onto the HBC 2017 steps a Haryana 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 (43N), with attributes as listed in Annex 10B.
- (d) Levels shall be stated relative to a named vertical datum. The relationship to the river datums of the CWC and I&WRD gauges on the receiving rivers and of I&WRD's drain, regulator and embankment levels, and, for a drain that reaches the Najafgarh drain, the levels of Delhi's Irrigation and Flood Control Department 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

Form	Title	Stage
10-3	Professional Design Certificate	1, 2
10-4	Hold-Point Inspection Record	3
10-5	As-built Certificate	4
10-6	Maintenance Declaration	5
10-7	Annual Maintenance Declaration and Inspection Report	6
10-8	Asset Handover Certificate	5

> **Commentary.** Runnable models and GIS data cost the applicant little and let the Authority check the work, and later build a city-wide picture of private storage. Haryana has no notified design return period or design storm for its urban drains. The NCR Planning Board's *Functional Plan on Drainage for NCR* (2016) reports that Haryana's drains were sized by the Boston Society formula Q = 200·√A (cusecs, square miles) cut by ad-hoc reduction factors of 1/12 to 1/4, and its urban channels for "25mm per hour" with a runoff coefficient of 1/8; it proposed, but did not make binding, a 5-year storm for internal and peripheral urban drains, a 10-year storm for main drains and a runoff coefficient of at least 0.6. The Sub-Regional Plan for the Haryana sub-region of NCR (2021) sizes rural drains for "three days rainfall of five years frequency to be drained in three days" and refers urban drains to CPHEEO. DTCP's master storm water drainage drawing for the Gurugram–Manesar Urban Complex (2012) gives Legs I, II and III (Badshahpur) as 541, 1,305 and 3,702 cusecs, and HUDA's catchment management plan for the Badshahpur drain (2017, revised 2020) gives reach discharges of up to 2,300 cusecs, but neither states a return period or a rainfall intensity. These figures are history, not a design basis: 25 mm/h is below the 2-year 1-hour intensity of 43.7 mm/h used for Delhi in 1976 (NCR Planning Board, 2016). In IMD's national IDF study (Das et al. 2022) the Hissar panel repeats a generic curve drawn for several other cities and is not used, and no station IDF has been published for any Haryana station. The State's sub-daily design values are therefore the CWC Flood Estimation Report for subzone 1(e) with the interim floors of Chapter 2, which in the NCR south take the absolute floors of the Delhi edition. Form 2-1 and Form 10-2 therefore carry the whole design basis of each submission. 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 Haryana 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 DTCP:

- (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 DTCP 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 HBC 2017 registration and adds empanelment for the higher-risk cases. The 1 ha limit is set by this Manual.

10.7 Review procedure and timelines

10.7.1 **Completeness check.** The Authority shall check each submittal against Form 10-1 within **5 working days** and either accept it for review or return it with a list of missing items.

10.7.2 **Technical review.** The Authority shall complete technical review and issue approval, conditional approval or a single consolidated list of comments within:

- (a) **15 working days** of acceptance for a first submittal; and
- (b) **10 working days** of acceptance for a resubmittal.

10.7.3 **No new comments.** On resubmittal, the Authority shall not raise new comments on matters that were unchanged and not commented on in the earlier review, unless the matter affects safety.

10.7.4 **Review capacity.** A Tier B authority, or a Tier A authority for overflow work, may use an empanelled reviewer from the DTCP list. The empanelled reviewer shall not have worked on the same site. The Authority remains the decision-maker.

10.7.5 **Concurrent clearances.** Where the consent of I&WRD for an outfall to, or a work on, one of its drains, canals, embankments or regulators, or for an obstruction within limits notified under s.45 of the Haryana Canal and Drainage Act 1974, such as the Ghaggar floodplain in Panchkula, the prior approval of the Haryana Pond and Waste Water Management Authority for a spatial or development plan that covers a pond, or its permission for construction in a pond's protected area (Haryana Pond and Waste Water Management Authority Act 2018, s.17), the written permission of the Commissioner to build on a municipal drain (Haryana Municipal Corporation Act 1994, s.206), the prior approval of the Central Pollution Control Board and the Haryana State Pollution Control Board for plans within 1–5 km of the Badkhal and Surajkund lakes (Supreme Court, 1996), the approval of the Wetland Authority of Haryana for a regulated activity in a notified wetland, the consent of the body that owns the receiving drain where that body is not the Authority (for example GMDA, FMDA, HSVP or HSIIDC), 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.

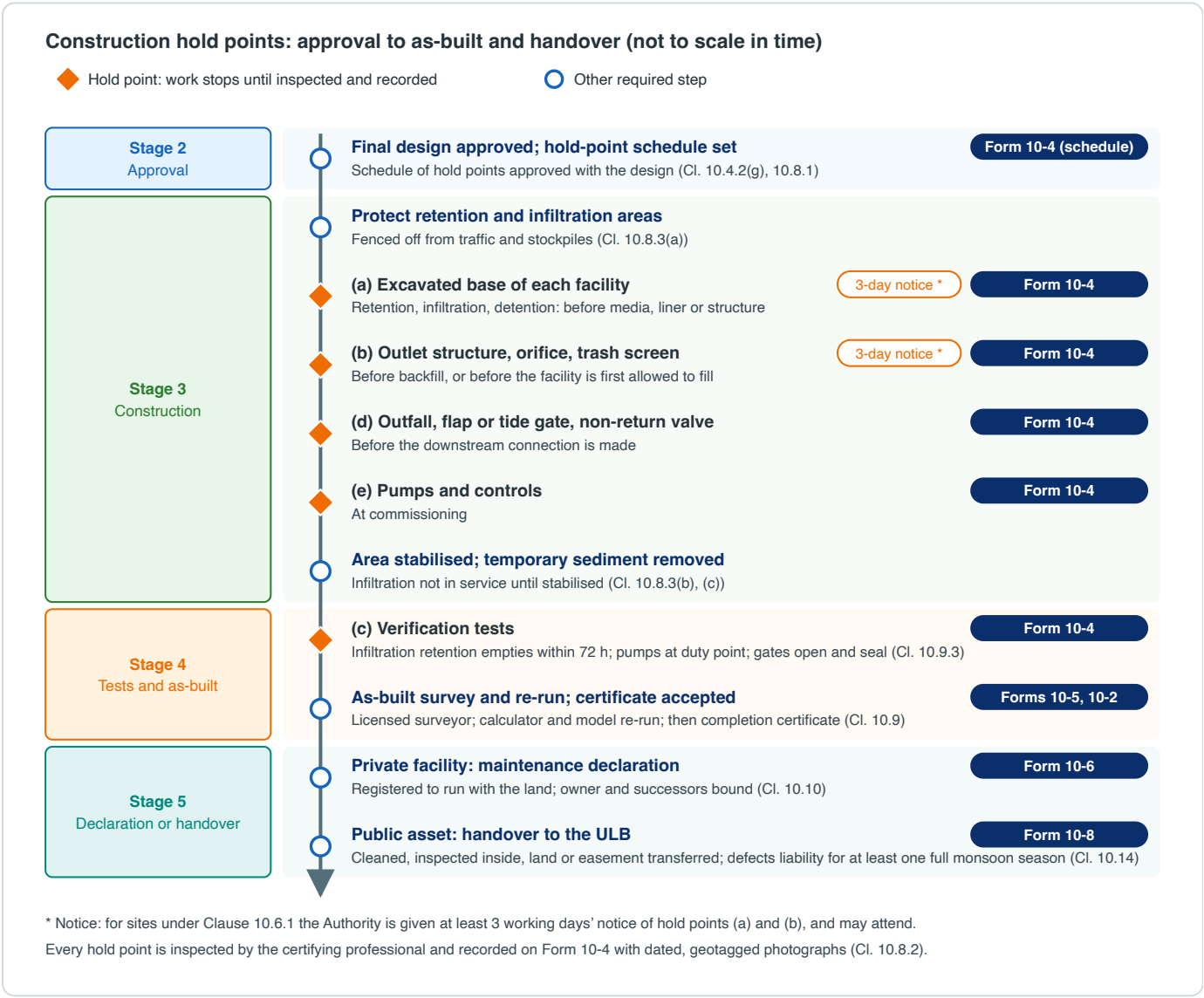

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement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

tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 15 June date is set by this Manual to fall before the south-west monsoon (June–September), when most Haryana 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. Haryana runs its monsoon season through the Haryana State Drought Relief and Flood Control Board, chaired by the Chief Minister, which approves flood-control schemes each year and has directed that short-term schemes, pump procurement and drain cleaning be finished before 30 June, or in one direction before 15 June (as reported), and through district flood control plans supervised by the Deputy Commissioners (as reported); no urban flood plan of HSDMA was found. For the town drains the orders found are local: Gurugram's pre-monsoon plans list 111 to 159 waterlogging hotspots (as reported), GMDA desilts the master drains without a published date (as reported), and the Union Ministry of Housing and Urban Affairs reported 141 pumps and 77 suction tankers deployed in Gurugram (Lok Sabha, 2025, as reported); in July 2023 the Municipal Corporation of Ambala ran 19 pump sets and I&WRD deployed inventory pumps of 962 cusecs against the Ghaggar (Haryana Vidhan Sabha reply). The rivers are run by gate operation: at Hathnikund barrage only the spillway bays are operated up to an inflow of 70,000 cusecs and all gates are fully opened at 2,15,400 cusecs and above (MoJS committee, 2024). No operating rule for any regulator, sluice, flap gate or pumping station in a Haryana town, linking it to a river stage, a release from Hathnikund barrage or the Kaushalya dam, or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

10.12 Inspection frequencies

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

Table 10.3 — Minimum owner inspection frequencies

Facility type	Routine	Pre-monsoon (by 15 June)	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 Haryana, the pre-monsoon inspection of regulators, sluices, flap gates, non-return valves and pumped facilities, including the pumps at underpasses and at outfalls to I&WRD drains, with the pump duty and gate seal tests, shall be completed by **15 June**; these facilities, with their standby generators, shall be certified ready by **25 June**, before the normal onset reaches the State (27 June at Sonipat to 3 July at Hisar), with every gate on an outfall to a river or an I&WRD drain operated through its full travel. Pumps, their standby power and the gates shall then be kept on monsoon standby, with the monthly test run, until **30 September**, and at an outfall to the Yamuna or the Ghaggar until the river at the governing gauge has fallen below its danger level and the releases upstream have ended, if that is later.

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).

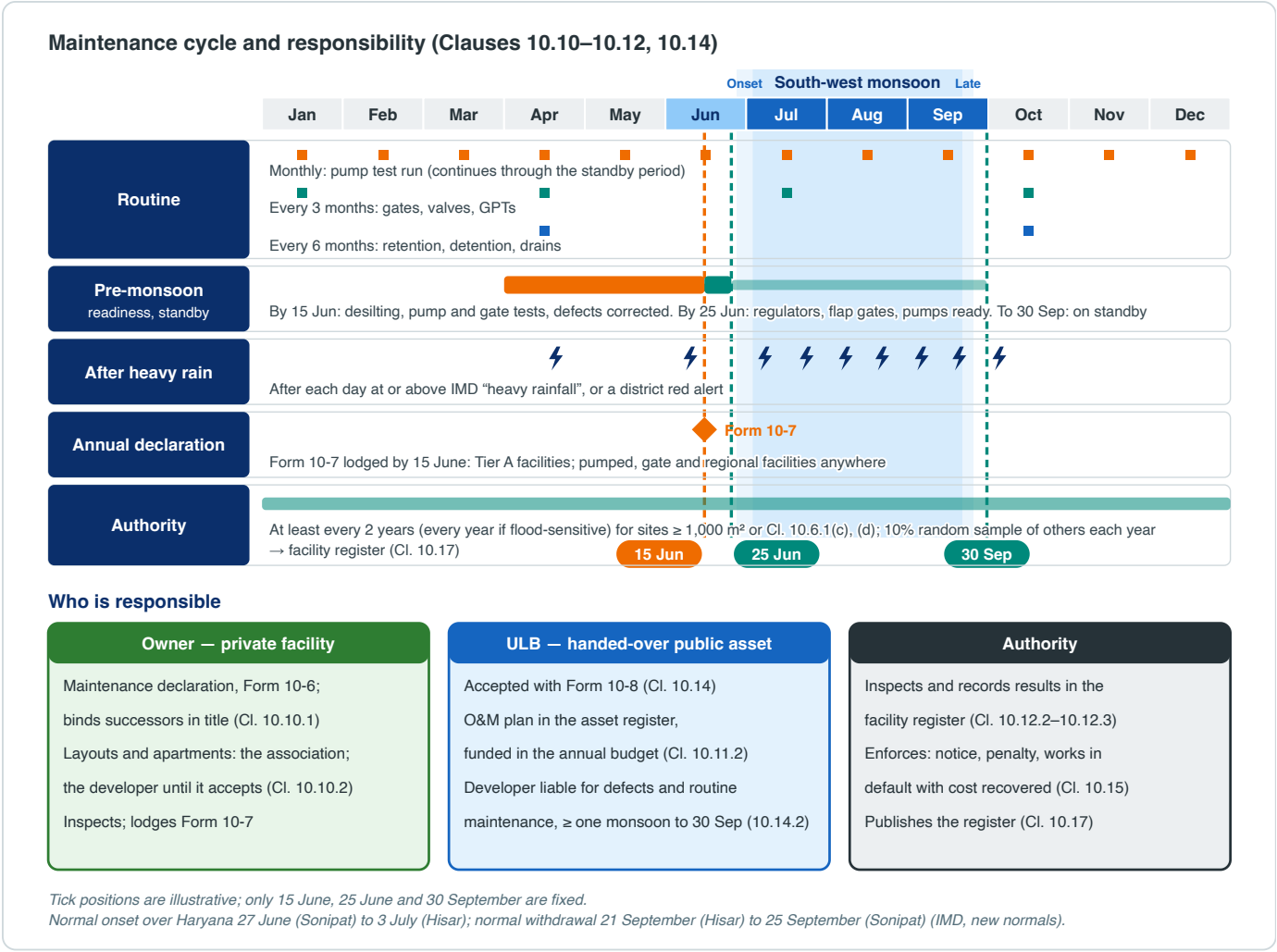

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 15 June) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the south-west monsoon (June–September); 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 15 June deadline is set by this Manual for the onset of the south-west monsoon in the last days of June: the normal onset is 27 June at Sonipat, 28 June at Ambala, 30 June at Bhiwani and 3 July at Hisar (IMD, 1961–2019 normals), and large falls have come at the onset, 297.9 mm at Rohtak and 261.2 mm at Gurgaon on 30 June 1981 (IMD). The State's own deadline for flood works and drain cleaning is usually 30 June, and once 15 June (as reported); 30 June falls after the onset in the north and east, so this Manual takes 15 June for desilting, the pre-monsoon inspection and the annual declaration. NDMA (2010) sets 31 March for pre-monsoon desilting nationally; this Manual allows until 15 June so that dry-season work can be finished. Regulators, sluices, flap gates, pumps and their standby generators must in addition be certified ready by 25 June, before the onset reaches Sonipat. The normal withdrawal runs from 21 September at Hisar to 25 September at Sonipat (IMD), so pumps and gates are kept on standby to 30 September (Figure 10.3), and at an outfall to the Yamuna or the Ghaggar until the river has fallen below its danger level and the releases upstream have ended, if that is later. October storms do occur, 141.6 mm at Ambala on 5 October 1973, 130.3 mm at Karnal on 9 October 1956 and 241.3 mm at Punahana on 2 October 1910 (IMD), and 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 Haryana cities make a fixed width hard to apply to every site, so this Manual sets functional requirements. Annex 10C covers maintenance access dimensions.

10.14 Handover of public assets to the ULB

10.14.1 Drains, roads, open space facilities, regional facilities and other stormwater assets that a developer builds for transfer to a ULB shall be handed over only when:

- (a) the as-built certificate (Clause 10.9) has been accepted;
- (b) the facility has been cleaned, and pipes and culverts have been inspected internally (for example by CCTV or manual entry), with the record handed over;
- (c) the land, or an easement over it, has been transferred to the ULB;
- (d) the O&M plan, drawings, GIS data and warranties have been handed over; and
- (e) the **Asset Handover Certificate (Form 10-8)** has been signed by both parties.

10.14.2 **Defects liability.** The developer shall remain responsible for defects and for routine maintenance for a defects liability period that includes at least **one full monsoon season, from 15 June to 30 September,** 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 Haryana 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 Haryana Building Code 2017 is issued and from the municipal Acts. The graduated steps are set by this Manual. In Haryana the courts have become the working regulators of lakes, ponds, the Aravallis and the drains. The Supreme Court barred construction in the green belt and within 1 km of the Badkhal and Surajkund lakes in Faridabad, with limited exceptions, and required the prior approval of the Central Pollution Control Board and the Haryana Pollution Control Board for every development scheme and building plan from 1 km to 5 km, noting that "the natural drainage pattern of the surrounding hill areas feed these water bodies" (*M.C. Mehta*, order of 11 October 1996); it later held that land notified under the Punjab Land Preservation Act 1900 is forest land and ordered constructions in Kant Enclave built after 18 August 1992 to be demolished (2018, as reported). The National Green Tribunal ordered unique identifiers and restoration for at least 123 water bodies in Gurugram and the exercise repeated statewide (OA 325/2015, 20 July 2018), has tracked the sewage in Gurugram's master drains, which must meet a BOD of 30 mg/l before they reach the Najafgarh drain (OA 454/2018), and questioned whether the procedure for the Ghaggar floodplain zone in Panchkula was followed (OA 421/2022, 22 May 2024). The Punjab and Haryana High Court, finding that "Gurugram is facing severe waterlogging during the monsoon season" while its groundwater falls and the channels that fed its water bodies "remain largely blocked", summoned officers of MCG, HSVP and GMDA (*Sunil Singh*, CWP-20032-2008,

order of 22 September 2026). The statutes carry real powers: the Divisional Canal Officer may remove an obstruction within notified limits and recover the cost as land revenue (Canal and Drainage Act 1974, s.46); the Commissioner may remove a structure built on a municipal drain (HMC Act 1994, s.206(2)); the Pond Authority may direct the removal of any obstruction within a protected area or on pond land, and building on pond land, its green belt or catchment is punishable with a fine of up to ₹25,000 or imprisonment of up to three months (Pond Authority Act 2018, ss.14, 15 and 20); and no occupation certificate is issued until rainwater harvesting is built (HBC 2017, Code 8.1(3)(ix)), a duty HSVP now asks allottees to reaffirm by undertaking (2024). DTCP issued more than 150 show-cause notices in one Gurugram colony in June 2025, among them for fully covered basements (as reported). CAG's Report No. 4 of 2026 includes a chapter on sewage and sewerage management in the urban areas of Haryana (as reported; the report could not be downloaded), and no audit by CAG of urban storm drainage, of GMDA or of HSVP drainage was found. This shows that a rule without routine enforcement does little, and that where the State has not drawn a line the courts have. Professional accountability (step 6) is often more effective than fines on owners, because it acts on the person who signs the design.

10.16 Monitoring and post-event review

10.16.1 **Monitoring network.** Tier A authorities shall maintain, or have access to, recording rain gauges and water-level gauges at their main outfalls and regional facilities. Data shall be archived at intervals of 15 minutes or less.

10.16.2 **Event reports.** After any event that floods buildings within a ULB area, the ULB shall prepare a short event report within **3 months**, recording:

- (a) rainfall at the nearest approved gauges, by duration, compared with the design depths of Chapter 2;
- (b) the level of the receiving river (the Yamuna at Hathnikund barrage or at the CWC gauges at Karnal and Mawi; the Ghaggar, the Tangri or the Markanda at the nearest I&WRD gauge) or of the receiving I&WRD drain, and, where it is gauged, at the outfall, each on a named datum; for a drain that reaches the Najafgarh drain, the level and flow at its outfall and at the Dhansa regulator; the state of every regulator, sluice, flap gate and pumping station on the outfall and on the drain upstream of it, including those at underpasses, with the hours each pump ran and any loss of power; and the releases from Hathnikund barrage, the Kaushalya dam or any other barrage, dam or regulator that set the receiving level;
- (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), HSDMA, 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. Haryana's urban floods have been examined by the courts and the press rather than by technical reviews. On 28 July 2016 Gurugram's NH-48 was jammed for more than 18 hours after about 46–54 mm of rain, figures that conflict and none of which is an IMD reading (as reported); the 91.8 mm often quoted for that day is from a report of 2021. On 19 August 2020 the city's underpasses flooded within half an hour of a three-hour spell (as reported); on 31 July 2024 three people were electrocuted near IFFCO Chowk in ponded water (as reported); and on 1 September 2025 more than 100 mm fell in four hours, by the district administration's account (as reported). On 9 July 2023 Chandigarh recorded

302.2 mm and Ambala 224.1 mm (IMD, real-time data), and the Ghaggar and its choes breached at Ambala, Kaithal, Fatehabad and Sirsa in the days that followed (as reported). On the Yamuna, Hathnikund barrage passed 8.28 lakh cusecs on 18 August 2019 (as reported) and 3,59,760 cusecs on 11 July 2023 (MoJS committee, 2024). The records of the past are larger still: 484.1 mm at Rohtak on 19 September 1933 and 398.8 mm at Palwal on 9 September 1875 (IMD). The Punjab and Haryana High Court took up Gurugram's waterlogging in 2026 (*Sunil Singh*), and the Haryana Human Rights Commission was reported to have opened a suo motu case after the floods of August 2026 (as reported). No technical review of any of these events was found, and no record of flood extents, depths or durations kept by any Municipal Corporation, GMDA or FMDA was found. NDMA (2010) called for automatic rain gauges at "1 in every 4 sq km" in Class I, II and III cities. Clause 10.16.1 asks only for gauges where they serve design and review. The report and sampling intervals are set by this Manual.

10.17 Data publication

10.17.1 Each Authority shall publish, on a public website, and update at least quarterly:

- (a) a **facility register**: location, type, design volume, release rate, owner, date of as-built acceptance, and the latest inspection result for every facility approved under this Manual;
- (b) a summary of each approved drainage report, with Forms 2-1 and 10-2;
- (c) the register of variances and waivers (Clause 1.10);
- (d) the alternatives adopted under the Policy Supplement (Clause 1.7);
- (e) enforcement actions (Clause 10.15.5); and
- (f) event reports and post-event reviews (Clause 10.16).

10.17.2 The State Stormwater Technical Committee shall publish the compliance calculator, all Annexes, the flood-sensitive catchment maps and the State-level summary of facility registers as open data.

10.17.3 Personal data other than the name of a corporate owner or association shall not be published. Security-sensitive details of critical infrastructure may be withheld, with the reason recorded.

10.17.4 Published data shall be machine-readable (for example CSV and GeoPackage) and released under the Government Open Data Licence – India or an equivalent open licence.

Commentary. Transparency is a design criterion in its own right here. Some of Haryana's drainage records are public: the Haryana Building Code 2017 and its amendment memos (in archived copies of the DTCP website), the Acts on the Pond Authority, the Canal and Drainage Act, the Municipal Corporations and GMDA (in PRS copies), the reports that GMDA, I&WRD, DTCP, the Pond Authority and the Wetland Authority have filed before the National Green Tribunal, including GMDA's copies of the master drainage drawings of Gurugram, replies in the Vidhan Sabha, the NCR Planning Board's drainage plan, the Sub-Regional Plan for the Haryana sub-region of NCR, CGWB's groundwater assessments and the Water Resources Atlas of the Haryana Water Resources Authority. Much else could not be found in the public domain: the hydrology behind the capacities of Gurugram's master drains, and GMDA's drainage master plan; any drainage norm of HSVP, FMDA or the Panchkula Metropolitan Development Authority; the Gazette text of the Ghaggar floodplain notification under s.45; any protected-area notification under the Pond Authority Act; the texts of the Building Code amendments of December 2025 and June 2026; an inventory of the regulators, sluices, flap gates and pumping stations of any town, with their capacities and operating rules; the operating rule of the Dhansa regulator; an urban flood plan of HSDMA; the list of wetlands notified under the Wetlands Rules 2017; and the text of CAG's Report No. 4 of 2026. 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, johad 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. Haryana's cities are spending on their drains, but no city drainage master plan with a design standard has been published. Gurugram's master drains were laid out in DTCP's "Master Storm Water Drainage, G.M.U.C. 2031" drawing (No. DTP(G) 2104/2012 of 9 November 2012), which takes Legs I, II and III (the Badshahpur drain) to the Najafgarh drain with discharges of 541, 1,305 and 3,702 cusecs, and HUDA's catchment management plan for the Badshahpur drain (3 November 2017, revised 24 November 2020) divides its catchment into zones of 792 to 12,200 ha, gives reach discharges of up to 2,300 cusecs and proposes check dams on the creeks and recharge wells along the drain (GMDA, report to the National Green Tribunal); GMDA began a fourth master drain whose design IIT Roorkee was reported to have approved, and in 2024 sought a consultant for a drainage plan of the city (as reported). None of these states a return period or a rainfall intensity. In Faridabad, FMDA desilts eight storm drains of about 30 km, among them the Budhiya nala (as reported), but no FMDA drainage plan or design norm was found. In Panchkula, I&WRD notified the floodplain of the Ghaggar under s.45 of the Canal and Drainage Act on 27 October 2023, drawn on a 100-year flood of 2,933.45 m³/s computed by Gumbel's method from 54 years of data, though the National Green Tribunal has questioned whether the procedure was followed (2024). The older regional norms are history, not a design basis: the NCR Planning Board's *Functional Plan on Drainage for NCR* (2016) reports Haryana's urban channels as designed for 25 mm/h with a runoff coefficient of 1/8 and proposed 5-year and 10-year storms for urban drains, and the Sub-Regional Plan for the Haryana sub-region of NCR (2021) sizes rural drains for a 5-year, 3-day rainfall drained in 3 days and says that "first master plan of drain should be prepared and only then drains should be provided". Gurugram's master drains and Outfall Drain No. 8 from the Rohtak–Jhajjar belt all end in the Najafgarh drain, which runs through Delhi to the Yamuna, so the basin is shared between two governments, and the National Green Tribunal

has asked an expert group to examine the flow through the Najafgarh drain and the "unwanted submergence of land areas" around the Najafgarh jheel (OA 153/2014, 2022). No published document sets a design return period for the storm drain network of any Haryana city; the only design floods found are the Ghaggar's 100-year flood in Panchkula and the capacities of Gurugram's master drains, without a stated return period. This chapter supplies the design storm, levels of service, storage and buffer criteria that such a plan needs, with the design storms of Chapter 2 and the levels of service of Clause 11.6; it has not been adopted by DTCP, HSVP, the Urban Local Bodies Department, any Municipal Corporation, GMDA, FMDA, PMDA, I&WRD or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, town drains that outfall to the Yamuna and the Ghaggar when the rivers are high, Gurugram's master drains that reach the Najafgarh drain in Delhi through narrow reaches, flat drains of the waterlogged Rohtak–Jhajjar–Sonipat belt that reach Outfall Drain No. 8 only as fast as its capacity allows, johads and bundhs filled or cut off by building, storm drains that carry sewage, single drains split between a Municipal Corporation, GMDA or FMDA, HSVP, licensed colonizers, HSIIDC and I&WRD, 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 Haryana: to town outfalls on the Yamuna, which releases from Hathnikund barrage can hold high for days, and on the Ghaggar and its Shivalik choes, on which CWC has no flood sites; to Gurugram's master drains and Outfall Drain No. 8, which end in the Najafgarh drain in Delhi, so that the State's largest drainage basin is shared with another government; to the waterlogged Rohtak–Jhajjar–Sonipat belt, where the water table is within 3 m of the surface and drainage depends on the capacity of the I&WRD drains and on pumping; to drains that carry sewage, as Gurugram's master drains and Faridabad's Budhiya nala do; to drains vested in the Municipal Corporations, master drains of GMDA and FMDA, sector drains of HSVP, internal drains of licensed colonies, drains and floodplains held by I&WRD, and ponds under the Pond Authority Act 2018, without an order that divides the drains between them; to a State whose only notified floodplain line is the Ghaggar's at Panchkula, and whose other lines around lakes and the Aravallis have been drawn by the courts; to a State with no published design return period for the drains of any city; to aquifers over-exploited across most of the State but standing near the surface in the Rohtak–Jhajjar belt; and to a south-west monsoon whose recorded days far exceed the 50-year depths of the CWC plates, 484.1 mm at Rohtak on 19 September 1933 and 398.8 mm at Palwal on 9 September 1875 (IMD).

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.

Term	Meaning in this Manual
Regional facility	A storage, conveyance or outfall work serving more than one development, identified in a BSMP.
Capital Improvement Programme (CIP)	The ranked, costed list of works in a BSMP (Clause 11.8.4).

11.3 Planning unit: the basin, not the ward

11.3.1 BSMPs shall be prepared **by hydrological basin**, not by ward, zone or local-body boundary. Where a basin crosses local-body boundaries, one BSMP shall cover the whole basin.

11.3.2 Basin boundaries shall be delineated from the digital elevation model of Clause 11.5.2, checked against the drain network, road embankments, canals and tank supply channels. Diversions between basins, whether by canal, drain or surplus course, shall be mapped and represented in the model.

11.3.3 No basin delineation has been published for any Haryana city. For the urban areas where the evidence identifies them, the basins are at least the following:

- **Gurugram, Badshahpur:** the catchment of **Leg-III**, the **Badshahpur drain**, from the Aravalli slopes through the city to its outfall to the **Najafgarh drain**, with the HUDA sub-catchments of 2017–2020, the reaches at **Khandsa** and **Hero Honda Chowk** and **Leg-IV** in the 1D network, its sewage interceptions mapped (Clause 8.9.5), and the level of the Najafgarh drain at the outfall as the boundary condition;
- **Gurugram, Legs I and II:** the catchments of **Leg-I** and **Leg-II** and the old town to their outfalls to the Najafgarh drain, with the **Ghata**, **Chakarpur**, **Jharsa** and **Wazirabad** bundhs and the water bodies inventoried by GMDA as storage in the basin in which each lies, and the inflow from the Ghata catchment in Delhi as a boundary condition;
- **Faridabad, Budhiya nala:** the catchment of the **Budhiya (Buria) nala** from the Aravalli slopes to the Yamuna, with the **Badkhal** and **Surajkund** lakes and the lines drawn around them by the Supreme Court shown, and the Yamuna level at the outfall as the boundary condition;
- **Panchkula and Ambala, Ghaggar:** the catchments that drain to the **Ghaggar**, the **Kaushalya** and the **Tangri** and their choes, with the floodplain notified under s.45 shown, releases from the **Kaushalya dam** and the floods from the Shivaliks as inflows, and the outfall-closed case a design case;
- **Yamuna-bank towns:** for **Yamunanagar–Jagadhri**, **Karnal**, **Panipat** and **Sonipat**, the catchments that drain to the **Yamuna** directly or through I&WRD drains such as **Drain No. 2** at Panipat, with the river level at the nearest CWC gauge or at Hathnikund barrage as the boundary condition and the outfall-closed case a design case;
- **Rohtak–Jhajjar waterlogged towns:** for **Rohtak**, **Jhajjar** and **Bahadurgarh**, the catchments that drain to **Outfall Drain No. 8** and on to the **Dhansa regulator**, with the capacity of the drain as the boundary condition, the water table as a design condition, and pumped outfalls with storage in the 1D network; and
- **Najafgarh drain, Haryana part:** the Haryana part of the basin of the **Najafgarh drain**, which takes the **Sahibi** below the **Masani barrage**, Outfall Drain No. 8 and Gurugram's master drains, prepared together with the plan for the part of the basin in Delhi, through I&WRD and Delhi's Irrigation and Flood Control Department, with agreed flows and levels at the State border at Dhansa and at the outfalls of the master drains.

Other Tier A bodies, among them Hisar, Sirsa, Kurukshetra, Kaithal, Rewari, Bhiwani and Manesar, shall define their basins in the first BSMP that covers them. Where I&WRD, CWC, the Pond Authority or a court has a high flood level, a design water level, limits notified under s.45, a protected area or a line around a lake, or an operating rule for a barrage, a dam, a regulator or a pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

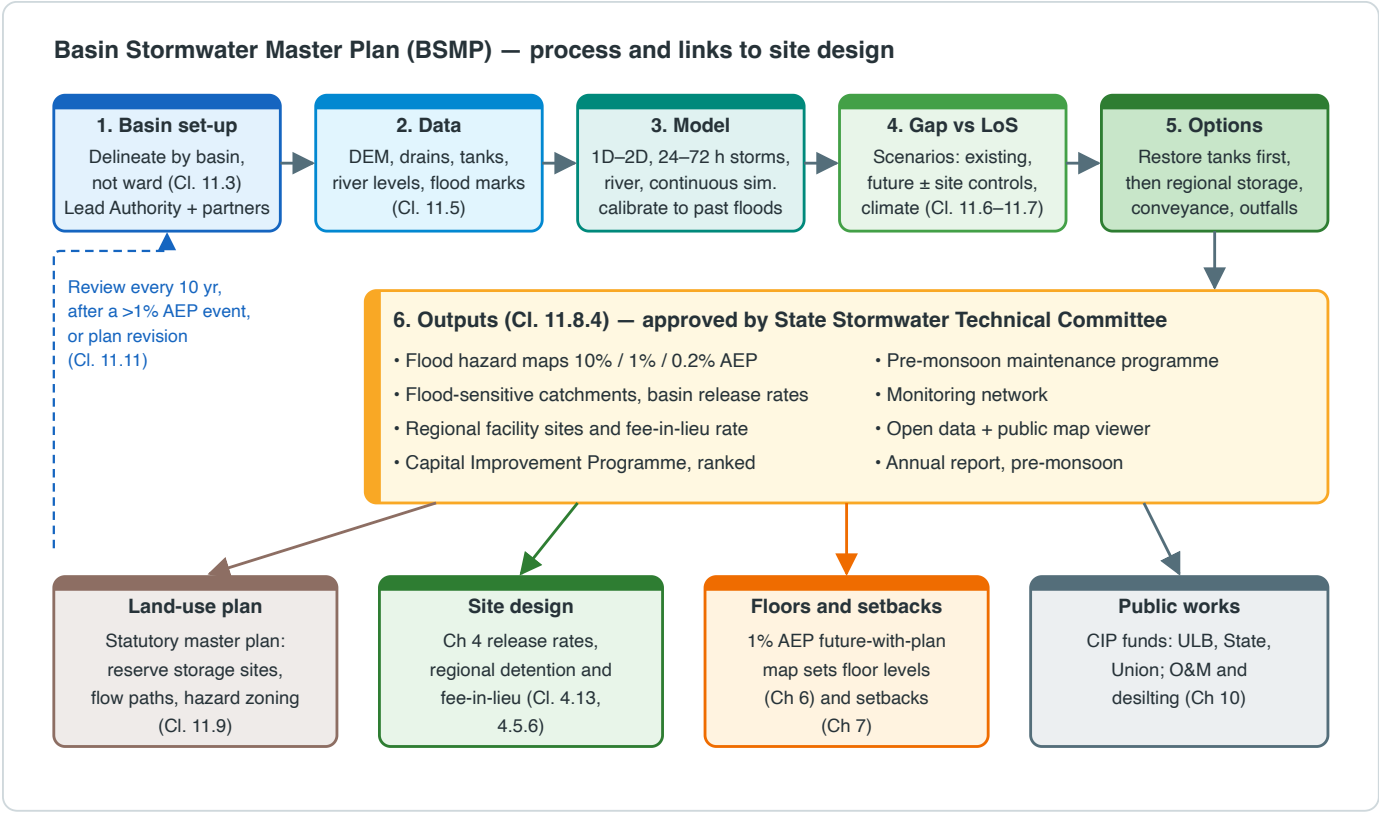

Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

Commentary. Water does not follow ward boundaries. A ward-by-ward drain plan can pass the problem to the next ward, and to the next local body. In Haryana a single drain can pass through several hands on its way to a river or to the Najafgarh drain. The Haryana Municipal Corporation Act 1994 vests in the Corporation all public drains and all drains in, alongside or under any public street (s.193), and the land appertaining to any public tank (s.161); GMDA's "infrastructure development work" includes drainage that connects two or more sectors, and its infrastructure development plan must cover storm water drainage (GMDA Act 2017, as read from the Bill); HSVP executes the external development works of its Urban Estates, storm drains among them, as the nodal agency, and the colonizer builds the internal drains of a licensed colony (DTCP, quoting the HDRUA Act 1975); HSIIDC runs the drains of its industrial estates; I&WRD's drainage works are the channels and embankments the State keeps for flood protection, which by definition exclude "works for the removal of sewage from towns" (Canal and Drainage Act 1974, s.2(7)); and the ponds of 0.5 acre or more on public land, with their green belt and catchment, fall under the Pond Authority (Pond Authority Act 2018, s.2). Of the 644 water bodies GMDA inventoried in Gurugram district, about 60% by number are owned by the local bodies, 35% by private owners and 5% by government departments (GMDA). No rule divides the I&WRD drains from the municipal, HSVP and GMDA drains (as this Manual reads the record). The drains carry sewage across these boundaries: GMDA reported in 2020 that 51.30 MLD of untreated discharge still had to be diverted from Legs I–III, and the Najafgarh drain into which they flow runs through Delhi. This clause makes the basin the planning unit, so that one model carries each drain from its head to the river or the Najafgarh drain whoever owns each reach, and so that the interception works are tested against the capacity of the drains they tap (Chapter 8, Clause 8.9.5).

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of a city with a Municipal Corporation: the **Municipal Corporation** (in Gurugram, **MCG**), in which the public drains and street drains vest (Haryana Municipal Corporation Act 1994, s.193), jointly with the **metropolitan development authority** where there is one (in Gurugram, **GMDA**; in Faridabad, **FMDA**; in Panchkula, **PMDA**), which plans and builds the drainage that connects sectors and carries it into its infrastructure development plan; either may prepare the plan as the State directs, and DTCP carries it into the development plan (Clause 11.9). Where a basin extends beyond the Corporation, the other local bodies and the authority in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the I&WRD drains from the drains of the local bodies, GMDA, FMDA and HSVP was found; until one is made, this Manual assigns the reaches within each BSMP as follows, each body being Lead Authority for the reaches and works it owns or runs and for the parts of the CIP on them: **I&WRD** for the rivers, the I&WRD drains (among them Outfall Drain No. 8 and Drain No. 2), the canals, embankments, regulators and barrages, Hathnikund barrage and the Kaushalya dam, and the floodplain limits notified under s.45 of the Canal and Drainage Act 1974; the **Haryana Pond and Waste Water Management Authority** for the ponds under its Act, their green belts, catchments and protected areas, with the Gram Panchayat or local body that owns each pond; the **Wetland Authority of Haryana** for notified wetlands; the **Municipal Corporation**, **Municipal Council** or **Municipal Committee** for the drains and public tanks vested in it; **GMDA**, **FMDA** and **PMDA** for the master drains that connect sectors (in Gurugram, Legs I to IV); **HSVP** for the sector drains of its Urban Estates until they are handed over; the **licensed colonizer** for the internal drains of a colony until they are taken over; **HSIIDC** for the drains of its industrial estates; and PWD (B&R) and NHAI for the drains of their roads.
- In Tier B bodies: the Lead Authority is named by the Urban Local Bodies Department with DTCP. Basins draining to a common river reach or I&WRD drain may be grouped into one district-level plan.

The Haryana Pond and Waste Water Management Authority shall be consulted on every BSMP whose basin includes a pond, since a spatial or development plan that covers a pond needs its prior approval (Pond Authority Act 2018, s.17); the Wetland Authority of Haryana on every BSMP whose basin drains to a notified wetland or a Ramsar site (Sultanpur or Bhindawas); HSDMA and the district administration on every BSMP; the Haryana State Pollution Control Board on every BSMP that proposes works on a drain that carries sewage; and, for a basin that is shared with Delhi, such as that of the Najafgarh drain, Delhi's Irrigation and Flood Control Department, through I&WRD.

I&WRD shall be a partner in every BSMP that includes a river, canal or tank under its control.

11.4.2 **When a BSMP is required.**

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

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

11.5 Data and surveys

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

Table 11.1 — Minimum data and surveys for a BSMP

Data	Minimum requirement
Terrain	Digital elevation model from LiDAR or photogrammetry, with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum
Drain network	Inventory of all public drains, culverts and outfalls with invert levels, sizes, condition and silt depth; private drains above 600 mm
Waterbodies	Survey of every tank, johad, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels, encroachment
Rivers and canals	Cross-sections at no more than 200 m spacing and at every structure
Outfalls, rivers and I&WRD drains	The datum of every level named; outfall invert levels against the warning, danger and high flood levels of the Yamuna at the nearest CWC gauge (at Karnal a danger level of 249.5 m and a high flood level of 250.07 m in 2013; at Mawi 230.85 m and 232.75 m) and its recorded peaks, with the release records of Hathnikund barrage; for the Ghaggar, the Tangri, the Markanda and the choes, on which CWC has no flood sites, the gauge zero, danger level and highest recorded levels of the I&WRD gauges, or surveyed marks of the July 2023 flood; for outfalls to I&WRD drains, the design discharge and design water level of the drain at the outfall from I&WRD (for Outfall Drain No. 8, a capacity of 4,000 cusecs against 5,000 cusecs observed at the Dhansa regulator in 2022); for drains that reach the Najafgarh drain, its level and capacity at the outfall, agreed with Delhi's Irrigation and Flood Control Department; the limits notified under s.45 of the Canal and Drainage Act (the Ghaggar floodplain in Panchkula, drawn on a 100-year flood of 2,933.45 m³/s) and the lines around the Badkhal and Surajkund lakes under the Supreme Court's orders; and the regulators, sluices, flap gates, bundhs, barrages (Masani on the Sahibi, crest 240.00 m) and pumping stations on the outfalls, with their capacities and operating rules
Rainfall and levels	All available rain gauges (IMD, including its observatories at Ambala, Hisar, Karnal, Gurgaon, Rohtak, Narnaul and Bhiwani and the automatic weather stations and rain gauges reported by the Meteorological Centre Chandigarh; the district and tehsil rain gauges of the State, such as those at Gurugram, Kadipur, Harsaru, Wazirabad and Sohna; the agromet observatories of CCS Haryana Agricultural University at Hisar and of CSSRI at Karnal; the rain and river gauges of CWC and of I&WRD, including those at Hathnikund barrage and on the Ghaggar; and any gauges kept by the Municipal Corporations, GMDA, FMDA and the Smart City companies) and water-level records, including those for the July 2016 (Gurugram), August 2019 (the Yamuna at Hathnikund), August 2020 (Gurugram), July 2023 (the Ghaggar at Panchkula, Ambala and Kaithal, and the Yamuna), July 2024 (Gurugram) and September 2025 (Gurugram) 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 khadar floodplains of the Yamuna and the Ghaggar, across the flat waterlogged plains of the Rohtak–Jhajjar–Sonipat belt, around the Najafgarh jheel depression on the Haryana side and the beds of the old bundhs of Gurugram, and around the margins of the johads, where the line of the full level decides what may be built, 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 July 2016 (Gurugram), August 2019 (the Yamuna at Hathnikund), August 2020 (Gurugram), July 2023 (the Ghaggar at Panchkula, Ambala and Kaithal, and the Yamuna), July 2024 (Gurugram) and September 2025 (Gurugram) events are the best calibration data Haryana 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 johad storage	No net loss of flood storage below the MWL in the basin, measured against the earliest available survey
Outfalls	Functioning under the joint and outfall-closed cases of Chapter 5

> **Commentary.** The building and road levels repeat Chapter 6, so that the basin plan and the site designs aim at the same outcome. The 0.2% AEP for critical facilities, the 6-hour ponding drain time and the no-net-loss rule for tank storage have no direct precedent and are set by this Manual. The drain time reflects what residents notice most after a storm. The no-net-loss rule reflects a loss of storage that has been counted but not measured. In law the State's ponds are protected in several layers: the Pond Authority Act 2018 treats as a pond any tank, lake or water body of 0.5 acre or more "whether it contains water or not" that is recorded as a talab, johar or tank, with its green belt, peripheral catchment, feeder inlets, bunds and weirs, bars building on pond land, green belt or catchment and any obstruction of inflow or outflow without permission, and lets the State notify a protected area around a pond (ss.2, 14 and 16), though none was found notified, and it excludes ponds on private land and those under 0.5 acre; in a Municipal Corporation the public tanks and the land appertaining to them vest in the Corporation (HMC Act 1994, s.161); and the National Green Tribunal has ordered unique identifiers for the water bodies of Gurugram and of the State (OA 325/2015, 2018). The Pond Authority has 19,665 ponds on its data system, 18,764 rural and 901 urban (2024). The losses are visible all the same: Gurugram's water bodies fell from 641 in the revenue record of 1956 to 487 in 1976, and of the 644 that GMDA has inventoried, covering about 1,142 acres, 35% by number are privately owned (GMDA); Damdama lake near Sohna shrinks from about 80 to about 35 acres within a month of the monsoon (as reported); and the Najafgarh jheel on the Haryana side had not been notified as a wetland by March 2024 (as reported). Sultanpur (143 ha) and Bhindawas (412 ha) became Ramsar sites on 25 May 2021, but no wetland notified under the Wetlands Rules 2017 was confirmed. No survey of the storage of any johad inside a Municipal Corporation was found.

11.7 Modelling and scenarios

11.7.1 **Model.** Each BSMP shall use a coupled 1D–2D hydraulic model of:

- the minor system;
- the major (overland) system;
- rivers, canals and tanks; and
- the outfalls.

Methods shall follow Chapter 3. Tidal and river boundaries shall follow Chapter 5.

11.7.2 **Design storms.** The model shall be run for the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs. Areal reduction shall be applied under Clause 2.7.3.

11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms arrive, and how often heavy rain coincides with a closed outfall. The two-step approach of Clause 3.13.5 may be used: a simplified storage model is run for the whole record, and the coupled 1D–2D model of Clause 11.7.1 is run only for the design storms, starting from the tank levels the continuous run gives. A continuous run of the full 1D–2D model is not required.

11.7.4 **Scenarios.** Each BSMP shall model at least:

- (a) **Existing:** existing land use, network, tanks and outfalls;
- (b) **Future, uncontrolled:** future land use under the statutory master plan, with no site controls;
- (c) **Future, controlled:** future land use with the site controls of Chapter 4;
- (d) **Future, with plan:** scenario (c) plus the works of the CIP; and
- (e) **Climate:** scenarios (a) and (d), with the climate factors of Clause 2.8, used unchanged: no projection of heavy rainfall for Haryana with a design factor was found, and the State Action Plan on Climate Change 2.0 both projects very heavy precipitation events rising by 2.5% by mid-century under RCP 8.5 and the one-day maximum falling marginally, two findings that do not agree; the station records of 30 June 1981 at Rohtak (297.9 mm) and Gurgaon (261.2 mm), after the CWC plates were drawn, exceed the 50-year depths of those plates (IMD; this Manual's reading), which is a reason to keep the factors, not to reduce them.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the July 2016 (Gurugram), August 2019 (the Yamuna at Hathnikund), August 2020 (Gurugram), July 2023 (the Ghaggar at Panchkula, Ambala and Kaithal, and the Yamuna), July 2024 (Gurugram) and September 2025 (Gurugram) events where data exist.

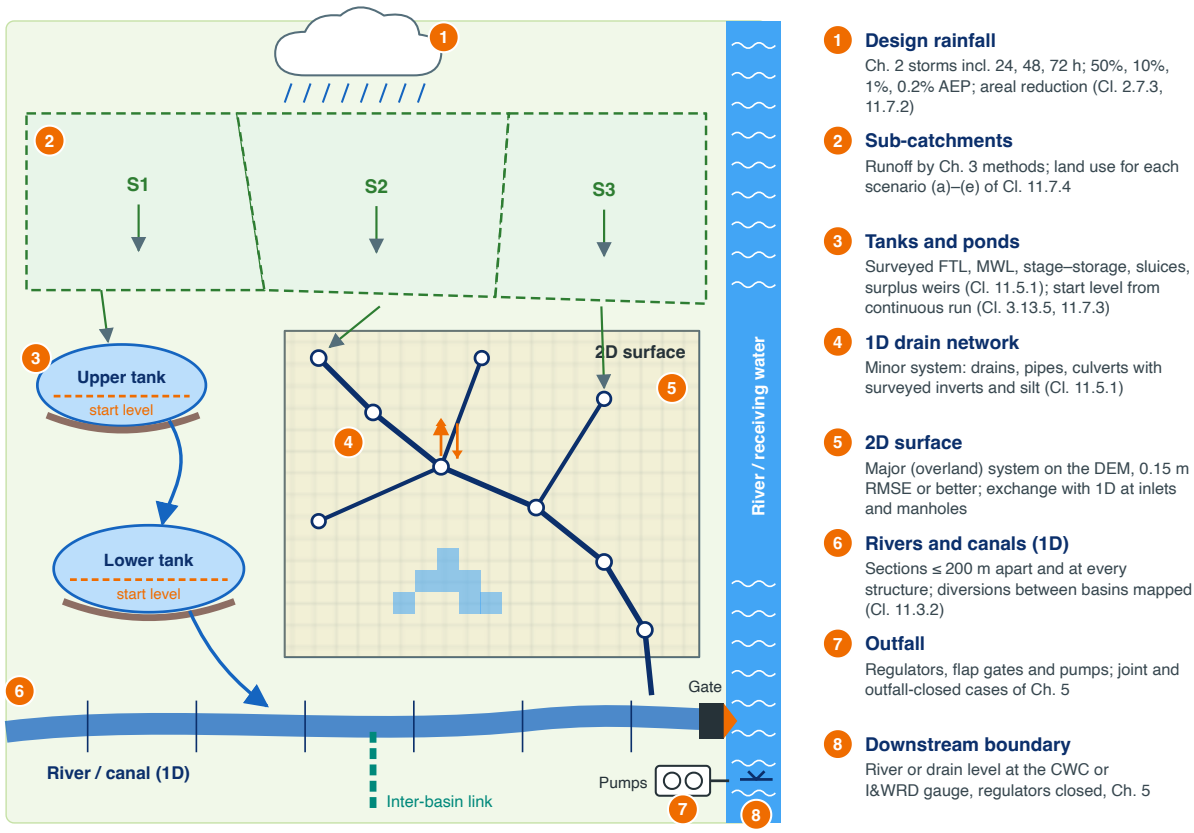

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and johads with starting levels from continuous simulation, and the tidal or river boundary at the outfall (schematic, not to scale). Original drawing for this Manual, 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:** johads, 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:** regulators, sluices and flap gates on the outfalls to the Yamuna, the Ghaggar and the I&WRD drains, pumping stations and the storage behind them where an outfall can be closed or its capacity is short, including those at Gurugram's underpasses and on the drains of the Rohtak–Jhajjar–Sonipat belt that reach Outfall Drain No. 8, interception works that keep sewage out of the master drains without taking their storm

capacity, the restoration of Gurugram's old bundhs as detention, the river embankments, and the operating rules of Hathnikund barrage, the Kaushalya dam and the regulators that set the receiving levels, agreed with I&WRD and, for the Najafgarh drain, with Delhi's Irrigation and Flood Control Department;

5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example IMD district rainfall warnings and nowcasts issued by the Meteorological Centre Chandigarh, CWC flood forecasts and river stages at its Yamuna sites against their warning and danger levels, notice of releases from Hathnikund barrage to the towns downstream, warnings from the I&WRD gauges on the Ghaggar, the Tangri and the Markanda, where CWC has no flood sites, and the district flood control rooms), 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 where the water table is deep and over-exploited, as under Gurugram, Faridabad, Kurukshetra, Karnal, Panipat and the south, waterlogging where it is within 3 m, as over about half of Rohtak and Jhajjar districts, and the quality of the groundwater, which is saline over much of the south, west and centre of the State, and of the drains and johads that the runoff reaches (Chapter 8);
- effect on downstream basins and the receiving river or drain; and
- who benefits.

11.8.3 **Basin release rates.** Where scenario (c) does not meet the level of service, the BSMP may set a basin-specific **permissible site discharge** ($m^3/s/ha$) stricter than Chapter 4, by AEP and sub-catchment. The rate takes effect under the notification procedure of Clause 4.5.4.

11.8.4 **Outputs.** Each BSMP shall produce:

- (a) flood hazard maps (extent, depth, velocity, hazard class) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan. The **1% AEP future-with-plan map** becomes the reference map for floor levels (Chapter 6) and setbacks (Chapter 7);
- (b) recommended flood-sensitive catchments and any basin release rates (Clauses 4.5.4 and 11.8.3);
- (c) regional facility sites, with storage volumes, land needs and the sites they serve;
- (d) the fee-in-lieu unit rate for the basin (Clause 4.13.3);
- (e) the **Capital Improvement Programme**: works ranked by risk reduction per rupee, with cost, phasing and agency;
- (f) a pre-monsoon **maintenance programme**: desilting, gate and pump testing, and tank operating rules (Chapter 10); and
- (g) monitoring needs: new rain gauges, level sensors and flood-mark survey points.

> Commentary. Restoring storage comes first because many of the outfalls of Haryana's towns are closed or limited in the wettest weeks. Gurugram's master drains end in the Najafgarh drain in Delhi, and reaches of the Badshahpur drain have been reported to carry far less than its drawn capacity (as reported); Outfall Drain No. 8 carried 5,000 cusecs at the Dhansa regulator against its capacity of 4,000 (I&WRD, 2022); and the Yamuna and the Ghaggar can stand above the town outfalls for days. Gurugram once held its runoff in storage: the Ghata, Chakarpur, Jharsa and Wazirabad bundhs were built in the late nineteenth century and have been made obsolete by building (Ministry of Housing and Urban Affairs, Lok Sabha, 2025, as reported), the city's water bodies numbered 641 in the revenue record of 1956, 487 on the Survey of India map of 1976 and 557 on imagery of 2011–12 (GMDA), and HARSAC found 47 ponds in and around the city dried up or filled with waste (2021). The city failed in July 2016 after about 50 mm of rain (as reported), which points to capacity and outfalls, not to an extreme storm. The storms are large for drains with no stated design basis: IMD has recorded 484.1 mm in a day at Rohtak (19 September 1933), 398.8 mm at Palwal (9 September 1875) and 282.2 mm at Gurgaon (14 July 1968), above the 50-year 24-hour depths of the CWC plates there (IMD; this Manual's reading). Conveyance

upgrades on their own move water faster to an outfall that the Yamuna or the Ghaggar in flood may close, or that is limited by the capacity of its regulator, its pumping station or the receiving drain, as at the Najafgarh drain and Outfall Drain No. 8. Groundwater in Haryana calls for recharge in most of the State and forbids it in part of it. The State's stage of extraction was 135.96% in 2024, with 88 of its 143 assessment units over-exploited, and every block of Gurugram, Kaithal, Karnal, Kurukshetra and Panipat over-exploited (CGWB); the water table is deeper than 30 m under 97% of Kurukshetra district and 51% of Gurugram (HWRA, June 2023). But every block of Rohtak and Jhajjar is "safe" because the water table is near the surface: it stood within 3 m over about half of Rohtak and 43% of Jhajjar district in June 2023, and the waterlogged or prone area of the State grew from about 2.93 lakh ha in June to about 3.79 lakh ha in October (HWRA; this Manual's arithmetic); there, recharge adds to waterlogging. Quality limits recharge too: CGWB describes the groundwater of the southern, western and central districts as mostly saline, and found 18.45% of its samples above 1.5 mg/L of fluoride (2021–22). The Building Code asks for recharge on every plot of more than 500 m² without regard to depth (Code 8.1(2)), while the Water Resources Authority Act 2020 requires the Authority to prevent activities likely to lead to waterlogging (s.21(7)). This is why recharge, waterlogging and groundwater quality are all assessment criteria. This Manual ranks projects by risk reduction per rupee so that limited budgets go first where most people are protected.

11.9 Integration with land-use planning

11.9.1 An approved BSMP shall be incorporated into the statutory land-use plan: the development plans of the controlled areas prepared by DTCP under the Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Act 1963 (s.5), among them the Final Development Plan 2031 of the Gurugram–Manesar Urban Complex, the sector plans of HSVP and the layouts of colonies licensed under the Haryana Development and Regulation of Urban Areas Act 1975, and the infrastructure development plans of GMDA, FMDA and PMDA under their Acts; and, for a plan that covers a pond, with the prior approval of the Haryana Pond and Waste Water Management Authority (Pond Authority Act 2018, s.17). 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. Haryana draws its water lines by notification in one place and by court order elsewhere. The Haryana Building Code 2017 sets no setback from a drain, river or pond, and keeps only the natural drainage inlets and outlets of large projects (Code 12.1); no I&WRD rule barring construction within a set distance of a drain or canal was found. Section 45 of the Canal and Drainage Act 1974 lets the State prohibit obstructions within notified limits along a river, stream or drainage channel, and the only such notification found is the Ghaggar floodplain in Panchkula (27 October 2023), drawn on a 100-year flood of 2,933.45 m³/s; the State has told the National Green Tribunal that all construction is banned on river floodplains under that section, but no notification for the Yamuna or any other river was found. The other lines come from the courts: the Supreme Court has barred construction in the green belt and within 1 km of the Badkhal and Surajkund lakes and made plans within 1–5 km subject to the pollution control boards (1996), and has held land notified under the Punjab Land Preservation Act 1900 in the Aravallis to be forest (2018, as reported). The Pond Authority Act 2018 provides for a protected area around a pond, by notification, but none was found notified; notified wetlands carry a 50 m line from the mean high flood level (Wetlands Rules 2017), though no wetland in Haryana was confirmed notified. These are river, lake and waterbody lines, not drainage-flood lines; the hydraulic corridor and setback zones of Chapter 7 are this Manual's proposal, and where the s.45 limits or a court line bind and are wider, they apply. A BSMP gives the

development plans the 1% AEP drainage-flood map, and the buffer widths of Chapter 7, that they need. Using open space land as storage or flow path has no direct precedent; this Manual adopts it because the Haryana Building Code 2017 already requires, for projects of 5,000–20,000 m² built-up, that the inlet and outlet points of the natural drainage be kept with a channel of adequate size and that at least 20% of the recreational open space be left unpaved, with one recharge bore per 5,000 m² (Code 12.1), and makes groundwater recharge mandatory for parks, parking, plazas, playgrounds and other common areas (Code 8.1(2)(ii)), but sets no detention or pervious-area rule; storage placed in a layout's open space builds on these duties, and because that land still serves as open space, the storage must stay usable as one. 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 June). 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 Haryana 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 Municipal Corporations and of the metropolitan development 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)	Municipal Corporation of Gurugram (MCG), and GMDA and every other Approving Authority within the Gurugram Metropolitan Area	1.6.1(a)
(b)	Every other Municipal Corporation constituted under the Haryana Municipal Corporation Act, 1994 (among them Faridabad and Manesar), with every other Approving Authority within its limits	1.6.1(b)
(c)	FMDA, PMDA and any metropolitan development authority constituted later by an Act of the State, with every Approving Authority within its notified area	1.6.1(c)
(c)	HSVP in its Urban Estates, and DTCP for the colonies it licenses, wherever they lie	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 Municipal Corporation and metropolitan development authority in the State, and of every Approving Authority within their areas, with the Urban Estates of HSVP and the colonies licensed by DTCP, 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 Gurugram Metropolitan Area as notified on 12 August 2018 (MCG, the municipal areas of Farukhnagar, Sohna and Pataudi and 41 gram panchayats) and its later changes (GMDA); the notified areas of FMDA and PMDA, and the status of the metropolitan development authorities reported for Sonipat (Bill passed in 2023) and Hisar (Bill of 2024) (as reported [TBC]); the current list and limits of the Municipal Corporations, Councils and Committees (the Urban Local Bodies Department); the Urban Estates and sectors of HSVP; the licensed colonies and the controlled areas (DTCP); the industrial estates of HSIIDC; and the district and tehsil boundaries (Revenue and Disaster Management Department, Survey of India). Until it is published, the tier is decided by the classes in Clause 1.6.1 and recorded on Form 1-1, and the Authority confirms it at the pre-application stage (Clause 1.5.9).

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

No.	Authority	Class (Municipal Corporation / Municipal Council / Municipal Committee / development 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 Municipal Corporation and metropolitan development area boundary map shall be published as open data in a machine-readable format (Clause 10.17.4), with the date of the notification it shows.

Annex 1B — Maps of flood-sensitive catchments

Supports Clauses 1.4, 1.6.5 and 1.10.3(d) of Chapter 1, and Clauses 4.5.3 and 4.5.4 of Chapter 4.

1B.1 The flood-sensitive catchments are listed in Clause 4.5.3.2. Table 1B.1 repeats that list. The maps of this annex and the boundaries of Annex 4A are the same data set and shall be issued together.

Table 1B.1 — Flood-sensitive catchments listed in Clause 4.5.3.2

Item	Catchment	Extent as described in Chapter 4
(a)	Gurugram on Legs I–III and the Badshahpur drain	The catchments of Leg-I, Leg-II and Leg-III (the Badshahpur drain), from the Aravalli foothills to their outfalls to the Najafgarh drain, including the land that drains to the Badshahpur drain at Khandsa and Hero Honda Chowk; the drains carry 541, 1,305 and 3,702 cusecs on DTCP's drawing of 2012, with no return period stated, and a bottleneck at Khandsa is reported (as reported)
(b)	Faridabad on the Budhiya nala	The catchment of the Budhiya (Buria) nala and of the city drains that join it, down to its outfall towards the Yamuna; the nala carried a BOD of 76 mg/l before the Yamuna at Manjhawali in 2023 (State of Haryana, report to the NGT)
(c)	The Rohtak–Jhajjar waterlogged towns	Rohtak, Jhajjar, Bahadurgarh, Beri and Sampla and the land that drains from them to Outfall Drain No. 8 and the other I&WRD drains of sub-area HR-D; the water table was within 3 m of the surface over about 50% of Rohtak and 43% of Jhajjar district in June 2023 (HWRA), and Outfall Drain No. 8 carried 5,000 cusecs against a capacity of 4,000 in 2022 (I&WRD)

Item	Catchment	Extent as described in Chapter 4
(d)	Panchkula and Ambala on the Ghaggar	The land of Panchkula and Ambala that drains to the Ghaggar and its tributaries and choes, among them the Kaushalya and the Tangri, including the Ghaggar floodplain zone notified in Panchkula under section 45 of the Haryana Canal and Drainage Act, 1974 (27 October 2023, on a 100-year flood of 2,933.45 m³/s)
(e)	The Yamuna floodplain at Karnal, Panipat and Sonipat	The land of those towns that drains across the Yamuna floodplain (khadar) to the river or to drains that outfall to it, whose outfalls are held up when the Yamuna is high; the CWC site at Karnal has a danger level of 249.5 m and a highest flood level of 250.07 m (2013) (as copied from CWC's list)
(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 drain network (the Municipal Corporations of Gurugram, Faridabad, Rohtak, Panchkula, Ambala, Karnal, Panipat and Sonipat, GMDA, FMDA, PMDA, HSVP, Survey of India); the master and sector drains with their outfalls, capacities and levels on a stated datum, among them DTCP's master storm water drainage drawing for Gurugram (No. DTP(G) 2104/2012) and HUDA's catchment plan for the Badshahpur drain (2017, revised 2020); the I&WRD drains, regulators and gauges, with Outfall Drain No. 8 and the Dhansa regulator, and the levels of the Ghaggar, the Kaushalya dam and the Tangri (I&WRD); the section 45 floodplain zone of the Ghaggar with its khasra list and boundary pillars; the CWC levels on the Yamuna at Karnal and Mawi; the depth to water in the Rohtak–Jhajjar belt (HWRA, CGWB); and the land flooded in 2016, 2019, 2023, 2024 and 2025, with the waterlogging hotspots listed by the district administrations (the Deputy Commissioners, HSDMA, the local bodies). Yamunanagar–Jagadhri on the Yamuna below Hathnikund; Kaithal (Guhla), Fatehabad and Sirsa on the Ghaggar, where the embankments breached in July 2023; Kurukshetra on the Markanda and the Saraswati; Hisar; Rewari on the Sahibi; Palwal; and Sohna and Nuh are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented. The river floodplains, the Badkhal and Surajkund buffers and the ponds under the Pond Authority Act are governed by Chapter 7 and by the notifications and orders that bind there rather than by this list. Until it is published, the Authority decides at the pre-application stage whether a site lies in a listed catchment, from the best boundary available, and the decision and its basis are recorded on Form 1-1 and in the drainage report (Clauses 1.5.9 and 1.11.5).

Table 1B.2 — Attributes of the flood-sensitive catchment layer (layout)

Field	Content	Unit or format
catchment_id	Unique identifier	text
name	Catchment name	text
basis	Clause 4.5.3.2 item (a) to (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 Haryana Stormwater Design Manual (the Manual) named in each alternative. An alternative applies within the area of an Approving Authority (the Authority) only from the date on which the Authority adopts it under P1.3.

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

P1.3 **Adoption.**

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

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

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

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

Part 2 — The alternatives

S-1 — Design-aid route for storage

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

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

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

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

S-2 — Permissible site discharge (PSD)

S-2.1 *Replaces:* the release rate Q_post(T) ≤ 0.9 × Q_pre(T) computed for the site (Clause 2.11.2).

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

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

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

S-3 — Fixed-width waterbody setback

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

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

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

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

S-4 — Downstream screening checklist

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

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

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

S-4.4 *Conditions:* the checklist is signed by the registered professional who signs the drainage report (Clause 10.6); flood-prone locations are those recorded by the local body, the Deputy Commissioner and the District Disaster Management Authority, HSDMA, I&WRD, GMDA, FMDA or PMDA in their areas, or the district administration in its list of waterlogging points (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 johad or tank storage identified in the basin plan (Clause 4.13.1).

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

S-5.4 *Conditions:*

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

Part 3 — Model council resolution

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

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

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

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

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

Annex 1D — Model HBC 2017 amendment and model ULB bye-law

Supports Clauses 1.3.1, 1.3.4, 1.11 and 1.12 of Chapter 1.

> **Model text for consideration by a competent authority. Not in force.** The text shows one way the instruments of Clause 1.3.1 could be drafted. Rule and section numbers are left blank.

Drafting note D1D.1. The rule numbers of the Haryana Building Code 2017 at which the new rule and the conditions would be inserted, and the enabling sections of the Haryana Development and Regulation of Urban Areas Act, 1975, the Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Act, 1963, the Haryana Shehri Vikas Pradhikaran Act, 1977 and the Acts of GMDA, FMDA and PMDA 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 Haryana Building Code 2017

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

- (1) These rules may be called the Haryana Building Code 2017 (Stormwater Management) Amendment, _____.
- (2) They shall come into force on the date six months after their publication in the Haryana Government Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building code issued by the Town and Country Planning Department with memo No. Misc-138-A-Loose/7/5/2006-2TCP of 7 March 2017, and applied by each Competent Authority under its own Act, the following rule shall be inserted:

Rule [_____]. Stormwater management.

(1) *Definitions.* In this rule, "the Manual" means the Haryana 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 Haryana 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 — Haryana 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 Haryana Building Code 2017 — 1.5.1(a): Yes / No	_____
B2	Public work by a ULB, State department, board or State undertaking — 1.5.1(b): Yes / No	_____
B3	Work by a Central agency needing the Authority's approval or no-objection — 1.5.1(c): Yes / No	_____
	C. Areas over the common plan of development (Clauses 1.4, 1.5.5)	
C1	Phases, plots and sub-divisions included (one layout approval or one ownership)	_____
C2	Total site area (ha)	_____
C3	Land disturbance (ha)	_____
C4	Existing impervious area (m²)	_____
C5	New impervious area (m²)	_____
C6	Replaced impervious area, removed to subgrade and rebuilt (m²)	_____
C7	New plus replaced impervious area, C5 + C6 (m²)	_____
C8	Plot area for the RWH mandate (m²) (Clause 1.5.3)	_____
	D. Thresholds and exemptions	
D1	Land disturbance 0.1 ha or more — 1.5.2(a): Yes / No	_____
D2	New or replaced impervious area 500 m² or more — 1.5.2(b): Yes / No	_____
D3	Redevelopment (existing impervious cover on the site) — 1.5.6: Yes / No	_____
D4	Constrained redevelopment route of Clause 4.5.6 proposed: Yes / No	_____

No.	Item (clause)	Entry
D5	Linear public work: added impervious area per drainage catchment crossed given in Table 1F.2 — 1.5.7: Yes / No / not applicable	_____
D6	Exemption claimed — 1.5.8(a) single dwelling below the thresholds / 1.5.8(b) resurfacing with no added impervious area / none	_____
D7	RWH mandate applies (HBC 2017, Code 8.1: rooftop of 100 m² or more in an area the Competent Authority has notified; groundwater recharge on plots of more than 500 m²; HSVP Urban Estates: rooftop of 100 m² or more (notification of 31 Oct 2001)) — 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 — Haryana 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 tehsil and block rain gauges whose readings the district administrations report, the gauges of I&WRD, and any automatic gauges of GMDA, the Municipal Corporations and the city command centres [TBC]), and district and basin boundaries (Survey of India, I&WRD). Until it is published, design depths are taken from NIH-DHAARA under Clause 2.3.1, the cross-checks of Clause 2.3.3 are reported on Form 2-1, and the zone of a site is the one agreed with the Authority and recorded on Form 2-1.

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

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

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

Table 2A.2 — Rainfall zones (layout)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
HR-Z1 Shivalik foothills	The Shivalik foothills and the piedmont below them, from Kalka–Pinjore and Morni through Panchkula, Naraingarh and Ambala to Yamunanagar–Jagadhri, Sadhaura and Kalesar, in CWC subzone 1(e) up to the zone 7 line, with the Kalka–Pinjore upland beyond it and the Morni and Kalesar hills on it (Clause 2.3.6(b)); catchments that cross a zone line take the higher zone value	Ambala 42103 (daily record 1901–2012), Chandigarh 42105 (1954–2009, the reference gauge for Panchkula)	District annual normals 988.0 mm at Ambala and 1,073.6 mm at Chandigarh, the highest in the State (IMD, 1901–1980). FER 50-yr 24-h about 240–262 mm (spot 262 at Chandigarh, about 250 at Ambala) and 100-yr about 240–289 mm (spot 289 at Chandigarh); 1-h ratio 0.34; the report asks for a "suitable increase" for steep foothill catchments. Records: Dadupur 444.5 mm (2 Jul 1966; name [TBC]), Chandigarh 302.2 mm (9 Jul 2023, real-time), Jagadhari 287.0 mm (2 Aug 1908), Ambala 246.2 mm (3 Aug 2004) and 224.1 mm (9 Jul 2023), Naraingarh 243.8 mm (13 Jul 1886) (IMD). NIH-DHAARA 50-yr 24-h high here (Panchkula 320, Morni 317, Yamunanagar 306 mm)
HR-Z1 Shivalik foothills: HR-A Shivalik foothills and choes	Panchkula, Pinjore–Kalka, Morni, Naraingarh, Ambala, Yamunanagar–Jagadhri, Sadhaura, Bilaspur and Kalesar; boundaries [TBC]	Ambala, Chandigarh	A piedmont belt about 2–4 km wide of coarse sand, gravel and boulders below the Shivalik sandstones and clays (CGWB); choes (seasonal torrents) carrying boulders. The worked example of the 1(e) report, the Ghaggar at road bridge No. 2 about 7 km west of Ambala City (1,126 km², slope 5.14 m/km), reads 25.0 cm at 50 years and gives a 50-year peak of 2,706 m³/s, about 2.4 m³/s/km². Receiving waters: the Ghaggar below the Kaushalya dam, with its floodplain zone notified in Panchkula under section 45 (27 Oct 2023; 100-year flood 2,933.45 m³/s); the Tangri and the Markanda (peaks of about 38,000–52,649 cusecs reported in 2023, conflicting [TBC]); the Somb and the Pathrala; and the Yamuna at the Hathnikund barrage (design flood 22,000 m³/s; record 8,28,072 cusecs on 18 Aug 2019, as reported). CWC has no flood site in the Ghaggar basin
HR-Z2 Northern, NCR and central plains	The alluvial plains of the Yamuna and the Ghaggar below the foothills, the NCR districts south to the Aravallis and the Sahibi, and the Rohtak–Jhajjar–Sonipat belt, in CWC subzone 1(e); catchments that cross a zone line take the higher zone value	Karnal 42137 (1949–2012), Gurgaon 42178 (1965–2012), Rohtak 42176 (1967–2012); New Delhi/Safdarjung 42182 (from 1901) for Gurugram and Faridabad (Clause 2.3.6(d))	District annual normals about 474–696 mm (Rohtak 474.4, Faridabad 564.3, Sonepat 567.0, Gurgaon 577.8, Kurukshetra 581.8, Karnal 695.8 mm; IMD, 1901–1980). FER 50-yr 24-h about 200–240 mm and 100-yr about 200–280 mm; 1-h ratio 0.34. The September storms of 1875, 1911 and 1933 put more than 240 mm in a day on several gauges at once in the south of the zone. NIH-DHAARA 50-yr 24-h 177–262 mm, low at Gurugram (194) and Rohtak (177), above the plates at Faridabad (262)
HR-Z2 Northern, NCR and central plains: HR-B Upper Yamuna–Ghaggar plains	Kurukshetra, Shahabad, Kaithal, Karnal, Panipat and Samalkha, along the GT Road; boundaries [TBC]	Karnal	Recent Yamuna and Ghaggar alluvium, with sodic soils in Kurukshetra, Kaithal and parts of Karnal; the deepest water tables in the State, more than 30 m below ground over 97% of Kurukshetra district in June 2023 (HWRA), and a trough along the GT Road in Panipat and Sonipat (CGWB). FER 50-yr 24-h about 200–240 mm. Records: Karnal 250.0 mm (21 Sep 1962), Panipat 254.0 mm (19 Sep 1933) (IMD). Receiving waters: the Yamuna at Karnal (CWC; danger level 249.5 m, highest flood level 250.07 m, 17 Jun 2013) and at Mawi (danger level 230.85 m, highest flood level 232.75 m, 18 Jun 2013) (as copied from CWC's list); Drain No. 2 at Panipat (6,325 cusecs, NCRPB); the Saraswati and the Ghaggar at Guhla (breaches in 2023, as reported)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
HR-Z2 Northern, NCR and central plains: HR-C NCR south (Aravalli–Sahibi)	Gurugram, Manesar, Sohna, Faridabad, Ballabgarh, Palwal and Nuh; boundaries [TBC]	Gurgaon, with New Delhi/Safdarjung	Aravalli rock and scree, about 17–23% of the mapped area of Gurugram, Faridabad and Mewat (CSSRI), over older alluvium; water tables more than 30 m deep over 51% of Gurugram district (HWRA); saline pockets. FER 50-yr 24-h about 220–240 mm, the band of Delhi; the absolute floors of Clause 2.3.6(g)(ii) apply. Records: Palwal 398.8 mm and Ballabgarh 299.7 mm (9 Sep 1875), Ferozepur Jhirka 315.0 mm (1 Sep 1884), Gurgaon 282.2 mm (14 Jul 1968) and 261.2 mm (30 Jun 1981) (IMD). Short falls: 103 mm in 90 minutes (9–10 Jul 2025) and more than 100 mm in 4 hours (1 Sep 2025) in Gurugram (as reported). Receiving waters: Gurugram's Legs I–III (the Badshahpur drain; 541, 1,305 and 3,702 cusecs on DTCP's drawing of 2012) to the Najafgarh drain; the Budhiya nala and the Gaunchi drain to the Yamuna at Faridabad and Palwal
HR-Z2 Northern, NCR and central plains: HR-D Rohtak–Jhajjar–Sonipat waterlogged belt	Rohtak, Jhajjar, Bahadurgarh, Sonipat, Gohana, Beri and Sampla, and the east of Jind district; boundaries [TBC]	Rohtak	Saline-sodic soils and marginal-saline groundwater; the water table within 3 m of the surface over about 50% of Rohtak and 43% of Jhajjar district in June 2023, and the waterlogged area larger by about 30% in October (HWRA); every block of Rohtak and Jhajjar "safe" (CGWB, 2024). FER 50-yr 24-h about 200–220 mm. Records: Rohtak 484.1 mm, Jhajjar 325.1 mm and Beri 279.4 mm (19 Sep 1933), Rohtak 297.9 mm (30 Jun 1981), Sampla 259.1 mm (9 Sep 1875) (IMD). Receiving waters: Outfall Drain No. 8 to the Dhansa regulator and the Najafgarh drain (capacity 4,000 cusecs; 5,000 cusecs in 2022, I&WRD); Drain No. 6 at Sonipat, diverted to the Narela drain in Delhi; the Sahibi at Dadri (highest flood level 214.98 m, 26 Aug 2008, CWC list)
HR-Z3 Dry south-west	The dry plains and dunes of the centre and south-west, and the Aravalli outliers of the south, in CWC subzone 1(e) near its line with subzone 1(a); catchments that cross a zone line take the higher zone value	Hissar 42131 (1914–2012), Narnaul 42177 (1966–2012); Bhiwani 42350 (1992–2012) as a check only	District annual normals about 325–520 mm (Sirsa 325.3, Hisar 396.5, Bhiwani 425.1, Mahendragarh 518.3 mm; IMD, 1901–1980). FER 50-yr 24-h about 160–220 mm and 100-yr about 180–240 mm; 1-h ratio 0.34. NIH-DHAARA 50-yr 24-h low here (Narnaul 113, Sirsa 116, Hisar 139, Bhiwani 154, Rewari 162 mm)
HR-Z3 Dry south-west: HR-E Central and south-west dry plains and dunes	Hisar, Hansi, Bhiwani, Charkhi Dadri, Sirsa, Fatehabad, Tohana and Ellenabad, and the west of Jind district; boundaries [TBC]	Hissar	Sand dunes and sandy and loamy-sand soils, with calcareous layers and saline groundwater (CGWB); water tables mixed, within 3 m over about 14% of Hisar district and deeper than 30 m over about half of Fatehabad (HWRA). FER 50-yr 24-h about 200–220 mm at Hisar, 180–200 mm at Bhiwani and 160–180 mm at Sirsa and Fatehabad. Records: Hissar 346.7 mm (16 Aug 1926), Bhiwani 246.6 mm (4 Sep 1995), Hansi 228.6 mm (1960) (IMD). Receiving waters: the Ghaggar at Chandpur and the Ottu weir (about 38,400 cusecs on 21 Jul 2023, as reported), with breaches in Fatehabad and Sirsa in 2023; inland depressions

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
HR-Z3 Dry south-west: HR-F Ahirwal Aravalli south	Rewari, Dharuhera, Kosli, Narnaul and Mahendragarh; boundaries [TBC]	Narnaul	Aravalli outliers and sandy plains; deep water tables, more than 30 m over 85% of Mahendragarh district (HWRA), and 76.50 m at Mandola after the 2021 monsoon (CGWB). FER 50-yr 24-h about 180–200 mm at Narnaul and about 200 mm at Rewari, inside a closed contour over the Sahibi. Records: Narnaul 237.4 mm (12 Aug 1972) (IMD). Receiving waters: the Sahibi at the Masani barrage (crest 240.00 m, bay walls 242.20 m, I&WRD; highest flood level 242.58 m, 2 Sep 1978, CWC list); the Krishnavati and the Dohan; flash floods from Rajasthan, as in 1977

Annex 2B — Sub-daily ratios P(t)/P(24h) by zone: NIH-DHAARA (hourly-based) vs the one-third rule

Supports Clauses 2.6.1 to 2.6.4 of Chapter 2.

To be prepared. This annex will tabulate, for each zone of Annex 2A, the ratios of the t-hour to the 24-hour design depth from NIH-DHAARA, which are derived from hourly records, against the ratios implied by IMD Das et al. (2022) and by the one-third rule. It needs NIH-DHAARA depths for each duration at representative points in each zone (NIH), IMD recording-gauge data and the IDF values of Das et al. (2022) (IMD). Until it is published, sub-daily depths are read directly from NIH-DHAARA or an approved station IDF (Clause 2.6.1). Where only daily depths are available, the ratios used are those agreed with the Authority, which in Haryana are those of Clause 2.3.6: the CWC Flood Estimation Report ratios for subzone 1(e) in Table 2B.1, raised at 1 and 3 hours to the floors of Clause 2.3.6(g) for the 10-yr and rarer storms (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 $P(t) = P(24)\cdot(t/24)^{(1/3)}$, 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
HR-Z1, HR-Z2 and HR-Z3 (all sub-areas)	CWC FER 1(e), 50-yr (interim design ratios, Clause 2.3.6(f))	0.340	0.475	0.560	0.680	0.840	1.00
HR-Z1, HR-Z2 and HR-Z3 (all sub-areas)	Ratio floor of Clause 2.3.6(g)(i), 10–100 yr	0.35		0.57			1.00
HR-Z2 (HR-C)	Floors of Clause 2.3.6(g)(ii) at 50-yr, as ratios to the 220–240 mm of the plates at Gurugram and Faridabad (comparison only; the floors are depths)	0.44–0.48		0.63–0.68			1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
HR-Z2 (HR-C): Gurugram	NIH-DHAARA, 50-yr, Gurugram cell (comparison only; 3- and 6-hour values not queried)	0.30	0.42			0.82	1.00
HR-Z1 (HR-A): Panchkula	NIH-DHAARA, 50-yr, Panchkula cell (comparison only; 3- and 6-hour values not queried)	0.28	0.45			0.88	1.00
HR-Z3 (HR-E): Hisar	NIH-DHAARA, 50-yr, Hisar cell (comparison only; 3- and 6-hour values not queried)	0.33	0.45			0.85	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&WRD and the tehsil rain gauges whose readings the State reports [TBC]), the benchmark points of Annex 2A, and a stated method for deriving the factors. Until it is published, design depths are taken as point values from NIH-DHAARA or an approved station IDF (Clauses 2.3.1 and 2.3.2). Grid-average values are not used as design depths unless a conversion agreed with the Authority is recorded on Form 2-1 (Clause 1.11.5).

2C.1 The commentary to Clause 2.7 shows why the factors matter, and in Haryana the reanalysis cells err in both directions. In the south and west they err low: the IMDAA cell of NIH-DHAARA (about 12 km) at Hisar gives a 50-year 24-hour depth of about 139 mm and a 100-year depth of about 156 mm, against a CWC plate value of about 200–220 mm and the 346.7 mm recorded at the Hissar observatory on 16 August 1926; at Rohtak about 177 mm, against the 297.9 mm of 30 June 1981 and the 484.1 mm of 19 September 1933; at Gurugram about 194 mm, against the 282.2 mm of 14 July 1968; and at Narnaul and Sirsa about 113 and 116 mm, against plate values of about 160–200 mm. In the Shivalik foothills they err high: about 320 mm at Panchkula, 317 mm at Morni and 306 mm at Yamunanagar, against about 240–262 mm on the plates. The cells' 50-year 1-hour depths, about 38–91 mm, are 0.25–0.36 of their 24-hour depths, and at Gurugram 58.0 mm (NIH-DHAARA, queried 7 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 Haryana 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 — Haryana 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 Haryana storms, in the form introduced by Huff (1967), by zone, storm-duration class and quartile, at stated probability levels. It needs storm hyetographs from recording gauges and automatic weather stations (IMD, its automatic weather stations and automatic rain gauges in the State, under the Meteorological Centre Chandigarh, and any recording gauges of I&WRD, GMDA and the city command centres [TBC]), separated into independent storms by a stated rule, and the storms of 9 September 1875 at Palwal, Ballabgarh and Gurgaon, 19 September 1933 at Rohtak, Jhajjar and Panipat, 30 June 1981 at Rohtak and Gurgaon and 9 July 2023 at Chandigarh and Ambala, and the Gurugram bursts of 9–10 July 2025 and 1 September 2025 among them. Until it is published, design storms use the alternating-block pattern of Clause 2.9.1 and the 48- and 72-hour pattern of Clause 2.9.2; for catchments of 25–5,000 km², the CWC Flood Estimation Report curves may be used with a sensitivity run under Clause 2.9.1 (Clause 2.9.4). SCS Type distributions are not used (Clause 2.9.3). For the disaggregation of daily records in continuous simulation (Clause 11.7.3), the method is agreed with the Authority and recorded (Clause 1.11.5).

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

Fraction of storm time	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10% probability curve	0										1.0
50% probability curve	0										1.0
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&WRD and the tehsil rain gauges whose readings the State reports [TBC]) and IMD gridded data with the factors of Annex 2C where stations are sparse. Until it is published, P_R is computed by the definition of Clause 2.10.1 from the long-term daily record of a station agreed with the Authority, by the steps in 2E.1, and recorded on Form 2-1 (Clause 1.11.5).

2E.1 **Computing P_R from a daily record.**

1. Take the daily (24-hour) rainfall series of the station for its full record.
2. Keep only the days with rain of 2.5 mm or more (wet days).
3. Rank the wet-day depths and take the depth not exceeded on 90% of them (the 90th percentile).
4. Do not apply the climate factor (Clause 2.8.3) or the fixed-interval factor; P_R is a statistic of everyday rainfall, not an AEP design depth.
5. Record the station, the period of record, the number of wet days and P_R on Form 2-1.

Table 2E.1 — Retention depth P_R by zone (layout)

Zone	Stations or grid cells used	Period of record	Number of wet days (≥ 2.5 mm)	P_R, 90th percentile (mm)	Issued on
HR-Z1 Shivalik foothills					
HR-Z2 Northern, NCR and central plains					
HR-Z3 Dry south-west					

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

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

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

No.	Item (clause)	Entry
E2	CWC subzone 1(e) 24-hour point value, catchments of 25–5,000 km²: subzone used	_____
E3	CWC floor governs for any AEP: No / Yes — AEPs	_____
	F. Retention depth (Clause 2.10)	
F1	P_R (mm) and source: Annex 2E zone value / computed under Annex 2E, 2E.1 — station and period	_____
F2	No climate factor applied to P_R (Clause 2.8.3): confirmed	_____
	G. Design storms (Clauses 2.9, 2.11, 2.12; items 5 and 6)	
G1	Storms up to 24 h: alternating block, peak at 50%; time step (≤ Tc/3 and ≤ 15 min)	_____
G2	48 and 72 h storms: built under Clause 2.9.2 (Table 2F.3)	_____
G3	Other pattern used: none / Annex 2D / CWC FER with sensitivity run (Clauses 2.9.3, 2.9.4)	_____
G4	Hyetographs attached as a table and a plot for each design storm: reference	_____
G5	AMC: III for every design storm of 1 July–15 September in HR-A and HR-D and on river floodplains, and of July–August in HR-B and HR-C, whatever its duration; at any other site or time, III for a storm that follows or contains a 5-day total of more than 53 mm; II otherwise (Clause 2.11.4)	_____
G6	Pre-development condition: greenfield, open land in good condition for the mapped HSG (Clause 2.11.5)	_____
G7	Release criterion: standard, Q_post ≤ 0.9 × Q_pre (Clause 2.11.2) / flood-sensitive, mixed-frequency rule (Clause 2.11.3)	_____
G8	Tailwater joint cases run (Clause 2.12): case (a) MHWS + sea-level allowance; case (b) 10% AEP 48 h storm with 1% AEP still-water level + sea-level allowance; governing case	_____
	H. Prepared by	
H1	I confirm that the values above are those extracted and used in the submittal. Name, registration number, signature, date	_____

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

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

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

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

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

ANNEXES TO CHAPTER 3

Hydrologic Methods

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

Annex 3A — Haryana 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 Haryana 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 Haryana Space Applications Centre (HARSAC) [TBC] series maps with their scales, measured saturated hydraulic conductivity and depth to an impermeable layer for each series, and observation-well records from the Central Ground Water Board and the Haryana Water Resources Authority, supplemented by piezometers in the Rohtak–Jhajjar–Sonipat waterlogged belt and the waterlogged parts of Hisar and Jind districts, the floodplains (khadar) of the Yamuna and the Ghaggar, including the Ghaggar floodplain zone notified in Panchkula, the sodic plains of Kurukshetra, Kaithal and Karnal, and the low-lying land along Outfall Drain No. 8 and the Najafgarh jheel. 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

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Annex 3B — Haryana CN calibration and supplementary land covers (choe beds and Shivalik scrub, Aravalli rock and scree, waterlogged and saline-sodic fields, dune sand, johad and bund beds)

Supports Clauses 3.8 and 3.15 of Chapter 3.

To be prepared. This annex will contain (a) curve numbers calibrated against observed rainfall and runoff in Haryana catchments, compared with the TR-55 values of Table 3.5, and (b) curve numbers for land covers that Table 3.5 does not list: the boulder, gravel and sand beds of the Shivalik choes and the scrub forest on the sandstone and clay of the Morni and Kalesar hills; the bare rock, scree and scrub of the Aravalli ridges of Gurugram, Faridabad, Nuh, Rewari and Mahendragarh; the waterlogged and saline-sodic fields of the Rohtak–Jhajjar–Sonipat belt and the sodic fields of Kurukshetra, Kaithal and Karnal, which either stand under water at the start of a storm or shed it from a sealed, crusted surface; the dune and sandy plains of Sirsa, Hisar, Bhiwani, Charkhi Dadri and Mahendragarh, bare or under sparse crops; and the beds of johads and talabs, and the pondage behind old bunds such as the Ghata bundh, that are dry or cultivated at the start of a storm. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from I&WRD gauging sites, agricultural research stations and tank gauges, analysed by event and by antecedent moisture. Until it is published: the pre-development reference stays open space in good condition for every site (Clause 3.3.2), so these covers do not enter the pre-development run; for off-site existing conditions, use the nearest Table 3.5 or TR-55 cover row, including the cultivated rows (Clause 3.8.3(c)), and state the row chosen and the reason on Form 3-1; land under standing water at the start of the design storm is modelled as water surface with no losses (Table 3.5; Clause 3.10.4(b)). Any departure from these defaults requires calibration under Clause 3.15 (Clause 3.15.1(d)).

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

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Boulder, gravel and sand bed of a Shivalik choe, dry at the start of the storm						
Scrub forest on Shivalik sandstone and clay, Morni and Kalesar hills						
Bare or nearly bare rock, scree and scrub, Aravalli ridges						
Waterlogged or saline-sodic field, Rohtak–Jhajjar–Sonipat belt, above standing water at the start of the storm						
Sodic field with a crusted surface, Kurukshetra, Kaithal and Karnal						
Dune or sandy plain, bare or under sparse crops, south-west						
Johad or talab bed, or pondage behind an old bund, dry or cultivated at the start of the storm						
Other (state)						

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

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

Annex 3C — Benchmark test problems for software acceptance

Supports Clauses 3.5, 3.6, 3.8, 3.9, 3.11, 3.12 and 3.16 of Chapter 3.

Purpose. Software not listed in Clause 3.16.1 shall reproduce the results of the five problems below (Clause 3.16.3). Each problem is fully specified and uses only the methods and tables of Chapter 3, so every answer can be checked by hand. The acceptance tolerance is ±5% on each tabulated result, the equivalence threshold of Clause 3.16.2; for closed-form results (Problems 3C-1 to 3C-4), software should agree to the rounding shown. The submittal shall report the software result next to each answer below.

Illustrative — not design values. The inputs (areas, intensities, rainfall depths, slopes and the basin) are chosen for testing only. They are not design data for any site.

Problem 3C-1 — Rational Method peak (Clause 3.5)

Inputs. A 2.0 ha catchment draining to one inlet: 1.2 ha concrete paving and roofs, C = 0.90 (Table 3.2, upper half of 0.80–0.95); 0.8 ha lawns on sandy soil, average slope, C = 0.15 (Table 3.2, upper half of 0.10–0.15). Design AEP 1% (100-yr). Rainfall intensity at Tc, including the climate factor: i = 120 mm/h.

Part (b): a separate 0.5 ha fully paved catchment, C = 0.90, design AEP 1%, i = 150 mm/h.

Table 3C.1 — Problem 3C-1 solution

Step	Calculation	Result
Composite C (Clause 3.5.4)	(1.2 × 0.90 + 0.8 × 0.15) / 2.0	0.60
Frequency factor (Table 3.3)	1% AEP	Cf = 1.25
C · Cf (≤ 1.0)	0.60 × 1.25	0.75
Peak flow (Clause 3.5.1)	0.75 × 120 × 2.0 / 360	**Q = 0.500 m³/s**
Part (b): C · Cf	0.90 × 1.25 = 1.125, capped at 1.0 (Clause 3.5.3)	1.00
Part (b): peak flow	1.00 × 150 × 0.5 / 360	**Q = 0.208 m³/s**

Problem 3C-2 — Time of concentration by the segment method (Clause 3.6)

Inputs. Pre-development flow path: sheet flow over greenfield, n = 0.15 (Clause 3.6.3), L = 30 m, S = 0.01; P2 (50% AEP 24-hour rainfall, no climate factor) = 80 mm. Shallow concentrated flow, unpaved, L = 200 m, S = 0.01. Channel flow, L = 400 m, bank-full velocity V = 1.0 m/s (given).

Table 3C.2 — Problem 3C-2 solution

Segment	Calculation	Travel time
Sheet flow (Clause 3.6.2(a))	0.091 × (0.15 × 30)^0.8 / (80^0.5 × 0.01^0.4) = 0.2138 h	12.83 min
Shallow concentrated (Clause 3.6.2(c))	V = 4.918 × 0.01^0.5 = 0.4918 m/s; 200 / (3,600 × 0.4918) = 0.1130 h	6.78 min
Channel (Clause 3.6.2(d))	400 / (3,600 × 1.0) = 0.1111 h	6.67 min
Tc (Clause 3.6.1; ≥ 10 min)	12.83 + 6.78 + 6.67	**26.27 min**
Lag (Clause 3.6.5)	0.6 × 26.27	15.76 min

Problem 3C-3 — SCS-CN runoff depth, AMC and Ia sensitivity (Clause 3.8)

Inputs. Pre-development reference on HSG C: CN = 74 at AMC II (Table 3.5), all pervious. Cumulative rainfall P = 100 mm; second case P = 25 mm.

Table 3C.3 — Problem 3C-3 solution

Case	S (mm)	Ia (mm)	Runoff Q (mm), P = 100 mm	Runoff Q (mm), P = 25 mm
(a) AMC II, Ia = 0.2S: S = 25,400 / 74 − 254	89.24	17.85	**39.38**	**0.53**
(b) AMC III, Ia = 0.2S: CN(III) = 23 × 74 / (10 + 0.13 × 74) = 86.75	38.80	7.76	**64.93**	—
(c) AMC II, Ia = 0.05S: S0.05 = 25.4 × 1.33 × (89.24 / 25.4)^1.15	143.31	7.17	**36.49**	**1.97**

Runoff is $Q = (P - Ia)^2 / (P - Ia + S)$. Case (c) gives less runoff than case (a) at 100 mm but more at 25 mm, as Clause 3.8.5 and Figure 3.3 describe.

Problem 3C-4 — Separate vs composite impervious representation, and SCS unit hydrograph peak (Clauses 3.9 and 3.11.2)

Inputs, part (a). A site that is 50% directly connected impervious (CN 98) and 50% open space on HSG B (CNp = 61), AMC II, Ia = 0.2S, P = 25 mm.

Inputs, part (b). A sub-area of A = 2.5 km² with Tc = 1.0 h and computation interval Δt = 0.1 h.

Table 3C.4 — Problem 3C-4 solution

Step	Calculation	Result
(a) Impervious half (Clause 3.9.2)	S = 5.18 mm, Ia = 1.04 mm; Q = 23.96² / (23.96 + 5.18)	19.70 mm
(a) Pervious half	S = 162.39 mm, Ia = 32.48 mm > P	0 mm
(a) Area-weighted runoff, separate sub-areas	0.5 × 19.70 + 0.5 × 0	**9.85 mm**
(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			
3C-3	Q, case (c), P = 25 mm (mm)	1.97			
3C-4	Runoff, separate sub-areas (mm)	9.85			
3C-4	Runoff, composite CN (mm)	1.83			
3C-4	qp (m³/s per mm)	0.800			
3C-5	Peak outflow (m³/s)	0.172			
3C-5	Peak storage (m³)	859			

Annex 3D — Peak rate factor study for flat coastal land

Supports Clauses 3.11.5 and 3.15 of Chapter 3.

> **Not required in Haryana.** Haryana is landlocked and has no flat coastal plain, so no land in the State meets Clause 3.11.5(a), and the standard factor 484 (PRF' = 0.208) applies to all land (Clause 3.11.5). The Rohtak–Jhajjar–Sonipat waterlogged belt, the floodplains of the Yamuna and the Ghaggar and the Najafgarh jheel depression are flat but are not coastal plain; their slow response is represented by storage and backwater (Clauses 3.10.4 and 3.12.4), not by a lower peak rate factor. The annex and the layout of Table 3D.1 are kept only so that the annex numbering is unchanged.

Table 3D.1 — Calibrated peak rate factors (layout)

Catchment	Area (km²)	Mean slope (m/m)	Drainage condition	Events used	Calibrated PRF (US customary)	PRF' (SI)	Range of applicability

---

Annex 3E — CWC SUH parameters for subzone 1(e), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzone 1(e) (Upper Indo-Ganga Plains), 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 CWC Flood Estimation Report for the Upper Indo-Ganga Plains subzone 1(e), approved at the 40th meeting of the Planning and Co-ordination Committee on 23–24 July 1984, which covers the plains of Haryana and whose design-office report number is not on the scanned copy read for this Manual [TBC], with the line of zone 7 (Western Himalayas) across the Kalka–Pinjore upland and the Morni and Kalesar hills, which this Manual has read only by eye from the plates of the 1(e) report, still to be confirmed on the plates of both reports [TBC] (see the References of Chapter 3), 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(e) relationship	Report reference
Peak discharge per unit area	qp	m³/s per km²	qp = 2.030 (L/√S)^−0.649	§3.9 (p. 42)
Time from centre of unit rainfall to peak	tp	h	tp = 1.858 qp^−1.038	§3.9 (p. 42)
Width of UH at 50% of peak	W50	h	W50 = 2.217 qp^−0.990	§3.9 (p. 42)
Width of UH at 75% of peak	W75	h	W75 = 1.477 qp^−0.876	§3.9 (p. 42)
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.812 qp^−0.907	§3.9 (p. 42)
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.606 qp^−0.791	§3.9 (p. 42)
Base width of UH	TB	h	TB = 7.744 tp^0.779	§3.9 (p. 42)
Unit duration	tr	h	2	§3.9
Design storm duration	TD	h	TD = 1.1 tp, limited to 24 h	§3.11 and §3.12 (p. 57)
Design loss rate	—	mm/h	3.0 (printed "3.0 mm per hour" and, in the worked example, 0.3 cm/h)	§3.11 (p. 57)
Design base flow	—	m³/s per km²	0.05 (the average of 126 flood events in the range 0.01–0.09)	§3.12 (p. 57)

Parameter	Symbol	Unit	Subzone 1(e) relationship	Report reference
Ratio of t-hour to 24-hour rainfall	—	—	50-yr: 1 h 0.340; 2 h 0.475; 3 h 0.560; 4 h 0.607; 5 h 0.647; 6 h 0.680; 9 h 0.770; 12 h 0.840; 15 h 0.890; 18 h 0.930; 24 h 1.000	Text table (p. 61) and table of Fig. 10 (p. 69)
Time distribution of 24-hour rainfall	—	cumulative fraction	Average curves of Fig. 12; the worked 12-hour storm puts 58% of the total in the first 2 hours, 74% by 4 hours, 86% by 6 hours, 92% by 8 hours and 95% by 10 hours; the 24-hour fractions were not transcribed [TBC]	Fig. 12
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	§4.2
Areal reduction factor	ARF	—	Table 6 of the report; at 50 km², 1 h 0.88, 3 h 0.92, 6 h 0.95, 12 h 0.96, 24 h 0.98, read by optical character recognition only, and the rows for larger areas incomplete in the reading [TBC]	Table 6
50-yr 24-hour point rainfall at Haryana cities	—	mm	Read by eye from Plate 9, within about one contour: Chandigarh and Panchkula about 262 (a printed spot value), Ambala about 250, Yamunanagar–Jagadhri 240–260, Karnal and Panipat 220–240, Kurukshetra and Kaithal 200–240, Sonipat about 220, Gurugram, Faridabad and Palwal 220–240, Rohtak, Jhajjar and Rewari about 200, Hisar and Jind 200–220, Bhiwani and Narnaul 180–200, Sirsa and Fatehabad 160–180; for 100-yr (Plate 10), about 289 at Chandigarh (a printed spot value), about 280 at Yamunanagar, 240–280 at Ambala, Karnal, Gurugram and Faridabad, 200–220 at Rohtak and 180–200 at Sirsa; the contours between Hisar, Rohtak and Rewari are of low confidence [TBC]	Plates 9 and 10
Catchment area for which the relationships apply	A	km²	25–2,500, for "reasonably free catchments" with interception of not more than 20%; for "foothill catchments (steep slopes)" a "suitable increase" is to be given, by an amount the report does not state	§6.1 to §6.3 (pp. 75–76)

Note: relationships as printed in the CWC Flood Estimation Report for subzone 1(e), approved on 23–24 July 1984 (report number not on the scanned copy [TBC]), read from a scanned copy by optical character recognition and checked against the page images. L is the length of the main stream in km and S its equivalent slope in m/km. Unlike most subzone reports, 1(e) relates the peak to L/√S, not to L·Lc/√S, and derives tp from qp. The report's own worked example is a Haryana catchment: the Ghaggar at road bridge No. 2 (30°24' N, 76°44' E), 1,126 km² of "moderate steep slope" which, by NEER's reading, lies about 7 km west of Ambala City and takes in the Shivalik headwaters above Panchkula, with L = 81.42 km, S = 5.14 m/km and L/√S = 35.91. The relationships give qp = 0.199 m³/s per km² and tp = 9.98 h, against the report's 0.198 and 10 h; TD = 1.1 tp = 11 h, rounded to 12 h; the 50-yr 24-hour point rainfall of 25.0 cm (Plate 9) × 0.84 (12-hour ratio) × 0.765 (areal reduction at 1,126 km²) = 16.06 cm; a loss of 0.3 cm/h and a base flow of 0.05 × 1,126 = 56.3 m³/s; and a 50-yr peak of 2,706 m³/s by the unit hydrograph, or 2,630 m³/s by the simplified formula, Q50 = K·A·R·S^0.324 / L^0.649 (K = 1.70 at 25 km² falling to 1.00 at 2,500 km², R the 50-yr TD-hour point rainfall in cm), both of which reproduce. That is about 2.40 m³/s per km², against about 0.02–0.1 m³/s per km² for the rural drains of the State as they were sized by the Boston Society formula with its reduction factors (NCR Planning Board, 2016; Chapter 4). The report was derived from 23 gauged catchments (137 bridge-years, 1961–1982); those in or on the edge of Haryana include the Ghaggar site and catchments on the Kalka–Ambala, Delhi–Ambala, Ambala–Saharanpur, Jind–Panipat, Narwana–Kurukshetra and Rewari–Phulera railway lines (read by optical character recognition only [TBC]). It applies to the rural nalas and choes that enter city limits, not to the city catchments themselves: the Ghaggar, the Kaushalya, the Tangri and the Markanda above Panchkula and Ambala, the Somb and Pathrala above Yamunanagar–Jagadhri, and the Aravalli nalas above Gurugram and Faridabad where their catchments exceed 25 km². The urban catchments of the Gurugram Legs and the Budhiya nala at Faridabad are drained, built over and controlled at their outfalls, so the SUH there is a benchmark of the natural condition only (Clause 3.11.4). The Sahibi above Outfall Drain No. 8 is larger than 2,500 km² (the report lists the Sahibi and Banganga at 19,381 km²) and is regulated at the Masani barrage and the Dhansa regulator, so it is outside the relationships. The design loss rate of 3.0 mm/h is a φ-index fitted to the monsoon

floods of whole rural catchments; it is not the infiltration capacity of any soil and shall not be used to assign an HSG or to size an infiltration practice (Clause 3.7). The 1-hour ratio of 0.34 gives a 50-yr 1-hour depth of only about 75–82 mm at Gurugram and Faridabad and about 85–89 mm at Ambala and Panchkula; the Gurugram storm of 9–10 July 2025 was reported as 103 mm in 90 minutes, and Delhi, in the same rainfall band as Gurugram, recorded 112.5 mm in one hour at Pragati Maidan on 31 July 2024 (as reported): the ratios understate the short storms of this belt, and are not to be used to derive intensities for durations shorter than the TD of the SUH (Chapter 2). The whole of Haryana's plains lies in subzone 1(e). On the report's plates the boundary of zone 7 (Western Himalayas) runs north-east of Chandigarh, with Panchkula city about 11 km inside 1(e), the Kalka–Pinjore upland beyond the line and the Morni and Kalesar hills on it; the line in the west, towards the Luni subzone 1(a), passes about 0.2° of longitude west of the State's western edge, so Sirsa and Ellenabad are in 1(e) (all by NEER's reading of Plate 9 [TBC]). The report for zone 7 names Jammu and Kashmir, Punjab, Himachal Pradesh and Uttar Pradesh, not Haryana. For a Shivalik catchment that drains from Himachal Pradesh into the State, such as the Ghaggar above Panchkula, the Kaushalya or the Markanda, the 1(e) relationships are used with the "suitable increase" for foothill catchments, which the designer shall state and justify, and the zone 7 report is run as a sensitivity check only, the higher 1% AEP peak being adopted.

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

A. Point of comparison (Clause 3.14.2)

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

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

B. Peak flows (Clauses 3.14.7–3.14.10)

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

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

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

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

C. Volumes and storage (Clauses 3.14.8–3.14.10)

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

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

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

D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

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

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

E. Associated checks (Clause 3.14.12)

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

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

F. Statement by the responsible engineer

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

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

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Haryana 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 Rohtak–Jhajjar–Sonipat waterlogged belt (sub-area HR-D of Annex 2A) and the waterlogged parts of Hisar, Jind and Ambala districts, the floodplains (khadar) of the Yamuna and the Ghaggar and of their tributaries, including the Ghaggar floodplain zone notified in Panchkula, and the beds and green belts of johads and talabs, 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&WRD, NRSC, Survey of India), the drains, embankments and regulators of I&WRD, among them Outfall Drain No. 8 and the Dhansa regulator, the Ghaggar floodplain zone notified in Panchkula under section 45 of the Haryana Canal and Drainage Act 1974 (27 October 2023), the 19,665 ponds on the Pond Data Management System of the Haryana Pond and Waste Water Management Authority and their green belts and catchments, the 644 water bodies inventoried by GMDA in Gurugram, the master storm-water drainage drawing of DTCP for Gurugram (No. DTP(G) 2104/2012 of 9 November 2012), the green belt and the 1 km and 5 km lines round the Badkhal and Surajkund lakes set by the Supreme Court in 1996, the boundaries of the Sultanpur and Bhindawas Ramsar sites, the land recorded as johad, talab, nala or khadar in the revenue records, town boundaries (DTCP, HSVP, the Urban Local Bodies Department, GMDA, FMDA, the Panchkula Metropolitan Development Authority, and the Municipal Corporations, Municipal Councils and Municipal Committees), flood maps held by HSDMA, observation-well records of the CGWB and the Haryana Water Resources Authority, and the extent of the waterlogged and saline-sodic soils of the Rohtak–Jhajjar–Sonipat belt, the sodic soils of Kurukshetra, Kaithal and Karnal, the Shivalik piedmont gravels, the Aravalli rock and scree, and the dune sands of the south-west from soil survey maps (NBSS&LUP, the Haryana Space Applications Centre (HARSAC) [TBC]). Until it is published: (a) the catchments named in Clause 4.5.3.2 apply, and whether a site lies in one is decided and recorded as set out in Annex 1B; and (b) every site to which Clause 4.12.1 may apply establishes its design groundwater level from site piezometer readings over one June–November season or, failing that, from the nearest CGWB or State observation well plus 0.5 m and the design flood level of any adjacent river, drain or johad (Clause 4.12.1(b)). For the flotation check in the Rohtak–Jhajjar–Sonipat waterlogged belt and the Yamuna and Ghaggar floodplains 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	Rohtak–Jhajjar–Sonipat waterlogged belt (HR-D); waterlogged part of Hisar, Jind or Ambala district; Yamuna floodplain (khadar); Ghaggar or other river floodplain; johad or talab bed and green belt; 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 (m^3/ha), standard	SSR (m^3/ha), flood-sensitive
HR-Z1 Shivalik foothills: HR-A Shivalik foothills and choes	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
HR-Z2 Northern, NCR and central plains: HR-B Upper Yamuna–Ghaggar plains	B / C / D	50% / 70% / 90%	—	—	—	—	—
HR-Z2 Northern, NCR and central plains: HR-C NCR south (Aravalli–Sahibi)	B / C / D	50% / 70% / 90%	—	—	—	—	—
HR-Z2 Northern, NCR and central plains: HR-D Rohtak–Jhajjar–Sonipat waterlogged belt	B / C / D	50% / 70% / 90%	—	—	—	—	—
HR-Z3 Dry south-west: HR-E Central and south-west dry plains and dunes	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
HR-Z3 Dry south-west: HR-F Ahirwal Aravalli south	A / B / 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

Permissible discharge (L/s)	H = 0.5 m	H = 1.0 m	H = 1.5 m	H = 2.0 m
150	315	265	240	225
200	365	305	275	260
300	450	375	340	315

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

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

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

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

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

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

Annex 4C — Worked example (Tier A) with full routing tables

Supports Clauses 4.4 to 4.9, 4.15 and 4.17 of Chapter 4.

Illustrative — not design values. This example continues the illustrative example of Clause 4.6.7. Its inputs are invented to be plausible for a sector draining to the Badshahpur drain in Gurugram; they are not NIH-DHAARA values and must not be used for design. Part 1 sets out the inputs, hydrographs and routing step by step, for a trial outlet. Part 2 finds that the trial outlet fails the drawdown check with the blockage of Clause 4.8.3, and revises it to the outlet reported in Table 4.2. Part 3 completes the spillway, outlet, safety and retention checks. The outfall-closed check of Chapter 5 for the same facility on an outfall to the Badshahpur drain in Gurugram 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

Item	Value	Basis
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

Time (h:min)	Rainfall in step (mm)	Inflow I (L/s)	Outflow O (L/s)	Storage S (m³)	Stage h (m)
60:15	6.88	1,066.0	265.5	2,613.3	1.045
60:20	5.23	1,089.1	306.9	2,853.0	1.141
60:25	4.34	897.5	334.8	3,025.0	1.210
60:30	3.77	653.2	349.9	3,117.6	1.247
60:35	3.36	403.6	353.8	**3,132.9**	**1.253**
60:40	3.05	301.5	352.3	3,117.3	1.247
60:45	2.81	254.8	348.6	3,088.7	1.235
60:50	2.61	224.9	343.7	3,052.4	1.221
60:55	2.45	203.3	337.9	3,011.3	1.205

Storage is greatest at the end of the step ending at 60:35. In the next step the mean inflow (302 L/s) is below the outflow (about 352 L/s), so storage falls.

Table 4C.8 — Routing of the 100-yr 72-hour storm through the trial outlet, hourly (Illustrative — not design values)

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
12	35.0	14	8	0.130	325
24	70.0	15	12	0.215	536
36	105.0	16	14	0.264	660
48	140.0	16	15	0.294	736
54	181.7	47	19	0.469	1,172
57	213.5	69	23	0.623	1,559
59	248.5	120	91	0.789	1,971
60	293.3	286	170	0.866	2,164
61	378.0	187	332	1.187	2,967
62	399.3	106	237	0.968	2,421
63	414.5	80	142	0.829	2,072
66	446.9	51	52	0.771	1,927
72	489.5	33	33	0.768	1,920
84	489.5	0	18	0.405	1,012
96	489.5	0	10	0.167	418
108	489.5	0	4	0.058	146

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

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

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

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

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

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

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

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

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

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

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

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

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

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
0.60	1,500	43.3	0.0	43.3
0.70	1,750	47.3	0.0	47.3
0.76	1,900	49.6	0.0	49.6
0.80	2,000	51.0	88.3	139.3
0.90	2,250	54.5	165.3	219.7
1.00	2,500	57.7	216.4	274.1
1.10	2,750	60.8	257.5	318.3
1.17	2,925	62.8	282.8	345.6
1.20	3,000	63.7	293.0	356.7
1.30	3,250	66.5	324.6	391.1

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

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

Findings:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Item	Value
Storage	2,500 m² plan area; 2,913 m³ at the 1% AEP maximum level of 1.17 m
Stage 1	170 mm orifice at the floor, with trash rack and anti-vortex plate
Stage 2	460 mm orifice, invert 0.53 m
Spillway	Crest 1.35 m, length 4.0 m, maximum level 1.65 m
Top of walls	≥ 1.95 m above the floor
100-yr peak release	343 L/s (cap 356 L/s)
2-yr peak release	34 L/s (cap 180 L/s)
10-yr drawdown, 50% blocked	45.3 h (limit 48 h)
Retention	RRV 552 m³ provided in addition; credit 7 m³
Still to be checked	Outfall-closed check on an outfall to the Badshahpur drain in Gurugram (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 — Haryana 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 Haryana 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 — Haryana 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 — Haryana 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 — Haryana 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 — Haryana 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 — Haryana Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 5

Downstream and Tailwater Analysis

These annexes support Chapter 5. Annex 5C is a worked example of the outfall-closed check of Clause 5.10, for the illustrative facility of Annex 4C. Annexes 5A and 5B need tidal, surge, survey and river data that this draft does not yet contain; each lists what the chapter already sets, gives the intended layout and states the interim rule of Chapter 5 that applies until it is published. Forms 5-1 and 5-2 are the submittal forms required by Clause 5.14. They are draft forms and have no statutory status.

Annex 5A — Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment

Supports Clauses 5.7, 5.9, 5.10, 5.11 and 5.12 of Chapter 5.

5A.1 Table 5A.1 shows how the values of this annex enter the design tailwater levels of Table 5.1. The sea-level allowance is set by Clause 5.7.4 and does not depend on this annex.

Table 5A.1 — Use of the Annex 5A values in the design tailwater (Table 5.1)

Design case	Tailwater	Annex 5A values used	Chapter value
Minor-system design	MHWS + SLA	MHWS	SLA ≥ +0.3 m (Clause 5.7.4)
Major-system and storage design	HAT + surge + SLA	HAT; 10% AEP surge (Clause 5.7.3(a))	SLA ≥ +0.3 m
Joint case (Clause 2.12(b))	1% AEP still-water level + SLA	1% AEP still-water level (Clause 5.7.3(b))	SLA ≥ +0.3 m
Datum conversion	Chart datum to project datum	Offset from chart datum to the Survey of India datum (Clause 5.7.2(b))	—

Not prepared for Haryana. Haryana has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Haryana content (Clause 5.1.4). Its tables are kept, empty, so that the annex and table numbers match the other editions of this Manual. Rows F1 to F7 of Form 5-1 are entered as "not applicable", and the tailwater is derived under rows F8 to F10; for a site with no defined outfall, row F10 records the 72-hour design volume and the overflow path instead (Clause 5.8.5(d)).

Table 5A.2 — Tidal datums, surge and still-water levels by coastal segment (layout)

Coastal segment	Reference port and tide-table edition	MSL (m CD)	MHWS (m CD)	HAT (m CD)	CD to Survey of India datum (m)	10% AEP surge (m)	1% AEP still-water level (m CD)	Wave set-up (m), open-sea outfalls	Sources

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
Yamuna from the Hathnikund barrage to the boundary with Delhi	Yamunanagar, Karnal, Panipat, Sonipat	Riverine outfall reach; Hathnikund releases included (largest reported about 8.28 lakh cusec, 18 August 2019; barrage design flood 22,000 m³/s; HFL 342.35 m, pond 334.32 m); design river level not below the transferred 268.66 m at Kalanaur (9 September 2010), 250.07 m at Karnal (17 June 2013), 232.75 m at Mawi (18 June 2013) and 212.8 m at Palla (8 September 1995; 213.275 m on the notice board), with the higher value applying where two are reported; danger 249.5 m at Karnal and 230.85 m at Mawi; datum [TBC]; lock of at least 7 days	5.8.1, 5.8.3, 5.8.5
Yamuna below Delhi	Faridabad, Palwal	Riverine outfall reach; design river level not below the transferred 193.96 m at Manjhawali (21 August 2019), 193.13 m at Mohna (6 September 1978; now listed as 192.43 m, 1995) and 182.25 m at Palwal (Rahimpur) (22 August 2019, since removed from the list); no danger level found [TBC]; lock of at least 7 days	5.8.1, 5.8.5
Budhiya (Buria) nala, Gaunchi drain and Drain No. 2	Faridabad; Faridabad and Palwal; Panipat	Major drains leading to the Yamuna; capacities as listed by NCRPB (2016): Buria nala 280 rising to 1,700 cusec, Gaunchi drain 900 rising to 6,000 cusec, Drain No. 2 6,325 cusec; owner, design water level and consent [TBC]	5.2, 5.8.5
Somb at Fatehgarh; Maskara at Ghodopipli	Yamunanagar district	Riverine outfall reaches; design river level not below the transferred 276.35 m and 271.25 m (both 18 August 2019); no danger level found; lock of at least 72 hours	5.8.1, 5.8.5
Ghaggar at Panchkula, with the Kaushalya dam above it, and its choes	Panchkula, Kalka, Pinjore	Riverine outfall reach; no CWC gauge; floodplain zone notified under section 45 (27 October 2023) on a 100-year flood of 2,933.45 m³/s; levels behind the zone not found [TBC]; modelled or surveyed level required; Kaushalya releases (about 4,000 cusec, 9 July 2023, as reported) included; lock of at least 72 hours	5.8.1, 5.8.3, 5.8.5
Ghaggar at Ambala; Tangri at Ambala; Markanda at Shahabad	Ambala, Kurukshetra	Riverine outfall reaches; no CWC gauge; I&WRD gauge levels and datum [TBC]; modelled or surveyed level, with the July 2023 flood marks, required; breach check; lock of at least 72 hours	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Ghaggar below Guhla, to the Ottu weir	Kaithal, Fatehabad, Sirsa	Riverine outfall reach; no CWC gauge; State gauges in feet (Khanauri danger mark 748 ft; Ottu danger mark 17 ft, as reported), gauge zero [TBC]; levelled tie required; breaches of July 2023; lock of at least 7 days	5.8.1, 5.8.3, 5.8.5
Sahibi at the Masani barrage and at Dadri	Rewari; Jhajjar	Riverine outfall reach; Masani weir without gates (crest 240.00 m, weir storage 242.20 m); design river level not below the transferred 242.58 m at Masani (2 September 1978) and 214.98 m at Dadri (26 August 2008); lock of at least 7 days	5.8.1, 5.8.3, 5.8.5
Outfall Drain No. 8, the Dhansa regulator and the Najafgarh drain	Rohtak, Jhajjar, Gurugram; Delhi	Major drain; capacity 4,000 cusec, 5,000 cusec observed at Dhansa (2022); Najafgarh drain level not below the transferred 213.58 m at Dhansa (6 August 1977), danger 212.44 m; operator of the Dhansa regulator [TBC]; level to be coordinated by I&WRD with Delhi's I&FC; no storage credit in the Najafgarh jheel	5.2, 5.8.5
Leg-I, Leg-II and Leg-III (Badshahpur drain), and Leg-IV	Gurugram	Major drains outfalling to the Najafgarh drain; stated discharges 541, 1,305 and 3,702 cusec (DTCP, 2012), no return period stated; Leg-III reported from 500 to 3,800 cusec, with bottlenecks at Khandsa and Hero Honda Chowk; the lowest reported capacity applies until GMDA confirms it [TBC]; Leg-IV not counted until commissioned	5.2, 5.8.5
The towns of the Rohtak–Jhajjar–Sonipat waterlogged belt	Rohtak, Jhajjar, Bahadurgarh, Sonipat	Pumped outfalls to I&WRD drains; permanent pumps less the largest; pumping credited only under I&WRD's consent while the receiving drain is full; no infiltration credit	5.8.5
Johads and depressions with no outlet	The dry south-west (sub-areas HR-E and HR-F) and elsewhere	No outfall; 72-hour design volume; johad receiving dry-weather flow starts full; Pond Authority permission for a pond of 0.5 acre or more	5.8.5
Ghata, Chakarpur, Jharsa and Wazirabad bunds; Damdama lake	Gurugram district	Bunds and lakes; Ghata pondage about 60 ha below 240 m and 100 ha up to 245 m, tailwater not below 245 m until surveyed [TBC]; catchment of the Ghata bundh mostly in Delhi; no storage credit in Damdama's seasonal water area	5.8.5
Badkhal and Surajkund lakes	Faridabad	Lakes; Supreme Court lines (green belt; 1 km; 1–5 km) (Chapter 7); no storage credit in a dry lake bed	5.8.5
Najafgarh jheel; Sultanpur and Bhindawas (Ramsar sites)	Gurugram and Jhajjar districts	Jheel not notified as of March 2024 (as reported), no storage credit; Wetland Authority permission for the Ramsar sites	5.8.5
Western Yamuna Canal and its branches, the Agra canal, and other irrigation and supply canals and channels of I&WRD receiving storm water, and drains of I&WRD, GMDA, FMDA, PMDA, HSVP, HSIIDC, Municipal Corporations, Municipal Councils and Municipal Committees 1.0 m wide or more	Haryana	Major drains; owner's consent, design water level and flap gate; a supply canal is not a drainage outfall without I&WRD's written consent	5.2, 5.8.5
Hathnikund barrage; Kaushalya dam; Ottu weir; Masani barrage	Yamunanagar; Panchkula; Sirsa; Rewari	Releases and gate operation to be included in river levels (operating rules and release records [TBC])	5.8.3, 5.8.5
River mouths subject to sand-bar closure	None in Haryana	Not applicable (Clause 5.1.4)	5.13.1

To be prepared. This annex will list and map (a) the major drains of each basin plan, (b) the riverine outfall reaches where backwater shall be modelled, with their upstream and downstream limits and the source of their design flood levels, and (c) the river mouths and creek inlets subject to seasonal sand-bar closure, with the most recent pre-monsoon bar crest levels and any I&WRD mouth-maintenance programme. It needs I&WRD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (I&WRD), the drain inventories of MCG 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&WRD canal, Outfall Drain No. 8 and the Najafgarh drain into which it falls at the Dhansa regulator, the Leg-I, Leg-II and Leg-III (Badshahpur) master drains and Leg-IV of Gurugram, the Budhiya (Buria) nala of Faridabad, the Gaunchi drain of Faridabad and Palwal, Drain No. 2 of Panipat, any drain of I&WRD, any drain maintained by GMDA, FMDA, PMDA, HSVP, HSIIDC, a Municipal Corporation, a Municipal Council or a Municipal Committee, or a licensed colonizer, with an internal width of 1.0 m or more, 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 the coastal States' rivers (there is none in Haryana) are assumed closed at the start of the SW monsoon unless I&WRD 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&WRD design or highest recorded flood level, or hydraulic model (Clause 5.8.2)	text
reservoir_release	Upstream reservoir or tank and its operating rule, where any (Clause 5.8.3)	text
bar_crest_level	Most recent pre-monsoon bar crest level, for mouths	m (Survey of India datum)
mouth_programme	I&WRD mouth-maintenance programme and certification (Clause 5.13.2)	text
source	Source agency and date	text
geometry	Line (drains and reaches) or point (mouths)	line / point

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Annex 5C — Worked example: outfall-closed check for a site on a tributary of the Badshahpur drain in Gurugram

Supports Clauses 5.9, 5.10, 5.11 and 5.12 of Chapter 5 and Clause 4.6.6 of Chapter 4.

Illustrative — not design values. This example applies the outfall-closed check of Clause 5.10 to the revised detention facility of Annex 4C. The site, its levels and its receiving drain are invented to show the method. No tidal level is used: the tide enters only through the illustrative statements in Table 5C.1 about whether the receiving drain is above or below the site outlet.

Inputs

5C.1 The site is the 2.0 ha flood-sensitive site of Annex 4C. It discharges through its own outlet chamber and a flap gate to a public storm drain that joins a tributary of the Badshahpur drain (Leg-III) in Gurugram, whose level rises when Leg-III runs full above its bottlenecks and when the Najafgarh drain is high, so Clause 5.10.1 applies to the facility. To show the method, this example uses the two 6-hour lock windows of Clause 5.10.3, as the coastal editions of this Manual do. In Haryana an outfall to a drain that is at or above its design water level has a drain lock of at least 72 hours, a river-locked outfall a single lock of at least 72 hours, or 7 days on the Yamuna, the Sahibi and the lower Ghaggar, under Clause 5.8.5, and a site with no defined outfall must hold the 72-hour design volume of Clause 5.8.5(d), so in each of those cases the facility must store or pump the whole storm volume (Clause 5.9.4); that needs more storage, or pumping, than this example shows. The routing, the volume balance of Clause 5.10.4 and the assessment are the same.

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

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

Assessment

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

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

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

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

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

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

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 25 June each year and after every event in which it closed against a storm flow (Clause 5.11.5).
- The deeper facility is checked for flotation with groundwater at the design groundwater level; in the Rohtak–Jhajjar–Sonipat waterlogged belt and the Yamuna and Ghaggar floodplains without piezometer readings that level is existing ground level (Clauses 4.12.1 and 4.12.3).
- The fence and signs of Annex 4C apply to the deeper facility (Clause 4.15).

Table 5C.5 — Summary (Illustrative — not design values)

Item	Value
Governing case	J4, 1% AEP 48-hour storm, Run B (first window starting at the peak 1-hour block)
Storage required	5,238 m³ (Annex 4C release-rate design: 2,913 m³)
Maximum stage	2.10 m, with 2,500 m² plan area
Spillway crest	2.25 m
Top of walls	≥ 2.85 m above the floor
Largest release after a lock window	584 L/s, to be included in the downstream J4 run
Drawdown	Annex 4C result applies: 45.3 h with the low-flow orifice 50% blocked

Form 5-1 — Downstream and Tailwater Report

Supports Clauses 5.3 to 5.14 of Chapter 5.

Draft form — Haryana 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 johad, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or johad: 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. I&WRD drains and the Najafgarh drain, river-locked outfalls, the Yamuna below Hathnikund, catchments with no outfall, pumped outfalls in the waterlogged belt, johads, bunds and lakes, and I&WRD channels and canals: for a drain outfall, I&WRD's or the owner's consent and permitted rate, design water level or computed drain level with all its inflows, present condition and narrowest section, the lowest reported capacity where capacities conflict, and the drain lock of not less than 72 hours where the drain is full; for a drain that ends in the Najafgarh drain, its level at the junction, not below 213.58 m at Dhansa transferred, the inflow of Outfall Drain No. 8 used, no jheel storage credited, and whether I&FC (Delhi) has confirmed the level through I&WRD; for a river outfall, operator of each gate and pumping station identified, gate sills, embankment or bund crest, installed capacity, operating levels and gate-closing level obtained, with every level tied to the datum of the nearest CWC or I&WRD gauge; 1% AEP river level at the outfall from a published study, the levels behind a section 45 zone or a model (not less than 2,933.45 m³/s in the Ghaggar zone at Panchkula), and not below the highest recorded level at the nearest gauge transferred to the outfall (250.07 m at Karnal, 232.75 m at Mawi, 242.58 m at Masani), with the profile used, or, on the Ghaggar system where no CWC gauge exists, a modelled or surveyed flood level, with the levelled tie of any gauge reading; 10% AEP river level, not below the danger level transferred (249.5 m at Karnal, 230.85 m at Mawi); drain behind the gate routed with its whole catchment and present storage, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the design river level; single river lock of not less than 7 days on the Yamuna, the Sahibi and the Ghaggar below Guhla, or 72 hours on the Shivalik streams, covering the whole storm, and its source; gate-failure and breach checks; the design storm with the largest recorded release at Hathnikund (about 8.28 lakh cusec) or of the dam or weir above, placed before, during and after the storm; for a site with no defined outfall, the 72-hour design volume, the storage below its overflow and its emptying time, the level of any shared basin, johad or depression with and without the project and its starting level, and the overflow path traced to public land; for a pumped outfall in the waterlogged belt, the pumping credited under I&WRD's consent while its drain is full, and no infiltration credit; for a johad, pond, bund or lake, the owner's consent and the Pond Authority's and Wetland Authority's permissions where required, spill level plus the head to pass the 1% inflow (full level + 0.5 m for a gated bund or lake with no surcharge computed; not below 245 m at the Ghata bundh), not below the highest recorded level, outfall below it treated as closed for the whole storm, the waterbody starting full; I&WRD's consent, whether the outfall lies in a section 45 zone and the court lines checked; canal owner's consent, permitted rate, design water level and flap gate (Clause 5.8.5)	

G. Joint cases (Clause 5.9; Clause 5.14, item 6)

Table 5F.8 — Form 5-1: joint-case results

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
J1				
J2				
J3				
J4				
R1				
R2				

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

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

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

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

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

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

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

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

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

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

Field	Entry
J1. Reason pumping is needed (Clause 5.12.1)	
J2. Duty capacity (m^3/s) at the static head for the J2 tailwater; standby capacity (Clause 5.12.2)	
J3. Effect on the receiving water level (Clause 5.12.3)	

Field	Entry
J4. Power supply: two independent supplies, or standby generation with 72 h of fuel; automatic changeover (Clause 5.12.4)	
J5. Level of electrical panels, controls, generators and fuel, against the higher of the 1% AEP flood level + 0.5 m and HAT + surge + SLA + 0.5 m (Clause 5.12.5)	
J6. Discharge arrangement (Clause 5.12.6); controls, alarms and logging (Clause 5.12.7); screens (Clause 5.12.8)	

K. Sand bar (Clause 5.13; Clause 5.14, item 10)

Table 5F.13 — Form 5-1: sand-bar assumption

Field	Entry
K1. River mouth or creek inlet concerned	
K2. Mouth assumed closed, or open with I&WRD certification attached (Clause 5.13.2)	
K3. Bar crest level from the most recent pre-monsoon survey (m) and the closed-mouth tailwater (Clause 5.13.3)	
K4. Extension of the lock duration, where required (Clause 5.13.5)	

L. Inspection and maintenance (Clause 5.14, item 11)

Table 5F.14 — Form 5-1: inspection and maintenance

Field	Entry
L1. Gate and valve inspection before 25 June and after closure events (Clause 5.11.5)	
L2. Pump test runs before 25 June (Clause 5.12.9)	
L3. Other requirements for the maintenance plan (Chapter 10)	

M. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 5 of the Haryana 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 — Haryana Stormwater Design Manual, Draft v1.0.

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — Haryana 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, MCG, HSDMA, I&WRD (Clause 5.3.3(d))		
B3. The site does not drain to a tidal or backwater-affected outfall		

C. Route plan

Table 5F.18 — Form 5-2: attachments

Attachment	Attached?
C1. Plan of the drainage route from the site outfall for 500 m downstream, with the receiving drain and any recorded flood-prone locations	
C2. Copy or reference of the drain capacity record	

D. Statement

I state that the site meets the conditions of Clause 5.3.4 as shown above, and that the records listed have been checked.

Table 5F.19 — Form 5-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Haryana 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 Haryana 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 Haryana 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 (Buildings and Roads) Department (PWD B&R), NHAI and Municipal Corporation of Gurugram standard details, NIT Kurukshetra, Deenbandhu Chhotu Ram University of Science and Technology (DCRUST) Murthal or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

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

Item	Requirement	Clause
Inlet type on public streets	Kerb-opening or combination inlets, unless the Approving Authority accepts grate-only inlets for a location	6.6.1(a)
Inlet level	Openings at road level; gutter depression where practicable	6.6.1(b)
Clean capacity	FHWA HEC-22 (4th ed., 2024) or the manufacturer's tested rating for the exact geometry; CPHEEO §5.6.2 equations as a cross-check only	6.6.2
Clogging, on grade	Grate 50%; kerb opening 10%	6.6.3, Table 6.5
Clogging, in a sag	Grate 50%; kerb opening 20%	6.6.3, Table 6.5
Spacing	By sequential calculation from the top of each gutter run; not more than 30 m on kerbed roads	6.6.4
Kerb opening size	Clear height at least 100 mm; length at least 1.0 m	9.11.4
Grate pattern	Openings parallel to the direction of travel not wider than 25 mm	9.11.3(a)

Item	Requirement	Clause
Load class	D400 in carriageways and medians; C250 within 0.5 m of the kerb; B125 in footpaths and cycle tracks (or the equivalent IS class)	9.11.2
Connection pipe	At least 300 mm diameter; gradient giving at least 0.9 m/s at the inlet's design flow	6.6.6
Silt sump	At least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7, 9.11.6

The intended layout of the annex is given in Tables 6A.2 to 6A.4.

Table 6A.2 — Register of standard inlet types (layout)

Type code	Description	Grate size or kerb opening (mm)	Gutter depression (mm)	Load class	Standard drawing
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6A.3 — Capacity on grade (layout; one table per inlet type)

Cross slope Sx (m/m)	Longitudinal slope SL (m/m)	Gutter flow Q (L/s)	Spread T (m)	Clean intercepted flow (L/s)	Design intercepted flow after clogging (L/s)	Bypass flow (L/s)
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Table 6A.4 — Capacity in a sag (layout; one table per inlet type)

Ponded depth at the inlet (mm)	Clean capacity (L/s)	Clogging factor (Table 6.5)	Design capacity (L/s)	Flow regime (weir, orifice or transition)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Annex 6B — Sediment yield for silt-trap sizing and calibration of the sediment allowance

Supports Clauses 6.7.4, 6.7.8, 6.13.3 and 6.13.10 of Chapter 6.

To be prepared. This annex will contain sediment yields for urban drains in Haryana, 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 Municipal Corporation of Gurugram and other urban local bodies, I&WRD records for channels, land cover from NRSC, soils from the Haryana 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.

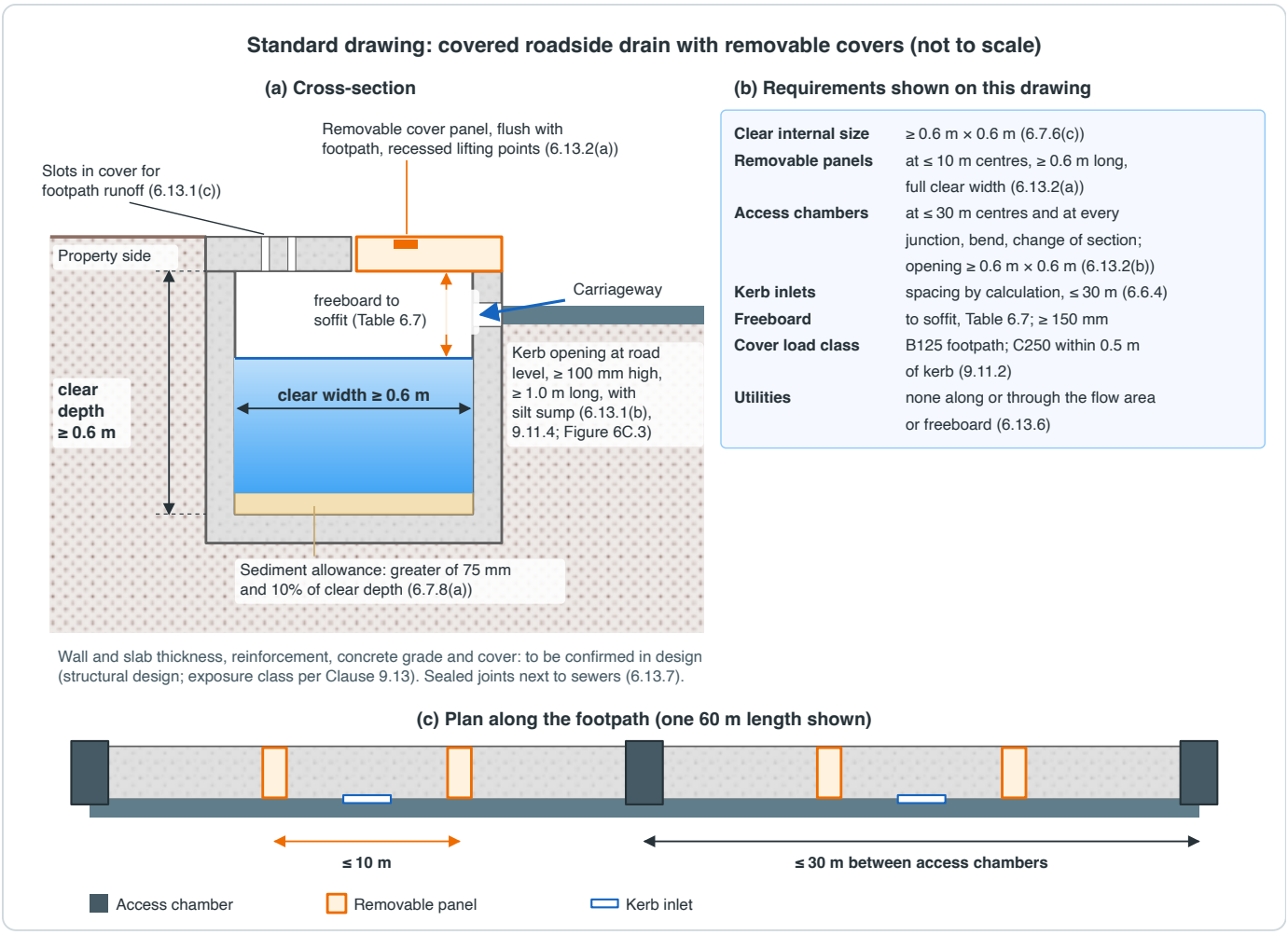

Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

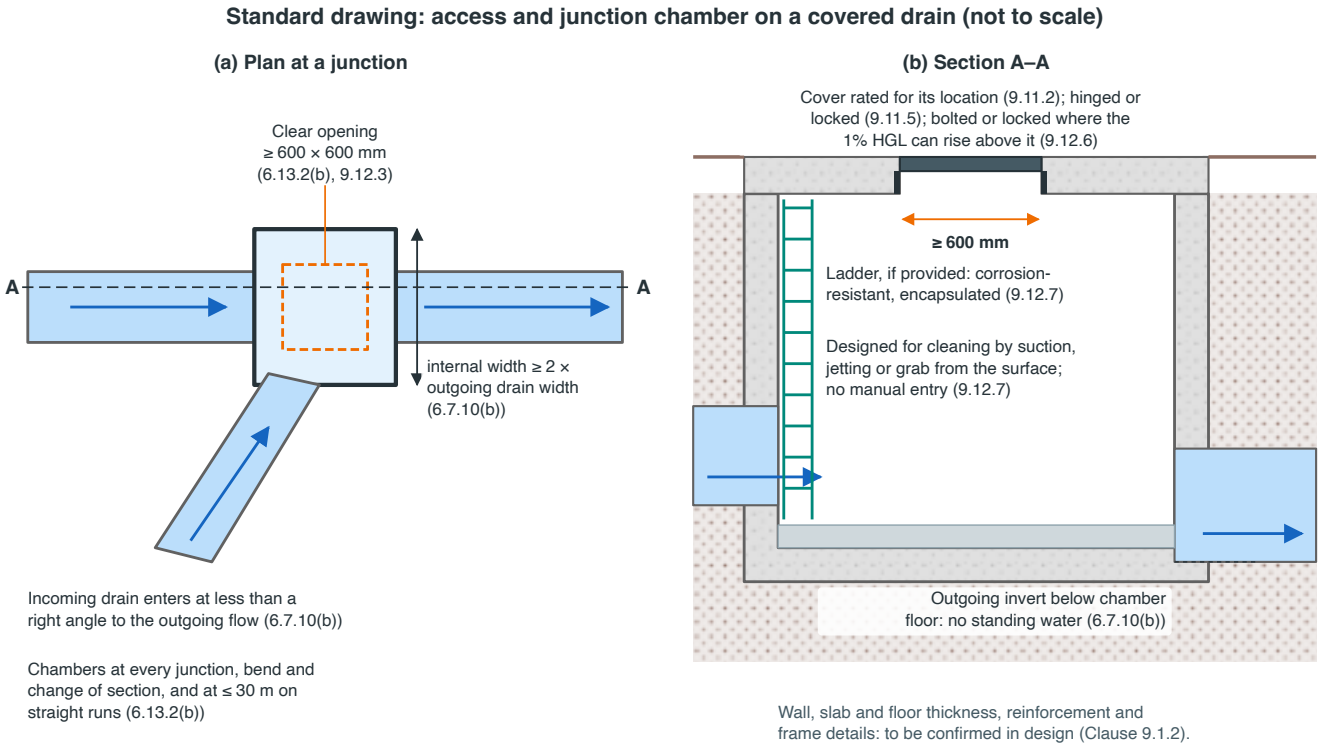

Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

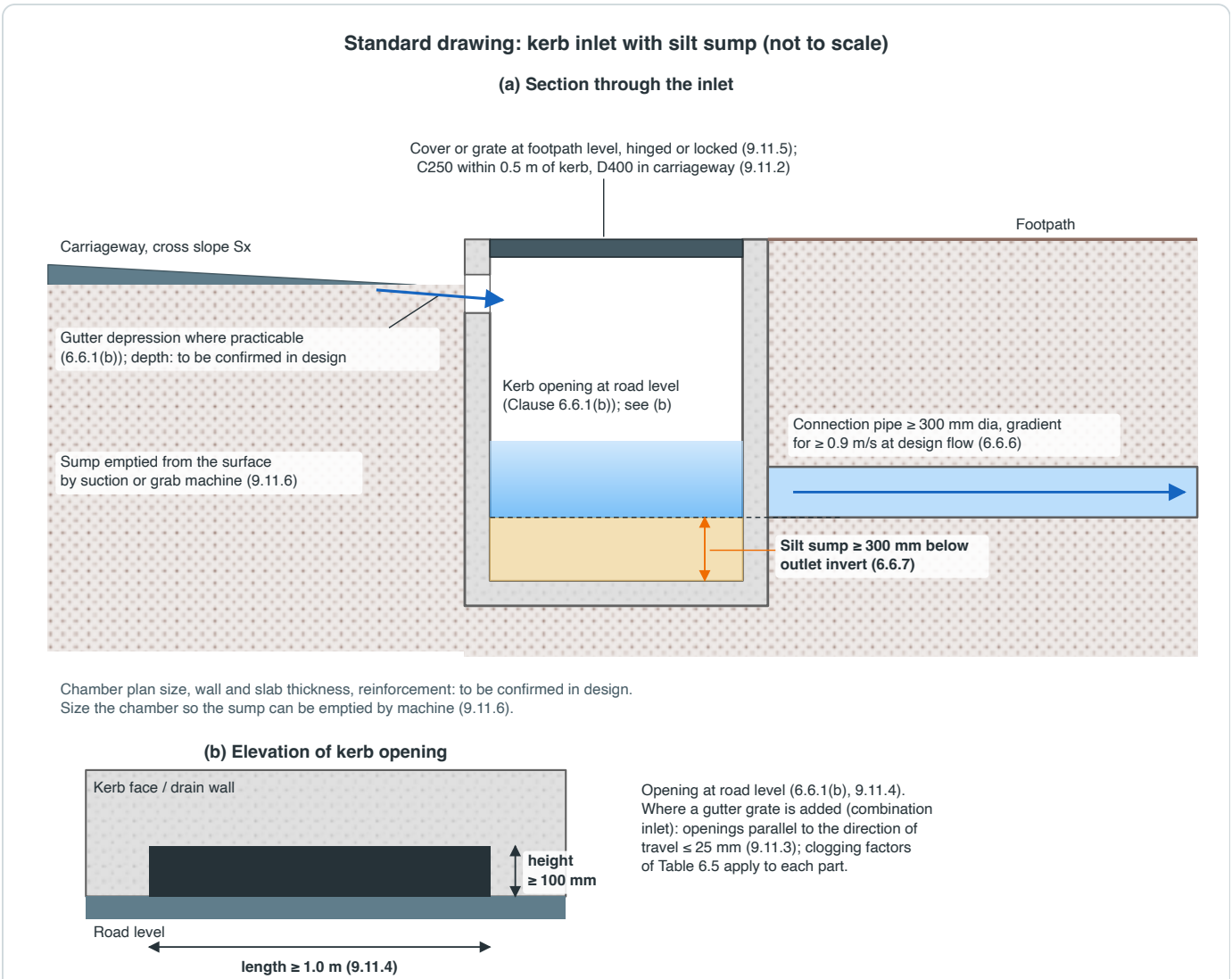

Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th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

ANNEXES TO CHAPTER 7

Waterbodies, Johads (Ponds) and Setbacks

These annexes support Chapter 7. They give the inventory field specification, the fixed-width setback table, a template operating rule, the desilting and restoration specification, a glossary of Hindi and Urdu 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&WRD and the Revenue and Disaster Management Department. It needs the Revenue records and khasra maps of the Revenue Department, in which johads, talabs and other ponds are entered as talab, johar, tank or by another name (the record on which a "pond" is defined in section 2(k) of the Haryana Pond and Waste Water Management Authority Act, 2018), with village ponds on shamlat deh, nalas, khadar land and land recorded as jhord; the Pond Data Management System of the Haryana Pond and Waste Water Management Authority, in which 19,665 ponds had been entered by February 2024, each with a unique ID; the inventory of 644 water bodies in Gurugram, with unique IDs, made by GMDA under the directions of the National Green Tribunal; the reaches and khasra lists notified under section 45 of the Haryana Canal and Drainage Act, 1974, such as the Ghaggar floodplain in Panchkula (Gazette of 27 October 2023); the public tanks, drains and watercourses vested in a Municipal Corporation under sections 161 and 193 of the Haryana Municipal Corporation Act, 1994; the waterbodies, drains and green belts shown in development plans and in the master storm-water drainage drawings of DTCP, HSVP and GMDA; the green belts of Badkhal and Surajkund lakes under the Supreme Court's order of 1996; the boundaries of the two Ramsar sites and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was confirmed for this Manual); and the wetlands of the national atlas that the State is ground-truthing; the I&WRD and Gram Panchayat tank registers with FTL and MWL; surveyed levels on a common datum; the ISRO National Wetland Inventory and Assessment (NRSC); Survey of India topographic maps; and any list of waterbodies published under court directions. Until it is published, each Applicant identifies waterbodies from all the sources of Clause 7.3.3, with the larger extent governing, and records them on the Waterbody Sheet (Form 7-1).

The field specification below is complete. It is written so that every field the chapter asks for (Clause 7.3.1(a) to (g)) has a defined name, type and source, and so that the same fields can be filled from a project's Form 7-1.

7A.1 Layers

- **WB_POLY** — one polygon per waterbody: the Revenue record boundary (Clause 7.3.1(c)).
- **WB_FTL** — the surveyed FTL contour (tanks, lakes, ponds) or top of bank (channels), as a polygon or line.
- **WB_MWL** — the MWL contour of each tank, as a polygon.

- **WB_FLOOD** — the 1% AEP flood extent, where mapped (Clause 7.3.1(f)), with the floodway where delineated (Clause 7.6.1).
- **WB_STRUCT** — points for surplus weirs, sluices, regulators, inlets and drain outfalls.
- **WB_LINK** — lines for supply channels, surplus courses and the links between tanks in a cascade (Clause 7.3.1(e)).
- **WB_ENCR** — polygons of known encroachments, each with the date recorded (Clause 7.3.1(g)).
- **WB_SETBACK** — Zone 1 and Zone 2 polygons (Clause 7.4), derived from the layers above.

All layers shall carry the waterbody identifier (WB_ID) so that they can be joined. All levels shall be stated to one datum (Clause 7.3.5), named in the layer metadata.

Table 7A.1 — Attribute fields of the waterbody inventory (WB_POLY)

Field	Type	Unit / domain	Required	Content	Clause
WB_ID	Text	District code + serial	Yes	Unique identifier, never reused	7.3.1
WB_NAME	Text	—	Yes	Name as in Revenue and I&WRD records, with local name	7.3.1(a)
WB_NAME_HI	Text	Hindi script	Yes	Name in Hindi	7.3.1(a)
WB_TYPE	Code	Table 7A.2	Yes	Waterbody type	7.2, 7.3.1(a)
SURVEY_NOS	Text	Village, survey and subdivision numbers	Yes	Revenue survey numbers of the waterbody	7.3.1(a)
VILLAGE	Text	—	Yes	Revenue village, tehsil and district	7.3.1(a)
CUSTODIAN	Code	Table 7A.2	Yes	Custodian body	7.3.1(b)
AREA_REC	Number	ha	Yes	Area within the Revenue record boundary	7.3.1(c)
AREA_FTL	Number	ha	Tanks	Waterspread at FTL, surveyed	7.2, 7.3.1(d)
FTL	Number	m (datum)	Tanks	Full tank level	7.3.1(d)
MWL	Number	m (datum)	Tanks	Maximum water level (Clause 7.2 definition)	7.3.1(d)
MWL_BASIS	Code	I&WRD record / 1% AEP computed	Tanks	Which value governs MWL	7.2
TBL	Number	m (datum)	Tanks	Top bund level, lowest point	7.3.1(d)
WEIR_CREST	Number	m (datum)	Tanks	Surplus weir crest level	7.3.1(d)
WEIR_LEN	Number	m	Tanks	Surplus weir crest length	7.3.1(d)
WEIR_TYPE	Text	—	Tanks	Surplus weir type (for example fixed crest, with shutters or falling boards)	7.3.1(d)
SLUICE_N	Integer	—	Tanks	Number of sluices; details in WB_STRUCT	7.3.1(d)
SUPPLY_CH	Text	WB_ID(s)	Tanks	Supply channel(s) feeding the tank	7.3.1(d)
SURPLUS_CS	Text	WB_ID(s)	Tanks	Surplus course(s) leaving the tank	7.3.1(d)
UPSTR_WB	Text	WB_ID(s)	Cascades	Upstream tank(s) in the cascade	7.3.1(e)
DNSTR_WB	Text	WB_ID	Cascades	Downstream tank, river, drain or sea outfall	7.3.1(e)
CATCH_AREA	Number	ha	Channels	Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1)	7.4.1

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

Table 7A.2 — Code lists

Code list	Values	Clause
WB_TYPE	River or seasonal stream (choe); natural drain or nala; I&WRD drain; canal; lake or jhil; pond (johad, johar, talab, pokhar); bandh pondage; marsh or low wet land (dabar); floodplain wetland or depression (khadar); abandoned quarry or mine pit; supply channel (feeder inlet); surplus course	7.2
CUSTODIAN	Municipal Corporation, Council or Committee (HMC Act ss. 161, 193); GMDA, FMDA or PMDA; HSVP (Urban Estate); licensed colonizer; I&WRD (division; s. 45 reach); Gram Panchayat (village pond, shamlat); Haryana Pond and Waste Water Management Authority (regulator; pond UID); Haryana State Wetland Authority or Forests and Wildlife Department (notified wetland, Ramsar site); HSIIDC; 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&WRD control, the operating rule is I&WRD's rule (Clause 7.8.4); this template sets out the content that Clause 7.8 asks for, so that the custodian's rule can be checked against it. Text in square brackets is to be completed for each tank.

7C.1 Identification

1. Tank: [name, WB_ID of Annex 7A, village, tehsil, district].
2. Custodian: [I&WRD division / ULB / Gram Panchayat / other].
3. Cascade position: upstream tank(s) [ ]; downstream tank, river or drain [ ].
4. Datum: [ ]. Surveyed levels (Clause 7.7.1(a)), date of survey [ ]: FTL [ ] m; MWL [ ] m; TBL (lowest point) [ ] m; surplus weir crest [ ] m, length [ ] m; sluice sills [ ] m.
5. Stage–storage curve (Clause 7.7.1(b)): survey date [ ]; attached as Schedule 1.
6. Controllable outlets (Clause 7.8.2(a)): [gated sluice / regulator / none]; capacity at FTL [ ] m³/s.

7C.2 Purposes and priority

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

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

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

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

Period	Target level (m)	Upper limit (m)	Lower limit (m)	Purpose
[1 Jan – date]	[ ]	FTL	[ ]	Holding for irrigation / supply

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 HSDMA red alert	IMD, HSDMA	Begin releases needed to reach the rule level, within the maximum release rate; notify downstream bodies (paragraph 21)	[ ]
City forecast system warning, where available	[ ]	[ ]	[ ]
Tank level reaches FTL	Gauge	Record outflow hourly; inspect bund and weir	[ ]
Tank level reaches [MWL − [ ] m]	Gauge	Emergency procedure; warning to the breach area of any emergency action plan (Clause 7.14.3(c))	[ ]

7C.7 Records and review (Clause 7.8.1(g))

22. During the SW monsoon (15 June to 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 June) 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 Haryana State Pollution Control Board (HSPCB) 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 Haryana State Pollution Control Board (HSPCB) 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 June**. 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 June)	As-built survey, stage–storage curve, silt disposal record	7.9.8, 7.7.1(b)

Annex 7E — Glossary of Hindi and Urdu waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Hindi and Urdu words for waterbodies, catchments, drains and riverine land as used in Haryana, given in Devanagari and, where Platts gives it, Urdu script. Haryana's regional speech (Haryanvi and its local forms) uses many of the same words, with regional forms, and many of them appear in place, lake and drain names (the Najafgarh jheel, the Ghata bandh, the Badshahpur and Budhiya nalas). The name used in the Revenue, Pond Authority, I&WRD or municipal record for each waterbody should be recorded in the inventory (Annex 7A) alongside the Manual's term. Only terms whose meaning was confirmed in J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884), or in Syamasundara Dasa, *Hindi Shabdasagara* (1965–1975), both as served by the Digital South Asia Library, or in a statute or court order, are listed in Tables 7E.1 to 7E.3; the meanings are Platts's English glosses, or a translation of the Shabdasagara, with the page shown by the Digital South Asia Library, and modern usage may be narrower or wider. No Haryanvi dictionary was consulted for this Manual, so the Haryanvi senses of these words, and the revenue term jhord, are not confirmed; they are listed in Table 7E.4 as not yet verified. The list is to be extended by the State Stormwater Technical Committee, with modern Revenue, Pond Authority, I&WRD and municipal usage and with a Haryanvi source.

The Manual's term for a tank or pond in Haryana is **johad (जोहड़)**, with **talab (तालाब)** as the standard Hindi equivalent, and on first use is written "johad (जोहड़; talab)": johad is the everyday word for the village pond across the State; its form johar is the word of the State's own pond law ("mentioned in revenue records as talab, johar, tank", Pond Act, 2018, s. 2(k)); and the Shabdasagara's gloss, "कच्चा तालाब", an unlined (earthen) tank, fits the earthen village ponds and depressions that this Manual designs for and restores. Talab is better sourced, in Platts and the Shabdasagara, is understood throughout the State and is the term of the neighbouring editions of this series. In this Manual a johad is a natural or excavated pond that stores rainfall runoff; it is not the earthen check bund that the same word names in parts of Rajasthan. Jhil, dabar, bandh, khadar and bangar keep their own meanings.

Table 7E.1 — Waterbodies

Term	Meaning	Source of the term	Manual term (Clause 7.2)
जोहड़ (johaṛ; johad)	In the Shabdasagara, "संज्ञा पुं० [देश०] कच्चा तालाब", a regional word for an unlined (earthen) tank. Not found in Platts, which has only *johārnā*, "to salute" (p. 399)	Shabdasagara, p. 1806	Johad (tank or pond), see the definitions after Clause 7.2
जोहर (johar)	In the Shabdasagara (जोहर १, from जोहड़), "a baoli; a small tank". The statutory spelling: a "pond" is a water body "mentioned in revenue records as talab, johar, tank or by any other name"	Shabdasagara, p. 1806; Pond Act, 2018, s. 2(k)	Johad (tank or pond)
तालाब / تالاب (tālāb; talab)	"Pond, pool, tank, reservoir of water (= talā'o ; cf. tāl)"; in the Shabdasagara, a reservoir; a lake; a pond (pokhara)	Platts, p. 306; Shabdasagara, p. 2071; Pond Act, 2018, s. 2(k)	Johad (tank or pond)

Term	Meaning	Source of the term	Manual term (Clause 7.2)
पोखर (pokhar)	In the Shabdasagara (from Sanskrit पुष्कर), "a talab; a pokhara"	Shabdasagara, p. 3113	Johad (tank or pond); less used in Haryana than johad and talab
झील / جھیل (jhīl; jhil, jheel)	"A pool, a shallow lake; a marsh, morass, swamp"; in the Shabdasagara, a very large natural water body enclosed by land	Platts, p. 411; Shabdasagara, p. 1848	Lake or marsh; a wetland under Clause 7.12 where listed there, such as the Najafgarh jheel
डाबर / ڈابر (ḍābar; dabar)	"Low or hollow ground where water collects (= ḍabrā and ḍahrā), a marsh, swamp, a pool, puddle, a small pond, pit, tank"; in the Shabdasagara, low ground; deep ground where water stands; a hollow in which rain water collects	Platts, p. 561; Shabdasagara, p. 1947	Marsh or low wet land; a recorded johad where it is one of GMDA's "natural low lying water collection areas"

Table 7E.2 — Channels, embankments and riverine land

Term	Meaning	Source of the term	Manual term (Clause 7.2)
नाला / نالا (nālā; nala, nallah, nullah)	"A watercourse; channel (for water), a ravine; a rivulet, brook, canal; a drain, gutter"; in the Shabdasagara, a hollow running across the ground in a line through which rain water goes to a river; a water channel	Platts, p. 1117; Shabdasagara, p. 2596	Natural drain or nala, see the definitions after Clause 7.2. In Haryana the word covers both natural watercourses (the Li, Kausat and Dhulaint nalas that meet at the Ghata gap) and large engineered drains (the Badshahpur and Budhiya nalas); the definition, not the word, decides which this chapter applies to
नाली / نالي (nālī; nali)	Among other senses, "a drain; … a small watercourse, or channel"; in the Shabdasagara (नाली १), a narrow way for water to flow; a channel for filth; a gutter (mori)	Platts, p. 1117; Shabdasagara, p. 2597	Drain (minor system); where it carries sewage or sullage into a storm drain or a johad, a cross-connection (Clause 8.9)
बाँध / باندھ (bāṅdh; bandh, bundh, bund)	"Fastening; tie … embankment; dam"; in the Shabdasagara, an embankment of earth or stone built on the bank of a river or tank to hold back floods	Platts, p. 127; Shabdasagara, p. 3433	Tank bund or dam (Clause 7.14); the Ghata, Chakarpur, Jharsa and Wazirabad bandhs and their pondages, see "Bandh pondage" in the definitions after Clause 7.2
खादर / کھادر (khādar; khadar)	"Low alluvial land fit for rice cultivation"; in the Shabdasagara, the low land by a river or lake in which the rain water stands for many days; the opposite of bangar	Platts, p. 867; Shabdasagara, p. 1151	Floodplain wetland or depression; within the 1% AEP extent until a study shows otherwise (definitions after Clause 7.2)
बाँगर / بانگر (bāṅgar; bangar)	"Hilly ground, high ground, upland"; in the Shabdasagara, land, as against khadar, that lies somewhat high and is never under water even when the river or lake rises	Platts, p. 127; Shabdasagara, p. 3432	Upland; the counterpart of khadar (no term of Clause 7.2)

Table 7E.3 — Statutory and court terms

Term	Meaning
pond (Pond Act)	"a tank or lake or any other inland water body having an area of 0.5 acre or more, whether it contains water or not, and mentioned in revenue records as talab, johar, tank or by any other name and includes green belt and the peripheral catchments areas, main feeder inlet and other inlets, bunds, weirs, sluices etc but does not include wet lands as notified by the Government from time to time" (Haryana Pond and Waste Water Management Authority Act, 2018, s. 2(k)); the Act does not apply to a pond of less than 0.5 acre, in a notified forest or on private land (s. 1(3))

Term	Meaning
protected area (Pond Act)	"a geographical area, green belt or catchment area around the pond" notified by the Government, in which no construction may be undertaken without the Authority's prior permission (ss. 16 and 17(2)); no notification was found for this Manual
drainage work (Canal and Drainage Act)	Includes "escape channels from canals, dams, weirs, embankments, sluices, groins and other works for the protection of lands from flood or from erosion, formed or maintained by the State Government", "but does not include works for the removal of sewage from towns" (Haryana Canal and Drainage Act, 1974, s. 2(7)); a river, stream or drainage channel within limits notified under s. 45 "shall be held to be a drainage-work"
Corporation drain	"All public drains, all drains in, along side or under any public street, and all sewage disposal works", vested in the Corporation (Haryana Municipal Corporation Act, 1994, s. 193); no structure may be erected on a municipal drain without the Commissioner's written permission (s. 206)
shamlat deh	The common land of a village, which includes lands kept "for the benefit of the community including … drinking wells or ponds" (Haryana Municipal Act, 1973, s. 2(22B)(iv), as indexed; the text was not read); most village johads stand on it
green belt (Badkhal and Surajkund)	The green belt around Badkhal and Surajkund lakes shown in the exhibits before the Supreme Court, in which no construction is permitted; outside it, no construction within 1 km of the lakes except as the Court allowed, and prior approval of the Central and Haryana Pollution Control Boards for plans from 1 km to 5 km (order of 11 October 1996)
natural low lying water collection areas	One of the seven categories of GMDA's inventory of Gurugram's water bodies, which "need to be preserved through appropriate legal mechanisms" (GMDA, report to the Tribunal in O.A. 325/2015)

Table 7E.4 — Terms not yet verified

The following terms are in use for Haryana's waterbodies, but their meaning or regional use was not confirmed in Platts, the Shabdasagara or an official source during research for this Manual. They shall not be used in a record or a drawing as defined terms until verified.

Term	Reported meaning or use	Status
झोड़ (jhord; spelling not confirmed)	A revenue entry for a water-holding area: a pond in Sector 7, Ambala City, is "recorded as a Jhord (water-holding area) in the revenue records" (CPCB reply in O.A. 351/2025)	Not found in this sense: the Shabdasagara's झोड़ is the areca tree (p. 1859), and Platts has no matching entry. Needs a revenue manual or a Haryanvi source. Land so recorded is shown on the Waterbody Sheet (Form 7-1) and treated as a waterbody under Clause 7.3, but the word is not defined in this Manual
choe (चो; spelling not confirmed)	A seasonal hill torrent of the Shivalik foothills, dry for most of the year and in spate in the monsoon, with a wide bed of sand and boulders	Not checked in a dictionary or a statute; used in this Manual only with its gloss, as a river or seasonal stream under Clause 7.2
Haryanvi forms of johad, talab, jhil, nala and the names of the parts of a johad	Regional forms of the terms of Tables 7E.1 and 7E.2, and the local words for a johad's bund, spill point, feeder inlets and green belt	Not checked in a regional dictionary

Form 7-1 — Waterbody Sheet

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

Draft form — Haryana Stormwater Design Manual, Draft v1.0. One sheet per waterbody. Attach the plan of Clause 7.3.2 at 1:1,000 or larger.

Table 7F.1 — Form 7-1, Section A: Project and waterbody

No.	Field	Entry	Clause
A1	Project name and Authority file number	_____	—
A2	Waterbody name (English and Hindi) and inventory ID (Annex 7A), if any	_____	7.3.1
A3	Waterbody type (Clause 7.2)	_____	7.2
A4	Position: within the site / within 100 m of the site boundary / downstream within the Chapter 5 extent	_____	7.3.2
A5	Survey numbers and village	_____	7.3.1(a)
A6	Custodian	_____	7.3.1(b)
A7	Sources checked (tick): Revenue records and khasra maps (talab, johar, tank; shamlat; jhord), HPWWMA Pond Data Management System, GMDA water-body UIDs, s. 45 notifications, municipal tank and drain records (HMC Act ss. 161, 193), development plans and master drainage drawings, Badkhal and Surajkund green belts, wetland and Ramsar boundaries □; I&WRD / Gram Panchayat registers □; Authority inventory or court list □; historical maps and imagery, including NWIA □; site survey □	_____	7.3.3
A8	Where sources conflict: which extent governs (the larger)	_____	7.3.3
A9	Datum of all levels, and conversion from any I&WRD datum	_____	7.3.5

Table 7F.2 — Form 7-1, Section B: Levels and features

No.	Field	Entry	Clause
B1	FTL (tanks, lakes, ponds) or top of bank (channels), m	_____	7.2
B2	MWL (tanks), m, and basis (I&WRD record or 1% AEP computed)	_____	7.2
B3	TBL, lowest point (tanks), m	_____	7.3.1(d)
B4	1% AEP flood level, m, and source (adopted map / hydraulic study / not available)	_____	7.3.4
B5	Drainage area at the site (channels), ha	_____	7.4.1(b)
B6	Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no)	_____	7.3.2
B7	Known encroachments, with date recorded	_____	7.3.1(g)

Table 7F.3 — Form 7-1, Section C: Setback

No.	Field	Entry	Clause
C1	Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B)	_____	7.15(1)
C2	Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)?	_____	7.3.4
C3	Floodway outer edge, m from FTL or top of bank, and how delineated	_____	7.6.1
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3

No.	Field	Entry	Clause
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider statutory, court or approval line: limits notified under section 45 of the Haryana Canal and Drainage Act, 1974 (such as the Ghaggar floodplain in Panchkula); the land, green belt, catchment area or notified protected area of a pond under the Haryana Pond and Waste Water Management Authority Act, 2018; the Badkhal and Surajkund green belt and 1 km line (Supreme Court, 1996); 50 m from the mean high flood level of a notified wetland; an I&WRD drain, embankment or canal line; another court or Tribunal line; or other (state which)	_____	7.4, Disclosure
C8	Uses proposed in Zone 1 and Zone 2, and the custodian's NOC for any work in Zone 1	_____	7.5, 7.15(5)
C9	Fill proposed in the flood fringe (yes / no); if yes, Form 7-3 attached	_____	7.6.3
C10	Zone 1 marker positions shown (not more than 30 m apart)	_____	7.13.4

Table 7F.4 — Form 7-1, Section D: Prepared by

Field	Entry
Name, registration and empanelment number (Clause 10.6)	_____
Signature and date	_____
Licensed surveyor for the levels (name, licence number)	_____

Form 7-2 — Tank Storage Credit Sheet

Supports Clauses 7.7, 7.8, 7.11, 7.14 and 7.15(4) of Chapter 7.

Draft form — Haryana 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&WRD freeboard standard, m; met?	_____	7.7.4(b)
C7	Storage between C1 and C4, from the stage–storage curve, m^3	_____	7.7.5
C8	Volume already committed to another facility or scheme, m^3	_____	7.7.5
C9	Creditable volume = C7 − C8, m^3	_____	7.7.5
C10	Register entry under Clause 10.17 (fee-in-lieu storage)	_____	7.11.2(d)

Table 7F.8 — Form 7-2, Section D: Bund safety

No.	Item	Entry	Clause
D1	Specified dam under the Dam Safety Act, 2021? Height, crest length, capacity, maximum flood discharge	_____	7.14.1
D2	Hazard class: high / low	_____	7.14.2
D3	High hazard: weir passes 1% AEP at MWL with freeboard; 0.2% AEP check without overtopping	_____	7.14.3(a)
D4	High hazard: breach analysis and emergency action plan (references)	_____	7.14.3(b), (c)
D5	High hazard: independent check under Clause 10.6 (name)	_____	7.14.3(d)

Table 7F.9 — Form 7-2, Section E: Signatures

Role	Name and designation	Signature and date
Designer (Clause 10.6)	_____	_____
Independent checker, where Clause 7.14.3(d) applies	_____	_____
Custodian's concurrence (Clause 7.7.1(e))	_____	_____

Form 7-3 — Compensatory Storage Calculation (by elevation band)

Supports Clauses 7.6.3 to 7.6.5, 7.9.5 and 7.15(3) of Chapter 7.

Draft form — Haryana 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 Haryana 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 Haryana 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 — Haryana 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 Haryana, 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 Haryana and known to tolerate both wet and dry periods; no Haryana source on planting for stormwater was researched for this Manual. Hindi or Urdu names are given only where J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884), or Syamasundara Dasa, *Hindi Shabdasagara* (1965–1975), both as served by the Digital South Asia Library, gives the name for the species or plant named, with its page; a dash means none was confirmed, and no Haryanvi name is given. Platts often uses older botanical names, which are given in the notes. Final selection shall be confirmed with a horticulturist or the State Forest Department for the site's soil, salinity and water table. Sites in the dry south-west (sub-areas HR-E and HR-F) need species that survive long droughts on sand, with no irrigation once established; sites on the saline and sodic soils of the waterlogged belt (HR-D) and of Kurukshetra, Kaithal and Karnal, species tolerant of salt and of a water table near the surface; Aravalli sites, species tolerant of dry, thin soils over rock; and johad-edge and floodplain (khadar) sites, species tolerant of standing water. Native trees and grasses in the catchment of a johad also keep it from eroding and silting the johad.

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

Use	Botanical name	Hindi / Urdu name	Notes
Swales, filter strips, bioretention edges	*Chrysopogon zizanioides* (vetiver)	ख़स / خس (ḵẖas)	Deep-rooted clump grass; tolerates flooding and drought; binds soil on side slopes and johad banks. Platts: "A fragrant grass, *Andropogon muricatum* (from the roots of which *taṭṭīs* are made)" (p. 489), an older name of this species
Swales and filter strips (turf)	*Cynodon dactylon* (Bermuda grass)	दूब / دوب (dūb)	Low turf; tolerates drought, traffic and short flooding. Platts: "Bent grass, panic grass, *Panicum dactylon*, or *Cynodon dactylon*" (p. 531)
Swales and banks on floodplain (khadar) sites	*Saccharum spontaneum*	कास / کاس (kās)	Native tall grass of river sands; binds banks; cut back where it would obstruct a channel. Platts: "A species of grass, of which ropes, &c. are made, *Saccharum spontaneum*" (p. 801)
Swales and filter strips in the dry south-west	*Cenchrus ciliaris* (buffel grass)	—	Native tufted grass; binds sandy soil. Dhaman, a name in use, is given by the Shabdasagara to a different plant (p. 2455), so it is not used here
Shrubs on swale banks and bioretention edges (dry south-west)	*Capparis decidua* (syn. *C. aphylla*)	करील, कैर / کریل، کیر (karīl, kair)	Leafless thorny shrub of dry sandy ground; very drought-tolerant. Platts (*karīr*): "a thorny leafless shrub, the caper bush, *Capparis aphylla* (which grows in deserts, and is eaten by camels)" (p. 830); *kair* and *karīl* are given as forms of *karīr* (pp. 888, 831)
Shrubs on swale banks and bioretention edges (dry)	*Ziziphus nummularia*	झड़बेरी / جھڑبیري (jhaṛ-berī)	Native thorny bush of dry ground. Platts: "A wild ber or jujube bush, *Zizyphus jujuba*; the wild lote-tree" (p. 404); that the name refers to this species was not confirmed in Platts
Trees beside bioretention and swales (dry south-west)	*Prosopis cineraria* (khejri)	खेजड़ी (khejaṛī)	Native tree of the dry plains; deep-rooted and drought-tolerant. In the Shabdasagara, खेजड़ी is "the shami tree" (p. 1178), and शमी "a large tree" (p. 4695). Not in Platts. Not to be confused with *Prosopis juliflora* (Table 8D.15)
Trees beside swales and channels	*Vachellia nilotica* (syn. *Acacia nilotica*; desi babul)	बबूल, कीकर / ببول، کیکر (babūl, kīkar)	Native; tolerates both drought and seasonal waterlogging; thorny. Platts: "The gum-acacia tree, *Mimosa arabica*" (p. 130), and *kīkar*, "The tree *Acacia* (or *Mimosa*) *arabica* (syn. *babūl*)" (p. 889), older names of this species. Not to be confused with *Prosopis juliflora* (Table 8D.15)
Trees on saline ground beside swales	*Salvadora persica*	पीलू / پیلو (pīlū); जाल / جال (jāl)	Native; tolerates saline soil and drought. Platts: *pīlū*, "The tree *Careya arborea*, or *Salvadora persica*" (p. 301), and *jāl*, "the tree *Salvador indica*" (p. 371); confirm the species with the supplier

Use	Botanical name	Hindi / Urdu name	Notes
Trees beside bioretention and swales	*Azadirachta indica* (neem)	नीम / نیم (nīm)	Native or long naturalised; drought-tolerant; not for waterlogged beds. Platts: "The Nīm-tree, *Melia azadirachta*" (p. 1169), an older name of this species
Trees on johad banks and saline wet edges	*Tamarix dioica* (syn. *T. indica*)	झाऊ / جھاو (jhā'ū, jhau)	Native; tolerates salt and standing water. Platts: "A tree of the Tamarisk kind, *Tamarix gallica*, or *T. Indica* (… from its growing in marshy or sandy ground …)" (p. 402); confirm the species with the supplier
Trees beside channels and on floodplain sites	*Dalbergia sissoo*	शीशम / شیشم (śīśam)	Native riverine tree. Platts: "The tree *Dalbergia sisu*, and its wood" (p. 740)
Trees beside bioretention and swales (north and east)	*Syzygium cumini*	जामुन, जामन / جامن (jāmun, jāman)	Native; tolerates wet ground; for the wetter north and east, not the dry south-west. Platts: "The tree *Eugenia jambelana*, or *Syzygium jambolanum*, and its fruit" (p. 372)
Trees beside bioretention and swales	*Millettia pinnata* (syn. *Pongamia pinnata*)	करंज / کرنج (karanj)	Native; tolerates waterlogging and drought. Platts names *Galedupa arborea*, an older name of this species, but also the fever-nut *Caesalpinia bonducella* under the same word (p. 828); confirm the species with the supplier. Keep roots clear of underdrains
Trees beside channels	*Terminalia arjuna*	अर्जुन / ارجن (arjun)	Native riverbank tree; tolerates seasonal flooding. Platts: "a certain tree, *Terminalia alata glabra*" (p. 39); that the name refers to this species was not confirmed in Platts
Trees beside wet ponds and channels	*Ficus racemosa* (syn. *F. glomerata*)	गूलर / گولر (gūlar)	Native fig of stream banks. Platts: "The wild fig, *Ficus glomerata*" (p. 926). Keep roots clear of underdrains, pipes and walls

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

Constructed wetlands and wet ponds are rarely practical in the dry south-west, where no permanent pool survives the dry months without a feed (Clause 8.7.8); these species are for the sites where the water balance shows that one does.

Zone	Botanical name	Hindi / Urdu name	Notes
Shallow macrophyte zone	*Typha* spp. (e.g. *T. domingensis*, syn. *T. angustata*)	—	Native; tolerates some salinity; spreads quickly and needs periodic harvesting. No Hindi name was confirmed in Platts: पटेर (paṭer), sometimes used for it, is glossed by Platts as *Cyperus* (p. 229)
Shallow macrophyte zone	*Phragmites karka*	नल / نل (nal); नरसल / نرسل (narsal)	Native reed; vigorous; keep out of nalas and drains where it would obstruct flow. Platts: "A species of reed, *Amphidonax karka*, or *Arundo karka*" (p. 1152) and "A large species of reed, *Arundo karka*" (p. 1132)
Shallow macrophyte zone	*Canna indica*	—	Naturalised; tolerates waterlogging; widely used in constructed wetlands in India
Open water and deep zones	*Nelumbo nucifera* (lotus)	कमल / کمل (kamal)	Native; for permanent pools only. Platts: "The lotus, *Nelumbium speciosum*" (p. 849)
Open water and deep zones	*Nymphaea nouchali* (blue water lily)	नीलोफ़र / نیلوفر (nīlofar)	Native; for permanent pools only. Platts: "the blue water-lily, *Nymphæa cyanea*" (p. 1168), an older name of this species

Table 8D.15 — Species not to be planted

Botanical name	Hindi / Urdu name	Reason
Prosopis juliflora (vilayati babul)	—	Invasive; forms dense thickets on johad beds, on embankments and along drains. Not to be confused with the native *Prosopis cineraria* (khejri) or *Vachellia nilotica* (desi babul) of Table 8D.13
Eichhornia crassipes (water hyacinth)	—	Invasive; chokes johads, jhils, drains and screens
Ipomoea carnea	—	Invasive in ponds and channels; obstructs flow

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Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

Table 8E.1 — Selection of measures (Clause 8.12.3)

Situation	Measure	Detail
Sheet flow leaving a disturbed area, along its downslope edge	Silt fence	Figure 8E.1
Concentrated flow from a disturbed area of up to 2 ha	Sediment trap	Figure 8E.2
Disturbed area of more than 2 ha	Sediment basin with surface dewatering outlet	Figure 8E.2
Existing drain inlet receiving site runoff	Inlet protection	Figure 8E.4
Vehicle exit to a public road	Stabilised construction exit, with wheel washing	Figure 8E.3
Stockpiles	Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the SW monsoon	Notes to Figure 8E.1
Dewatering	Through a sediment basin, settling tank or filter bag; never pumped directly to a drain or waterbody	Notes to Figure 8E.2
Concrete washout	Lined pit; never into a drain	Notes to Figure 8E.3

8E.1 Silt fence

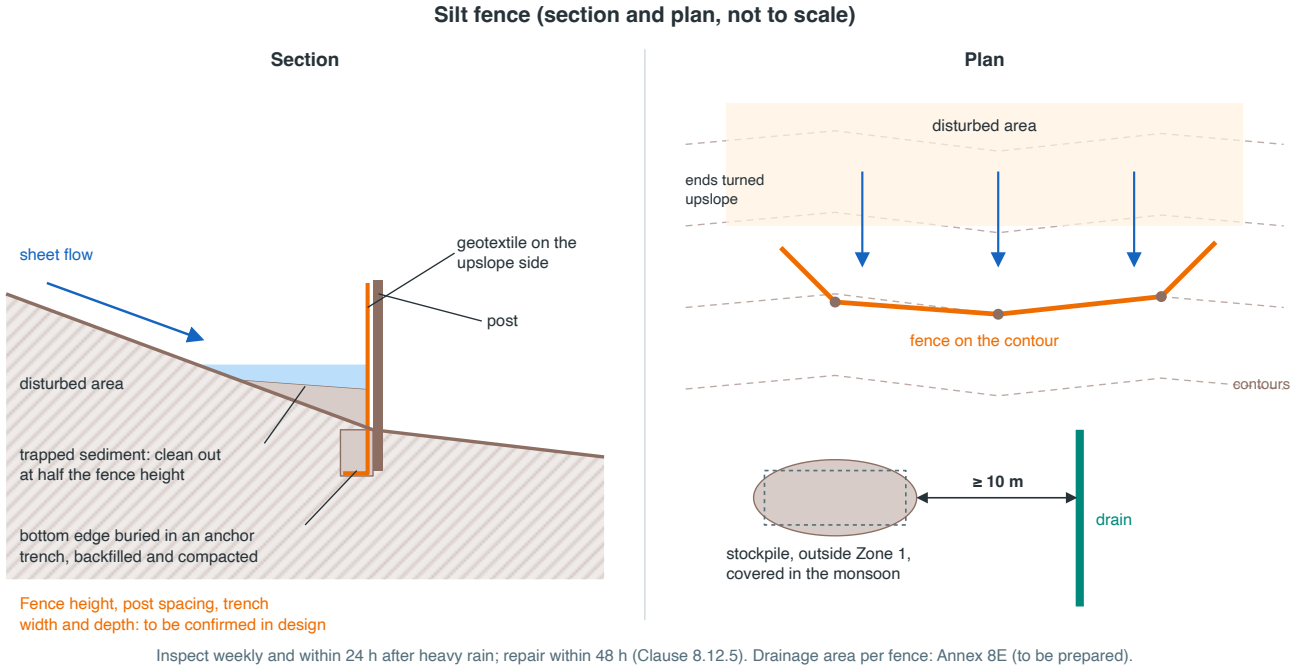

Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

To be prepared. Clause 8.12.3(a) refers to this annex for the limit on the area draining to each silt fence. That limit, and the maximum slope length above a fence, need to be set by the State Stormwater Technical Committee for Haryana 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

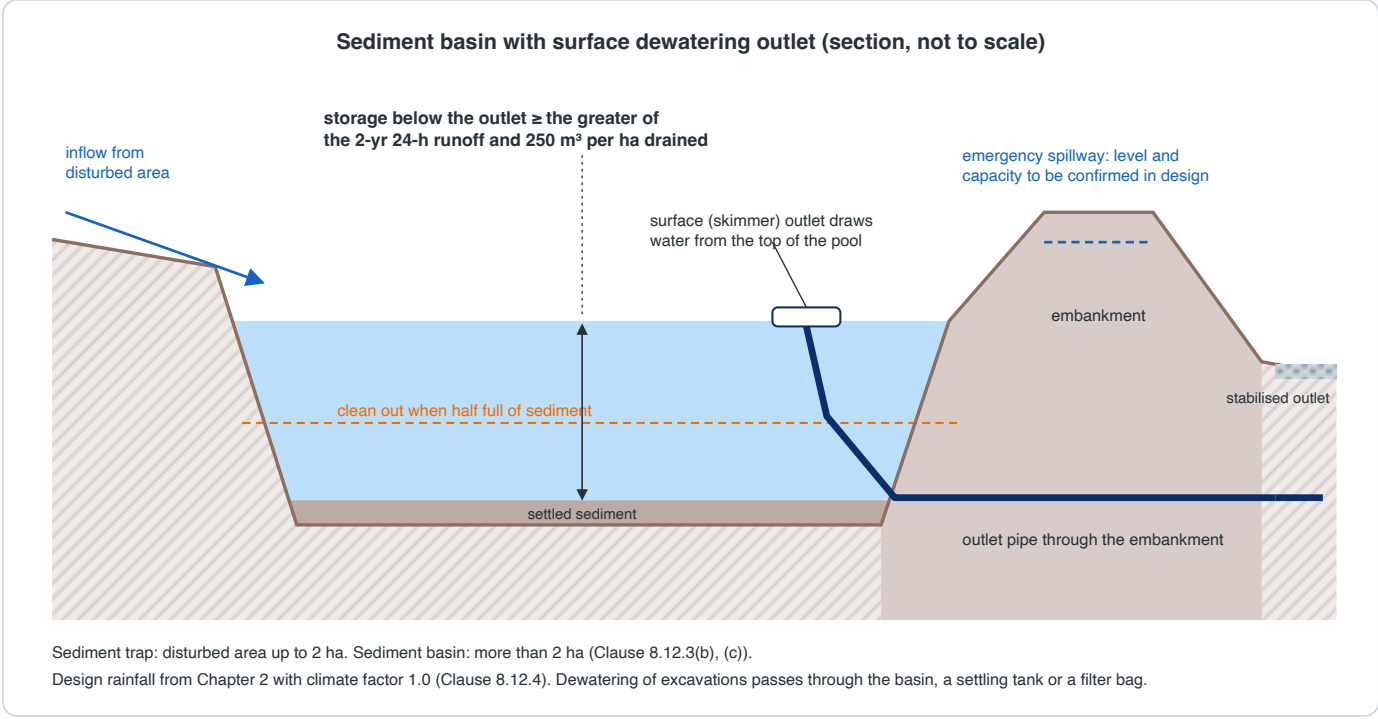

Figure 8E.2 — Sediment trap or basin in section: inflow, storage volume below the outlet, surface dewatering outlet (skimmer) drawing water from the top of the pool, emergency spillway, and sediment cleanout level at half the storage. Original drawing for this Manual, adapted from US EPA, NPDES Construction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

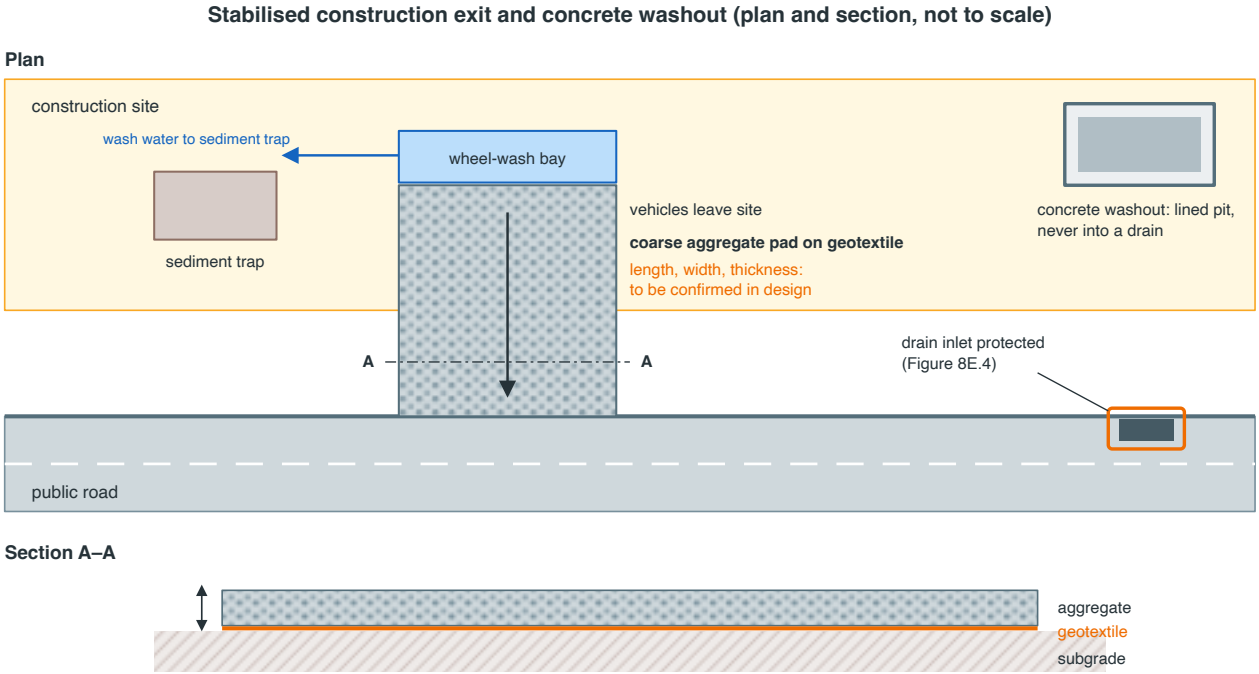

Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing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

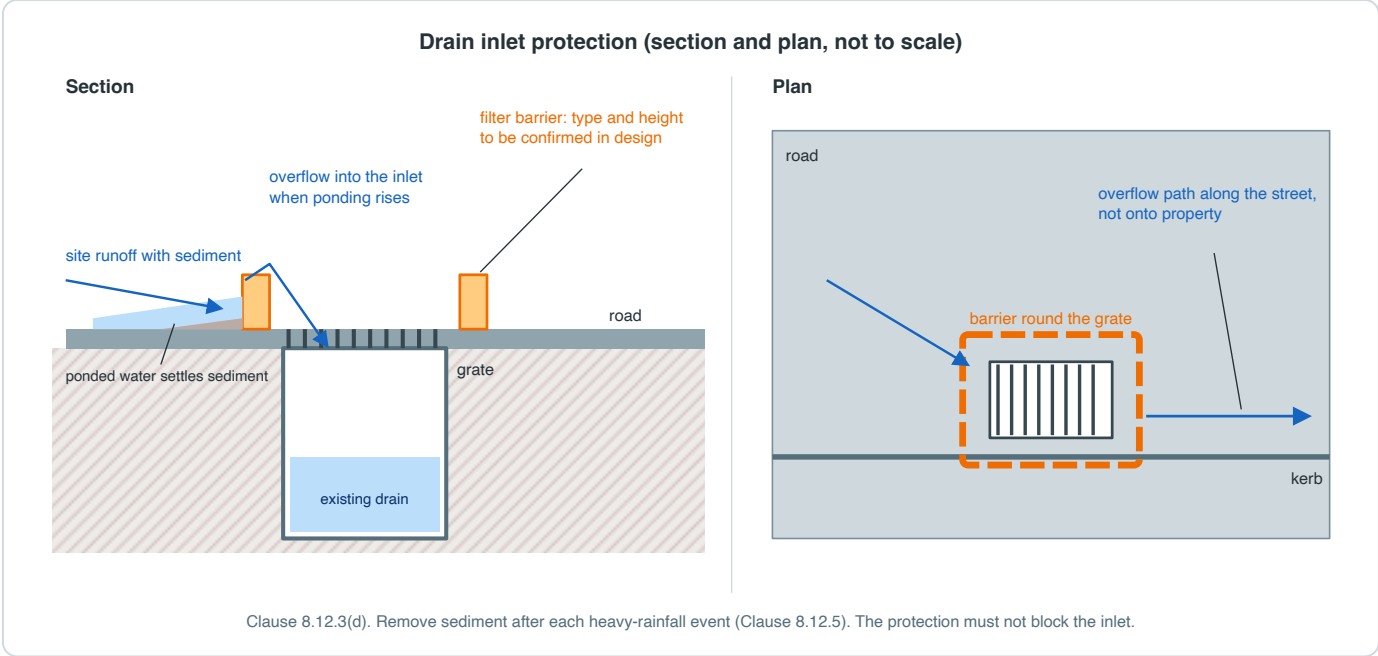

Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual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

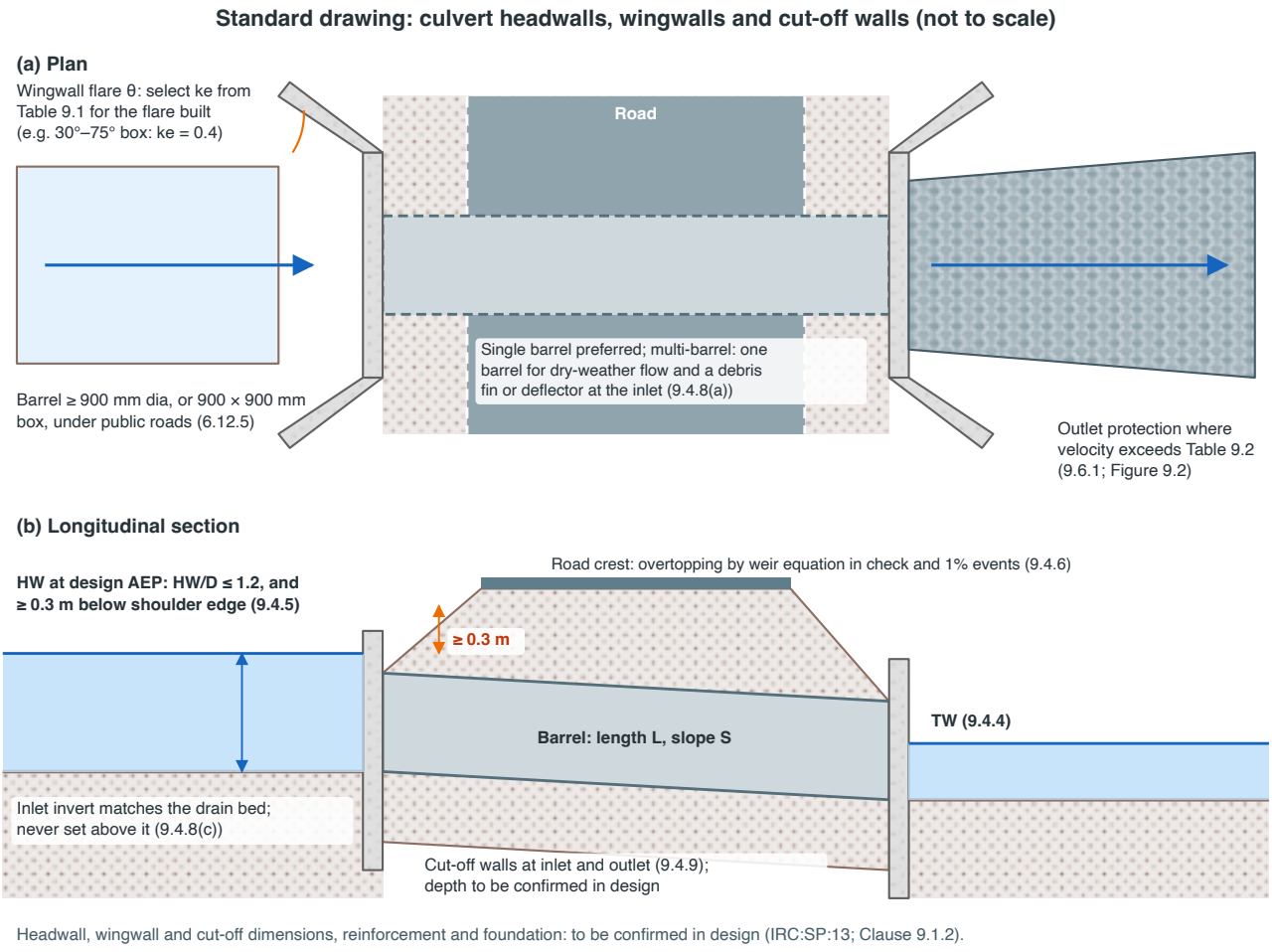

Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

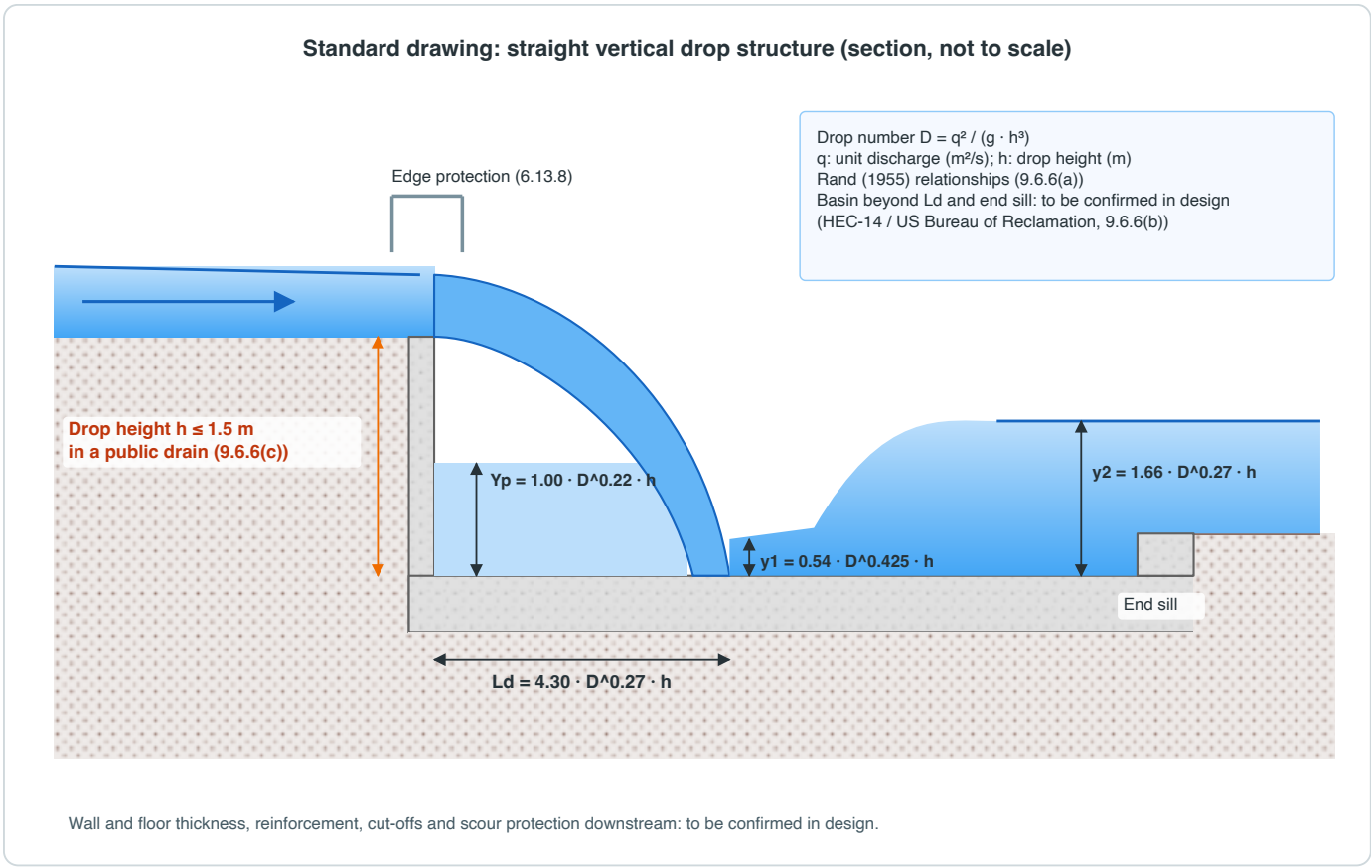

Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

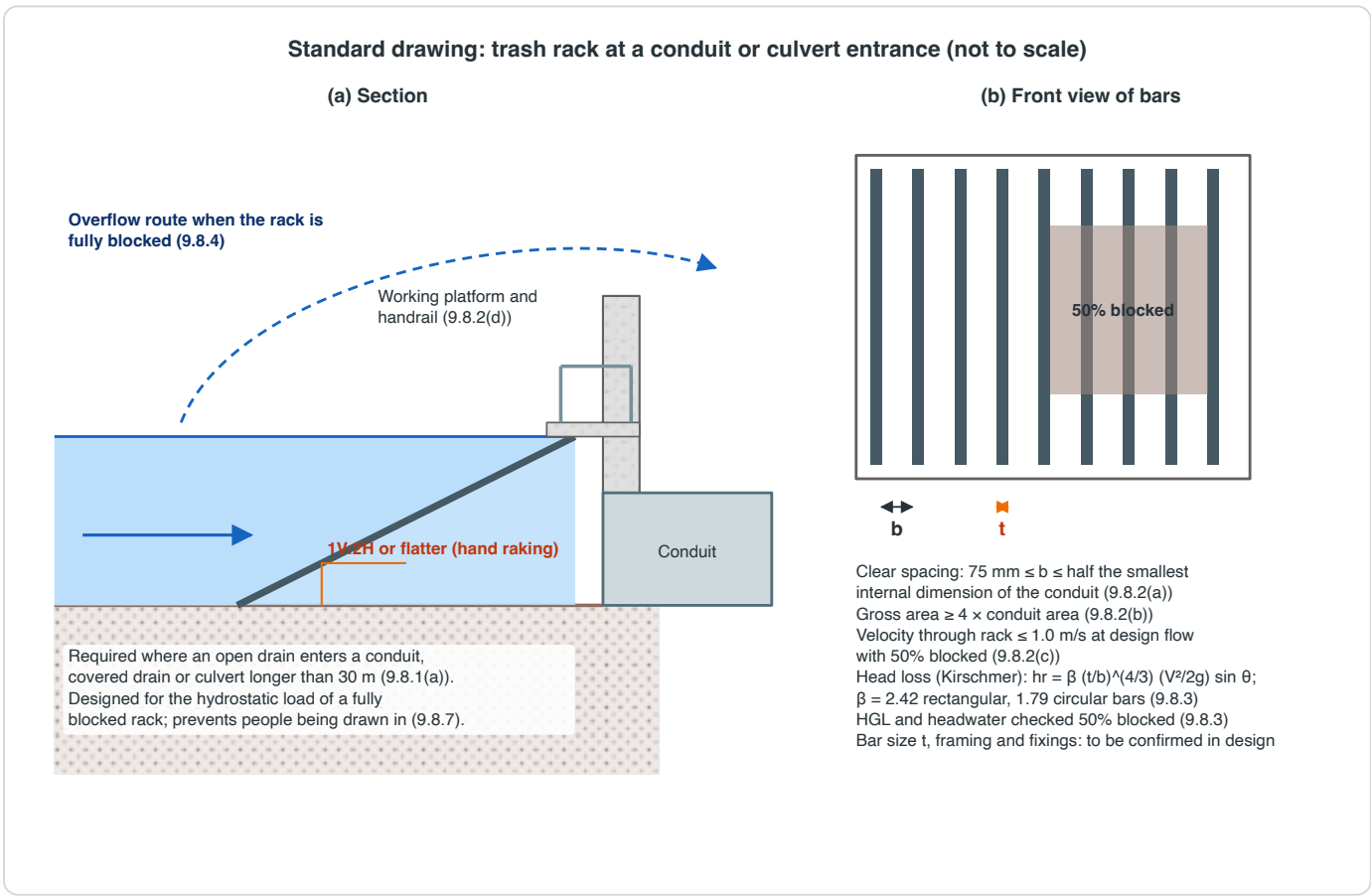

Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

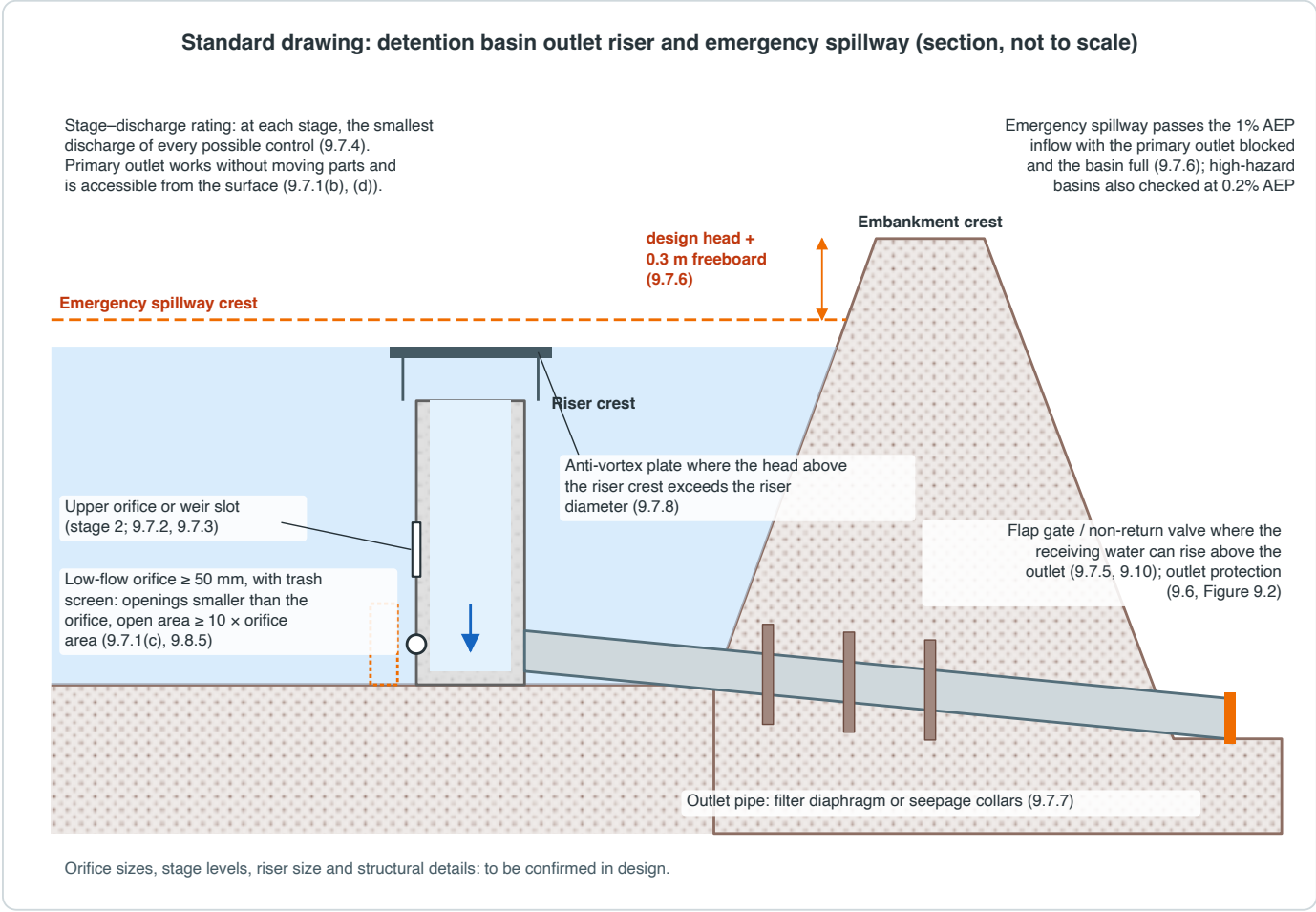

Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — Haryana 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 — Haryana Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

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

Annex 10A — Compliance calculator and user guide

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

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

10A.1 General requirements

The calculator shall:

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

10A.2 Inputs

Table 10A.1 — Calculator inputs

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

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

10A.3 Calculations, by clause

Table 10A.2 — Calculations the calculator shall perform

Step	Calculation	Clause
C1	**Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies to buildings on plots of more than 500 m², by groundwater recharge (Haryana Building Code 2017, Code 8.1(2)), and, in the areas the Competent Authority notifies, by roof rainwater harvesting where the rooftop is 100 m² or more (Code 8.1(1)); recharge is credited, with pre-treatment, where the seasonal high water table is deeper than 10 m, after a hydrogeologist's check where it is 3–10 m deep, and not at all where it is within 3 m, as in the Rohtak–Jhajjar–Sonipat belt and much of the floodplains, where detention and drainage govern; road runoff is recharged only through filtered surface infiltration, and the groundwater rules of the CGWA notified area (Gurgaon district) apply there.	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 43N (EPSG:32643), whichever contains the site (Clause 10.4.4(c)). One system shall be used for all layers.
- (c) **Vertical reference.** All levels shall be in metres relative to a named vertical datum, stated in the metadata. The metadata shall also state the relationship between that datum and the river datums of the CWC and I&WRD gauges on the receiving rivers and of I&WRD's drain, regulator and embankment levels, and, for a drain that reaches the Najafgarh drain, the levels of Delhi's Irrigation and Flood Control Department 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 `MCG–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 river datums of the CWC and I&WRD gauges on the receiving rivers and of I&WRD's drain, regulator and embankment levels, and, for a drain that reaches the Najafgarh drain, the levels of Delhi's Irrigation and Flood Control Department (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

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

Table 10B.8 — Status codes (STATUS)

Code	Meaning
PROPOSED	In a Stage 1 or Stage 2 submittal
APPROVED	Stage 2 approved; not yet built
ASBUILT	As-built certificate accepted (Clause 10.9)
HANDEDOVER	Accepted by the ULB (Clause 10.14)
ALTERED	Changed with the Authority's approval (Clause 10.3.5)
REMOVED	Removed with the Authority's approval

Table 10B.9 — Inspection result codes (INSP_RES)

Code	Meaning
OK	Working as designed; no defect
MINOR	Defect found and corrected; date in the inspection record
MAJOR	Defect affecting storage, outlet or safety; notice issued (Clause 10.15.2, step 1)
NOACCESS	Inspection could not be made
NOTFOUND	Facility missing, filled, covered or changed in use (Clause 10.15.1(c))

10B.5 Facility register extract

The public facility register of Clause 10.17.1(a) is an extract of SW_FAC: FAC_ID, FAC_TYPE, location (centroid), V_DET (and V_RET, V_WQ), Q_100 (and Q_2, Q_10), OWNER_NM, ASB_DATE, LAST_INSP and INSP_RES. It is published as CSV and GeoPackage under the licence of Clause 10.17.4. Personal data are not published (Clause 10.17.3).

Annex 10C — Maintenance access dimensions

Supports Clause 10.13 of Chapter 10.

Clause 10.13 sets access by function. This annex collects the access dimensions that the Manual already sets in other chapters, and lists the dimensions that it does not set. Where a dimension is not set by the Manual, the designer shall state it on the drawings, show that it suits the plant and equipment named in the O&M plan (Clause 10.11.1(h)), and mark it "to be confirmed in design".

Table 10C.1 — Access dimensions set by the Manual

Element	Requirement	Clause
Open drains with a top width of 2 m or more	Maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m	6.9.4
Drainage reserves	Width not less than Table 6.9, based on the required drain size; where the access strip of Clause 6.9.4 is wider, the wider governs	6.9.7
Covered drains, minimum section	0.6 m × 0.6 m clear	6.7.6
Covered drains, removable covers	Panels at not more than 10 m centres, each at least 0.6 m long and spanning the full clear width, liftable by two workers or a hand-operated device	6.13.2(a)
Covered drains, access chambers	Clear opening at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than 30 m centres on straight runs	6.13.2(b)
Manholes and access chambers on public drains	Clear access opening at least 600 mm	9.12.3
Inlet chambers on public roads	Silt sump at least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7
Underground tanks and vaults	Access openings over the outlet chamber and over every inlet; in tanks over 500 m², not more than 30 m apart; floor falling at least 1% to a sump at the outlet	4.10.2(b), (c)
Detention outlets serving more than 1 ha	A means of isolating the outlet (stop-log slot or penstock)	4.8.6
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)

Element	Requirement	Clause
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 Haryana cities vary widely (Clause 10.13, Commentary). The State Stormwater Technical Committee may add standard values to Table 10C.2 when it issues the standard drawings of Annexes 6C and 9B.

Annex 10D — Model O&M plans by facility type

Supports Clauses 10.11, 10.12 and 10.13 of Chapter 10.

The model plans below are starting points. The designer adapts them to each facility and completes the items marked "_____". Inspection frequencies are the minimum frequencies of Table 10.3; a plan may set more frequent inspection, never less. Where this annex leaves a value to the designer, the Manual does not set it.

10D.1 Contents of every O&M plan

Every plan shall contain the items of Clause 10.11.1:

Table 10D.1 — Contents of an O&M plan

Item	Content	Clause
1	Inventory and plan drawing of each facility, with design levels, volumes and outlet details (from SW_FAC, Annex 10B)	10.11.1(a)
2	Routine tasks and their frequency (Tables 10D.2 to 10D.8)	10.11.1(b)
3	Trigger for sediment removal, as a depth (mm) or a percentage of design volume: _____	10.11.1(c)
4	Inspection checklist matching Form 10-7	10.11.1(d)
5	For pumps, gates and valves: operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning	10.11.1(e)
6	Actions against standing water and mosquito breeding, consistent with the drawdown times of Clause 4.7	10.11.1(f)
7	Safety: confined spaces, deep water, public access	10.11.1(g)
8	Access routes and equipment (Annex 10C)	10.11.1(h)
9	Annual cost estimate (₹ _____ per year) and who pays it	10.11.1(i)
10	Records to be kept, and for how long: _____ years (pump records at least 5 years, Clause 9.9.8(c))	10.11.1(j)

10D.2 Model plans

Table 10D.2 — Retention and infiltration (soakaways, trenches, bioretention, permeable paving)

Task	Frequency	Standard or trigger	Clause
Inspect surface, inlets, pretreatment and overflow	Every 6 months; before 15 June; 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 June; 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)

Task	Frequency	Standard or trigger	Clause
Safety features	Every 6 months	Signs in Hindi and English and a depth marker in place; fences and gates sound where required	4.15.3, 4.15.5
Embankment (if any)	Every 6 months and after events	No cracks, slips, seepage or animal burrows	4.9.6

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

Task	Frequency	Standard or trigger	Clause
Inspect from the access openings: inlets, outlet, orifice, screen, sump, vents	Every 6 months; before 15 June; 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 June	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 15 June	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

Task	Frequency	Standard or trigger	Clause
Seal test	Before 15 June	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 June	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 15 June	No corrosion that would stop the gate working	9.10.6
Property non-return valves	Every 3 months	Cleaning eye accessible; valve seals	5.11.4

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

Task	Frequency	Standard or trigger	Clause
Inspect and empty	Every 3 months; before 15 June; 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 June	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 DTCP. 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 Haryana Building Code 2017 (Clause 1.4);
    - (c) have at least [ ] years of experience in drainage design after graduation, shown by a list of at least [ ] projects with the applicant's role in each (Clause 10.6.2); and
    - (d) have completed a training course on this Manual, with an assessment, within the [ ] years before application (Clause 10.6.2).
3. **Eligibility for list (b).** As for list (a), with at least [ ] years of experience, of which at least [ ] years in the design or review of drainage under this Manual or an equivalent standard.
4. **Basin modelling endorsement (c).** A Stormwater Design Professional who shows experience in basin-scale 1D–2D modelling, including calibration, on at least [ ] studies (Clause 11.4.3).
5. **Independence of a checker.** A checker under Clause 10.6.4 shall not be employed by, or a partner of, the designer's firm or the Applicant, and shall not have worked on the design.
6. **Conflict of interest of a reviewer.** An Empanelled Reviewer shall not review a site on which the reviewer, or the reviewer's firm, has worked in any capacity (Clause 10.7.4), and shall declare any other interest before accepting a review. The Authority remains the decision-maker (Clause 10.7.4).
7. **Application.** The application shall include proof of degree and registration, the project list with references, the training certificate, and a signed declaration that the information is true.
8. **Term and renewal.** Empanelment is valid for [ ] years. Renewal requires evidence of continuing practice and of any refresher training issued after a revision of the Manual (Clause 1.12).
9. **Suspension and removal.** The competent authority may suspend or remove an empanelled person after a false or negligent certificate (Clause 10.6.5), on a report under step 6 of Table 10.4, or on loss of registration. The person shall be given notice and an opportunity to be heard. Every suspension and removal shall be published on the list.
10. **Publication.** The lists shall be published and kept current, with each person's name, registration number, list, endorsement and validity date.

Form 10-1 — Drainage Report Checklist

Supports Clauses 10.4.1 to 10.4.4 and 10.7.1 of Chapter 10.

Draft form — Haryana Stormwater Design Manual, Draft v1.0. Lodge with every Stage 1 and Stage 2 submittal. For each item give the page or sheet where it is addressed, or the reason it does not apply. The Authority does not start technical review without a completed Form 10-1 (Clause 10.4.3).

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

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

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

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

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

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

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

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

No.	Item	Clause	Provided (yes / no)	Detail
D1	Reports and drawings as searchable PDF	10.4.4(a)	_____	_____
D2	Models in native, runnable format; software name and version	10.4.4(b)	_____	_____
D3	GIS data to Annex 10B; horizontal reference system (EPSG code)	10.4.4(c)	_____	_____
D4	Vertical datum named; relationship to the Chapter 5 river datums of the CWC and I&WRD gauges on the receiving rivers and of I&WRD's drain, regulator and embankment levels, and, for a drain that reaches the Najafgarh drain, the levels of Delhi's Irrigation and Flood Control Department	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 — Haryana 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 — Haryana 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, HBC 2017 registration number	_____	10.6.1
A4	Empanelment number, where required, and the reason: Tier A ≥ 1 ha / flood-sensitive / embankment or high-hazard basin / pumped, tide gate or regional facility	_____	10.6.1(a)–(d)
A5	Variances or waivers approved (Form 1-2 references), or "none"	_____	10.6.3(a)

Table 10F.12 — Form 10-3, Section B: Certificate of the designer

No.	I certify that:	Initials
B1	the design complies with the Haryana 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 — Haryana 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 — Haryana 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 — Haryana Stormwater Design Manual, Draft v1.0. Model text for consideration by a competent authority. Not in force. Executed by the owner of every private stormwater facility before the completion certificate is issued, and registered so that it runs with the land.

> **Drafting note D10A.1.** The instrument under which this declaration is registered, and the Act that gives the Authority its right of entry and its power to carry out works in default, are to be confirmed by the competent authority. This form does not cite statute sections.

Table 10F.21 — Form 10-6, Section A: Parties and land

No.	Field	Entry
A1	Owner (the declarant): name and address; for a company or association, its registration number	_____
A2	Authority	_____
A3	Land: survey numbers, village, tehsil, district; extent	_____
A4	Approval reference (file number, Stage 2 approval date)	_____
A5	For multi-owner developments: the association or body that takes over after the developer (Clause 10.10.2)	_____

Table 10F.22 — Form 10-6, Section B: Schedule of facilities

Facility (FAC_ID)	Type	Location on the attached plan	Design volume (m³)	Outlet	O&M plan reference
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Model declaration. I/We, the owner named in Section A, declare and undertake, for myself/ourselves and for every successor in title to the land:

1. to operate, inspect and maintain each facility in Section B under the approved O&M plan, and to make the inspections of Clause 10.12 (Clause 10.10.1(b));
2. to give the Authority, its officers and its contractors a right of entry to inspect each facility and the access route shown on the plan, and to carry out works in default under Clause 10.15, with the cost recoverable from the owner (Clause 10.10.1(c));
3. not to remove, fill, cover, reduce or change the use of any facility, or obstruct its access route, without the Authority's written approval (Clauses 10.10.1(d), 10.13.5);
4. where Clause 10.10.3 applies, to lodge an Annual Maintenance Declaration and Inspection Report (Form 10-7) by 15 June 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 — Haryana Stormwater Design Manual, Draft v1.0. Due by **15 June** 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 June) 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 — Haryana Stormwater Design Manual, Draft v1.0. Signed by the developer and the ULB when drains, open space facilities, regional facilities or other stormwater assets built by a developer are handed over.

Table 10F.30 — Form 10-8, Section A: Asset and parties

No.	Field	Entry
A1	Developer: name and address	_____
A2	ULB	_____
A3	Layout or project, approval reference	_____
A4	Assets handed over (FAC_ID, type, length or volume), with a plan	_____

Table 10F.31 — Form 10-8, Section B: Conditions of handover (Clause 10.14.1)

No.	Condition	Met (yes / no)	Reference or date
B1	As-built certificate (Form 10-5) accepted	_____	_____
B2	Facility cleaned; pipes and culverts inspected internally (CCTV or manual entry), record handed over	_____	_____
B3	Land, or an easement over it, transferred to the ULB	_____	_____
B4	O&M plan, drawings, GIS data (Annex 10B) and warranties handed over	_____	_____

Table 10F.32 — Form 10-8, Section C: Defects liability and register

No.	Field	Entry	Clause
C1	Defects liability period: from _____ to _____ (includes at least one full monsoon season, from 15 June to 30 September, 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 Haryana 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, johad 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&WRD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, GMDA or DTCP, HSDMA] (Clause 11.4.1).
3. **Study area:** the whole of the [name] basin, draining to [outfall], as delineated under Clause 11.3, including the parts outside the client's limits (Clause 11.3.1). The provisional boundary is in [Annex 11B / attached map]. The consultant shall confirm it in Task 2.

4. **Links to other basins:** [for example the receiving river or drain 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, johad, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels and encroachment, in the fields of Annex 7A;
- (d) rivers and canals: cross-sections at no more than 200 m spacing and at every structure;
- (e) outfalls, rivers and I&WRD drains: outfall invert levels, on a named datum, against the warning, danger and high flood levels of the Yamuna at the nearest CWC gauge and its recorded peaks, with the release records of Hathnikund barrage; for the Ghaggar, the Tangri, the Markanda and the choes, the gauge zero, danger level and highest levels of the I&WRD gauges, or surveyed marks of the July 2023 flood; for outfalls to I&WRD drains, the drain's design discharge and design water level at the outfall; for drains that reach the Najafgarh drain, its level and capacity at the outfall, agreed with Delhi's Irrigation and Flood Control Department; the limits notified under s.45 of the Canal and Drainage Act and the lines drawn under court orders where they bind; and regulators, sluices, flap gates, bundhs, barrages and pumping stations on the outfalls, with their capacities and operating rules;
- (f) rainfall and water levels: all available records (IMD, including its observatories at Ambala, Hisar, Karnal, Gurgaon, Rohtak, Narnaul and Bhiwani and the automatic weather stations and rain gauges reported by the Meteorological Centre Chandigarh; the district and tehsil rain gauges of the State, such as those at Gurugram, Kadipur, Harsaru, Wazirabad and Sohna; the agromet observatories of CCS Haryana Agricultural University at Hisar and of CSSRI at Karnal; the rain and river gauges of CWC and of I&WRD, including those at Hathnikund barrage and on the Ghaggar; and any gauges kept by the Municipal Corporations, GMDA, FMDA and the Smart City companies), including the July 2016 (Gurugram), August 2019 (the Yamuna at Hathnikund), August 2020 (Gurugram), July 2023 (the Ghaggar at Panchkula, Ambala and Kaithal, and the Yamuna), July 2024 (Gurugram) and September 2025 (Gurugram) 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 July 2016 (Gurugram), August 2019 (the Yamuna at Hathnikund), August 2020 (Gurugram), July 2023 (the Ghaggar at Panchkula, Ambala and Kaithal, and the Yamuna), July 2024 (Gurugram) and September 2025 (Gurugram) 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 where the water table is deep and over-exploited, as under Gurugram, Faridabad, Kurukshetra, Karnal, Panipat and the south, waterlogging where it is within 3 m, as over about half of Rohtak and Jhajjar districts, and the quality of the groundwater, which is saline over much of the south, west and centre of the State, and of the drains and johads that the runoff reaches; effect on downstream basins and the receiving river or drain; and who benefits.

Task 8 — Basin inputs for site design. Where scenario (c) does not meet the level of service, propose basin release rates (m³/s/ha) by AEP and sub-catchment (Clause 11.8.3). Recommend catchments for notification as flood-sensitive, with the evidence of Clause 4.5.4.1. Identify regional facility sites, with storage volumes, land needs and the sites they serve, and compute the fee-in-lieu unit rate, including land, construction and 10 years of maintenance (Clauses 4.13.3, 11.8.4(c), (d)).

Task 9 — Capital Improvement Programme. Rank the works by risk reduction per rupee, with cost, phasing and responsible agency (Clause 11.8.4(e)).

Task 10 — Maintenance and monitoring. Prepare the pre-monsoon maintenance programme: desilting, gate and pump testing, and tank operating rules (Clause 11.8.4(f); Chapters 7 and 10). Specify monitoring needs: new rain gauges, level sensors and flood-mark survey points (Clause 11.8.4(g); Clause 10.16.1).

Task 11 — Land-use integration. Prepare the material for the statutory land-use plan required by Clause 11.9.1: sites to be reserved; the 1% AEP hazard map with the Chapter 7 setbacks; land in hazard classes H5–H6 in the 1% AEP event; and open space locations that can form part of flow paths or regional storage.

Task 12 — Consultation. Publish the draft BSMP for public comment for at least 60 days, with public meetings in each affected local body (Clause 11.10.1). Keep a log of comments and responses.

Task 13 — Final BSMP and publication. Revise the BSMP after consultation. Prepare the package for approval by the State Stormwater Technical Committee, including the model for review (Clause 11.11.1). Publish the data, models, maps and CIP under Annex 11D (Clause 11.10.2).

11A.5 Deliverables

Table 11A.1 — Deliverables

No.	Deliverable	Task	Due (months from start)
D1	Inception report, data inventory and survey plan	1	[ ]
D2	Data report and data sets (Annex 11D)	2	[ ]
D3	Model build report and model files	3	[ ]
D4	Calibration and validation report	4	[ ]
D5	Scenario results, hazard maps and level-of-service assessment	5, 6	[ ]
D6	Options report, with basin inputs for site design	7, 8	[ ]
D7	Draft BSMP with draft CIP, for consultation	9–12	[ ]
D8	Final BSMP, consultation log, approval package and open-data release	13	[ ]

11A.6 Ownership and publication

All data, models, maps and reports produced under these terms are owned by the Lead Authority and shall be published under Annex 11D. The consultant shall not use any software licence, data licence or format that prevents publication, or that prevents a third party from re-running the model with the stated software version.

Annex 11B — Basin lists and boundaries for Tier A bodies

Supports Clauses 11.3 and 11.4 of Chapter 11.

To be prepared. This annex will contain the list of basins for every Tier A body, with a GIS layer of basin boundaries delineated under Clause 11.3.2. It needs the list of Tier A bodies (Annex 1A), a DEM of the accuracy of Clause 11.5.1, the drain network of every drain-owning body (the Municipal Corporations, GMDA's, FMDA's and PMDA's master drains, HSVP's sector drains, the internal drains of licensed colonies, HSIIDC's industrial-estate drains and the sewage interceptions on the drains), the I&WRD drains with their design discharges and design water levels, the regulators, sluices, flap gates, bundhs, barrages and pumping stations on the outfalls with their operating rules, the ponds on the Pond Authority's data system and the water bodies inventoried by GMDA, with their levels, the floodplain limits notified under s.45 of the Canal and Drainage Act and the lines drawn under court orders, the levels and capacity of the Najafgarh drain from Delhi's Irrigation and Flood Control Department, and the catchments used for DTCP's master drainage drawing of Gurugram (2012) and HUDA's Badshahpur catchment plan (2017–2020) (other likely sources: Survey of India, CWC, CGWB, the Haryana Water Resources Authority and HARSAC). No basin map of any Haryana city was found. Until the annex is published, the basins of Gurugram, Faridabad, Panchkula and Ambala, the Yamuna-bank towns, the Rohtak–Jhajjar waterlogged towns and the Haryana part of the Najafgarh drain basin 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
Gurugram (MCG, GMDA)	Leg-III, the Badshahpur drain, from the Aravalli slopes to the Najafgarh drain, with Leg-IV	Khandsa and Hero Honda Chowk reaches in the 1D network; sewage interceptions mapped (Clause 8.9.5); Najafgarh drain level at the outfall as boundary
Gurugram (MCG, GMDA)	Legs I and II and the old town, to the Najafgarh drain	Ghata, Chakarpur, Jharsa and Wazirabad bundhs and GMDA's inventoried water bodies as storage; Ghata inflow from Delhi as boundary
Faridabad (Municipal Corporation, FMDA)	Budhiya (Buria) nala, from the Aravalli slopes to the Yamuna	Badkhal and Surajkund lake lines under the Supreme Court's orders shown; Yamuna level as boundary
Panchkula and Ambala (Municipal Corporations, PMDA)	Catchments draining to the Ghaggar, the Kaushalya and the Tangri and their choes	s.45 floodplain shown; Kaushalya dam releases and Shivalik floods as inflows; outfall-closed case a design case
Yamunanagar–Jagadhri, Karnal, Panipat and Sonipat (Municipal Corporations)	Catchments draining to the Yamuna, directly or through I&WRD drains such as Drain No. 2	River level at the nearest CWC gauge or Hathnikund barrage as boundary; outfall-closed case a design case
Rohtak, Jhajjar and Bahadurgarh	Catchments draining to Outfall Drain No. 8 and the Dhansa regulator	Drain capacity as boundary; water table as a design condition; pumped outfalls with storage
Haryana part of the Najafgarh drain basin (I&WRD with the bodies above)	The Sahibi below the Masani barrage, Outfall Drain No. 8 and Gurugram's master drains	Prepared together with the plan for the part in Delhi; flows and levels agreed at Dhansa and the master-drain outfalls
Other Tier A bodies, including Hisar, Sirsa, Kurukshetra, Kaithal, Rewari, Bhiwani and Manesar	To be defined in the first BSMP	Clause 11.3.3

Table 11B.2 — Attributes of the basin boundary layer (layout)

Field	Type	Content
BASIN_ID	Text	Basin identifier
NAME_EN, NAME_HI	Text	Basin name in English and Hindi
TIER_A	Text	Tier A body or bodies in the basin
OUTFALL	Text	Outfall to the sea, river or major waterbody (Clause 11.2)
AREA_KM2	Real	Basin area, km²
LEAD_AUTH	Text	Lead Authority (Clause 11.4.1)
PARTNERS	Text	Partners, including I&WRD where it applies
LINKS	Text	Diversions to and from other basins (Clause 11.3.2)
BSMP_STAT	Text	None / in preparation / draft published / approved
BSMP_DATE	Date	Date of approval of the current BSMP
REVIEW_DUE	Date	Date of the next review (Clause 11.11.2)

Annex 11C — Depth–damage curves for Haryana 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 Haryana 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 July 2016 (Gurugram), August 2019 (the Yamuna at Hathnikund), August 2020 (Gurugram), July 2023 (the Ghaggar at Panchkula, Ambala and Kaithal, and the Yamuna), July 2024 (Gurugram) and September 2025 (Gurugram) floods (Revenue and Disaster Management Department and HSDMA damage assessments, insurers), and replacement costs (PWD (B&R) 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, river and drain levels and outfall structures, rainfall and levels, flood evidence, land use, soils and groundwater, sewer interaction)	GeoTIFF (terrain); GeoPackage (features); CSV (tables and time series)	Summary	Yes, except security-sensitive asset details
Model files: native, runnable, with all boundary-condition, rainfall and control files, the software name and version, and a run log	Native format, zipped	No	Yes
Calibration and validation report	Searchable PDF	Yes	Yes
Consultation log of comments and responses	PDF or CSV	—	Yes

11D.2 Formats and references

- (a) Raster data shall be GeoTIFF, preferably cloud-optimised, with the cell size stated. Vector data shall be GeoPackage. Tables and time series shall be CSV in UTF-8, with a header row and units in the column names.
- (b) Horizontal and vertical references shall be as in Annex 10B.1(b) and (c). The vertical datum and its relationship to the Chapter 5 river datums of the CWC and I&WRD gauges on the receiving rivers and of I&WRD's drain, regulator and embankment levels, and, for a drain that reaches the Najafgarh drain, the levels of Delhi's Irrigation and Flood Control Department 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 `badshahpur_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 — Haryana 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 June** (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 June) 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 johad 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	_____