PUNJAB

Stormwater Design Manual

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

Preserve | Retain | Detain | Convey | Maintain

Draft v1.0

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Prepared by

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About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Punjab, its Council of Ministers or the Punjab Vidhan Sabha, or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Department of Housing and Urban Development (HUD) or its Department of Town and Country Planning (DTCP), the Punjab Urban Planning and Development Authority (PUDA), the Greater Mohali Area Development Authority (GMADA), the Greater Ludhiana Area Development Authority (GLADA) or any other development authority, the Department of Local Government (DLG), any Municipal Corporation, Municipal Council or Nagar Panchayat, the Water Resources Department (WRD) or its Drainage-cum-Mining & Geology wing, the Punjab Water Regulation and Development Authority (PWRDA), the Punjab Water Supply and Sewerage Board (PWSSB), the Punjab Municipal Infrastructure Development Company (PMIDC), the Department of Soil and Water Conservation, the Department of Rural Development and Panchayats, or any other agency. Where it names a body, such as the Punjab Pollution Control Board (PPCB), the Punjab State Wetlands Authority, the Punjab State Disaster Management Authority (PSDMA), the Department of Revenue, Rehabilitation and Disaster Management, the State Flood Control Board, the Bhakra Beas Management Board (BBMB), Punjab Agricultural University (PAU), a Smart City company, a Deputy Commissioner or a district administration, the Punjab and Haryana High Court, the Supreme Court of India, the National Green Tribunal (NGT), or a body of the Union, such as the Central Pollution Control Board (CPCB), the Central Water Commission (CWC), the India Meteorological Department (IMD) or the Central Ground Water Board (CGWB), it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role. Nor has the Manual or its Supplement been adopted, notified or endorsed by the Administrator of the Union Territory of Chandigarh, the Chandigarh Administration or any of its bodies (see **Supplements** below).

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. A competent authority (for example DLG for municipal building approvals, HUD for the 2021 Building Rules, or WRD for drains and choes) could adopt it. Until then, the Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021, each as amended, the master plans and zoning regulations made under the Punjab Regional and Town Planning and Development Act, 1995, the limits notified under section 38 of the Punjab Canal and Drainage Act, 2023 (or under section 55 of the Northern India Canal and Drainage Act, 1873, before it), the Directions of PWRDA, drainage schemes, orders of courts and tribunals and approval conditions in force continue to apply.

Building rules. Punjab has two building instruments, each for its own territory, and this Manual cites both. The **Punjab Municipal Building Bye-Laws 2018 (PMBBL)**, notified by DLG (No. CTP(LG)/2018/3548 of 22 November 2018) under section 201(1) of the Punjab Municipal Act, 1911 and section 399(2) of the Punjab Municipal Corporation Act, 1976, apply in the municipal areas of every Municipal Corporation, Municipal Council and Nagar Panchayat. The **Punjab Urban Planning and Development Building Rules 2021**, notified by HUD (G.S.R. 144 of 31 August 2021) under sections 180 and 43(2) of the Punjab Regional and Town Planning and Development Act, 1995, apply to the rest of the State, outside municipal limits, the *lal lakir* of village *abadi*, Cantonment Boards and protected monuments, and they do apply in the urban estates and other schemes of the development authorities. **"PUDBR" is an abbreviation set by this Manual**; the State uses none, and the "PUDA Building Rules" are the 2018 rules that the 2021 Rules repealed. The shared chapters write "PMBBL/PUDBR" where both instruments are meant, and cite a clause with its instrument and edition, for example "PMBBL 2018 (as amended), cl. 10.1" or "PUDBR 2021 (as amended), r.40". The **Punjab Unified Building Rules 2025**, notified on 15 December 2025 and stayed in part by the High Court on 24 December 2025, were withdrawn on 27 April 2026, as reported, restoring the 2021 Rules and PMBBL 2018 "as if the 2025 Rules had never been notified". This Manual cites them as history only (Chapter 1).

Chandigarh and the capital. Chandigarh is the capital of Punjab, and also of Haryana, but it is a Union Territory and lies outside the State's jurisdiction. The chapters of this Manual do not apply there; Chandigarh is covered only by Supplement S01. Where a shared clause names the State's principal city or its municipal corporation, this Manual names **Ludhiana**, the State's largest city, and the **Municipal Corporation Ludhiana (MC Ludhiana)**, the State's largest municipal drainage system. Ludhiana is not the capital, and the choice says nothing about the status of Chandigarh; it only keeps the State's own rules on the State's own ground. Amritsar, Jalandhar, Patiala and SAS Nagar (Mohali) are named beside Ludhiana wherever a clause lists bodies. The IMD observatory at Chandigarh (42105) is used as the reference gauge for SAS Nagar, Zirakpur and Kharar, and the N-Choe, the Sukhna Choe and the Patiali-ki-Rao, which leave Chandigarh, are Punjab drainage once they cross the boundary.

Supplements. The Manual carries one supplement, for a place that adjoins Punjab but lies outside the State's jurisdiction. Supplement S01 covers the Union Territory of Chandigarh, the capital of Punjab and of Haryana, administered under Article 239 of the Constitution by an Administrator, an office held by the Governor of Punjab since 1 June 1984, as reported. Chandigarh lies at the foot of the Shivalik hills between SAS Nagar (Mohali) in Punjab and Panchkula in Haryana, and its storm water leaves the Union Territory through three choes, the N-Choe, the Sukhna Choe below Sukhna Lake and the Patiali-ki-Rao, into SAS Nagar district and on to the Ghaggar. The supplement has not been adopted, notified or endorsed by the Administrator, the Chandigarh Administration, the Municipal Corporation Chandigarh, the Chandigarh Housing Board, Chandigarh Smart City Ltd or any of the Administration's departments or agencies, nor by the Governments of Punjab, Haryana or Himachal Pradesh. What this notice says of the Manual applies to the supplement.

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

- older sources and IMD stations use **Jullundur** or Jullundar for **Jalandhar**, **Rupar** or **Ropar** for **Rupnagar**, **Ferozepore**, Ferozpur or Firozpur for **Ferozepur**, **Bhatinda** for **Bathinda** and **Ludiana** for **Ludhiana**. **SAS Nagar** (Sahibzada Ajit Singh Nagar) is the district and city also called **Mohali**, **SBS Nagar** (Shaheed Bhagat Singh Nagar) is **Nawanshahr**, and **Sri Muktsar Sahib** is also written **Muktsar**. The district map has changed: as generally recorded, and to be confirmed before a clause relies on it, Fatehgarh Sahib was formed from Patiala in 1992, Moga, Sri Muktsar Sahib and Nawanshahr in 1995, Tarn Taran from Amritsar, SAS Nagar from Rupnagar and Barnala from Sangrur in 2006, Pathankot from Gurdaspur and Fazilka from Ferozepur in 2011, and Malerkotla from Sangrur in 2021. The CWC flood reports and IMD's *Climate of Punjab* (1993) and *Extremes* tables use the districts of their time, and a clause that names a district must be checked against the current list;
- the **Sutlej** is also written **Satluj**. The **Patiala ki Rao** is also written **Patiali-ki-Rao** or Patiala Ki Rao, and is called a *nadi* or *choe* in its notification; the **Buddha Nallah** of Ludhiana is also written Budha Nallah or Buddha Nullah, and is called the Buddha Dariya. Of the *beins* of the Doaba, the **Kali Bein** is also called the Holy Bein, the **Chitti Bein** the East Bein, and the **Black Bein** is the **Kala Sanghian drain**. The place on the Sutlej where the dhussi bandh broke in August 2019 is **Janian**, also written Jania or Janian Chahal;
- river and reservoir levels in Punjab's sources are given in **feet** at WRD headworks and BBMB dams (Bhakra, Pong) and on district gauges, and in **metres** at Ranjit Sagar; river flows are given in **cusecs** (cubic feet a second; 1 cusec = 0.0283 m³/s) and **lakh cusecs** (100,000 cusecs). CWC has no flood-forecasting or level-monitoring site in Punjab, as reported, so no Punjab river has a CWC danger level. This Manual quotes levels as given, names the gauge and its datum with each one, and treats gauge zeros not found tied to mean sea level as [TBC];
- **Majha** (the land between the Ravi and the Beas, around Amritsar, Tarn Taran and Gurdaspur), **Doaba** (between the Beas and the Sutlej, around Jalandhar, Kapurthala and Hoshiarpur) and **Malwa** (south of the Sutlej, from Ludhiana and Patiala to Bathinda and Fazilka) are regions, not administrative units. The **Shivalik** hills, also written Siwalik, rise along the north-eastern edge of the State, from Pathankot and Dhar Kalan past Hoshiarpur, Garhshankar and Anandpur Sahib to the hills above Kharar and Mullanpur; and
- the **Kandi** is the belt of boulder-and-gravel fans, 10 to 15 km wide, at the foot of the Shivaliks, crossed by choes, and the **Sirowal** is the belt of finer soils with a shallow water table and springs below it, as CGWB uses the names. Both are administrative and hydrogeological terms, not dictionary words.

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 Punjab Municipal Corporation Act, 1976, and **Municipal Councils** and **Nagar Panchayats** under the Punjab Municipal Act, 1911. The CAG counted 13 Municipal Corporations, 101 Municipal Councils and 52 town councils, the Nagar Panchayats, in March 2023, and Barnala was reported to have become the fourteenth Corporation in October 2025; the current list is [TBC]. All are urban local bodies (ULBs), overseen by **DLG**, which issues PMBBL through its Town Planning Wing (CTP(LG)). The sections of the two Acts that vest drains in a local body and govern connections to them were not read [TBC];
- **HUD** is the Department of Housing and Urban Development, which issues PUDBR; its **Department of Town and Country Planning (DTCP)**, under the Chief Town Planner, issues the Uniform Zoning Plan (Drawing No. 01/2020 CTP(Pb)). In this Manual DTCP always means the Punjab department and is named with HUD. **PUDA** is the Punjab Urban Planning and Development Authority, and **GMADA** (SAS Nagar and New Chandigarh) and **GLADA** (Ludhiana) are the development authorities under it; the development authorities of Amritsar, Jalandhar, Patiala and Bathinda are [TBC], and the sections of the PRTPD Act that constitute them were not read. A shared clause that says "a development authority" means any of them;
- **WRD** is the Water Resources Department. Its canal wing runs the canals, distributaries and watercourses, and its **Drainage-cum-Mining & Geology** wing, called the Drainage Wing in this Manual, runs the rivers, choes, notified drains and dhussi bandhs and notifies limits under section 38 of the **Punjab Canal and Drainage Act, 2023** (Punjab Act 11 of 2023). That Act repeals the **Northern India Canal and Drainage Act, 1873** in its application to Punjab (s.61) and carries over its section 55 as section 38, under which a notified reach "shall be held to be a drainage-work". Its "drainage work" excludes the removal of sewage from towns, villages or any other habitat (s.2(7)). The date on which it came into force was not found [TBC], and notifications made under the 1873 Act before then are cited under section 55. The State's observation wells are WRD's, with CGWB's; **PWRDA**, the Punjab Water Regulation and Development Authority, constituted under the Punjab Water Resources (Management and Regulation) Act, 2020, regulates groundwater extraction and charges for it under its Directions of 2023;
- **PWSSB** (the Punjab Water Supply and Sewerage Board) and **PMIDC** (the Punjab Municipal Infrastructure Development Company, the State's nodal agency for AMRUT) build water, sewerage and drainage works for the local bodies, and **BBMB**, the Bhakra Beas Management Board, operates the Bhakra and Pong dams, whose releases set the stage of the Sutlej and the Beas;
- village ponds are commons (*shamlat*) of the Gram Panchayat under the Punjab Village Common Lands (Regulation) Act, 1961, in the charge of the Department of Rural Development and Panchayats. No pond statute and no pond authority was found; and
- a **tehsil** is the revenue subdivision of a district, under a Tehsildar.

Some abbreviations have more than one meaning:

- **MC** in this Manual means a **Municipal Corporation** only, as in MC Ludhiana. A Municipal Council is always written in full, although Punjab's sources, the CAG among them, also abbreviate councils as MC;
- **AMC** is the antecedent moisture condition in Chapters 2 and 3; this Manual does not use it for Amritsar or for any municipal body;
- **ADA, BDA, JDA and PDA** are used in Punjab's sources for the development authorities of Amritsar, Bathinda, Jalandhar and Patiala, whose names are [TBC]; the same letters name other bodies in other States, and this Manual writes the names out;
- **PUDBR** is set by this Manual for the Punjab Urban Planning and Development Building Rules 2021, and **PMBBL** is the Punjab Municipal Building Bye-Laws 2018; neither abbreviation is the State's own;
- **HFL** is the highest flood level recorded at a gauge. It is not a design level, and sources sometimes give different values for the same gauge. In Punjab most river levels are headworks, dam or district gauge readings in feet, and 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, in metres or, in older WRD records, in feet; and

- **SWD** is a storm water drain.

The sense is clear from the context. Punjabi terms used in the text are explained where they first appear and in Annex 7E, with their Gurmukhi spelling and the dictionary that gives it (Bhai Maya Singh, *The Panjabi Dictionary*, 1895, and Platts, 1884; the *Mahan Kosh* and the Punjabi University dictionary were not consulted):

- a **chhappar** (ਛੱਪੜ; toba ਟੋਭਾ; pond) is the village pond of Punjab, natural or dug, which stores rainwater runoff and often the village's sullage ("A pond; a puddle", Maya Singh). It is the word the State's own pond programme uses. Written ਛੱਪਰ, *chhappar* means a thatched roof, and Platts gives only the thatch sense, so the Gurmukhi is always printed at first use. **Toba** (ਟੋਭਾ, "An unwalled tank, a pond, a pool") is the same thing, common in Malwa, and is not *tobá* (ਤੋਬਾ), repentance. **Dhab** (ਢਾਬ, "a natural pool, a lake, a deep depression in the earth") is kept for larger natural depressions and seasonal lakes;
- a **choe** or cho (ਚੋ, "the bed of a torrent") is a seasonal torrent from the Shivalik hills, dry for most of the year, with a wide bed of sand, gravel and boulders; it rises and falls within hours and carries sand and debris as well as water. A **rao** or rau (ਰੌ, "A small stream from the mountains, the dry bed of such a stream") is the same kind of stream, as in the Patiala ki Rao;
- a **bein** (ਬੇਈਂ, "An irregular stream with a clay bottom, having the appearance of a canal") is a sluggish plains stream of the Doaba, such as the Kali Bein and the Chitti Bein; a **nala** or **nallah** (ਨਾਲਾ, "A brook, a rivulet") is a natural channel or a large open drain, such as the Buddha Nallah;
- a **khal** (ਖਾਲ) is a field channel or watercourse, and a **kassi** (ਕੱਸੀ, "A small distributary channel from a canal") is a canal distributary. Neither is a storm drain;
- **bet** (ਬੇਟ, "Low, alluvial lands, or islands in the bed of rivers") is the riverine floodplain land of the Sutlej, Beas, Ravi and Ghaggar; and
- a **dhussi bandh**, also written dhussi bundh, is an earthen flood embankment along a river, as WRD uses the term. No dictionary gives this sense, and this Manual does not print a Gurmukhi spelling for it, nor for *kandi* or *Sirowal*.

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

Punjab's towns flood for three reasons. The storm of 4–5 October 1955 showed the first, when a single day of rain exceeded the 100-year depth of the CWC design map at ten or more stations at once, across Majha, Doaba and central Malwa, after the monsoon's normal withdrawal; the Sutlej, the Beas, the Ravi and the Ghaggar showed the second in 2023 and again in 2025, when they rose against their dhussi bandhs and headworks; and the State shows the third every year, with its groundwater drawn down across the centre while the south-west is waterlogged.

1. **Storms that outrun the design maps, on towns drained for a 2-year storm or for none.** IMD's records show Ludhiana with 354.3 mm on 4 October 1955 and Patiala with 356.5 mm on 11 July 1993, against a 100-year day of about 240–280 mm and 260 mm on the CWC map; the CWC zone-7 report lists 475 mm at Batala on 5 October 1955; Ludhiana's PAU observatory recorded 338.0 mm and Kapurthala 284.2 mm on 24 September 1988; and in July 2023 Chandigarh, beside Mohali, recorded 302.2 mm on the 9th, a July record, and Ropar 35 cm (350 mm) in the 24 hours to 08:30 on the 10th, above the 310.4 mm of the district's earlier record. The only design storms found for Punjab's town drains are project choices: the trunk storm sewers of Amritsar's walled city were specified for "a return period of once in two years" in the Smart City tender of 2018, and the Buddha Nallah, Ludhiana's main drain, was designed for a 2-year storm "with reduced run-off within the city reach due to active storm water detention" (PMIDC, 2020). Under AMRUT, "No work was done" on storm water drainage in Punjab by September 2020, the CAG found. In Jalandhar the storm water network covers about 5% of the city, and rain is "largely discharged in to the sewer network".
2. **Rivers held behind embankments and headworks whose stage dams and the border set, and canals across the line of drainage.** WRD's own pages give about 1,800 km of flood embankments, along rivers that dams upstream and headworks downstream control. On 3 September 2025 Harike headworks passed 3,35,030 cusecs, as reported, above the 3 lakh cusecs beyond which a discharge "falls under the High Flood category", and in late August a gate of Madhopur headworks on the Ravi was washed away under less than 2 lakh cusecs, as reported. In July 2023 the Ghaggar reached 754.2 ft at Khanauri against a danger mark reported as 748 ft (752 and 753 ft are also reported), and broke its banks in Sangrur and Mansa districts, as reported. Pong received a record inflow of 7.3 lakh cusecs on 14 August 2023, as reported. Amritsar drains through the Tung Dhab and the City Outfall drains to the Hudiara drain, which flows into Pakistan, where Punjab cannot set the level. Across the plains, canals, distributaries and their feeders block the natural drainage, and in 2023 breaches in the SYL canal and the Narwana branch were reported to have flooded Rajpura.
3. **Ground that is over-drawn in the centre and waterlogged in the south-west.** In 2024 Punjab drew 156.87% of its extractable groundwater, and 115 of its 153 assessment units were over-exploited; the area where the water lay deeper than 10 m in June grew from 14.9% of the State in 1989 to 68% in 2019. Yet "Water logging conditions exist in some parts of south-western districts", where the water table stood 0.79 m below ground at Abohar in June 2019, and the groundwater is saline, with an electrical conductivity of up to 8,320 µS/cm at Abohar. In the Kandi the water lies deep, below a belt of sand and gravel fans crossed by more than 100 choes in Hoshiarpur district alone. Recharge that is right for Sangrur or Jalandhar is wrong for Sri Muktsar Sahib or Fazilka, and no single rule serves the State.

Behind all three lie the drains and ponds that carry sewage and the land beside them that no rule protects. About 700 MLD of wastewater passes down the Buddha Nallah to the Sutlej, which below it turns from Class B to Class E; in April 2024, before its confluence with the river, the drain carried a BOD of 161 mg/l, against a limit of 30. In September 2023 the State reported a treatment gap of 326.58 MLD in its 166 towns, and in Amritsar the road-side drains are "connected to the sewerage system typically at the road junctions, thus making the sewerage system as combined system". Neither building instrument sets any distance from a river, nallah, choe, pond or canal. The village chhappars are Panchayat commons, protected by the Supreme Court's judgment in *Jagpal Singh v. State of Punjab* (2011) and a High Court order of 2020 to remove encroachments, as reported, but by no pond law. The first census of water bodies counted 16,012 in

the State, 1,578 of them encroached, as reported, and in April 2025 the State announced ₹4,573 crore for about 15,000 ponds in about 13,500 villages, as reported. Six Ramsar sites lie in the State, from Harike (1990) to Keshopur-Miani, the Beas Conservation Reserve and Nangal (2019), but no wetland notified under the Wetlands Rules, 2017 was found.

Design for Punjab therefore has to cover a monsoon that arrives late in June and can bring its largest storms in September and October, on Kandi gravels, alluvial plains, bet land and the dune sands of the south-west, in towns that drain to rivers raised by dam releases, to drains that carry sewage and across canals that block their way. The monsoon normally reaches Jalandhar by 26 June, Patti by 28 June and Ludhiana by 1 July, withdraws from all three by 21 September, and by 1 October has left most of the State; paddy is transplanted from 1 to 9 June, and much of the plains is under ponded paddy before the rains begin. Annual normals run from 388.6 mm in Ferozepur district and 429.8 mm in Bathinda to 660.3 mm in Ludhiana and 1,106.1 mm in Gurdaspur. Large days fall outside the season too: 160.6 mm at Patiala on 8 June 2000, 144.2 mm at Patiala on 16 April 1983, and 119.6 mm at Ludhiana on 4 January 1911.

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, choe or river is high, when a headworks or regulator is being operated, or when the flap gate in a dhussi bandh is shut.

The Manual also sets how public drains, roads, nallahs, choes, chhappars 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 Punjab's south-west monsoon from late June to September, with its late-season storms and its winter rains; the Sutlej, the Beas, the Ravi and the Ghaggar, the dams and headworks that control them and the dhussi bandhs that hold them; the choes and raos of the Shivalik foothills, the beins and nallahs of the plains and the drains of WRD; the canals and kassis that cross the land; the gravels of the Kandi, the alluvium and bet land of the plains and the sands and saline ground of the south-west, over aquifers drawn down across most of the State and brimming in a few places; the village chhappars; and towns whose new sectors and colonies 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.** Two CWC *Flood Estimation Reports* as the interim source: the report for subzone 1(e) (Upper Indo-Ganga Plains, 1984), which covers the plains and the Kandi piedmont up to the Shivalik front, and the report for zone 7 (Western Himalayas, 1994), which covers Pathankot and the Shivalik fringe. Their maps are checked against IMD's 24-hour records, which exceed them at most long-record stations, and their short-storm ratios are given floors where Punjab's recording gauges show them to be low. IMD's rainfall intensity curve for Amritsar (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 Punjab station; and frequency analysis of gridded rainfall by the National Institute of Hydrology (NIH), Roorkee, is used only to compare climate ratios.
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.** PMBBL 2018 and PUDBR 2021; the Punjab Regional and Town Planning and Development Act, 1995 and the master plans made under it; the Punjab Municipal Corporation Act, 1976 and the Punjab Municipal Act, 1911; the Punjab Canal and Drainage Act, 2023; the Punjab Water Resources (Management and Regulation) Act, 2020 and the Directions of PWRDA; the Punjab Preservation of Subsoil Water Act, 2009; the Punjab Land Preservation (Chos) Act, 1900 in the Kandi; the Punjab Village Common Lands (Regulation) Act, 1961; the Wetlands (Conservation and Management) Rules, 2017; and the orders of the Supreme Court, the Punjab and Haryana High Court and the NGT on ponds, choes, floodplains, drains and sewage. This Manual follows them or, where disclosed, makes them stricter. PUDBR is cited from its Gazette text with its corrigendum of 16 March 2022 and the Amendment Rules of 29 March 2022; its amendments of 14 July and 7 September 2026 have been reported but were not read. PMBBL is cited from DLG's text and its amendment of 31 December 2019; an amendment of 9 August 2023 was seen only in DLG's list. None of those read concerns detention or a setback from water. The Canal and Drainage Act is cited from its Bill and its enacted particulars, and the Municipal Acts, the PRTPD Act, the Subsoil Water Act, the Land Preservation Act and the Village Common Lands Act were not read in full. 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 Punjab 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, Amritsar, and it repeats the curve printed for many other cities: it implies a 2-year day of about 170 mm, 28% of Amritsar's normal of 598.7 mm a year. The CWC report for subzone 1(e), which covers almost the whole 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: Patiala recorded 356.5 mm in a day against a 100-year depth of about 260 mm on the map, Ludhiana 354.3 mm against about 240–280 mm, and a raingauge at Bhatinda 256.1 mm on 18 August 1964 against about 180 mm. The reanalysis grids of NIH-DHAARA spread the State wider still: they read 443 mm for a 50-year day at Pathankot, against about 320 mm on the map, but 126 mm at Bathinda, half that gauge's record.

Punjab has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of PWSSB, PUDA, GMADA, GLADA or the Drainage Wing of WRD, or in any Smart City or AMRUT project, that fixes a return period or a design rainfall for town storm drains. What exists is project practice and WRD's own numbers: the Amritsar walled-city storm sewers on a 2-year return period with a minimum time of concentration of 15 minutes and surcharge allowed inside the manholes (Smart City tender, 2018); the Buddha Nallah on a 2-year return period with detention (PMIDC, 2020); WRD's floodplain method, a 100-year flood by Gumbel's method and a waterway by Lacey's

formula, within which "no construction is to be allowed"; and WRD's rooftop rainwater harvesting for government buildings, sized for 40 mm/h, which is a recharge figure and not a drain design storm. This Manual is offered as a technical companion to PMBBL, PUDBR, the Municipal Acts, the Canal and Drainage Act and the master plans: it supplies the design storm, detention, water-level and buffer values that they leave open. It has not been adopted by DLG, HUD, WRD or any other body. In particular:

- **The building rules require rainwater harvesting, but not detention.** PMBBL requires "the complete proposal of rainwater harvesting" for every building on a plot of 100 m² or more in a municipal area, recharge on plots of more than 500 m², and, in public open spaces of more than 500 m², the "complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites"; it sets up a rainwater harvesting cell in each local body to inspect systems before a completion certificate or a service connection is given (PMBBL 10.1–10.6). PUDBR requires rainwater harvesting above 250 m² for residential plots and public buildings, above 100 m² for commercial and industrial buildings and on all group housing, designed and certified by an engineer, with industry "not to inject contaminated water into recharge structures" (r.40). Neither sets a volume, and the thresholds differ by instrument. Both require that "Concrete paving to be avoided and permeable materials are to be used" for the open parking of group housing, the State's only permeable-paving rule. No rule requires on-site detention, limits peak runoff or sets "zero runoff";
- **There is no setback from water.** Neither instrument sets a distance from any river, nallah, choe, pond or canal; PUDBR's setbacks depend on building height (r.26). PMBBL requires a plinth of at least 450 mm, sited so "that adequate drainage of the site is assured" (5.2.1.1), and PUDBR one of 900 mm above the crown of the road in front for residential plots (r.3(A)(1)); both require that surface drainage does not enter a basement (PUDBR r.30(5)(iv)(e); PMBBL 4.23(vii)). PUDBR keeps septic tanks and absorption pits 30 m from a source or stream used for drinking (r.45(7)), which is a health rule, not a waterbody setback. A drainage-wing approval for projects within 150 m of a water body was announced by the Water Resources Minister on 20 September 2023, as reported, but no notification or order was found, and this Manual does not apply it;
- **No pond law gives a method.** Ponds are protected as village commons and by the courts, and are being cleaned under the State's programme on the Seechewal and Thapar models, as reported. No law sets a distance, a design flood or a storage to be kept, and a buffer around a chhappar is this Manual's proposal;
- **A floodplain is notified on one reach only, and not on the line its method gives.** WRD's Chief Engineer (Drainage) told CWC in May 2024 that the State notifies the area of waterway for the 100-year flood under section 55 and that no construction is to be allowed in it. The first such zone, on the Sutlej in Ferozepur and Tarn Taran districts (March 2024), was computed for a 100-year flood of 5,34,441 cusecs and a Lacey width of 0.58 km, but was declared as the land between the existing embankments, about 4.5 km apart; the NGT found "no material … indicating the exercise for demarcating the flood plain zone as per the applicable zone". No zone was found for the Ghaggar, the Beas, the Ravi or any choe. The pillars marking the Patiala ki Rao at a width of 200 ft were placed under a High Court case (CWP 5901 of 2017), on the Chandigarh side but not yet in Punjab in January 2024; that width is case-specific, not a WRD norm. The report of Master Plan Jalandhar proposes, along the Chitti Bein, a 30 m buffer from the bank and no construction within at least 200 m "untill concrete bandh is constructed", and a 30 m plantation buffer along the Black Bein: the only numeric river setbacks found in a Punjab plan text, and plan proposals, not statutory buffers. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7); it does not replace any line that the State notifies or a court draws, and where such a line binds and is wider, it governs; and
- **No document sets the river or drain level for which an outfall is designed.** CWC has no flood site in Punjab; the levels that exist are WRD headworks, BBMB dam and district gauge readings, mostly in feet, with gauge zeros not found; the drains of WRD carry no published design levels; and the Hudiara drain's level is set in another country.

So each agency and each local body interprets the central manual its own way. The Municipal Corporations, the Municipal Councils and Nagar Panchayats, PUDA and the development authorities, colonisers, WRD, PWSSB, PMIDC, the Smart City companies, 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. No rule divides the drains between the bodies that build and run them: a sector drain in SAS Nagar may be built by GMADA, run by the Municipal Corporation, and end in a choe that WRD has notified, which flows on into the Ghaggar and Haryana.

The drains also carry sewage: the Buddha Nallah's water is non-compliant with the limits for BOD, COD and suspended solids before it reaches the Sutlej, and storm pumping stations in Bathinda are reported to be connected to the sewers. 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 four rainfall zones and six sub-areas, with the two CWC reports, a 24-hour record check against IMD's long-record stations, a checked station analysis to govern where one exists, and floors where the CWC ratios understate short storms (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, choes, headworks reaches and rivers, gated, flap-gated or pumped, against a design river or drain level, with no discharge to a canal or kassi without WRD's consent (Chapter 5);
- a design flood line, and corridors and setbacks along rivers, choes, beins and nallahs and around chhappars, which no rule now sizes, proposed by this Manual for use with the limits notified under section 38 and the lines the courts have drawn (Chapter 7);
- recharge first in the Kandi fans and where the water table is deep, no recharge credit where it lies within 3 m of the ground, as across much of the south-west, the Sirowal and the bet lands, and treatment where drains carry sewage (Chapter 8); and
- basin-wide master plans, so that the agencies that share a basin plan together, across the boundaries with Chandigarh, Haryana and Himachal Pradesh where a basin crosses them (Chapter 11).

It uses the route the CPHEEO manual itself provides: a State may adopt standards higher than the national values (CPHEEO 2019, Table 4.1, Note 2). A Municipal Corporation, a development authority or DLG 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 Punjab, Department of Local Government, Punjab Municipal Building Bye-Laws, 2018, Notification No. CTP(LG)/2018/3548 dated 22 November 2018, cl. 1.3, 2.44, 3.10.7, 4.23, 5.2.1, 5.16, 10.1–10.6, 11.2.1 and Table 15.1, and amendment No. LG/CTP(LG)/2019/3977 of 31 December 2019; Government of Punjab, Department of Housing and Urban Development, Punjab Urban Planning and Development Building Rules, 2021, Notification No. G.S.R. 144/P.A.11/1995/Ss.180 and 43/2021 dated 31 August 2021 (Punjab Government Gazette, 10 September 2021), r.1(3), 3(A)(1), 11, 26, 30, 40, 43, 45, 52 and 53, corrigendum of 16 March 2022 and Amendment Rules, G.S.R. 23 of 29 March 2022 (as circulated by PPCB); HUD notification withdrawing the Punjab Unified Building Rules, 2025 (27 April 2026; as reported); Punjab Canal and Drainage Act, 2023 (Punjab Act 11 of 2023), ss.2, 5, 38, 39, 52 and 61 (Bill No. 20 of 2023 as read; enacted particulars from the Gazette); Northern India Canal and Drainage Act, 1873, s.55; Punjab Water Resources (Management and Regulation) Act, 2020 (Act 2 of 2020); PWRDA, Punjab Ground Water Extraction and Conservation Directions, 2023 (27 January 2023); WRD, notification under s.55 for the Patiala ki Rao (4 March 2013), and the Local Commissioner's report of 8 January 2024 in CWP 5901 of 2017, as filed in NGT O.A. 180/2026; WRD affidavit in NGT O.A. 303/2023, with the Chief Engineer (Drainage)'s email to CWC of 2 May 2024 and the Tribunal's order of 14 March 2024 (as quoted); WRD project report on rooftop rainwater harvesting for government buildings (undated); State of Punjab status report in E.A. 35/2023 in NGT O.A. 673/2018; CPCB reply of 13 October 2025 in NGT O.A. 327/2025; PPCB reply in NGT O.A. 413/2025 with the River Rejuvenation Committee proceedings of 28 October 2025; Amritsar Smart City Ltd, tender 07/ASCL/2018-19 (November 2018); PMIDC, feasibility report on the Buddha Nallah (January 2020); Master Plan Jalandhar 2031, report, §9.3 and §13.8; CAG, Report No. 7 of 2021 (AMRUT and Smart Cities) and Report No. 1 of 2026 (Local Bodies); Supreme Court of India, Jagpal Singh v. State of Punjab (28 January 2011; as reported); Punjab and Haryana High Court, suo motu order on village ponds (2020; as reported); Rajya Sabha reply on the Ramsar sites (as quoted); CWC, Flood Estimation Report for Upper Indo-Ganga Plains Subzone 1(e) (1984), Plates 9 and 10 (read by eye) and Table 1, and Flood Estimation Report for Western Himalayas Zone 7 (WH/22/1994), Annexes 4.3 and 4.4; IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); IMD, Climate of Punjab (1993); IMD, Monthly Climate Summary, July 2023, and press releases of 9 and 10 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(ii); NIH-DHAARA (accessed 13 November 2026); CGWB and the State, Dynamic Ground Water Resources of Punjab, 2020 and 2024; Punjab Preservation of Subsoil Water Act, 2009 schedule of transplanting dates for 2025 (as reported); WRD, Kandi Area Development and drainage pages; CWC list of flood forecasting sites (as copied by SANDRP); reports of the floods of 2023 and 2025, of the Harike, Madhopur, Pong and Khanauri levels and flows, of the 2023 canal breaches near Rajpura, of the Bathinda storm pumping stations, of the pond programme and of the 150 m approval (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.

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

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

Where to start.

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

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10	Submittals, Review, Operation & Maintenance and Enforcement	Annexes 10
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Abbreviations

Abbreviation	Meaning
AEP	Annual exceedance probability
AMC	Antecedent moisture condition (not Amritsar)
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
ARF	Areal reduction factor
AWS	Automatic weather station
BBMB	Bhakra Beas Management Board
BOD	Biochemical oxygen demand
BSMP	Basin Stormwater Master Plan
CAG	Comptroller and Auditor General of India
CBR	Chandigarh Building Rules (Urban) 2017 (Supplement S01)
CDMA	Chandigarh Disaster Management Authority (Supplement S01)
CDP	City Development Plan, Chandigarh (Supplement S01)
CETP	Common effluent treatment plant
CGWB	Central Ground Water Board

Abbreviation	Meaning
CHB	Chandigarh Housing Board (Supplement S01)
CN	Curve number (SCS/NRCS method)
COD	Chemical oxygen demand
CPCB	Central Pollution Control Board
CPCC	Chandigarh Pollution Control Committee (Supplement S01)
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CTP(LG)	Chief Town Planner (Local Government), the Town Planning Wing of DLG
CWC	Central Water Commission
DLG	Department of Local Government, Punjab
DPR	Detailed project report
DTCP	Department of Town and Country Planning, Punjab (under HUD)
DWF	Dry-weather flow
EIA	Environmental impact assessment
ESC	Erosion and sediment control
ESZ	Eco-sensitive zone (Supplement S01)
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FTL / MWL	Full tank level / maximum water level
GLADA	Greater Ludhiana Area Development Authority
GMADA	Greater Mohali Area Development Authority
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Punjab)
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HSG	Hydrologic soil group
HUD	Department of Housing and Urban Development, Punjab
IDF	Intensity–duration–frequency
IMD	India Meteorological Department
IRC	Indian Roads Congress
MC	Municipal Corporation (only; Municipal Councils are written in full)
MCC	Municipal Corporation Chandigarh (Supplement S01)
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs

Abbreviation	Meaning
NDMA	National Disaster Management Authority
NGT	National Green Tribunal
NICDA	Northern India Canal and Drainage Act, 1873 (repealed in Punjab by the PCDA)
NIH	National Institute of Hydrology, Roorkee
NOC	No-objection certificate
PAU	Punjab Agricultural University, Ludhiana
PCDA	Punjab Canal and Drainage Act, 2023 (Punjab Act 11 of 2023)
PLPA	Punjab Land Preservation (Chos) Act, 1900
PMBBL	Punjab Municipal Building Bye-Laws 2018, as amended (municipal areas)
PMIDC	Punjab Municipal Infrastructure Development Company
PPCB	Punjab Pollution Control Board
PRTPD Act	Punjab Regional and Town Planning and Development Act, 1995
PSD	Permissible site discharge
PSDMA	Punjab State Disaster Management Authority
PUDA	Punjab Urban Planning and Development Authority
PUDBR	Punjab Urban Planning and Development Building Rules 2021, as amended (outside municipal areas and in authority schemes; abbreviation set by this Manual)
PWRDA	Punjab Water Regulation and Development Authority
PWRM Act	Punjab Water Resources (Management and Regulation) Act, 2020
PWSSB	Punjab Water Supply and Sewerage Board
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
SDMP	State Disaster Management Plan
SLA	Sea-level allowance (coastal term; not applicable in Punjab)
SoI	Survey of India
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
SW monsoon / JJAS	South-west monsoon, June–September
SWD	Storm water drain
TSS	Total suspended solids
ULB	Urban local body (a Municipal Corporation, Municipal Council or Nagar Panchayat)

Abbreviation	Meaning
UTM	Universal Transverse Mercator
WLS	Wildlife sanctuary (Supplement S01)
WQv	Water quality volume
WRD	Water Resources Department, Punjab
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 Punjab. 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 and the late storms of early October, which fall on paddy fields ponded since June and on rivers already raised by the releases of Bhakra, Pong and Ranjit Sagar, and have put more than 350 mm in a day on Ludhiana (4 October 1955) and Patiala (11 July 1993) and more than 450 mm on Aliwal, Batala and Khara in Majha (5 October 1955), as well as for short-duration intensities;
- (d) to design outfalls for the stage of the Sutlej, the Beas, the Ravi and the Ghaggar, held behind dhussi bandhs and set by the releases of Bhakra, Pong and Ranjit Sagar and by the headworks at Ropar, Harike, Hussainiwala and Madhopur; the levels of the WRD drains that receive the town drains, such as the Buddha Nallah, which joins the Sutlej at Walipur Kalan, and the Tung Dhab and Hudiara drains, which carry Amritsar's storm water into Pakistan; and the sand-laden beds of the Kandi choes, which rise and shift with every flood, including the case where the outfall is closed;
- (e) to protect tanks (chhappars), marshes, rivers, supply channels and surplus courses as part of the drainage system;
- (f) to give every element of the drainage network a safe overland path for the 1% AEP (100-yr) storm;
- (g) to make design inputs, approvals and facility records public, so that designs can be checked and repeated; and
- (h) to make sure that facilities, once built, are maintained and remain effective.

1.1.3 This Manual does not replace the rainwater harvesting (RWH) mandate, the building bye-laws made by the Department of Local Government on 22 November 2018 for the municipal areas of the State, and the building rules made by the Department of Housing and Urban Development on 31 August 2021 for the rest of the State and for the schemes of the development authorities (the Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> **Commentary.** Punjab's floods come from three sources, often together. The first is the long, heavy storm on the plains. On 4–5 October 1955, after the monsoon had withdrawn, a single day put more than 330 mm on ten or more gauges at once across Majha, Doaba and central Malwa, among them Aliwal 495.3 mm, Batala 474.5 mm and Khara 457.2 mm, with 354.3 mm at the Ludhiana observatory (IMD, *Climate of Punjab* and *Extremes*); the draft State plan records the largest flood damage to houses of any year, "627000 houses", in 1955, but no figure for deaths or area was found (draft SDMP). Patiala recorded 356.5 mm on 11 July 1993 and Ludhiana PAU 338.0 mm on 24 September 1988 (IMD), both above the 100-year value of the CWC plates drawn in 1984. The second

source is the rivers, fed from the Himalayan and Shivalik hills, held behind dhussi bandhs and set by the releases of Bhakra, Pong and Ranjit Sagar. The figures for the great floods conflict, and are given here with their sources. The draft State plan's table records 7,203 villages, 15,057 km² and 95 lives lost in 1962; 341 villages, 741 km² and 10 lives in 1988; 5,017 villages, 7,977 km² and 359 lives in 1993; and 6,585 villages and 157 lives in 1995 (draft SDMP, from the Economic Adviser of Punjab); its quality is poor, with identical rows for 2004 and 2005 and a sentence on floods coinciding with "high tide" copied from a coastal template. For 1988 the State's climate plan gives 1,483 villages and 607 deaths (Punjab SAPCC 2.0), the press quotes official data of "9,221.2 sq km (18.3% area)" inundated, worst in Ferozepur, and other accounts give 9,000 villages and 600–1,500 deaths, with Bhakra at 1,685 ft and 2.4 lakh cusecs at the Ropar headworks (as reported); for 1993 the press quotes "9,757.4 sq km (19.4%)", worst in Fatehgarh Sahib, with Mansa and Sangrur flooded by "congested" drainage (as reported). On 19–20 August 2019 the Sutlej breached the dhussi bandh near Shahkot, flooding Janian and Janian Chahal, and at Gidderpindi and Mandala, with 2.35 lakh cusecs at Harike and eight lives lost (as reported); the official record of that flood was not read [TBC]. In July 2023 Ropar recorded 27 cm and then 35 cm in successive 24-hour readings (IMD), the Ghaggar breached in Sangrur and Mansa districts, and Pong received a record inflow of 7.3 lakh cusecs in August (as reported); the State reported 41 deaths by 25 July (as reported), and the Union's provisional table gives 77 lives lost to all the hydro-meteorological events of 2023-24 (MHA). In August–September 2025 the Ravi, the Beas, the Sutlej and the Ghaggar flooded together, the gates of the Madhopur headworks failed and Harike passed 3,35,030 cusecs; the State's bulletin of 16 September reported 56 dead, 2,483 villages in 23 districts and more than 1.98 lakh ha of crops damaged (as reported), a reply in the Rajya Sabha gave 40 deaths, 14,065 houses and about 1.93 lakh ha (as reported), and the Union's provisional table gives 28 lives, 14,062 houses and 1.93 lakh ha (MHA); no post-disaster needs assessment was found. The third source is the town whose drains fail in a fall that is not extreme: the Lakhnaur choe floods Phase 11 of Mohali when it is not cleared, Bathinda waterlogs every monsoon, and Mohali, Ludhiana, Jalandhar and Amritsar flooded on 1–3 September 2025 (as reported).

Missing design makes all three worse. No State or urban local body storm-drain standard was found. The only design return periods found in Punjab urban drainage documents are 2 years, for the trunk storm sewers of Amritsar's walled city (Amritsar Smart City bid, 2018) and for the Buddha Nallah through Ludhiana (PMIDC, 2020), a channel that carries about 700 MLD of treated and untreated effluent to the Sutlej (PPCB, reply to the NGT, 2025); and under AMRUT "No work was done" on storm-water drainage in the State to September 2020 (CAG, Report No. 7 of 2021). 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 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.

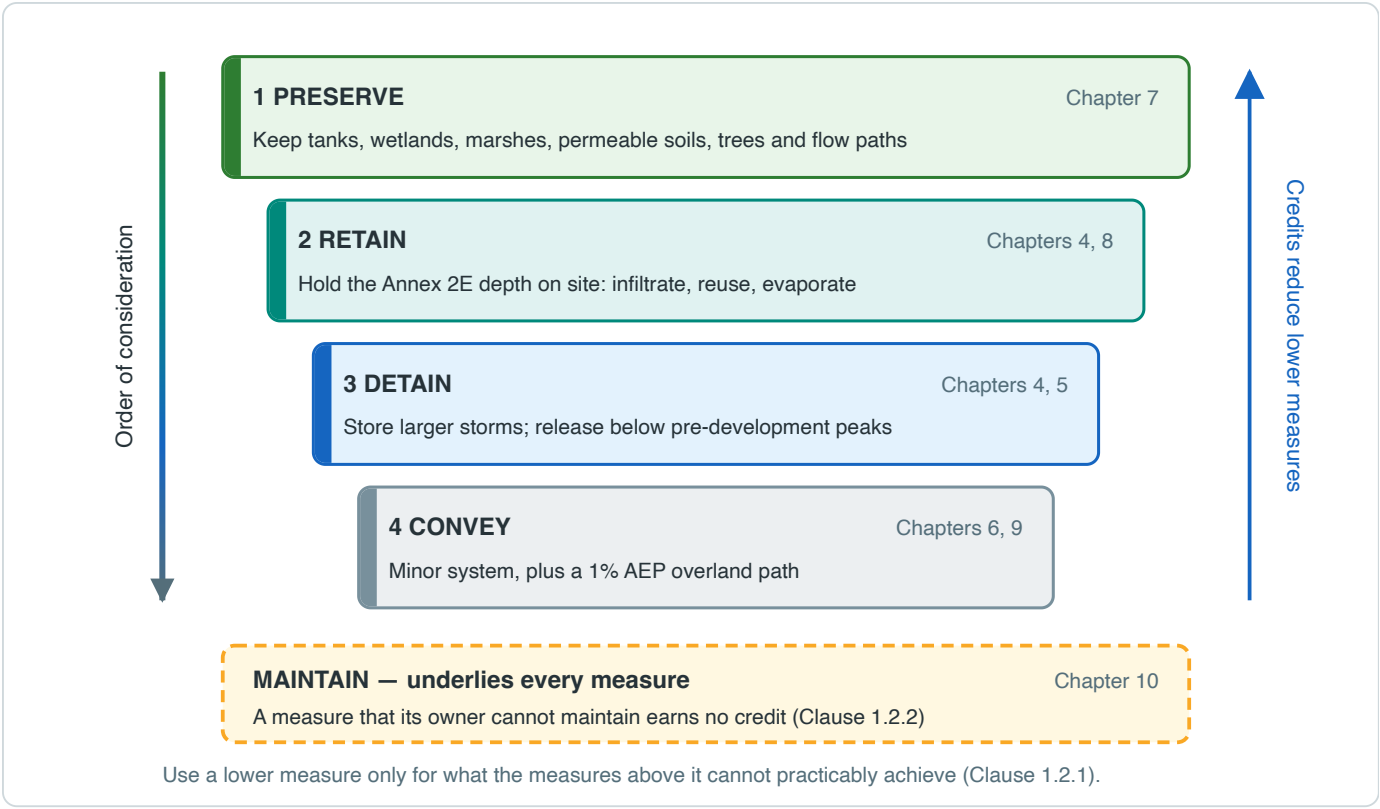

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

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 Punjab, the top layer has a particular meaning. The storage that matters is in the village ponds, the chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond) of almost every village, about 15,000 of which the State has taken up for cleaning in some 13,500 villages, with ₹4,573 crore earmarked in April 2025 (as reported), and of which the first census of water bodies counted 16,012 in the State, 1,578 of them encroached (as reported); in the larger natural depressions, the dhabs; in the bet lands of the Sutlej, the Beas, the Ravi and the Ghaggar between the dhussi bandhs; in the beds of the Kandi choes, where the boulder and gravel fans take water into the ground; and in the six Ramsar sites, Harike, at the confluence of the Sutlej and the Beas (1990), Kanjli on the Kali Bein and Ropar (2002), and Keshopur-Miani (344 ha), the Beas Conservation Reserve (6,429 ha) and the Nangal Wildlife Sanctuary (116 ha) (26 September 2019) (as reported). Losing it has a record: the High Court's Local Commissioner found the Punjab portion of the Patiala ki Rao "heavily encroached by squatters" in 2024 (CWP 5901/2017), and the GMADA social impact assessment for a storm-sewer road in SAS Nagar recorded that "the village Abadi area is seven feet lower than the level of stream (Nadi)" (GMADA, 2021). The law protects only part of it. The chhappars are Panchayat commons (shamlat), held under the Punjab Village Common Lands (Regulation) Act, 1961, and the Supreme Court ordered encroachers on pond land in a Punjab village to restore it to the Gram Panchayat (*Jagpal Singh v. State of Punjab*, 28 January 2011, as reported); the High Court ordered encroachments on village ponds removed within six months in 2020, with PPCB to monitor the water (as reported). No pond statute or pond authority was found in the State [TBC], no wetland notified under rule 7 of the Wetlands Rules, 2017 was found, and no buffer distance round any pond, wetland or

Ramsar site was found; the Punjab State Wetlands Authority recommended 72 water bodies for notification in September 2025 (as reported). Any buffer round a chhappar in this Manual is therefore its own proposal. 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 Punjab through:

- (a) an amendment to the Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 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 Punjab the building rules are split by territory between two instruments (PMBBL/PUDBR). In the municipal areas of all Municipal Corporations, Municipal Councils and Nagar Panchayats they are the Punjab Municipal Building Bye-Laws, 2018 (PMBBL), made by the Department of Local Government (DLG) through its Town Planning Wing by notification No. CTP(LG)/2018/3548 of 22 November 2018, under section 201(1) of the Punjab Municipal Act, 1911 and section 399(2) of the Punjab Municipal Corporation Act, 1976 (PMBBL 1.3), and amended on 31 December 2019 and, for independent floors, on 9 August 2023 (the second as listed by DLG; text not read). In the rest of the State, except the Lal Lakir of village abadi, Cantonment Boards and sites under the Archaeological Survey of India, and in the urban estates and other schemes of the development authorities wherever they lie, they are the Punjab Urban Planning and Development Building Rules, 2021, made by the Department of Housing and Urban Development (HUD) by G.S.R. 144/P.A.11/1995/Ss.180 and 43/2021 of 31 August 2021, under section 180 read with section 43(2) of the Punjab Regional and Town Planning and Development Act, 1995 (r.1(3)), with a corrigendum of 16 March 2022 and the Amendment Rules of 29 March 2022; amendments of 14 July 2026 (mixed use) and 7 September 2026 are reported (as reported; texts not read), and none found touches rainwater harvesting, plinths, basements or drainage. The State gives the 2021 Rules no abbreviation; "PUDBR" is an abbreviation set by this Manual, and "PUDA Building Rules" names the rules of 2018 that the 2021 Rules repealed (r.53). The Punjab Unified Building Rules, 2025, notified on 15 December 2025, were stayed in part by the High Court on 24 December 2025 and withdrawn by HUD on 27 April 2026, restoring PUDBR and PMBBL "as if the 2025 Rules had never been notified" (as reported); they are history and are not cited as current. PUDBR requires building plans to show the disposal of storm water (r.11); both instruments require rainwater harvesting above thresholds that differ by instrument (PMBBL cl. 10.1; PUDBR r.40), set the plinth from the surrounding ground (PMBBL cl. 5.2.1.1, 450 mm) or from the crown of the road in front (PUDBR r.3(A), 900 mm for residential plots), keep surface drainage out of basements (PMBBL cl. 4.23(vii); PUDBR r.30(5)(iv)(e)), and, for group housing, ask for permeable materials in all open parking, Punjab's only permeable-paving rule. They

set no design storm, return period, release rate or detention volume, no "zero runoff" rule, and no setback from a river, nallah, choe, pond or canal. The route of Clause 1.3.1(a) therefore runs through two departments: DLG could amend PMBBL under the same sections of the municipal Acts, and HUD could amend PUDBR under sections 180 and 43(2) of the Act of 1995; and WRD could notify the lines along rivers, choes and drains under section 38 of the Punjab Canal and Drainage Act, 2023, which Chapter 7 uses. Both are notifications made under an Act, as Clause 1.3.1 and Annex 1D assume; PUDBR was published in the Punjab Government Gazette of 10 September 2021. This Manual is a draft; neither the Government nor any department or 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 authority that sanctions the building plan, layout or scheme for the site, which is, within municipal limits, the Municipal Corporation, Municipal Council or Nagar Panchayat under PMBBL 2018; in the urban estates and other schemes of PUDA, GMADA, GLADA and the other development authorities, that authority under PUDBR 2021; and elsewhere in the State, the competent authority under PUDBR 2021 (its definition in the Rules was not read for this Manual [TBC]), or a department for its own works.
Applicant	The owner, developer or department that seeks approval, and its successors in title.
Development	Any building, layout, sub-division, road, paving or land-use change that requires approval under the Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 or that is executed as a public work.
Redevelopment	Development on a site where impervious cover already exists.
Land disturbance	Clearing, grading, excavation, filling or paving of land, measured in plan area over the whole of a common plan of development (Clause 1.5.5).
Impervious area	Roofs, paving, compacted gravel, decks and other surfaces that prevent infiltration. Permeable paving designed to Chapter 8 is counted as pervious only for the area it treats.
New or replaced impervious area	Impervious area created, or removed and rebuilt down to the subgrade, by the development. Resurfacing that leaves the base in place is not "replaced".
Retention	Permanent removal of runoff from the drainage system on site, by infiltration, reuse or evapotranspiration (Chapter 4).
Detention	Temporary storage of runoff with a controlled outlet, emptied after the storm (Chapter 4).
Rainwater harvesting (RWH)	Collection of rainfall for supply or recharge under the RWH mandate. RWH storage is not detention unless Chapter 4 allows it.
Minor system	Drains, pipes and inlets designed for the minor-system AEP of Chapter 6.
Major system	The overland and floodway path that carries the 1% AEP (100-yr) flow (Chapter 6).
Pre-development condition	Greenfield: open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted (Chapter 3).

Term	Meaning in this Manual
Flood-sensitive catchment	The catchments of the Buddha Nallah, its city reach through Ludhiana and the land that drains to it; of the Shivalik choes that cross SAS Nagar, Zirakpur, Kharar, Dera Bassi and New Chandigarh, among them the N-Choe, the Patiali-ki-Rao, the Sukhna Choe, the Jayanti Devi ki Rao and the Lakhnaur choe, and of the Ghaggar at Bhankharpur; of the Badi and Chhoti Nadi, the Ghaggar and the canal crossings at Patiala, Rajpura and Samana; of the Ghaggar at the towns of Sangrur and Mansa districts, Moonak, Khanauri, Makraud Sahib and Sardulgarh; of the Kali and Chitti Bein and the Kala Sanghian drain at Jalandhar, Kapurthala and Phagwara, with the Sutlej at Phillaur and Shahkot; of the walled city of Amritsar and its outfall by the Tung Dhab drain to the Hudiara drain; of the Ravi, the Chakki Khad and the dhussi bandh at Pathankot, Gurdaspur and Dera Baba Nanak; of the choes of the Kandi towns of Hoshiarpur, Garhshankar, Mukerian and Talwara, with the Beas below Pong; of the Sutlej below Bhakra and the Swan at Rupnagar, Nangal and Anandpur Sahib; of Ferozepur and the Harike–Hussainiwala reach of the Sutlej; and of the waterlogged towns of the south-west, Bathinda, Sri Muktsar Sahib, Fazilka, Abohar and Faridkot, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (chhappar), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7).
Regional facility	A detention, retention or tank storage facility serving more than one development, built or restored under a basin plan (Chapter 4).
Tier A / Tier B authority	An Approving Authority classed under Clause 1.6.
Policy supplement	The set of adoptable alternative clauses in Clause 1.7 and Annex 1C.
Drainage report	The preliminary or final report required by Chapter 10.
Registered professional	A person registered under the Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 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 Punjab Government Gazette.
PMBBL	The Punjab Municipal Building Bye-Laws, 2018, as amended, made by the Department of Local Government (notification No. CTP(LG)/2018/3548 of 22 November 2018) under section 201(1) of the Punjab Municipal Act, 1911 and section 399(2) of the Punjab Municipal Corporation Act, 1976. They apply to building in the municipal areas of all Municipal Corporations, Municipal Councils and Nagar Panchayats (PMBBL 1.3). Cited as "PMBBL 2018 (as amended), cl. …".
PUDBR	The Punjab Urban Planning and Development Building Rules, 2021, as amended, made by the Department of Housing and Urban Development (notification No. G.S.R. 144/P.A.11/1995/Ss.180 and 43/2021 of 31 August 2021) under section 180 read with section 43(2) of the Punjab Regional and Town Planning and Development Act, 1995. They apply to the whole State except within municipal limits, the Lal Lakir of village abadi, Cantonment Boards and sites under the Archaeological Survey of India, and they do apply to the urban estates and other schemes of the development authorities (r.1(3)). "PUDBR" is an abbreviation set by this Manual; the State uses none. Cited as "PUDBR 2021 (as amended), r. …".
Competent authority	The authority that sanctions a building plan under PMBBL (the Municipal Corporation, Municipal Council or Nagar Panchayat) or under PUDBR (the development authority in its schemes, and the authority the Rules name elsewhere; the Rules' definition was not read for this Manual [TBC]). 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021;
- (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 Punjab, 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 in the municipal areas, under PMBBL 2018 (as amended), cl. 10.1, to every building on a plot of **100 m²** or more and to group housing, public, commercial and industrial buildings of any size, with groundwater recharge on plots of more than **500 m²** (cl. 10.5) and inspection by the municipal Rainwater Harvesting Cell before a completion certificate or a service connection is issued (cl. 10.6); and elsewhere in the State, under PUDBR 2021 (as amended), r.40, to residential plots and public and institutional buildings of more than **250 m²**, to commercial, mixed-use and industrial buildings of more than **100 m²** and to group housing of any size, with the design certified by a civil engineer, 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.

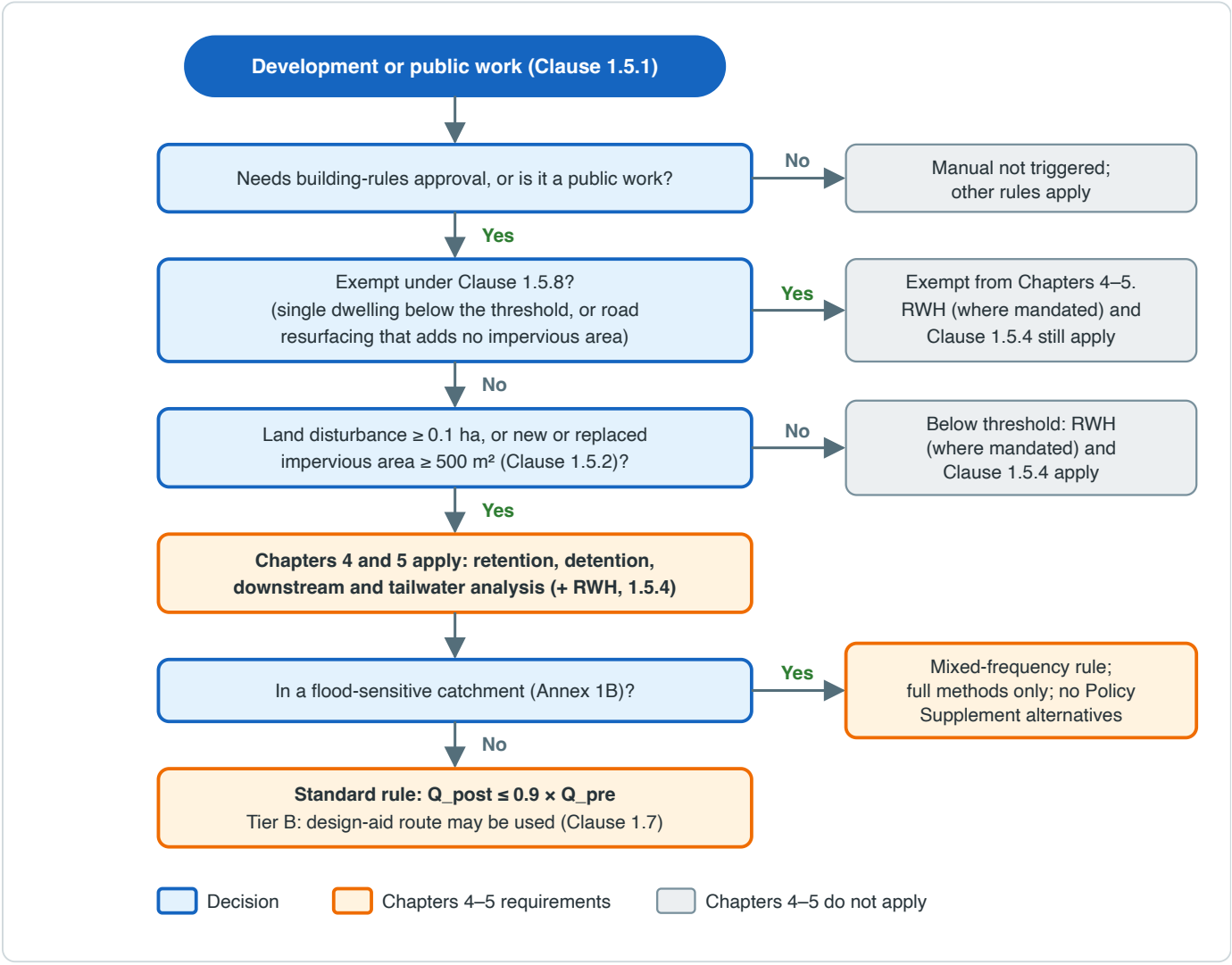

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Punjab plots are small and the cumulative effect of many small plots is what fills Ludhiana's drains. For small buildings in Punjab, the two building instruments set different thresholds, and each must be cited with its own number. In municipal areas, PMBBL 2018 (as amended), cl. 10.1, requires "the complete proposal of rainwater harvesting" with the building plans of every plot of 100 m² or more, and recharge on plots of more than 500 m² (cl. 10.5); elsewhere, PUDBR 2021 (as amended), r.40, requires rainwater harvesting on residential plots of more than 250 m², commercial and industrial plots of more than 100 m², and group housing of any size, with the design certified by a civil engineer. Earlier rules used other thresholds, 400 m² (2010) and 500 sq yd (2013) (as reported). Neither instrument sizes the system to a runoff volume, and neither limits what leaves the plot. The plinth is set at not less than 450 mm "from the surrounding ground level", sited so "that adequate drainage of the site is assured" (PMBBL 2018, cl. 5.2.1.1), or at 900 mm "from the crown of adjoining road in front" for residential plots (PUDBR 2021, r.3(A)(1)), not from any flood level; both require that "surface drainage does not enter the basement" (PMBBL 2018, cl. 4.23(vii); PUDBR 2021, r.30(5)(iv)(e)), without a design level for the ramp crest. Clause 1.5.4(b) applies to every building whatever its size for this reason. How a site meets the retention of Clause 1.5.2 depends on its ground, and Chapters 4 and 8 set three regimes for the State: the Kandi fans and choe beds of sub-area PB-A, where recharge is preferred, but not on the Shivalik slopes themselves, where the hill rule of Clause 4.11 bars infiltration; the over-exploited central plains, where 115 of the State's 153 assessment units were over-exploited in 2024 (CGWB) and recharge is encouraged with protection of groundwater quality; and the waterlogged south-west, the Sirowal belt and the bet lands, where the water table is within 3 m and no infiltration is credited. This Manual applies within the State of Punjab; the Union Territory of Chandigarh, which is not part of the State, is covered only by Supplement S01.

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 Ludhiana (MC Ludhiana), with GLADA and every other approving authority within GLADA's area;
- (b) the Municipal Corporation SAS Nagar (Mohali), with GMADA and every other approving authority within GMADA's area, among them the local bodies of Zirakpur and Kharar and the authority for New Chandigarh; and
- (c) every other Municipal Corporation constituted under the Punjab Municipal Corporation Act, 1976, among them those of Amritsar, Jalandhar and Patiala (13 at March 2023 by the CAG, with Barnala reported as the fourteenth; list [TBC]), with every other approving authority within its limits; and, wherever they lie, PUDA and the development authorities in their urban estates and schemes.

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

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

Table 1.1 — Differences between Tier A and Tier B authorities

Item	Tier A	Tier B
Performance criteria (Chapters 2–9)	Apply in full	Apply in full

Item	Tier A	Tier B
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 DLG 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 development authority (GMADA, GLADA or another authority under the Punjab Regional and Town Planning and Development Act, 1995) as notified, 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 Ludhiana, with its engineering wing and, beside it, GLADA in its schemes and WRD for the Buddha Nallah and the other notified drains, and a small Nagar Panchayat with one assistant engineer cannot be asked to review the same hydrograph models. The Kansas City solution was to keep one regional standard and publish adoptable alternatives for the most contested criteria, so that smaller agencies can "opt down" without leaving the standard (MARC Supplement, Nov 2025). The tiers here keep the performance criteria the same in both tiers and vary only the method, so that a building in a Tier B town is protected to the same level as one in Ludhiana.

1.7 Policy supplement: adoptable alternatives

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

1.7.2 The alternatives are:

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

No.	Main-text requirement	Adoptable alternative	Eligibility
S-1	Storage sized by hydrograph method (Chapter 3)	**Design-aid route:** retention and detention volumes taken from the unit-storage tables (m³ per ha, by rainfall zone, soil group and impervious fraction) in Annex 4 and the compliance calculator	Sites ≤ 2 ha outside flood-sensitive catchments; ≤ 0.5 ha within them (as Clause 4.14.1)
S-2	Release rate $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$, computed for the site	**Permissible site discharge (PSD):** a tabulated unit-area release rate (m³/s/ha) by zone and AEP, derived from the $0.9 \times Q_{pre}$ rule	Any site outside flood-sensitive catchments

No.	Main-text requirement	Adoptable alternative	Eligibility
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
Punjab Municipal Building Bye-Laws, 2018 (PMBBL; DLG notification No. CTP(LG)/2018/3548 of 22 November 2018, under s.201(1) of the Punjab Municipal Act, 1911 and s.399(2) of the Punjab Municipal Corporation Act, 1976; amended on 31 December 2019 and 9 August 2023)	Continue, in the municipal areas of all Municipal Corporations, Municipal Councils and Nagar Panchayats (PMBBL 1.3). They site the plinth "so … that adequate drainage of the site is assured", at not less than 450 mm above the surrounding ground (cl. 5.2.1.1); keep surface drainage out of basements and require sewage from a basement to be pumped to the sewer "to avoid any risk of the sewerage or sludge heading back into the basement" (cl. 4.23(vii)–(viii)); carry roof water away from the building to a drain or covered channel (cl. 5.16.1); keep at least 20% of recreational open space unpaved and "The inlet and outlet point of natural drain system … with adequate size of channel" on large sites (cl. 11.2.1(iv); Table 15.1); and ask for permeable materials in all open parking of group housing (Table 10.1). They set no design storm, release rate or detention volume, and no setback from a drain, choe, 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 PMBBL, a master plan, a statute or a court order is stricter, it governs (Clause 1.3.3).
Punjab Urban Planning and Development Building Rules, 2021 (PUDBR, an abbreviation set by this Manual; HUD notification No. G.S.R. 144/P.A.11/1995/Ss.180 and 43/2021 of 31 August 2021, Gazette of 10 September 2021, under s.180 read with s.43(2) of the Punjab Regional and Town Planning and Development Act, 1995; corrigendum of 16 March 2022; Amendment Rules of 29 March 2022; amendments of 14 July and 7 September 2026 reported)	Continue, in the whole State except within municipal limits, the Lal Lakir of village abadi, Cantonment Boards and sites under the Archaeological Survey of India, and in the urban estates and other schemes of the development authorities wherever they lie (r.1(3)). Plans show "methods of disposal of waste water, sewerage and storm water" and the surroundings to 15 m (r.11); the plinth of a residential plot is 900 mm "from the crown of adjoining road in front" (r.3(A)(1)); no basement is allowed in a "No construction Zone" or "Master Plan Green area", and "surface drainage does not enter the basement" (r.30(5)(iii) and (iv)(e)); septic tanks and absorption pits are kept 30 m from drinking-water sources and streams, and absorption pits have no outlet to a storm drain (r.45(7)–(8)); a certificate in Form H precedes the use of drainage (r.44(5)), and connections to public sewers are made in Form L (r.45); MoEFCC's conditions of S.O. 3999(E) of 9 December 2016 apply to large buildings (r.43); and NBC 2016 applies where the Rules are silent (r.52). No setback from any river, nallah, choe, pond or canal is set (r.26). The Punjab Unified Building Rules, 2025, which were to replace PUDBR and PMBBL, were withdrawn on 27 April 2026 (as reported) and are not cited as current.
Rainwater harvesting: PMBBL 2018, Ch. X; PUDBR 2021, r.40; Punjab Groundwater Extraction and Conservation Directions, 2023 (PWRDA)	Continue unchanged. PMBBL requires a harvesting proposal on every plot of 100 m² or more and in group housing, public, commercial and industrial buildings of any size, recharge on plots of more than 500 m², and inspection by a municipal Rainwater Harvesting Cell before a completion certificate or service connection, with every building above 1,000 m² verified each year (cl. 10.1–10.6); PUDBR requires harvesting above 250 m² for residential and public plots and above 100 m² for commercial and industrial plots, in group housing of any size, and "not to inject contaminated water into recharge structures" in industrial areas (r.40). The Directions make harvesting voluntary for users who extract groundwater, earning one water-conservation credit, and a rebate of ₹2.50, for each cubic metre conserved under an approved scheme (Directions 2.7 and 4.7). 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 156.87% of its annual extractable groundwater in 2024, and 115 of its 153 assessment units were over-exploited (CGWB); yet the water table lay within 5 m of the surface over about 5,723 km² of the south-west in 2019 (CGWB and WRD). Recharge structures may count toward retention where they meet Chapters 4 and 8, which make recharge the first choice, with pre-treatment and a quality screen, where the seasonal high water table is deeper than 10 m, give no recharge credit where it is within 3 m, ask for a site check in between, and bar infiltration on the Shivalik slopes (Clause 4.11).

Instrument	Relationship
Punjab Regional and Town Planning and Development Act, 1995 (Punjab Act 11 of 1995); the master plans; PUDA and the development authorities	Continue. PUDBR is made under ss.180 and 43(2) of the Act; master plans are notified under it, as the Master Plan Ludhiana (2007–2031) was on 12 September 2008 under s.70(5) (HUD, reply to the NGT in O.A. 1295/2024); and PUDA, GMADA, GLADA and the other development authorities develop urban estates and schemes under it. The Act itself, and the sections that constitute the authorities, were not read for this Manual [TBC]. The report of the Master Plan Jalandhar (Vision 2031) proposes no construction within at least 200 m of the Chitti Bein "untill concrete bandh is constructed", except a 30 m buffer zone from its bank, and a 30 m plantation strip along the Black (Kala Sanghian) Bein; these are proposals of a plan report whose notification was not seen, not statutory buffers. This Manual does not decide zoning; the drain reserves and regional facility sites of Chapters 4 and 7 are meant to be shown in the master plans and in the layouts of the authorities.
Punjab Municipal Corporation Act, 1976 (Act 42 of 1976); Punjab Municipal Act, 1911 (Act 3 of 1911); Punjab One-Time Voluntary Disclosure and Settlement of Violations of the Buildings Bye-Laws Act, 2019	Continue. The Acts are the parents of PMBBL (s.399(2) and s.201(1)), and govern the Municipal Corporations, Municipal Councils and Nagar Panchayats; their sections on the vesting of drains, connections to them and building over them were not read for this Manual [TBC]. This Manual does not change those powers; Chapter 7 treats chhappars and choes as drainage assets and Chapter 8 keeps sewage out of storm drains.
Punjab Canal and Drainage Act, 2023 (Punjab Act 11 of 2023; assent 18 December 2023; Gazette (Extra.) 27 December 2023), ss.2, 5, 38, 39, 41, 52 and 61; notifications under s.55 of the Northern India Canal and Drainage Act, 1873	Continues. The Act comes into force on a date the Government notifies (s.1(3)); no commencement notification was found [TBC]. Where obstruction of a river, stream or drainage channel may cause injury, the Government may by notification bar obstruction within defined limits, and the reach so notified "shall be held to be a drainage-work" (s.38, which carries over s.55 of the Act of 1873, repealed in its application to Punjab by s.61); the Divisional Canal Officer may remove an obstruction (s.39); damaging, altering or constructing a drainage work, or altering the flow of a river or stream so as to endanger one, is an offence punishable with a fine of ₹5,000–50,000 or up to six months' imprisonment (s.52); and the removal of sewage from towns is not a drainage work (s.2(7)). The 150 m limit of s.5 protects State tubewells and is not a buffer round a water body. WRD notified 393 of 869 drains, choes and rivers under s.55 (WRD) or 514 of 935 (as reported); no notification text, list or width was found. Its notifications include the Patiala ki Rao in Kharar tehsil (No. 4/8/2013-iw(3)26573/1 of 4 March 2013) and the floodplain of the Sutlej in Ferozepur and Tarn Taran (4 March 2024), which WRD computed as a 100-year Lacey waterway of 0.58 km but declared as the land between the embankments, about 4.5 km apart; the NGT found "no material … indicating the exercise for demarcating the flood plain zone as per the applicable zone" (order of 14 March 2024, as quoted). A drainage-wing NoC for projects within 150 m of a water body was announced by the Water Resources Minister on 20 September 2023 (as reported); no notification or order was found, and this Manual does not apply it as a rule. No floodplain zoning Act exists (as reported). Where a s.38 line is wider than the corridor of Chapter 7, it governs (Clause 1.3.3).
Punjab Water Resources (Management and Regulation) Act, 2020 (Act 2 of 2020); Punjab Groundwater Extraction and Conservation Directions, 2023 (in force 1 February 2023)	Continue. The Act establishes PWRDA (s.3), lets it categorise areas by the stage, trend, level and quality of groundwater (s.14(5)), and direct "water conservation and groundwater recharge, including rain water harvesting" (s.15(2)(ix)) and advise on the "utilization and storage of surface runoff" (s.15(7)(ii)). The Directions charge for groundwater by zone and slab, ₹0–22 per m³, exempt drinking and domestic use, agriculture, urban local bodies, panchayats and development authorities, and penalise the non-maintenance of recharge structures with ₹10,000–1,00,000. The recharge rules of Chapters 4 and 8 state recharge volumes in m³ a year so that they can be linked to the credits; the link is not a mandate.
Punjab Preservation of Subsoil Water Act, 2009 (Act 6 of 2009)	Continues. The dates from which paddy may be transplanted, 1, 5 or 9 June by district in 2025 (as reported), set the start of the ponded-field season that Clause 2.11.4 uses; the Act's text was not read [TBC].
Punjab Land Preservation (Chos) Act, 1900	Applies where it binds. The Government may notify erosion-prone Kandi areas (s.3) and regulate, restrict or prohibit clearing, quarrying, cultivation and the cutting of trees in them (s.4) (as seen through an index); a notification under s.4 covers 21,944 acres in 15 villages of the Shivalik foothills near Chandigarh (as reported). Which department administers the Act, and the list of notified areas, are to be confirmed [TBC]. Earthworks and drainage works in notified Kandi areas are subject to it.

Instrument	Relationship
Punjab Village Common Lands (Regulation) Act, 1961; the orders of the courts on village ponds	Apply where they bind. Village chhappars are Panchayat commons (shamlat) under the Act; the Supreme Court ordered encroached pond land restored to a Gram Panchayat (*Jagpal Singh v. State of Punjab*, 28 January 2011), and the High Court ordered encroachments on village ponds removed within six months in 2020, with PPCB to monitor pond water (as reported). No pond statute or pond authority was found [TBC]. Any buffer round a chhappar in Chapter 7 is this Manual's proposal.
Wetlands (Conservation and Management) Rules, 2017; the Punjab State Wetlands Authority; the Ramsar sites	Continue. The six Ramsar sites are Harike (1990), Kanjli and Ropar (2002), and Keshopur-Miani, the Beas Conservation Reserve and the Nangal Wildlife Sanctuary (26 September 2019) (as reported). The State Wetlands Authority under r.5 had recommended 72 water bodies for notification by September 2025 (as reported); no notification under r.7 and no buffer distance was found [TBC]. 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 choes, drains, rivers and ponds	Apply where they bind. Patiala ki Rao: the High Court's case on encroachment (*Shamsher Singh v. State of Punjab*, CWP 5901/2017, judgment of 2 June 2017; contempt petition COCP 1105/2023 pending), in which pillars "measuring 200 Ft." apart were fixed on the Union Territory side and were pending on the Punjab side in January 2024 (Local Commissioner's report of 8 January 2024), a width fixed for that case and not a WRD norm; and a petition for an embankment along it (*Ram Lal v. State of Punjab*, CWP-PIL 79/2025). The NGT has heard the pollution of the Sutlej and the Beas (O.A. 916/2018, as reported; O.A. 673/2018), the Sutlej floodplain zone (O.A. 303/2023), the realignment of a drain at Manauli, for which WRD requires its prior permission (O.A. 279/2024), the narrowing of the Buddha Nallah (O.A. 327/2025), the rivers of the State (O.A. 413/2025), groundwater (O.A. 694/2023), the Patiala ki Rao (O.A. 180/2026) and the Master Plan Ludhiana (O.A. 1295/2024). 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.
Disaster Management Act, 2005; PSDMA; the draft State Disaster Management Plan; the State Flood Control Board	Continue. A draft State plan of about 2011 was found, which names drainage congestion and waterlogging as the main problem of the monsoon and asks that streams be desilted "before the onset of monsoons every year" (draft SDMP); no current State plan and no urban flood plan was found [TBC]. No State order fixes a date for pre-monsoon works; ministers and Deputy Commissioners set 30 June most years (as reported). Chapter 10 sets 15 June, ahead of the onset at Jalandhar and Patti.
Earlier design values: Amritsar Smart City Ltd, bid No. 07/ASCL/2018-19 (2018); PMIDC, feasibility report for the Buddha Nallah (2020); WRD, rooftop rainwater harvesting of government buildings (undated)	Superseded for works designed under this Manual. The walled-city trunk sewers of Amritsar were designed for "a return period of once in two years" with surcharge in manholes, and the Buddha Nallah for a "2 year return period with reduced run-off within the city reach due to active storm water detention"; WRD sized rooftop recharge for 40 mm/h. These are design values of single projects and of recharge structures, cited as the history of practice; the return periods of Table 2.1 and the rainfall of Chapter 2 apply instead (Clause 2.3.6(n)).
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 Punjab 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 late-season storm, such as those of 24 September 1988 and 4–5 October 1955,

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.

Punjab is spending on its drains and rivers. The rejuvenation of the Buddha Nallah in Ludhiana was sanctioned at ₹650 crore and awarded at ₹839.79 crore with its operation and maintenance (as reported); WRD lists the channelisation of the N-Choe in Sector 101 of SAS Nagar (₹22.43 crore), flood works on the Swan (₹284.98 crore) and embankments and widening of the Ghaggar on a case recommended by CWPRS (₹1,104.11 crore), and took up 19 flood-protection works worth ₹1,091.40 lakh in SAS Nagar district for the monsoon of 2024 (WRD); the Smart City companies of Ludhiana, Jalandhar and Amritsar have storm-drain projects, among them the rehabilitation of the storm drains of Ludhiana's area-based development (₹17.79 crore) and of Dugri (₹41.35 crore) (CAG, Report No. 7 of 2021); and a revamp of the Badi and Chhoti Nadi at Patiala has been discussed at ₹208.33 crore (as reported). None of these works was found with a stated design rainfall, and only the Buddha Nallah and the Amritsar walled-city sewers with a return period, 2 years. 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. Section 38 of the Punjab Canal and Drainage Act, 2023 lets the Government notify limits along a river, stream or drainage channel within which obstruction is barred, and the reach so notified becomes a drainage work (as section 55 of the Act of 1873 did before); WRD has used the power for the Patiala ki Rao (2013) and the Sutlej in Ferozepur and Tarn Taran (2024), and computes its floodplains on a 100-year discharge by Gumbel's method with a waterway by Lacey's formula (WRD, letter to CWC, 2024). Building plans must show "methods of disposal of waste water, sewerage and storm water" (PUDBR r.11); a municipal Rainwater Harvesting Cell must inspect harvesting structures before a completion certificate or a service connection is issued (PMBBL cl. 10.6); PMBBL asks public open spaces of more than 500 m² for "complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (cl. 10.4), and large sites to keep "The inlet and outlet point of natural drain system … with adequate size of channel" (Table 15.1); the Water Resources (Management and Regulation) Act, 2020 lets PWRDA direct "water conservation and groundwater recharge, including rain water harvesting" (s.15(2)(ix)), and its Directions of 2023 earn a rebate for each cubic metre conserved under an approved scheme (Directions 2.7 and 4.7); and town sewage works are not drainage works (Punjab Canal and Drainage Act, 2023, s.2(7)). 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 choe's corridor must be, or how much storage a filled chhappar or a paved plot removes. This Manual's checks are framed as part of the building-plan, completion and occupation stages of PMBBL and PUDBR, 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 State: it supplies the design storm, detention and corridor numbers they do not set, as a proposal for the Government and the authorities to consider. Neither DLG, HUD, WRD nor any other body has adopted it.

1.9 Roles and responsibilities

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

Table 1.4 — Roles and responsibilities under this Manual

Agency	Role under this Manual
Department of Local Government (DLG), with its Town Planning Wing (CTP(LG))	Makes PMBBL and its amendments for the municipal areas; oversees the Municipal Corporations, Municipal Councils and Nagar Panchayats; and runs the in-situ remediation of drains in 22 urban local bodies, 12 of them incomplete in October 2025 (PPCB, reply to the NGT). Would make the amendment to PMBBL of Clause 1.3.1(a) if it adopted the Manual, issue the model bye-law of Clause 1.3.1(b), give regional support to Tier B authorities (Table 1.1) and maintain the empanelled reviewer list (Clause 10.7).

Agency	Role under this Manual
Department of Housing and Urban Development (HUD), with the Department of Town and Country Planning (Chief Town Planner)	Makes PUDBR and its amendments for the rest of the State and the schemes of the development authorities; issues the Uniform Zoning Plan (Drawing No. 01/2020 CTP(Pb) of 28 July 2020); and notifies master plans under the Punjab Regional and Town Planning and Development Act, 1995. Would make the amendment to PUDBR of Clause 1.3.1(a) if it adopted the Manual, and show the drain reserves and regional facilities of Chapters 4 and 7 in master plans and layouts.
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).
Municipal Corporation Ludhiana (MC Ludhiana) and the other Municipal Corporations; Municipal Councils and Nagar Panchayats	Sanction building plans within their limits under PMBBL, and must each constitute a Rainwater Harvesting Cell that inspects harvesting structures before a completion certificate or service connection is issued (PMBBL cl. 10.6). MC Ludhiana built the road along the Buddha Nallah that is alleged to have narrowed it (NGT, O.A. 327/2025). Their powers over drains under the municipal Acts were not read [TBC]. Would apply this Manual to their works, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15).
PUDA and the development authorities (GMADA, GLADA, and those of Amritsar, Jalandhar, Patiala and Bathinda [TBC])	Develop urban estates and other schemes, in which PUDBR applies and they sanction plans; GMADA has acquired land for a 200-ft sector road "for Disposal of Storm Sewer" in SAS Nagar, whose social impact assessment asks it to recalculate the runoff of the nadi and to make "strong provisions … in the 'City Drainage Plan'" (GMADA, 2021), a plan not found [TBC]. Would apply this Manual to their layouts and drains and hand them over under Clause 10.14.
Water Resources Department (WRD): the Drainage-cum-Mining & Geology wing and the canal wing; the State Flood Control Board	The Drainage wing holds the rivers, choes and notified drains, about 7,200 km of drains, about 1,800 km of flood embankments (dhussi bandhs) and 3,800 river-training works (WRD); notifies limits under s.38 of the Punjab Canal and Drainage Act, 2023, as for the Patiala ki Rao, enforced by the Executive Engineer of the Water Management Investigation Division, Rupnagar, and the Sutlej in Ferozepur and Tarn Taran; computes floodplains on a 100-year Gumbel discharge and Lacey's waterway (letter to CWC, 2024); and requires its permission for the realignment of a notified drain (O.A. 279/2024). The canal wing holds the canals, distributaries and watercourses. As the Water Resources Department, WRD keeps the State's observation wells and, with CGWB, assesses groundwater. The State Flood Control Board, chaired by the Chief Minister, reviews flood works (as reported). Would provide design river and drain levels, headworks operating rules and release scenarios for Chapter 5, consent to outfalls into its drains and canals, and keep the s.38 lines that Chapter 7 applies.
Punjab Water Regulation and Development Authority (PWRDA)	Regulates groundwater extraction under the Act of 2020 and the Directions of 2023, charges for it, and grants water-conservation credits for approved harvesting; it had processed 985 applications and collected ₹253.52 crore by 2024 (Amendment Bill, 2025). Would accept the recharge volumes of Chapters 4 and 8, stated in m³ a year, in applications for credits.
Punjab Pollution Control Board (PPCB) and the River Rejuvenation Committee	Monitors the rivers at 41 stations, 11 of them in real time, among them the Buddha Nallah and the Ghaggar below the Patiala Nadi (PPCB); grants consents to the treatment plants that discharge to drains and rivers; and was told by the High Court in 2020 to monitor the water of village ponds (as reported). Supports the removal of sewage from storm drains (Chapter 8).
PSDMA and the District Disaster Management Authorities	A draft State plan of about 2011 was found; no current State plan or urban flood plan 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).
Punjab State Wetlands Authority	Constituted under r.5 of the Wetlands Rules, 2017 (as reported); keeps the inventory of wetlands, and recommended 72 water bodies for notification in September 2025 after ground-truthing 1,143 sites (as reported). Would permit regulated activities in notified wetlands and Ramsar sites (Chapter 7).
Department of Revenue, Rehabilitation and Disaster Management: the Deputy Commissioners and the tehsil offices	Keep the revenue (khasra) records in which chhappars, tobas, dhabs, choes, raos, beins and bet land are recorded, and run the district flood-control action plans. Would certify the recorded extent of a choe, nala or chhappar for Chapter 7.

Agency	Role under this Manual
Punjab Water Supply and Sewerage Board (PWSSB) and the Punjab Municipal Infrastructure Development Company (PMIDC)	Build sewers and sewage treatment plants in many towns; PMIDC is the nodal agency for AMRUT and prepared the feasibility report for the Buddha Nallah (2020). Would apply Chapter 8 to the interception of sewage that now flows in storm drains, and this Manual to the drains they build.
Smart City companies of Ludhiana, Amritsar and Jalandhar	Build storm-drain and sewer works in their area-based development, such as the walled-city trunk sewers of Amritsar. Would apply this Manual to them and hand them over under Clause 10.14.
Department of Rural Development and Panchayats and the Gram Panchayats	Own most village chhappars, which they are cleaning on the Seechewal and Thapar models (as reported); the CAG found a choked screening chamber discharging untreated wastewater into the drain at the pond works of Punnawal and Bhalwan (Report No. 1 of 2026). Would apply Chapter 7 to chhappars that receive town or highway runoff.
Department of Soil and Water Conservation; Department of Forests	Soil and Water Conservation reuses treated sewage for irrigation, with a target of 1,519 MLD (PPCB, reply to the NGT, 2025), and is assigned the check dams of the Kandi in Table 1.5; Forests manages land closed under the Punjab Land Preservation (Chos) Act, 1900 [TBC]. Would apply Clause 6.3.6 to works on the choes.
Bhakra Beas Management Board (BBMB), a body of the Union	Operates Bhakra and Pong, whose releases set the stage of the Sutlej and the Beas. Would supply release notices and reservoir levels for the outfall-closed checks of Chapter 5.
Central Water Commission (CWC), a body of the Union	Publishes the Flood Estimation Reports for subzone 1(e) and zone 7 used in Chapters 2 and 3; it has no flood-forecasting or level-monitoring site in the State (as reported).
Central Ground Water Board (CGWB), a body of the Union	Assesses the State's groundwater with WRD, 115 of 153 units over-exploited in 2024. Would supply groundwater levels and quality with WRD.
National Institute of Hydrology (NIH), Roorkee	Runs NIH-DHAARA (Chapter 2).
IMD (Meteorological Centre Chandigarh) and PAU; road and rail owners (PWD (B&R), NHAI, Indian Railways)	IMD's stations and PAU's observatories supply the rainfall records of Chapter 2. Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. The roles in Table 1.4 are those each body would have if the Manual were adopted; until then they describe its present functions only. Stormwater in Punjab is split by territory and by kind of channel: between DLG, through PMBBL and the Municipal Corporations, Municipal Councils and Nagar Panchayats, in the municipal areas; HUD, through PUDBR, the master plans and the development authorities, in the rest of the State and in the authorities' schemes; WRD, through the rivers, choes, notified drains and dhussi bandhs of its Drainage wing, the canals of its canal wing and the s.38 lines; the Gram Panchayats, through the village chhappars; and the Department of Revenue, Rehabilitation and Disaster Management, through the revenue records, with the courts and the NGT setting the lines along the Patiala ki Rao and the conditions on the Buddha Nallah. SAS Nagar shows why the split matters. Its sectors, built by GMADA, drain to choes that come down from the Shivaliks and through Chandigarh, among them the Patiala ki Rao, whose Punjab reach WRD's Executive Engineer at Rupnagar enforces under a notification of 2013 while the local body of Naya Gaon supplies "only … the manpower and machinery" (reply to the NGT, 2026), and on to the Ghaggar, which WRD embanks; and when a drain near Manauli was to be realigned, WRD said that no realignment could be made without its permission, while GMADA's acquisition of the land was "under process" (O.A. 279/2024). No rule or order found divides the drains of WRD from those of the

local bodies and the 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, choes, raos, nadis and beins; the drains notified under s.38 of the Punjab Canal and Drainage Act, 2023 (s.55 of the Act of 1873 for earlier notifications) and every other drain that WRD maintains, among them the Buddha Nallah, the Tung Dhab, the City Outfall drain, the Hudiara, the Sakki/Kiran, Patti, Kasur and Chand Bhan drains and the Kala Sanghian drain; dhussi bandhs, flood embankments and river-training works	WRD (Drainage-cum-Mining & Geology wing)
Canals, branches, distributaries, minors, kassis and watercourses, with their siphons and escapes	WRD (canal wing)
Sector and scheme drains of the urban estates and other schemes, until transferred to the local body	PUDA or the development authority (GMADA, GLADA or another authority [TBC])
Street drains, public drains and sewers within the limits of a local body	The Municipal Corporation, Municipal Council or Nagar Panchayat, under DLG
Drains and sewers built under AMRUT and for the Buddha Nallah, until handed over	PWSSB or PMIDC, as builder
Storm-drain works of the Smart City projects of Ludhiana, Amritsar and Jalandhar, until handed over	The Smart City company, as builder
Drains, culverts and cross-drainage of State and national highways and other roads	PWD (B&R) or NHAI
Village chhappars (shamlat ponds) and village drains	The Gram Panchayat, under the Department of Rural Development and Panchayats
Check dams of the Kandi	The Department of Soil and Water Conservation, and WRD for its low dams
Land and choes in Kandi areas notified under the Punjab Land Preservation (Chos) Act, 1900	The Department of Forests [TBC]

Sewage in storm drains is dealt with in Chapter 8; the removal of sewage from towns is not a drainage work under s.2(7) of the Act of 2023. 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. Punjab has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to the Sutlej, the Beas, the Ravi or the Ghaggar through a flap gate in a dhussi bandh, to a WRD drain whose level is held up by the river it joins, such as the Buddha Nallah at Walipur Kalan, to the Hudiara drain, whose level is set across the border, or only by pumping, as in the depressions of the south-west, 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 Punjab, the first census of water bodies counted 16,012 in the State, 1,578 of them encroached (as reported), the High Court's Local Commissioner found the Punjab portion of the Patiala ki Rao "heavily encroached by squatters" in January 2024 (CWP 5901/2017), and a road built along the Buddha Nallah in Ludhiana is alleged to have cut the channel's width "from 58 feet to 35 feet" (NGT, OA 327/2025).

1.11 Transition provisions

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

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

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

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

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

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

1.12 Review and amendment

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

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

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

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Municipal Corporations and of the areas of GMADA, GLADA and the other development authorities
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model PMBBL/PUDBR 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 Punjab. Where a Municipal Corporation, Municipal Council or Nagar Panchayat, PUDA, GMADA, GLADA or another development authority has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

Commentary. Most past drainage failures in Punjab trace to the rainfall input, not the hydraulics. Punjab shows how. No storm-drain design standard of the State, of PWSSB, PUDA, GMADA or GLADA, or of any urban local body was found, and no drain design rainfall for any city. The two design statements found in Punjab urban drainage documents are choices of single projects: the trunk storm sewers of Amritsar's walled city were designed for "a return period of once in two years", with a "Minimum time of concentration … 15 mins" and surcharge "inside the manhole … (without flooding)" (Amritsar Smart City bid, 2018), and the widening of the Buddha Nallah through Ludhiana for a "2 year return period with reduced run-off within the city reach due to active storm water detention" (PMIDC, 2020); neither states the rainfall used, and no design discharge for the Buddha Nallah was found. Under AMRUT, "No work was done" on storm-water drainage in the State to September 2020 (CAG, Report No. 7 of 2021). The one intensity found in a WRD document, 40 mm/h, sizes the rooftop recharge of government buildings, not drains. The published sources that seem to fill the gap do not. The panel for Amritsar 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 598.7 mm; NIH-DHAARA's reanalysis-based depths are far too high on the Shivalik front and less than half the station records in the south-west; and the CWC plates of 1984 are exceeded by a single day at most of the State's long-record gauges (Clause 2.3.6). The CWC ratios, the only regional sub-daily source, give less than the 93 mm that the Patiala recording gauge recorded in an hour. 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 Punjab is 439.8 mm (IMD, as used by ICAR-CRIDA in its bulletin of 30 Sep 2025), against an annual mean of 660.4 mm for the sub-division in 1901–1980 (IMD, *Climate of Punjab*). District annual normals of 1901–1980 run from 388.6 mm in Ferozpur, 429.8 mm in Bhatinda and 433.0 mm in Faridkot to 660.3 mm in Ludhiana, 801.4 mm in Rupnagar, 818.8 mm in Hoshiarpur and 1,106.1 mm in Gurdaspur (IMD, *Climate of Punjab*). The label is the calendar season; the monsoon itself arrives in late June. IMD's new normal date of onset is 26 June at Jalandhar, 28 June at Patti and 1 July at Ludhiana (26 June under the old normal), and of withdrawal 21 September at all three, with Chandigarh at 28 June and 23 September; "By 1st October, monsoon withdraws from most areas of … Punjab" (IMD, new normals of 2020; the table's caption gives the withdrawal period as 1961–2019 and its column header as 1971–2019). Amritsar, Patiala, Bathinda, Ferozepur, Pathankot and Gurdaspur are not in the table. The plains are wet before the onset: paddy is transplanted under the Punjab Preservation of Subsoil Water Act, 2009 from 1 June in Faridkot, Bathinda, Ferozepur, Sri Muktsar Sahib and Fazilka, from 5 June in Gurdaspur, Pathankot, Amritsar, Tarn Taran, Rupnagar, SAS Nagar, Fatehgarh Sahib and Hoshiarpur, and from 9 June in the other districts (2025 schedule, as reported). 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 onset at Jalandhar and Patti, with regulators, flap gates, pumps, siphon crossings and choe crossings certified ready by 25 June and kept on standby to 15 October (Chapter 10). No State order fixes a date; the target of 30 June that ministers and Deputy Commissioners set each year (as reported) falls after the onset at Jalandhar and Patti and is not used.
Storms outside the season	Large falls come at the edges of the season and outside it. The storm of record fell after the withdrawal: on 4–5 October 1955 Ludhiana recorded 354.3 mm and Amritsar 190.5 mm, and Aliwal, Batala, Khara, Gurdaspur, Raya, Madhopur and Moga recorded 335–495 mm (IMD, *Climate of Punjab* and *Extremes*). September brings many of the State's largest days: Jagraon 433.6 mm (18 September 1950), Zira 301.7 mm (17 September 1950), Amritsar 308.4 mm (22 September 1962), Ludhiana PAU 338.0 mm and Kapurthala 284.2 mm (24 September 1988) and Ludhiana 286.8 mm (5 September 1995) (IMD). In June, before the monsoon is established, Patiala recorded 160.6 mm on 8 June 2000 and Tarn Taran 258.3 mm on 19 June 1894; in winter and before the monsoon, Ludhiana recorded 119.6 mm on 4 January 1911, 118.0 mm on 5 March 2000 and 115.0 mm on 9 December 1997, and Patiala 144.2 mm on 16 April 1983 and 112.4 mm on 24 December 1980 (IMD). Design statistics use annual maxima from all months, and no works deadline or operating rule shall assume that heavy rain is confined to June–September; the works calendar of Chapter 10 keeps standby to 15 October for this reason.
Climate factor (CF)	Multiplier applied to present-day design depths to represent the design-life climate.
Approved source	A rainfall source listed in Clause 2.3.

2.3 Approved sources of design rainfall

2.3.1 **Primary source.** Design rainfall depths and intensities shall be taken from the National Institute of Hydrology, Roorkee **NIH-DHAARA** platform (Design Hydrology and Advanced Rainfall Analysis, nihdhaara.in). Use its IDF / frequency tools for the site's coordinates, for each duration and AEP required by Clause 2.4. In Punjab 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.

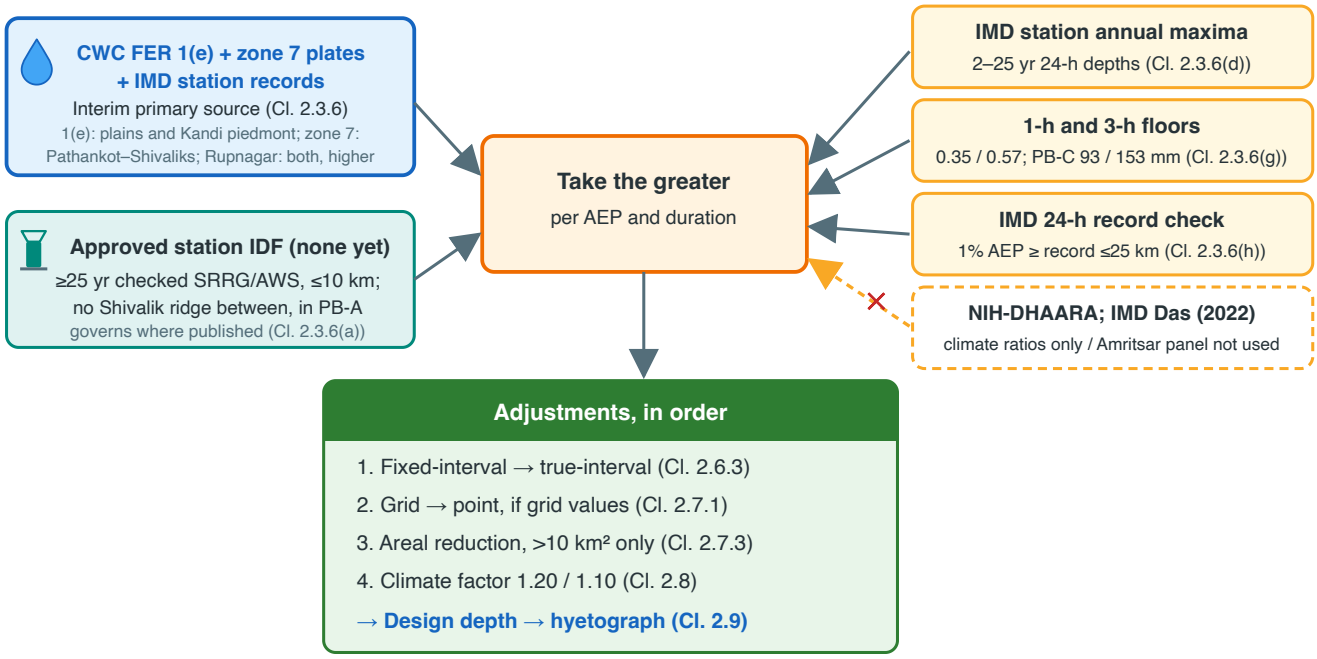
2.3.3 **Cross-checks (mandatory, not alternatives).** The designer shall report, but need not adopt, the following values for comparison:

- (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 plains and the Kandi piedmont up to the Shivalik front, or zone 7 (Western Himalayas), in Pathankot, Dhar Kalan, Sujanpur, Talwara, Nangal, Anandpur Sahib and the Shivalik hills of Hoshiarpur, Nawanshahr, Rupnagar and SAS Nagar, as applicable.

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



Punjab (Cl. 2.3.6): no station IDF yet; FER plates × ratios by report; 24-h record check; short-storm floors statewide and in PB-C.

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

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station and in the same sub-area of Annex 2A, for the durations and AEPs it covers, in place of (f), and subject to the floors of (g); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e) and (h), and the CWC floor of Clause 2.3.3 still applies. A record is checked when its annual totals and annual maxima have been compared with the IMD normals and station extremes for the station, and every year that disagrees has been explained or removed. An IDF derived from daily data by the one-third rule (Clause 2.6.4) or by any other fixed ratio is not a station IDF. In Punjab 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), and in sub-area PB-A the gauge shall not be separated from the site by a Shivalik ridge (set by this Manual, because the Shivalik front catches rain that the land on either side of it does not: the district normal of 1901–1980 was 1,106.1 mm in Gurdaspur, which then included the Pathankot hills, and 703.0 mm in Jullundur (IMD, *Climate of Punjab*)). No IDF has yet been published in Annex 2B, and no station IDF with constants was found for any town in the State: the panel for Amritsar in IMD Das et al. (2022) is not station data (m); the study of the Saleran watershed in the Kandi (PAU) rests on ten years of recording-gauge charts, 1987–1996, and its constants were not obtained, so it is not a station IDF [TBC]; and no IDF constants were found from PAU, Thapar Institute, PEC, IIT Ropar, NIT Jalandhar or Guru Nanak Dev University [TBC]. The first data request of this Manual is for the IMD recording-gauge and automatic weather station annual maxima and return-period tables of Ludhiana(A), 42099, Ludhiana PAU, 06203, Patiala, 42101, Amritsar(A), 42071, Ferozepore, 42096, Kapurthala, 42074, Bhatinda, 42097, and Chandigarh, 42105 (for SAS Nagar), with Halwara, Adampur and Pathankot; for the series of the three recording gauges of the zone-7 report in the State, at Madhopur, Patiala and Hoshiarpur; for the records of the PAU observatories at Ludhiana, Ballowal Saunkhri and Bathinda; and for the hourly data of 8–10 July 2023 (Ropar, Nangal, Balachaur and Rajpura), 1–3 September 2025 (Mohali, Ludhiana, Amritsar and Jalandhar), 11 July 1993 (Patiala) and 24 September 1988 (Ludhiana PAU). The years of recording-gauge and automatic weather station data held at each are to be confirmed [TBC].

- (b) **Reports, zone and sub-area.** Two CWC reports cover the State. The report for subzone 1(e), Upper Indo-Ganga Plains (1984, approved at the 40th meeting of the Planning and Co-ordination Committee), states that the subzone "covers almost entire Haryana and Punjab", names Amritsar and Ferozepur among its towns, and notes that "The plains in the Punjab State are flat with the exception of Hoshiarpur tract where the general elevation varies between 300 m to 400 m"; it covers the plains and the Kandi piedmont up to the Shivalik front. The report for zone 7, Western Himalayas (WH/22/1994), names Punjab among its States, includes "parts of Punjab", drew ordinary rain-gauge data from five districts of the State and recording-gauge data from three, and marks Gurdaspur, Hoshiarpur and Rupar as partly and Jullundar and Patiala as wholly outside the zone (CWC, zone 7, Annex 4.3). On Plate 9 of the 1(e) report the line between the two reports, read by eye to about ±5–10 km, leaves the international border at Dera Baba Nanak, passes about 15 km north of Gurdaspur and north of Mukerian and Dasuya, runs about 0.25° north-east of Hoshiarpur and along the Shivalik front past Garhshankar and Balachaur, which lie on the 1(e) side, passes between Anandpur Sahib and Nangal, on the zone-7 side, and Rupnagar, which lies on the line, marginally on the 1(e) side, and then runs north-east of Chandigarh and Mohali, keeping Kharar, Mohali and Zirakpur in 1(e). The 1(e) report is therefore used everywhere in the State except in the zone-7 part of sub-area PB-A, Pathankot, Dhar Kalan, Sujanpur, Talwara, Nangal, Anandpur Sahib and the Shivalik hills of Hoshiarpur, Nawanshahr, Rupnagar and SAS Nagar, where the zone-7 report is used. At Rupnagar, on the line, both reports are read at every AEP and duration and the higher depth governs (set by this Manual). For a Kandi choe of 25 km² or more that rises in the Shivaliks, such as the choes of Hoshiarpur, the Siswan, the Jayanti Devi ki Rao, the Patiali-ki-Rao, the N-Choe, the Sukhna Choe and the Lakhnaur choe, the zone-7 report is also run as a

sensitivity check under Chapter 3 and the higher result is reported, under (i). Subzones 1(a) and 1(f) are not used: 1(f) does not reach Punjab, and Fazilka (74.03°E) and Abohar (74.20°E) lie just inside 1(e) near its line with 1(a); any sliver of the far south-west that lies beyond that line is read as 1(e) (set by this Manual). The lines are to be confirmed on the reports' index maps [TBC]. The rainfall zone and sub-area of the site are those of Annex 2A: zone **PB-Z1 Shivalik–Kandi**, with sub-area **PB-A Shivalik foothills and Kandi (Pathankot–Talwara–Hoshiarpur–Garhshankar–Nangal–Anandpur Sahib–Rupnagar–Mullanpur)**; zone **PB-Z2 Northern and central plains**, with sub-areas **PB-B Majha–Doaba north (Gurdaspur–Batala–Jalandhar–Kapurthala–Phagwara–Nawanshahr)** and **PB-C Central Sutlej–Ghaggar belt (Ludhiana–Khanna–SAS Nagar–Zirakpur–Rajpura–Patiala–Fatehgarh Sahib)**; zone **PB-Z3 Western and Malwa plains**, with sub-areas **PB-D Majha west and the border (Amritsar–Tarn Taran–Patti–Ferozepur–Zira)** and **PB-E Malwa centre (Sangrur–Barnala–Malerkotla–Moga–Mansa)**; and zone **PB-Z4 South-west**, with sub-area **PB-F South-west sands, waterlogging and salinity (Bathinda–Sri Muktsar Sahib–Malout–Fazilka–Abohar–Faridkot)**. They fix the ratios of (f), the floors of (g) and the rule of (i); the plate value at the site governs the depth. A catchment that crosses the line between two reports, zones or sub-areas takes, at every duration, the higher value of the two (set by this Manual). The town lists of Annex 2A are a guide, and their boundaries are to be confirmed [TBC]. The Union Territory of Chandigarh lies outside Annex 2A and is covered by Supplement S01; its choes enter sub-area PB-C.

- (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, the 50- and 100-year isopluvial maps, of the report that covers the site under (b), whatever the catchment area. Where the site lies between two contours, the higher contour value is used; where it lies inside a closed high, a closed contour with no higher contour within it, the value is that contour plus one contour interval (40 mm); where it lies inside a closed low, a closed contour whose value is lower than the contours outside it, the value is the enclosing contour, never lower; and where the plate cannot be read at the site, the highest contour legible within 25 km of the site is used until the plate has been read for it [TBC] (all set by this Manual). The rule for a closed low is added for Punjab because the 1(e) plates draw a closed 160 mm cell over Bathinda, with a spot of 148 mm inside it, which the rule takes as **160 mm** at 50 years, and a closed loop round Jalandhar on the low side of the "240 arm", which it takes as **200 mm** (a reading of low confidence [TBC]). Plates are read by the coordinates of the site, not by the town labels; bridge numbers printed beside crosses on the plates are not rainfall values; every reading is by eye to about one contour on a scan, and is recorded on Form 2-1 with the contours on either side. In the zone-7 part of PB-A the 50-year value is read from Plate 9 of the zone-7 report; its Plate 10 is misregistered by about 0.1–0.2° on the copy used for this Manual and is not read, and the 100-year value there is the Plate 9 value plus one contour interval until Plate 10 has been re-registered [TBC] (set by this Manual). For orientation only, the 50-year and 100-year plates of the 1(e) report give about 255–262 mm and 280–289 mm at Mohali, Kharar and Zirakpur, next to the spots of 262 mm and 289 mm at Chandigarh; a spot of 263 mm at Hoshiarpur at 50 years and about 280–292 mm at 100 years (the zone-7 plate reads about 280–320 mm there); about 240–260 mm and 280 mm at Rupnagar, on the line; about 240–255 mm and 240–280 mm at Ludhiana, inside a central cell bounded by the 240 mm line; about 240 mm and 260 mm at Patiala and Rajpura; about 240–260 mm and 240–292 mm at Gurdaspur, Batala and Kapurthala; about 220 mm (200–240 mm) and 240 mm at Amritsar, Tarn Taran and Ferozepur; about 220–240 mm and 240 mm at Sangrur and Sunam; about 200–240 mm at Moga at both return periods (low confidence); about 200 mm and 220–240 mm at Jalandhar (low confidence); about 160–180 mm and 180–200 mm at Fazilka and Sri Muktsar Sahib; about 160–200 mm and 180–200 mm at Mansa (low confidence); and 160 mm and about 180 mm at Bathinda and Abohar, by the rule above. Plate 9 of the zone-7 report gives about 320 mm at Pathankot and Dhar Kalan, on a poorly registered scan, and about 280 mm at Nangal and Anandpur Sahib. The worked example of the 1(e) report, the Ghaggar at road bridge No. 2 on the Punjab–Haryana border (1,126 km²), reads 25.0 cm at 50 years and gives a 50-year peak of 2,706 m³/s, about 2.40 m³/s/km². The long-record gauges of the State exceed the plates (h). Where the Gumbel estimate of (d) for the station of the site is higher for the same AEP, it governs; the 24-hour depth is then checked under (h).

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr).** The 1(e) 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, with 30 or more years of daily record, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3. The station is, for example, Ludhiana(A), 42099 (daily record 1901–2012), for Ludhiana, Khanna and Samrala, with Ludhiana PAU, 06203 (1966–2011), as a check; Patiala, 42101 (1901–2012),

for Patiala, Rajpura and Nabha; Amritsar(A), 42071 (1948–2011), for Amritsar and Tarn Taran; Ferozepore, 42096 (1950–2012), for Ferozepur and Zira; Kapurthala, 42074 (1972–2012), for Kapurthala, Jalandhar and Phagwara; and Chandigarh, 42105 (1954–2009), for SAS Nagar, Zirakpur and Kharar (IMD). Bhatinda, 42097 (1959–1982), has fewer than 30 years and is used only as a check. No IMD station with 30 years of record was found in the tables read for Bathinda, Sri Muktsar Sahib, Fazilka, Mansa, Moga, Sangrur, Hoshiarpur, Pathankot or Gurdaspur [TBC]; there the depth is the higher of the estimate at the nearest qualifying station and the value of the plate. 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 its final value [TBC]. No Gumbel fit to the annual maxima of any station in the State was found for this Manual [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, as checked under (h).

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

    - in sub-areas **PB-B** to **PB-F** and in the 1(e) part of **PB-A**, the Kandi piedmont, the 50-year ratios of the 1(e) report: 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; and
    - in the zone-7 part of **PB-A**, the ratios of the zone-7 report, derived from the 10-year partial-duration depths of the recording gauges of the zone: 0.425 at 1 hour, 0.600 at 3 hours, 0.725 at 6 hours, 0.790 at 9 hours, 0.845 at 12 hours, 0.895 at 15 hours and 0.935 at 18 hours; at Rupnagar both sets are applied, each to its own report's plate, and the higher depth governs.

  The zone-7 ratios are those that the Himachal Pradesh edition of this Manual uses for the same Shivalik front across the Chakki and the Swan, and at Pathankot they give about 136 mm in 1 hour at 50 years. The alternative, to use 0.34 at Pathankot because the Madhopur recording gauge recorded 100 mm in its largest hour and 329 mm in its largest 24 hours, a ratio of 0.30 (CWC, zone 7, Annex 4.4), is rejected: the largest hour fell on 16 September 1975, between 19 and 20 hours, and the largest day on 23–24 July 1974, so 0.30 is the ratio of two different storms, not the ratio of an event, and the 100 mm hour itself lies below the product of the zone-7 ratio. Where a station IDF governs in the zone-7 part of PB-A under (a), its 1-hour depth for every AEP shall be not less than 0.34 times the 24-hour depth of (c) or (d) for the same AEP (set by this Manual), because a fit to a short record at the wet front may otherwise fall below the ratio of either report. Between the tabulated durations the ratio is interpolated on logarithmic axes; the 2-hour ratio of zone 7, which the report does not give, is interpolated in the same way. The 1-, 2- and 3-hour depths are then subject to (g).

- (g) **Short storms: floors at 1 and 3 hours.** For the 10% AEP (10-yr) and rarer storms (all set by this Manual):

    - (i) **Statewide.** The 1-hour and 3-hour depths shall be not less than 0.35 times (1 hour) and 0.57 times (3 hours) the 24-hour depth of (c) or (d) for the same AEP, before the check of (h). The 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). No frequency ratio has been published for a gauge in Punjab, but the State's own recording gauges point the same way: the largest hour of the Patiala gauge was 0.44 of its largest day and that of the Hoshiarpur gauge 0.59, as single events (CWC, zone 7, Annex 4.4), against 0.34 in the 1(e) report, which is evidence that 0.34 is low on the plains.
    - (ii) **Sub-area PB-C Central Sutlej–Ghaggar belt.** At a site in PB-C, or in a catchment that crosses its boundary, the 2% AEP (50-yr) 1-hour depth shall be not less than **93 mm** and the 3-hour depth not less than **153 mm**. For the other AEPs of 10% and rarer, each is scaled by the ratio of the site's 24-hour depth for that AEP to its 24-hour depth for the 2% AEP, both before the check of (h), and is never less than the floor of (i). The two depths are the largest hour and the largest 3 hours of the Patiala recording gauge, 93 mm between 10 and 11 hours on 21 July 1982 and 153 mm (CWC, zone 7, Annex 4.4); they exceed the products of the plate and the 1(e) ratios at Patiala, about 82 mm and 134 mm, and are taken as 50-year

depths because the gauge's record length is not printed [TBC] and the floor is meant to stop the design depth from falling below an hour already recorded in the belt, not to set a frequency curve. Patiala lies in the belt of Ludhiana, SAS Nagar and Patiala that shares the central cell of the plates, which is why the floor is applied across PB-C.

Where a floor of this paragraph governs the 1-hour or 3-hour depth, the 2-hour depth shall be not less than the value interpolated on logarithmic axes between the 1-hour and 3-hour depths for the same AEP. No absolute floor in millimetres is set in sub-areas PB-A, PB-B, PB-D, PB-E or PB-F, because no hourly record above the products of (f) has been documented there: the largest hour of the Hoshiarpur recording gauge, 81 mm on 5 August 1982, is below the screening value of about 89 mm for Hoshiarpur, and the 100 mm of Madhopur below the zone-7 product at Pathankot; a fall of 74.5 mm in 3 hours at Mohali is known only from a press report without a date and is not used. 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, to be revisited when Annex 2B publishes frequency analyses of the recording-gauge and automatic weather station records of the stations of (a): if any shows 1- or 3-hour depths above those of (f) and (g) for a sub-area, a floor shall be set or raised for it; if together they show depths well below them, a reduction may be proposed to the State Stormwater Technical Committee.

- (h) **24-hour record check.** The 1% AEP (100-yr) 24-hour depth of (c) or (d) shall be not less than the highest qualifying 24-hour rainfall recorded at any station or district rain gauge within 25 km of the site, where that record is higher; the record is used as printed, without the fixed-interval factor, and is treated as a 1% AEP depth; the 2% AEP (50-yr) 24-hour depth is then not less than the 1% AEP depth so raised less one contour interval of the plates, 40 mm (all set by this Manual). A record qualifies only when it is printed by IMD (in *Extremes of Temperature and Rainfall for Indian Stations*, in *Climate of Punjab*, in a monthly climate summary, or in an IMD press release that names the gauge and the day) or in Annex 4.3 of the zone-7 report; the number of years of data at its gauge is confirmed by an IMD table as at least 20; it was made in 1901 or later, or IMD has confirmed that the gauge that made it stood where the present gauge stands and was read in the same way; it falls in a month in which a fall of that size is plausible for the station; the location of its gauge is known; and it is not contradicted by another IMD table for the same gauge. A record that fails any test is excluded until IMD confirms what it lacks (set by this Manual). In Punjab IMD's tables give the periods of record, so records count. *Climate of Punjab* (IMD, 1993) prints the years of data of each district gauge with its heaviest fall to 1980, and was read for this Manual on its page images; a gauge named for a village is placed at the village of that name in its district of 1980 until IMD's station list fixes it [TBC] (set by this Manual). The outcomes, which the designer reports on Form 2-1, are:

    - **Ludhiana(A), 42099**: 354.3 mm on 4 October 1955 (daily record 1901–2012; the observatory's 80 years in *Climate of Punjab*). The 1% AEP depth within 25 km of the gauge is not less than 354.3 mm and the 2% AEP depth not less than 314.3 mm, against plate values of about 240–280 mm and 240–255 mm. Ludhiana PAU's 338.0 mm (24 September 1988) and the 73-year Ludhiana gauge's 289.6 mm (4 October 1955) also count and are lower.
    - **Jagraon**: 433.6 mm on 18 September 1950 (73 years). The 1% AEP depth within 25 km of Jagraon is not less than 433.6 mm, and the 2% AEP depth not less than 393.6 mm. Halwara Aero's own 249.4 mm (5 July 1967, 22 years) counts and is lower.
    - **Patiala, 42101**: 356.5 mm on 11 July 1993 (1901–2012). The 1% AEP depth within 25 km is not less than 356.5 mm and the 2% AEP depth not less than 316.5 mm, against about 260 mm and 240 mm.
    - **Chandigarh, 42105**: 302.2 mm on 9 July 2023 (IMD, Monthly Climate Summary, July 2023; the previous July record was 262 mm). The 1% AEP depth at SAS Nagar, Zirakpur and Kharar within 25 km of the gauge is not less than 302.2 mm and the 2% AEP depth not less than 262.2 mm, against plate values of about 280–289 mm and 255–262 mm; IMD's final value is to be confirmed, and figures of 322.2 mm and 290.9 mm in the press conflict with it [TBC].
    - **Rupnagar**: 310.4 mm on 30 July 1951 (69 years). The 1% AEP depth within 25 km is not less than 310.4 mm, against about 280 mm.
    - **Garhshankar**: 470.0 mm on 31 July 1976 (72 years). The 1% AEP depth within 25 km is not less than 470.0 mm and the 2% AEP depth not less than 430.0 mm.

- **Gurdaspur district**: Aliwal 495.3 mm (63 years), Batala 474.5 mm (73 years; 475 mm in the zone-7 annex) and Gurdaspur 370.3 mm (73 years), all on 5 October 1955, and Tibri 385.6 mm on 4 September 1950 (72 years). Within 25 km of Aliwal the 1% AEP depth is not less than 495.3 mm and the 2% AEP depth not less than 455.3 mm, about 70% above a 100-year plate value of about 280–292 mm: the largest change that any record makes in this edition.
- **Pathankot**: Pathankot Aero observatory 355.0 mm on 14 July 1980 (23 years), Madhopur 351.0 mm on 5 October 1955 (71 years) and Malikpur 298.4 mm on 20 August 1963 (23 years). They raise the 1% AEP depth only where the zone-7 reading at the site, under (c), is lower; on a reading of about 320 mm at 50 years, the rule of (c) gives about 360 mm at 100 years, and they raise nothing.
- **Amritsar(A), 42071**: 308.4 mm on 22 September 1962 (the aerodrome's 30 years; 1948–2011). The 1% AEP depth within 25 km is not less than 308.4 mm and the 2% AEP depth not less than 268.4 mm, against about 240 mm and 220 mm. In the same district, Khara recorded 457.2 mm and Raya 367.0 mm on 5 October 1955 (64 years each), which set the depths within 25 km of those gauges.
- **Kapurthala, 42074**: 284.2 mm on 24 September 1988 (1972–2012). The 1% AEP depth within 25 km is not less than 284.2 mm where the plate is lower, which takes in Jalandhar, about 19 km from the gauge (to be checked by coordinates [TBC]), and the 2% AEP depth not less than 244.2 mm, against about 200 mm at Jalandhar.
- **Moga**: 335.0 mm on 5 October 1955 (73 years). The 1% AEP depth within 25 km is not less than 335.0 mm and the 2% AEP depth not less than 295.0 mm, against about 200–240 mm.
- **Ferozepur district**: Zira 301.7 mm on 17 September 1950 (73 years; the year is misprinted as "950" in the table and corrected in the book's list of errata) and Ferozpur Sadar 282.7 mm on 18 August 1964 (73 years). They set the depths within 25 km of those gauges, against about 240 mm at 100 years. Ferozepore, 42096, 240.0 mm on 1 August 1976 (1950–2012), lies at the plate and raises nothing.
- **Bhatinda**: the rain gauge's 256.1 mm on 18 August 1964 (25 years). The 1% AEP depth within 25 km is not less than 256.1 mm and the 2% AEP depth not less than 216.1 mm, against 180 mm and 160 mm. The observatory recorded 181.4 mm on the same day (14 years; IMD station 42097, 1959–1982); the two are different gauges and both stand.
- **Sangrur district**: Bandhar 266.7 mm (69 years) and Bharala 275.6 mm (33 years), both on 26 September 1945, set the depths within 25 km of those gauges, against about 240 mm at 100 years.

Excluded because the gauge's record is shorter than 20 years: Jawahrke 377.2 mm (4 October 1955; 18 years), Mansa 332.7 mm (4 October 1955; 19 years), the Kapurthala district gauge's 339.1 mm (5 October 1955; 13 years; not the IMD station of 1972–2012), Balad 331.1 mm (12 September 1958; 16 years; the name is as printed), Lad Banjara 330.2 mm (28 September 1958; 15 years), Ramnagar 279.4 mm (4 October 1955; 19 years), and Rohti 538.5 mm (28 September 1958; 15 years; a year of 313% of normal at the gauge). Excluded pending confirmation [TBC]: **Ropar 350 mm in the 24 hours to 08:30 on 10 July 2023**, printed in an IMD press release in whole centimetres, above the Rupnagar record of 310.4 mm, but not called a record by IMD, and from a gauge whose identity with the 69-year Rupnagar gauge and whose years of data are not in an IMD table read for this Manual; it is reported on Form 2-1 beside the design depth as the stress case at Rupnagar for sub-areas PB-A and PB-C, and once IMD confirms the gauge it raises the 1% AEP depth within 25 km of Rupnagar to 350 mm; Nangal's 280 mm in the 24 hours to 08:30 on 9 July 2023, which lies at the zone-7 plate in any case; and the 329 mm of the Madhopur recording gauge (23–24 July 1974), whose record length is not printed and which is below the 351.0 mm of the Madhopur daily gauge in any case. Excluded because made before 1901, unless IMD confirms the continuity of the gauge: Amritsar 396.2 mm (10 July 1881), Hoshiarpur 360.7 mm (19 August 1878), Jullundur 304.8 mm (18 August 1878), Pathankot 294.1 mm (19 June 1894), Nakodar 287.0 mm (1880), Samrala 283.5 mm (6 September 1892), Dasuya 278.6 mm (19 June 1894), Kharar 261.6 mm (20 September 1888) and Tarn Taran 258.3 mm (19 June 1894). Until Annex 2A is published, the designer lists on Form 2-1 every record within 25 km of the site, with the tests it passes or fails. The check raises the 24-hour depth and, through (e), the 48- and 72-hour depths, in every sub-area. It does not raise the depths of (f) and (g) for 1 to 18 hours, because the records are daily totals, the storm of 4–5 October 1955 that set most of them was a long rain after the monsoon had withdrawn, and no hourly record of any of them exists. The check is made because the plates of 1984 are exceeded at most of the State's long-record gauges, and because the largest days at Ludhiana PAU (1988), Patiala (1993) and Ropar (2023) came after the plates were drawn (commentary).

- (i) **Kandi and Shivalik catchments.** For a catchment in sub-area PB-A, and for a choe that rises in the Shivaliks wherever it runs, the 24-hour depth is the larger of the plate value of (c), from the 1(e) report or, beyond the line, the zone-7 report, and a station fit under (d) whose series includes the storms of 31 July 1976 (Garhshankar), 9–10 July 2023 (Ropar, Nangal, Balachaur and Ballowal Saunkhri) and August–September 2025, once IMD supplies them [TBC]. For the rural inflow of a choe of 25 km² or more, the zone-7 report is run as a sensitivity check under (b) and the higher result is reported, and the 1(e) report's "suitable increase" for "foothill catchments (steep slopes)" is applied to its unit hydrograph (Chapter 3). The choes carry sand and boulders and leave "thick deposits of sand and silt" where they leave the hills (Hoshiarpur District Environment Plan), so a sand-bulking allowance and erosion-resistant inverts at choe crossings are required by Clause 6.3.6, which sets their values; and a choe bed is treated as the receiving system, with the setbacks of Chapter 7, not as a drain to be narrowed. No cloudburst rule is set for the hill towns of PB-A: no gauge in the State is known to have recorded more than 100 mm in an hour, and the Madhopur recording gauge's 100 mm (16 September 1975) equals the threshold that IMD is quoted as using (CWC, zone 7, Annex 4.4; as quoted).

- (j) **Durations below 1 hour.** No sub-hourly frequency analysis for any station in the State was found in research for this Manual. Until Annex 2B gives one, the ratio of the depth for a duration below 1 hour to the 1-hour design depth is agreed with the Authority, from a published recording-gauge analysis whose source is stated, and recorded on Form 2-1 [TBC]; the average intensity for a duration below 1 hour shall be not less than the 1-hour design intensity for the same AEP (set by this Manual). The Saleran study of the Kandi gives 10-minute intensities of 90–150 mm/h and 60-minute intensities of 37–80 mm/h at 5–25 years, from ten years of charts (Gill, Bhardwaj & Satpute, 2023, abstract only); it may be reported on Form 2-1 for comparison in PB-A. The storms of the State are front-loaded: the 1(e) report puts 58% of a 12-hour storm in its first 2 hours, and the Madhopur gauge recorded 217 mm in 3 hours of its 329 mm day of 23–24 July 1974 (CWC).

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

- (l) **NIH-DHAARA.** Its present-day values at the site may be reported on Form 2-1 beside the interim values, for comparison only and flagged as such; they are never a design value, a check or a floor in the State, because they err in both directions by more than in any other edition of the series (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.

- (m) **IMD Das et al. (2022).** The paper's only panel in the State, for Amritsar, repeats the curve that it prints for a dozen other cities, about 60–109 mm/h at 1 hour for 2–100 years. For Amritsar that curve implies a 2-year day of about 170 mm, 28% of the district's annual normal of 598.7 mm, against a 2-year depth of 83 mm in NIH-DHAARA's cell, and a 100-year day of about 370 mm, above the station's record of 308.4 mm in 1948–2011 and the plate's 240 mm. The paper has no panel for Ludhiana, Patiala, Bathinda, Jalandhar, Pathankot or Chandigarh. 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: its 24-hour upper bound is below the records of Aliwal (495.3 mm), Batala (474.5 mm), Garhshankar (470.0 mm), Khara (457.2 mm) and Jagraon (433.6 mm).

- (n) **Earlier design values.** The figures found for the State are not a design source. The Amritsar Smart City bid for the trunk storm sewers of the walled city adopted "a return period of once in two years", a "Minimum time of concentration … 15 mins", and surcharge "inside the manhole … (without flooding)" (Amritsar Smart City Ltd, bid No. 07/ASCL/2018-19, 2018); the feasibility report for the Buddha Nallah states that "Proposed design of the Nallah is carried out considering 2 year return period with reduced run-off within the city reach due to active storm water detention" (PMIDC, 2020), and no design discharge for the channel was found; WRD sized the rooftop rainwater harvesting of government buildings for 40 mm/h, with runoff coefficients of 0.8–0.9 for roofs, 0.6–0.7 for paved areas and 0.1–0.2 for green areas, a figure for recharge structures and not a drain design storm (WRD, undated); WRD defines floodplains by a 100-year discharge computed by Gumbel's method and a waterway by Lacey's formula, and used a 100-year discharge of 5,34,441 cusecs for the Sutlej in Ferozepur and Tarn Taran (WRD, replies to the NGT, 2024); and the 1(e) report's worked example gives the Ghaggar at the border about 2.40 m³/s/km² at 50 years. Under AMRUT no storm-water drainage work was done in the State to

September 2020 (CAG, Report No. 7 of 2021), and no State or urban local body standard for storm drains was found. A student study at Patiala used runoff coefficients for a 2-year storm from the literature (Bedi, 2013); it is not a norm. The return periods of Table 2.1 and the depths of this clause apply instead; the 2-year choices are design values of single projects, not State standards, and are cited, with the others, as the history of practice.

- (o) **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 Punjab 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 by more than in any other State of the series. Its 50-year 24-hour depths are above the CWC plates on the Shivalik front, 443 mm at Pathankot, against about 320 mm on the zone-7 plate, 341 mm at Gurdaspur and 300–307 mm at Hoshiarpur, Rupnagar and Nangal, and far below the plates and the station records in the south-west: 126 mm at Bathinda, against a plate value of 160 mm and a record of 256.1 mm; 123 mm at Mansa; 146 mm at Firozpur; and 104–116 mm at Abohar, Fazilka and Sri Muktsar Sahib, against about 160–180 mm. Its 50-year 1-hour depths, 39–105 mm, are 0.24–0.39 of its 24-hour depths (NIH-DHAARA, queried 13 Nov 2026; IMD; CWC). A source that errs by these margins cannot be adopted, so Clause 2.3.6 uses the two CWC reports and the long IMD station records until Annex 2A has been done, and uses NIH-DHAARA only for the ratio of its projected to its present-day depths. Three things set Punjab's interim source apart. First, two reports cover the State: the plains and the Kandi piedmont lie in subzone 1(e), whose unit hydrograph was partly fitted on Punjab streams, among them the White Bein, the Sunam Choe, the Patti Nalla and the Siswan and Sughrao on the Sirhind–Nangal line, and Pathankot and the Shivalik hills lie in zone 7, whose ratios the Himachal Pradesh edition uses on the same front; the line between them runs past Rupnagar, which reads both. Second, the records exceed the plates over most of the State. The storm of 4–5 October 1955, after the monsoon had withdrawn, put a single day above the 100-year plate on ten or more gauges at once across Majha, Doaba and central Malwa, among them Aliwal 495.3 mm, Batala 474.5 mm, Khara 457.2 mm, Gurdaspur 370.3 mm, Raya 367.0 mm, Ludhiana 354.3 mm, Madhopur 351.0 mm and Moga 335.0 mm; Jagraon recorded 433.6 mm in September 1950, Garhshankar 470.0 mm in July 1976 and Patiala 356.5 mm in July 1993; and three of the largest days, at Ludhiana PAU (1988), Patiala (1993) and Ropar (2023), came after the plates of 1984 were drawn (IMD; CWC). Clause 2.3.6(h) answers that with a check rather than a new statistic, as the series does elsewhere. Because *Climate of Punjab* prints the years of data of every district gauge, the check's test of record length could be applied here, unlike in the hill States, and most of the large falls pass it: the check is the largest correction that the interim source makes to the plates in the State, raising the 100-year depth by about 70% within 25 km of Aliwal and by roughly a quarter to four-fifths at Ludhiana, Jagraon, Patiala, Garhshankar, Moga and Bathinda. Its test of length keeps out gauges of fewer than 20 years, among them Jawahrke, Mansa and Rohti, whose falls of 1955 and 1958 would otherwise set the depth of whole districts. The check stops at 24 hours, because a record day says nothing about its peak hour. Third, the short storms of the plains are not well represented by the 1(e) ratios: the Patiala recording gauge recorded 93 mm in an hour on 21 July 1982, and 153 mm in 3 hours, more than the plate and the ratios give Patiala for a 50-year storm, which is why Clause 2.3.6(g) sets a ratio floor across the State and, in PB-C, the absolute floors that the gauge supports. The design figures found for the State are the history of practice, not a design basis: the 2-year storms of the Amritsar walled-city sewers and of the Buddha Nallah are choices of single projects, and WRD's 40 mm/h sizes recharge structures, not drains (Clause 2.3.6(n)). The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the report and sub-area of each town, the ratios of the zone-7 part of PB-A, the floors, the record check, the Kandi rule and durations below 1 hour are set by this Manual. Several points are unresolved. The plate values were read by eye on scans, to about one contour; the readings at Jalandhar, Moga and Mansa are of low confidence, the spots near Dhuri and Rajpura are illegible, the zone-7 Plate 10 is misregistered at Pathankot, and the line between the two reports at Gurdaspur, Mukerian, Anandpur Sahib and Rupnagar, and the meeting of

subzones 1(a) and 1(e) at the Fazilka border, are to be read on the reports' index maps [TBC]. The record length of the Patiala recording gauge, on which the floors of PB-C rest, is not printed in the zone-7 report [TBC]. The village gauges of *Climate of Punjab*, among them Aliwal, Khara, Raya, Tibri, Malikpur, Bandhar and Bharala, are to be located from IMD's station list [TBC]; the gauge that recorded 350 mm at Ropar on 10 July 2023 is to be identified, and its record confirmed, before it counts [TBC]; and Chandigarh's 302.2 mm of 9 July 2023 is IMD's real-time value, against 322.2 mm and 290.9 mm in the press [TBC]. The June 1986 monthly total of 431.8 mm printed for Bhatinda in IMD's station extremes falls outside the station's record of 1959–1982 and is not relied on [TBC]. Digitised plates of both reports, from CWC and IMD, are the first request after the station data of Clause 2.3.6(a).

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: Ludhiana, Amritsar, Jalandhar, Patiala and SAS Nagar (Mohali) 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. Punjab's worst floods have come from long wet spells and multi-day storms on ground and rivers already full. In October 1955 Ludhiana received 587.5 mm in the month, with 354.3 mm on the 4th, and the storm of 4–5 October put more than 330 mm in a day on ten or more gauges at once across Majha, Doaba and central Malwa, after the monsoon had withdrawn (IMD); the draft State plan records the largest flood damage to houses, 6,27,000, in that year (draft SDMP). In September 1988 Ludhiana PAU received 668.5 mm and Kapurthala 591.4 mm in the month, with 338.0 mm and 284.2 mm on the 24th (IMD), while Bhakra stood at 1,685 ft and the Ropar headworks passed 2.4 lakh cusecs (as reported). In July 1993 Patiala recorded 356.5 mm on the 11th (IMD), and Mansa and Sangrur were flooded by "congested" drainage (as reported). On 8–10 July 2023 the Ropar gauge recorded 27 cm and then 35 cm in successive 24-hour readings, and Nangal 28 cm, Balachaur and Ballowal Saunkri 27 cm and Rajpura 26 cm (IMD press releases); the Ghaggar stood above its danger mark at Khanauri for days and breached in Sangrur and Mansa (as reported), and Pong received a record inflow of 7.3 lakh cusecs a month later, on 14 August (as reported). The 2025 season was 41% above normal, 621.8 mm against 439.8 mm (ICAR-CRIDA), and the Ravi, the Beas, the Sutlej and the Ghaggar flooded together in August and September. Where the outfall is held up behind a flap gate in a dhussi bandh, 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 Punjab recording gauges. They shall not be lower than the ratios of the CWC Flood Estimation Report for subzone 1(e) in the plains and the Kandi piedmont, or for zone 7 (Western Himalayas) in Pathankot and the other towns of the Shivalik fringe that lie in that zone, and the short-storm floors of Clause 2.3.6 apply over them. The IMD Das et al. (2022) Amritsar panel repeats a generic curve and is not used.

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

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

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

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

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

2.7 Point, grid and areal rainfall

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

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

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

- for 25–5,000 km² in subzone 1(e) or zone 7 (Western Himalayas): use the ARF curves of the applicable CWC Flood Estimation Report;
- for 10–25 km²: interpolate linearly between ARF = 1.0 at 10 km² and the CWC value at 25 km².

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

> **Commentary.** Gridded and district-average return levels are much lower than point values. For example, NIH-DHAARA's IMDAA cell at Bathinda (about 12 km) gives a 50-year 24-hour depth of 126 mm, while the Bhatinda rain gauge recorded 256.1 mm on 18 August 1964, and the cell at Ludhiana gives 211 mm, while the Ludhiana observatory recorded 354.3 mm on 4 October 1955 (NIH-DHAARA, queried 13 Nov 2026; IMD). On the Shivalik front the error runs the other way: the cell at Pathankot gives 443 mm, against about 320 mm on the CWC zone-7 plate. 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 Punjab. The State's action plan projects annual rainfall rising by 5.4–12.5% under RCP4.5 and 9.8–12.8% under RCP8.5, most in Gurdaspur and Hoshiarpur and least in Mansa, and gives no projection of heavy rainfall (Punjab SAPCC 2.0). The evidence on trends points different ways. The same plan counts days of more than 100 mm per decade, averaged over the stations it lists, as 2.7 in the 1970s, 8.3 in the 1980s, 8.0 in the 1990s, 3.8 in the 2000s and 4.3 in the 2010s, and records "16 years of deficit monsoon rainfall" in 2000–2020 (Punjab SAPCC 2.0); a study of satellite-based rainfall for 1981–2020 finds increasing annual and monsoon rainfall in every tehsil studied except Dhar Kalan (Kumar et al., 2021, seen through a summary [TBC]). Recent extremes have not fallen: Ludhiana PAU (1988), Patiala (1993), Ludhiana (1995) and Ropar (2023) set their largest days after the CWC plates of 1984 were drawn, Pong received its record inflow in August 2023, and the 2025 season was 41% above normal (IMD; ICAR-CRIDA; as reported). In the central plains the larger correction is not the climate factor but the base value: the record check of Clause 2.3.6(h) raises the 100-year 24-hour depth by a quarter or more at Ludhiana, Patiala and Moga and by about 70% near Aliwal, where a factor of 1.10 adds a tenth. NIH-DHAARA offers projected depths, but in the State its present-day values err too widely to be used except as the ratio of projected to present depths under Clause 2.3.6(l). The factors of Table 2.2 are therefore interim values, not Punjab 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.

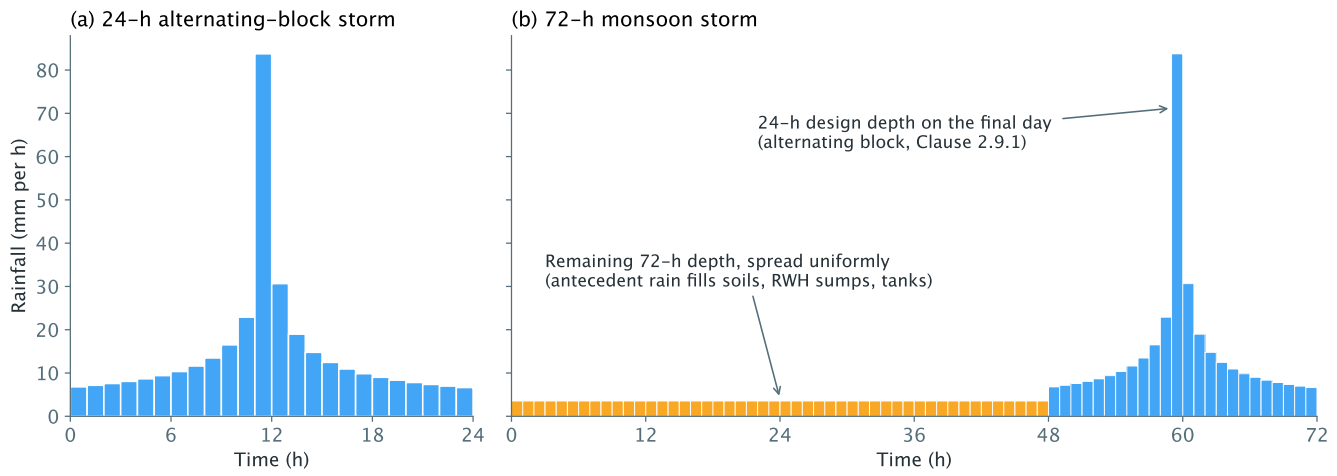


Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour SW monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Punjab 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 Punjab monsoon sequence: by the time the largest falls arrive in July–September and early October, the paddy fields of the plains have stood ponded since June, the water table of the south-west and the Sirowal belt is at its highest, the chhappars are full, and the Sutlej, the Beas, the Ravi and the Ghaggar, fed by rain on the Himalayan and Shivalik catchments above Bhakra, Pong, Ranjit Sagar and Panchkula, may already be holding up the outfalls through the dhussi bandhs. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Punjab 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 the Buddha Nallah at Ludhiana, the Shivalik choes and the Ghaggar at SAS Nagar, Zirakpur and Dera Bassi, the Patiala nadis and the Ghaggar towns of Sangrur and Mansa, the beins of Jalandhar and Kapurthala, the walled city of Amritsar, the Ravi at Pathankot and Gurdaspur, the Kandi towns, the Sutlej at Rupnagar–Nangal and Ferozepur, and the waterlogged south-west, 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 15 June to 30 September in a catchment, or the part of a catchment, under paddy or other ponded fields in sub-areas PB-B to PB-F of Annex 2A, and on the bet (floodplain) land of the Sutlej, the Beas, the Ravi or the Ghaggar anywhere in the State; and from 1 July to 31 October at a site in sub-area PB-F South-west sands, waterlogging and salinity, or in the Sirowal belt of sub-area PB-A Shivalik foothills and Kandi, where the October water table is within 3 m of the surface. At any other site or time, including built-up urban catchments and the Kandi fans of PB-A, 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 Punjab that holds most strongly where the ground is wet before the storm. Paddy is transplanted from 1–9 June (as reported) and its fields stand ponded over most of the plains of sub-areas PB-B to PB-F through the season; the bet lands of the rivers flood when the rivers are high; and in the south-west the water table lay within 1.5 m of the surface over about 1% of the State and within 1.5–5 m over a further 14–17% (June and October), shallowest in October, with 0.53 m at Kot Bhai in Sri Muktsar Sahib district in October 2019 (CGWB and WRD, assessment of 2020). The Sirowal belt at the toe of the Kandi is a seepage zone with a shallow water table (CGWB). By contrast, the water table lay deeper than 10 m over about 68% of the State in June 2019,

and "deep water levels are recorded in Kandi belt" (CGWB and WRD), so built-up catchments and the Kandi fans are not saturated at the start of every storm. This Manual therefore uses AMC III from 15 June to 30 September under paddy and other ponded fields and on the bet lands, from 1 July to 31 October in PB-F and the Sirowal belt where the October water table is within 3 m, and at other sites and times, including built-up urban catchments and the Kandi fans, only after a 5-day total of more than 53 mm, the NRCS growing-season threshold for AMC III (Clause 2.11.4). Paddy bunds are counted as storage only where they are surveyed and maintained. AMC I is not used even on the Kandi gravels and the dune sands of the south-west, because the storms that govern there, such as those of September 1950 and October 1955, 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 a choe in SAS Nagar (Mohali) 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.

Punjab 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 Sutlej, the Beas, the Ravi or the Ghaggar, held behind dhussi bandhs; the WRD drains that receive town drains, such as the Buddha Nallah, the Kala Sanghian drain and the Chitti Bein; the choes of the Kandi; and, for Amritsar, the Tung Dhab and City Outfall drains and the Hudiara drain, which enters Pakistan near Lalo, so that the level at the outfall is set by flows outside Indian control. 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). CWC has no flood-forecasting or level-monitoring site in Punjab (as reported), so no CWC danger level exists for any Punjab river; the levels known are those of the WRD headworks, BBMB and district gauges, mostly in feet and from press reports. Harike counts a discharge above 3,00,000 cusecs as "High Flood", and passed 3,35,030 cusecs at 686.50 ft upstream on 3 September 2025, when Hussainiwala passed 3,02,508 cusecs at 646.50 ft; the Ghaggar at Khanauri reached 753 ft on 13 July and 754.2 ft on 15 July 2023, against a danger mark given as 748 ft, 752 ft and 753 ft in different reports; Pong, whose full reservoir level is 1,390 ft (BBMB is also reported to give 1,394 ft and 1,410 ft as limits), received a record inflow of 7.3 lakh cusecs on 14 August 2023; and the gates of the Madhopur headworks on the Ravi jammed and one washed away on 27–28 August 2025 under a flow reported as less than 2 lakh cusecs (all as reported). Releases from Bhakra, Pong and Ranjit Sagar give hours to days

of warning of the rivers, but none of a local storm. When a river or a receiving drain is high, outfalls through the dhussi bandhs are held up behind flap gates, so storage and pumps are checked for the outfall-closed condition, with the local storm falling before, during or after the high water. No canal, distributary or minor is a receiving system: an outfall to one needs WRD's written consent, and a siphon or culvert under a canal is checked as a control on the flood level upstream (Clause 5.8.5(f)). No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC]; Clause 5.8.5 sets the interim rules for the Sutlej-front towns, the Ghaggar towns, the Ravi and Beas towns, Amritsar, the choes, the canals and the south-west depressions. Every level is stated on a named gauge and datum, with its unit, as Chapter 5 requires; the gauge zeros of the levels quoted here are to be confirmed [TBC].

> Commentary. Punjab has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the stage of the Sutlej, the Beas, the Ravi and the Ghaggar and of the WRD drains that receive the town drains. The coincidence is on record. On 8–10 July 2023 the Ropar gauge recorded 27 cm and then 35 cm in successive 24-hour readings and Chandigarh 30 cm (IMD), the Ropar headworks passed 1.79 lakh cusecs, and within a week the Ghaggar stood at 754.2 ft at Khanauri and had breached at Moonak, Khanauri and Makraud Sahib and in Mansa district (as reported). In September 1988 the rain of the 24th, 338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala (IMD), came while Bhakra stood at 1,685 ft and the Ropar headworks passed 2.4 lakh cusecs (as reported). In August–September 2025 Pong and Ranjit Sagar released heavily, the gates of the Madhopur headworks failed, Harike passed 3,35,030 cusecs and urban flash floods struck Mohali, Ludhiana, Jalandhar and Amritsar in the same days (as reported). Releases from the dams give hours to days of warning of the rivers but none of a local storm, and CWC has no flood site on any river in the State (as reported). At Amritsar the receiving water is the Hudiara drain, whose level is set downstream in Pakistan. The levels of these sources are known in feet on WRD and BBMB gauges whose zeros are not published, which is why Chapter 5 requires every level to name its gauge and datum. Because rainfall and surge share a weather cause (in Punjab, which has no coast, the counterpart of surge is the stage of the Sutlej, the Beas, the Ravi 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 and by the releases of the dams that those systems fill: in the 24 hours to 08:30 on 9 and 10 July 2023 the Ropar gauge recorded 27 cm and then 35 cm (IMD), the Ropar headworks passed 1.79 lakh cusecs, and the Ghaggar rose to 754.2 ft at Khanauri on 15 July against a danger mark reported as 748 ft (as reported); and in August–September 2025 Pong and Ranjit Sagar released heavily while the plains flooded, and Harike passed 3,35,030 cusecs on 3 September, 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.

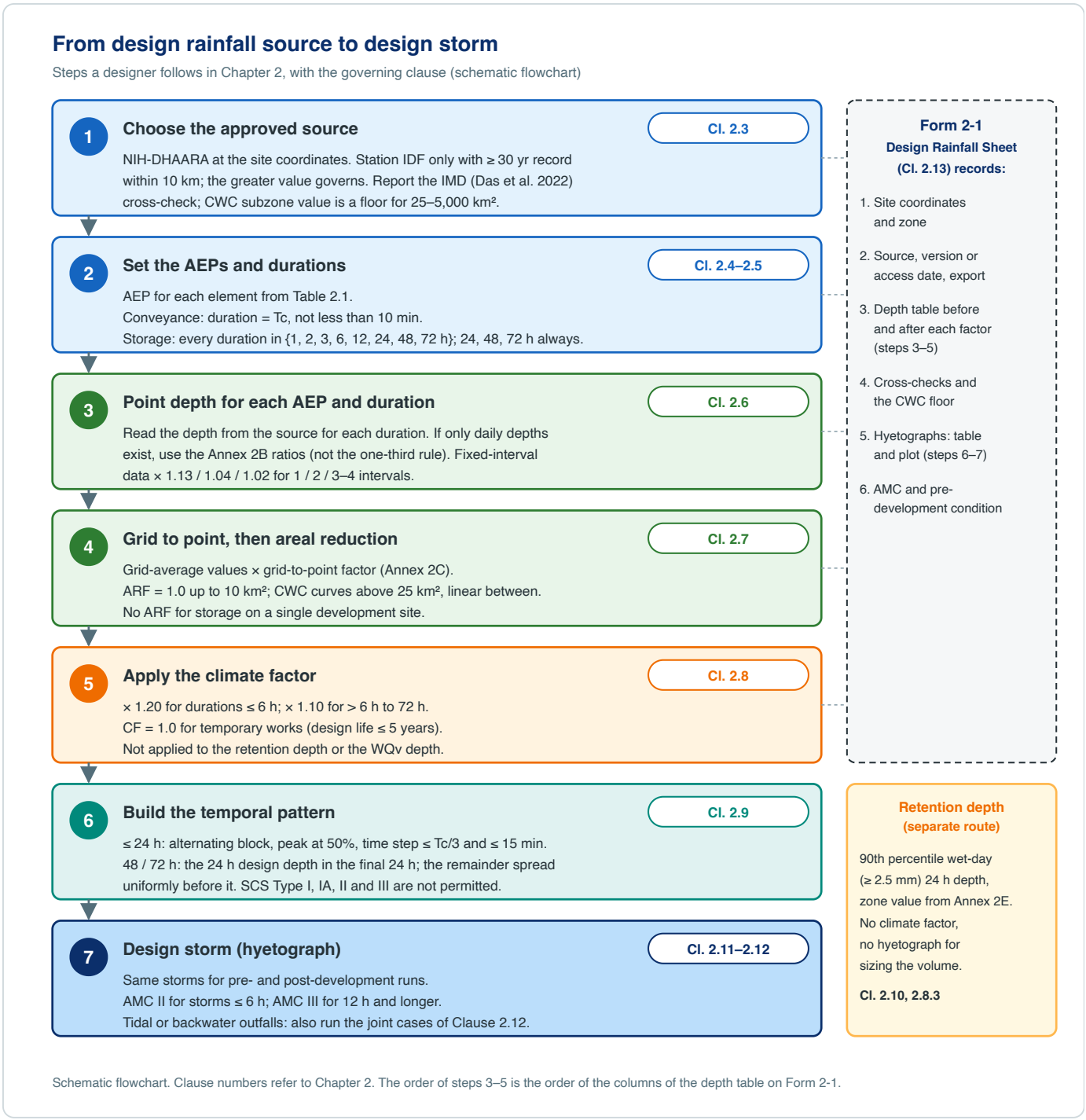


Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the 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
2D	Punjab 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 (chhappar) 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 (chhappars) 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 recent and old alluvium of the Punjab plains, the Kandi boulder-gravel fans and the Sirowal of the Shivalik foothills, the bet lands of the rivers, and the dune sands and saline-sodic soils of the south-west, where an HSG A to C jump would be excessive. The 35% minimum imperviousness for unplanned upstream land in 3.3.5(a) is the APWA value (2011, §5602.3E.2). Using the master-plan land use for conveyance follows CPHEEO, which requires C to reflect "ultimate development of the catchment as per the master plan" (CPHEEO 2019, Part A §4.4.1.5).

3.4 Selection of method

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

Table 3.1 — Permitted hydrologic methods

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

Purpose	Catchment / condition	Permitted method	Clause
Pipe or drain network with backwater, tidal or tank tailwater	Any size	Hydrograph method with dynamic-wave hydraulic routing	3.12.4; Chapter 5
Catchment-scale flows	25–5,000 km² in CWC subzone 1(e) or zone 7 (Western Himalayas)	HEC-HMS or SWMM, benchmarked against the CWC synthetic unit hydrograph (SUH)	3.11.4
Regional facilities	Draining > 25 km²	Design-storm hydrograph method **plus** continuous simulation	3.13
Tank (chhappar) cascades	Any size	Design-storm hydrograph method **plus** continuous simulation	3.13
Tier B: small sites under Chapter 1	Within the limits of the design aid	Design aids issued under Chapter 4, which are themselves derived by the methods of this chapter	3.4.4
Small sites, any authority	≤ 1 ha, within the limits of Clause 4.14.3	Fixed-coefficient route of Chapter 4 (fixed release coefficients, rainfall-mass storage)	3.4.4; 4.14.3

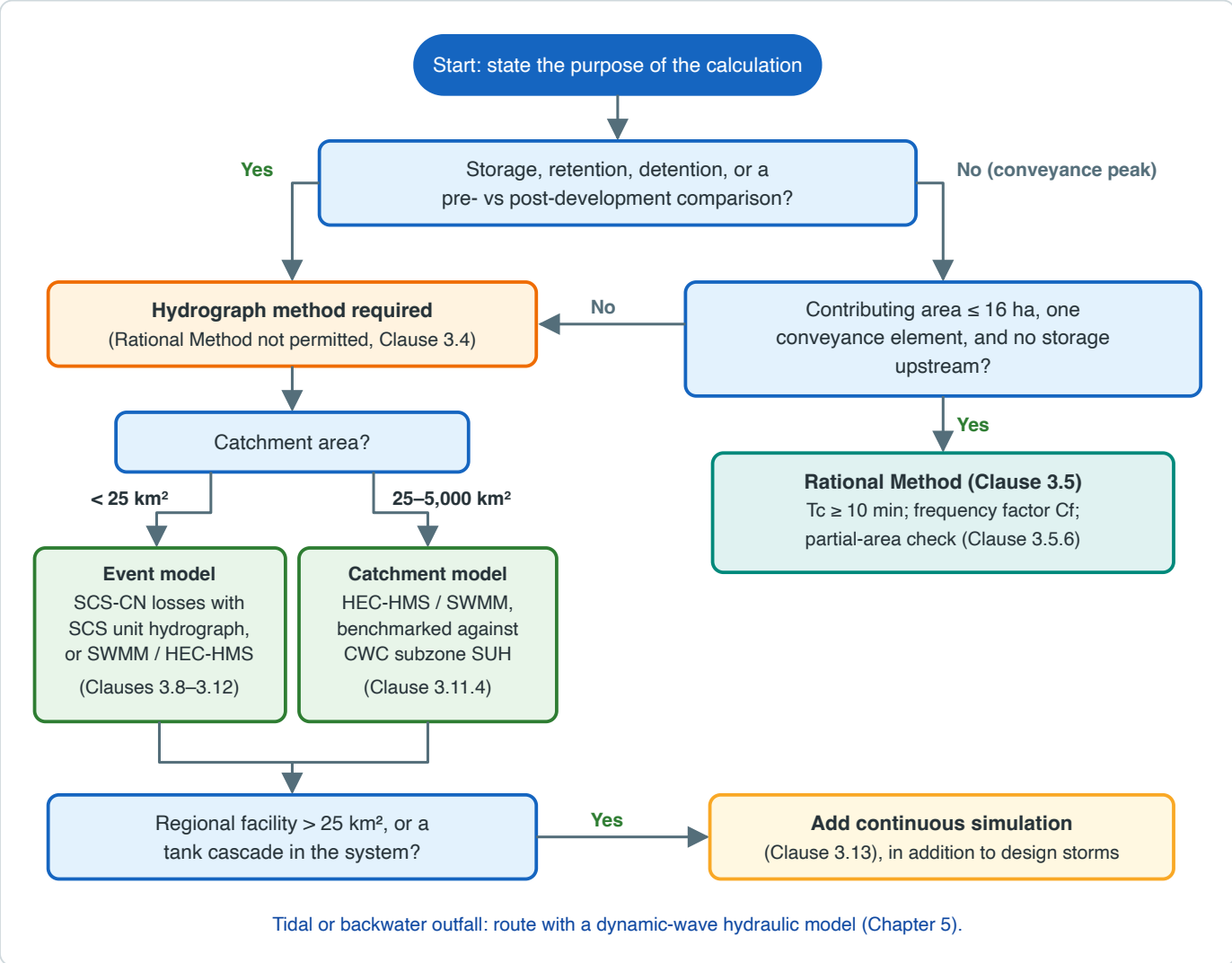

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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

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

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

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

Surface or land use	C	Source
Institutional	0.70–0.95	CPHEEO 2019, Table 4.2
Residential, high density	0.60–0.75	CPHEEO 2019, Table 4.2
Residential, low density	0.40–0.60	CPHEEO 2019, Table 4.2
Recreational	0.10–0.25	CPHEEO 2019, Table 4.2
Asphalt	0.70–0.95	CPHEEO 2019, Table 4.2
Concrete	0.80–0.95	CPHEEO 2019, Table 4.2
Brick paving	0.70–0.85	CPHEEO 2019, Table 4.2
Roofs: tiles	0.80–0.90	CPHEEO 2019, Table 4.2
Roofs: metal	0.70–0.90	CPHEEO 2019, Table 4.2
Roofs: concrete	0.70–0.90	CPHEEO 2019, Table 4.2
Lawns, sandy soil, flat (≤ 2%)	0.05–0.10	ASCE/WPCF 1969
Lawns, sandy soil, average (2–7%)	0.10–0.15	ASCE/WPCF 1969
Lawns, sandy soil, steep (> 7%)	0.15–0.20	ASCE/WPCF 1969
Lawns, heavy (clay) soil, flat (≤ 2%)	0.13–0.17	ASCE/WPCF 1969
Lawns, heavy soil, average (2–7%)	0.18–0.22	ASCE/WPCF 1969
Lawns, heavy soil, steep (> 7%)	0.25–0.35	ASCE/WPCF 1969
Undeveloped land (maximum for any condition)	0.30	KC APWA 5600 (2011), §5602.3E

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

Table 3.3 — Frequency factor Cf

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

3.5.4 **Composite C.** Where a catchment contains more than one surface, C shall be the area-weighted value C = Σ(Cj · Aj) / ΣAj, computed from the measured areas of each surface. Cf is applied to the composite C.

3.5.5 **Time of concentration and networks.**

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

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

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

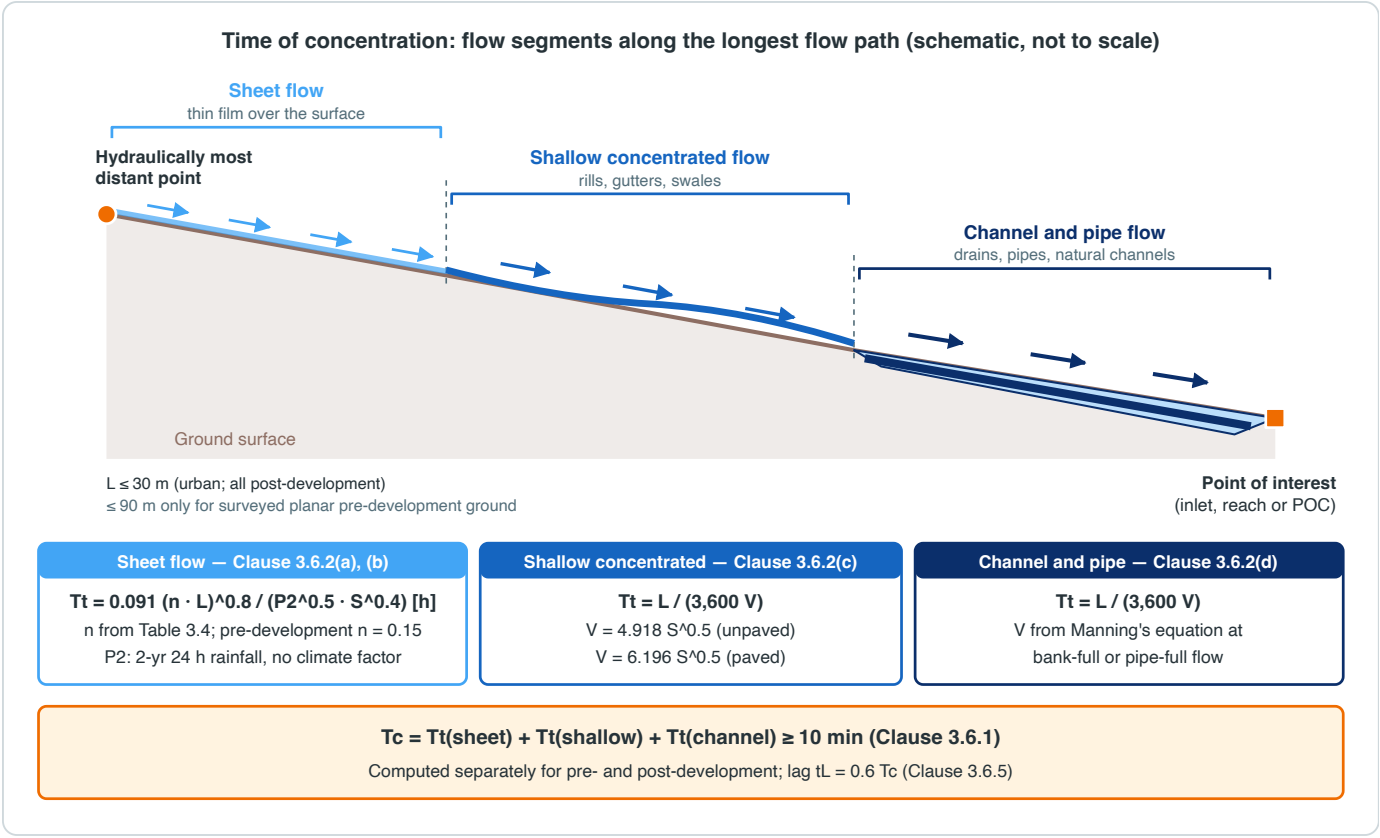

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986), 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 Punjab Remote Sensing Centre (PRSC) or Punjab Agricultural University (PAU) [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 Punjab: the boulder–gravel fans of the Kandi belt below the Shivalik hills and the beds of the choes that cross it, HSG A, but HSG B where the fan is clayey or carries a loamy cover, and HSG C where the boulder bed is cemented or a clay layer lies within 1 m of the surface; the sandstone and clay slopes of the Shivalik hills of Pathankot, Hoshiarpur, Nawanshahr, Rupnagar and SAS Nagar, HSG C, and HSG D where clay or rock lies within 50 cm; the Sirowal, the belt of seepage and springs at the foot of the Kandi, HSG C, and HSG D wherever the seasonal high water table is within 3 m of the surface, whatever a test shows; the sandy loams and loams of the central plains and the Doaba, from Gurdaspur, Amritsar, Jalandhar and Kapurthala to Ludhiana and Moga, HSG B, and HSG C where a field infiltration test gives less than 6 mm/h, and any field that is puddled for paddy HSG C for storms between 15 June and 30 September and HSG D where it stands under water at the start of the storm; the old alluvium with kankar between the Sutlej and the Ghaggar, in Patiala, Sangrur, Barnala and Mansa, HSG B where it is a sandy loam and HSG C where it is a loam or clay loam or a kankar layer lies within 1 m of the surface, and its sodic (alkali) patches HSG D for every design storm, whatever their texture; the bet (floodplain) soils of the Sutlej, Beas, Ravi and Ghaggar, HSG B, and HSG D wherever the seasonal high water table is within 3 m of the surface; the dune sands and loamy sands of the south-west, in Bathinda, Fazilka, Abohar and Sri Muktsar Sahib, HSG A (A or B on a loamy sand), except that a sand with a kankar 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 a sand where the October water table is within 1.5 m of the surface is HSG D; every soil of sub-area PB-F of Annex 2A where the October 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 it earns infiltration credit (Clause 4.4); and made ground and fill, HSG C, and HSG D where it is compacted. 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, clay band 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 bet lands, in the Sirowal and in sub-area PB-F the seasonal high water table, read from the October (post-monsoon) record, 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 in the Kandi, where an open boulder–gravel fan that takes in water quickly can be cemented, or capped by clay, within a metre of the surface, because its deposits "show gradation from boulders to clays" (CGWB); in the south-west, where a dune sand that takes in water quickly at the surface may lie on a kankar pan, or on a water table that rises to within 1.5 m of the surface by October; in the Sirowal and on the bet lands, where a test made on dry ground in May says nothing about a soil that is saturated from below by August; and in the paddy belt, where a test on a fallow field in spring does not represent a puddled field under standing water in July. No statewide HSG map of Punjab, no statewide area shares of soil texture from NBSS&LUP, PAU or PRSC, and no measured basic infiltration rate by soil group for the Kandi or the central plains 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 upper reaches of the Ravi, Beas, Sutlej and Ghaggar, calcareous soils of alluvial origin in their middle reaches, saline and alkaline soils "in some parts", "old alluvial soils … between Sutlej and Ghaggar", 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 that "Immediately south-west of the hills, Kandi belt is 10 to 15 km wide followed by Sirowal", that the Kandi deposits "show gradation from boulders to clays", explored to 450 m, and that the Kandi slopes at "16 metres per kilometer", decreasing towards the west (CGWB, Hoshiarpur district report); about 9.5% of the State is "hilly and undulating" Kandi (TERI, 2015, as reported). The only measured rates found are from the dry south-west: double-ring tests on the aridisols of Bathinda gave final intake rates of 0.26 cm/min on a sand and 0.09 and 0.05 cm/min on loamy sands and sandy loams, about 156, 54 and 30 mm/h by NEER's arithmetic (Singh, Singh and Chaudhary, *Annals of Arid Zone*, 1995). They were measured on dry, recently cultivated soil and are upper bounds, not design rates; the design rate of Clause 4.4.3 comes from a site test. 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 south-west, the Sirowal and on the bet lands the water table governs: groundwater levels in the State "vary from almost near surface to about 60 m bgl", "Water logging conditions exist in some parts of south-western districts", and the shallow area, with the water table less than 5 m below ground, is about 5,723 km², "mainly in the south-western districts"; the shallowest well in the State was 0.79 m below ground at Abohar in June 2019 and 0.53 m at Kot Bhai in Sri Muktsar Sahib district in October 2019, and about 1% of the State had water within 1.5 m and about 15–17% within 1.5–5 m (CGWB and WRD, *Ground Water Resources of Punjab State* as on 31 March 2020). Puddled paddy is treated as a wet soil because that is what it is from June to September: transplanting begins on 1 June in Faridkot, Bathinda, Ferozepur, Sri Muktsar Sahib and Fazilka, on 5 June in the northern districts and on 9 June in the central districts (2025 schedule under the Punjab Preservation of Subsoil Water Act 2009, as reported), and a bunded field under standing water has no infiltration capacity left for a storm. The only regional measures of losses are the design loss rates of the CWC reports, 3.0 mm/h for subzone 1(e) and 5 mm/h for

zone 7 (Annex 3E). They are φ-indices fitted to the monsoon floods of whole rural catchments, which include the land under standing water and beside saturated channels; they shall be used only in rural SUH runs under Clause 3.11.4, not to assign an HSG, not in an urban SCS-CN or SWMM model and not to size an infiltration practice, and the 1(e) value is too high for the waterlogged south-west and probably too low for the Kandi gravels and the dune sands. The AMC rule of Clause 3.8.4 follows the same evidence. The monsoon reaches Jalandhar on about 26 June, Patti on 28 June and Ludhiana on 1 July, and withdraws from all three on about 21 September (IMD, Pai et al., 2020), but the paddy is transplanted from 1–9 June, so the central plains are wet before the monsoon arrives; AMC III is therefore applied from 15 June to 30 September under paddy and other ponded fields and on the bet lands. In sub-area PB-F and the Sirowal, where the water table is at its shallowest in October, AMC III is applied from 1 July to 31 October. Built-up catchments and the Kandi fans, whose water tables are deep, follow the 5-day rule alone. AMC I is not used, even on the dune sands and the Kandi gravels, because the State's largest recorded storms fell after weeks of rain: 354.3 mm at Ludhiana on 4 October 1955 in a month of 587.5 mm, and 338.0 mm at Ludhiana PAU on 24 September 1988 in a month of 668.5 mm (IMD, *Extremes*). 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 and 1.5 m water-table rules, the treatment of puddled paddy, 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 Punjab. Slope and storage matter as much as soil, and in opposite ways in the two parts of the State. The following rules are set by this Manual. (a) On the flat plains, where the CWC report finds that the slopes of the rivers "seldom exceed 0.38 m per km", Tc shall be built up from velocities by the segment method of Clause 3.6.2, with Manning velocities in the surveyed drains and channels; Kirpich-type formulae, fitted to sloping farm catchments, overstate Tc on such ground (NEER's reading), and the Kirpich formula of Clause 3.6.4 shall not be used, even as a cross-check, where the average slope of the main flow path is less than 1 m per km. (b) On the paddy and canal plains the outflow is governed by storage behind canal banks, raised roads and railways and the bunds of paddy fields, released through the siphons, culverts and bridges under them; a peak-flow method overstates the outflow and understates its duration there. Such a catchment shall be modelled with the storage behind each embankment routed through its cross-drainage opening (Clause 3.12.1), the bunds and embankments counting as storage only where they are surveyed and their upkeep is assured (Clause 3.12.3), and every such model shall report, besides the peak, the volume and the duration of ponding behind each embankment in the 1% AEP storm of 72 hours (the volume check). (c) A catchment that runs from the Shivalik hills across a Kandi fan to the plain, such as the choes of Hoshiarpur and Garhshankar, the Siswan and the Patiala ki Rao, shall be split at the break of slope at the head of the fan and again at the Sirowal toe, and the hill sub-area modelled on its own, so that the long, flatter lower reach does not average away the fast response of the hill. The losses of a choe into the gravels of its bed are real, and WRD records that "About 40% of this rain water gets wasted in floods" in the Kandi (WRD, Kandi Area Development), but they shall not be credited in the 1% AEP design, because the bed is saturated by the time of the design storm; at the Sirowal toe, where the seepage returns to the surface and the choe spreads, the flow is routed through the storage of the toe and the spill paths are mapped. (d) On the Shivalik slopes of sub-area PB-A, Tc shall be found by the segment method of Clause 3.6.2 and shall not be taken below the 10-minute minimum of Clause 3.6.1; the Kirpich formula shall not be used even as a cross-check where the average slope of the flow path exceeds 10%; and the sheet-flow segment over bare rock, a road cut or a paved hill street shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (e) No method of this chapter predicts the sand and debris that the choes carry; the design flow at a choe crossing is bulked for sediment and the crossing protected against blockage under Chapters 6 and 9.

3.8 SCS curve number (SCS-CN) loss method

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

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

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
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 15 June to 30 September in a catchment, or the part of a catchment, under paddy or other ponded fields in sub-areas PB-B to PB-F of Annex 2A, and on the bet (floodplain) land of the Sutlej, the Beas, the Ravi or the Ghaggar anywhere in the State; from 1 July to 31 October at a site in sub-area PB-F, or in the Sirowal belt of sub-area PB-A, where the October water table is within 3 m of the surface; at any other site or time, including built-up urban catchments and the Kandi fans of PB-A, 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.

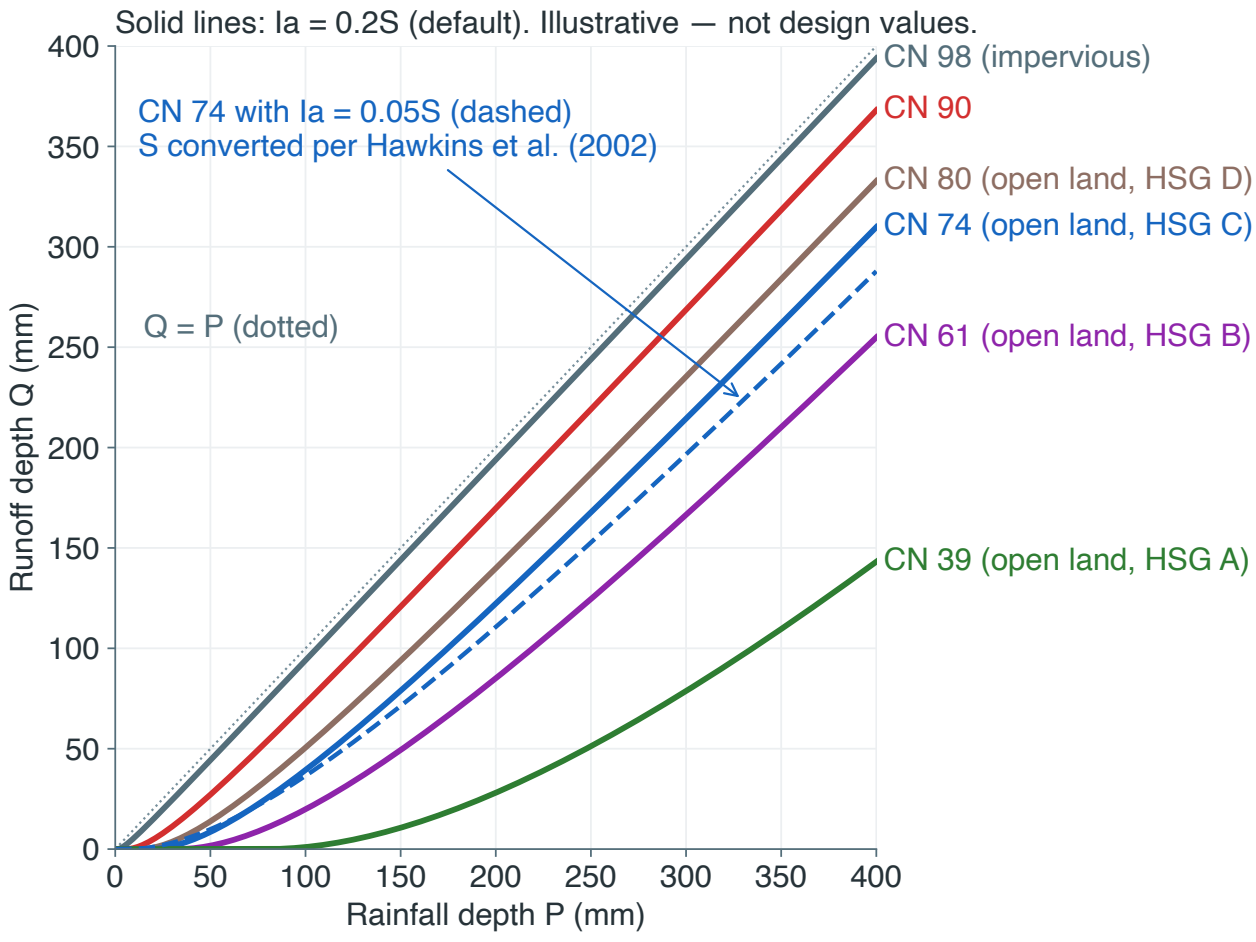

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion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

3.10.3 **Infiltration-based losses.** Where Green–Ampt, Horton or soil-moisture-accounting losses are used instead of SCS-CN, the cumulative infiltration in any storm shall not exceed the storage available in the soil above the seasonal high water table.

3.10.4 **Tank and waterbody backwater.** Where a site or sub-catchment drains to a tank, chhappar, 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 waterlogged south-west, in the Sirowal below the Kandi and on the bet lands of the rivers the water table stands close to the surface, and whatever infiltration capacity the soil has in the dry season is gone when a July–September design storm arrives. Groundwater levels in Punjab "vary from almost near surface to about 60 m bgl"; "The deep water levels are recorded in Kandi belt. Water logging conditions exist in some parts of south-western districts. In the remaining part of Punjab the water table varies from 3 to 40 m bgl" (CGWB and WRD, *Ground Water Resources of Punjab State* as on 31 March 2020). In June 2019 depths ranged from 0.79 m at Abohar in Fazilka district to 65.10 m at Sardulgarh in Mansa district, and in October 2019 from 0.53 m at Kot Bhai in Sri Muktsar Sahib district to 67.27 m; about 1% of the State had water within 1.5 m of the surface and about 14% (June) to 17% (October) within 1.5–5 m, the shallowest in Faridkot, Fazilka and Sri Muktsar Sahib and, at 1.5–5 m, also in parts of Gurdaspur, Hoshiarpur, Pathankot and Ropar, where the Sirowal lies; and the area with water less than 5 m below ground was about 5,723 km², "mainly in the south-western districts" (same report). The waterlogged area itself is reported only in weak and conflicting figures, from about 19,900 ha in 2001 to 52,500 ha in 2009, "around 2 lakh hectares" in Sri Muktsar Sahib, Ferozepur, Fazilka and Faridkot, and about a quarter of 84,800 ha of critically waterlogged land lying beside the Rajasthan and Sirhind feeders, whose seepage feeds it (as reported); no official area by depth class was found [TBC]. The same State is, over most of its area, the opposite case: the stage of groundwater extraction was 156.87% in 2024, with 115 of its 153 assessment units over-exploited (CGWB, *Dynamic Ground Water Resources of Punjab* 2024), and the area with water deeper than 10

m in June grew from 14.9% in 1989 to 68% in 2019 (CGWB and WRD, 2020). The dual-group rule therefore bites only in the south-west, the Sirowal and the bet lands, and Annex 3A is to map them; no monsoon water-table depths for individual town sites were obtained [TBC]. Clause 3.10.2 takes the seasonal high water table as the highest level recorded in the SW monsoon season. In Punjab the CGWB and WRD wells are read before the monsoon (June) and after it (October), and the October reading is the shallowest of the year in the waterlogged belt, so in this State the seasonal high level of Clause 3.10.2 is read from the October record, and a June reading alone is not accepted (set by this Manual). Clause 3.10.4 reflects the receiving waters of the plains, which are rivers held behind dhussi bandhs and WRD drains with controlled or pumped outfalls. The Central Water Commission has no flood-forecasting or level-monitoring site anywhere in Punjab (SANDRP, 2018 and 2022, from the CWC site lists), so the levels used in floods are those of WRD's headworks and drainage gauges and of BBMB, mostly in feet and known to this Manual largely from the press: at Harike "discharge above 3,00,000 cusecs falls under the High Flood category", and on 3 September 2025 the upstream gauge stood at 686.50 ft with 3,35,030 cusecs; the Ghaggar at Khanauri reached 754.2 ft on 15 July 2023 against a danger mark reported as 748 ft (752 and 753 ft are also reported) (as reported). The gauge zeros and datums of these gauges were not found [TBC], and every level used under Clause 3.10.4 shall name its gauge and datum.

3.11 Unit hydrographs and runoff transformation

3.11.1 **Permitted transforms.**

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

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

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

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

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

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

3.11.4 **CWC synthetic unit hydrograph.** For catchments of 25–5,000 km² in CWC subzone 1(e) (Upper Indo-Ganga Plains), which covers the plains and the Kandi piedmont up to the Shivalik front, or zone 7 (Western Himalayas), in Pathankot, Dhar Kalan, Sujanpur, Talwara, Nangal, Anandpur Sahib and the Shivalik hills of Hoshiarpur, Nawanshahr, Rupnagar and SAS Nagar:

- (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 and 1994; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the reports of 1984 and 1994 (the Punjab catchments behind the 1(e) relationships were gauged between 1962 and 1983, and the Chakki Khad at Pathankot, the Punjab bridge behind the zone 7 relationships, in 1963–67), so they represent pre-development conditions, not urbanised ones. That is why the SUH is used as a benchmark rather than as the post-development model. Clause 3.11.4(d) mirrors the floor principle of Clause 2.3.3. HEC-HMS has been calibrated against CWC subzone SUH responses in Indian studies, which shows the two can be linked.
>
> The lower-factor option of 3.11.5 is based on the NRCS Delmarva unit hydrograph, which uses a peak rate factor of 284 (PRF' ≈ 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 chhappars (ਛੱਪੜ; toba ਟੋਭਾ; pond), tobas and dhabs full to their overflow level in 3.12.5, unless a surveyed operating level exists, because Punjab's heaviest rain falls in the middle and late monsoon and after it, on ponds that have taken the earlier rains and the village sullage, and are not drawn down for drainage. The State's largest recorded days fell in July, September and October: 356.5 mm at Patiala on 11 July 1993, 308.4 mm at Amritsar on 22 September 1962, 338.0 mm at Ludhiana PAU on 24 September 1988 and 354.3 mm at Ludhiana on 4 October 1955 (IMD, *Extremes*), and the storm of 4–5 October 1955 put more than 450 mm in a day at Aliwal, Batala and Khara, in Gurdaspur and Amritsar districts (IMD, *Climate of Punjab*). A chhappar is a combined basin: most village ponds receive the sullage of the village drains all year, which the pond-treatment designs of the Seechewal and Thapar models are meant to treat (as reported), so a pond is seldom low when the monsoon arrives. No chhappar in Punjab was found to have a documented operating rule or a record of water levels [TBC], and the inventory is large and uncertain: about 15,000 ponds in about 13,500 villages are in the State's pond-cleaning programme of April 2025 (₹4,573 crore, as reported), of which about 1,062 had been dewatered and about 400 desilted by the Minister's account (as reported); the first census of water bodies counted 16,012 in Punjab, 1,578 of them encroached (as reported). A pond that the programme has dewatered for desilting before the monsoon is lower at the start of the season, but it fills with the first rains and the village outflow, and the Manual does not credit the dewatering. The same rule applies to the low dams and check dams of the Kandi: WRD reports 12 low dams completed under its Kandi Area Development works, with "Flood attenuation" among their benefits, and 410 check dams on rivers and nallahs (WRD, Kandi Area Development; WRD reply in NGT O.A. 694/2023), none with a published operating rule [TBC], so each starts at its spillway crest. Water bodies should therefore be assumed full from July and modelled below their overflow level only where a continuous simulation under Clause 3.13 or a notified operating rule supports it. The window of 1 July to 15 October in Clause 3.13.5(a) is set by this Manual. It starts just after the normal onset of the monsoon, which reaches Jalandhar by about 26 June, Patti by 28 June and Ludhiana by 1 July (IMD, Pai et al., 2020), because a chhappar is at its lowest before the monsoon and the dry days of June would lower the starting level; and it ends on 15 October, the date to which this Manual keeps pumps and gates on standby, because the storm of record fell on 4–5 October, after the normal withdrawal of about 21 September.

3.13 Continuous simulation

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

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

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

3.13.2 **Rainfall input.**

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

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

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

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

- (a) the **starting level of each tank**, taken as the level exceeded on 10% of the days from 1 July to 15 October over the record; and
- (b) the **antecedent soil-moisture condition**, taken from the same days and compared with the AMC rule of Clause 3.8.

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

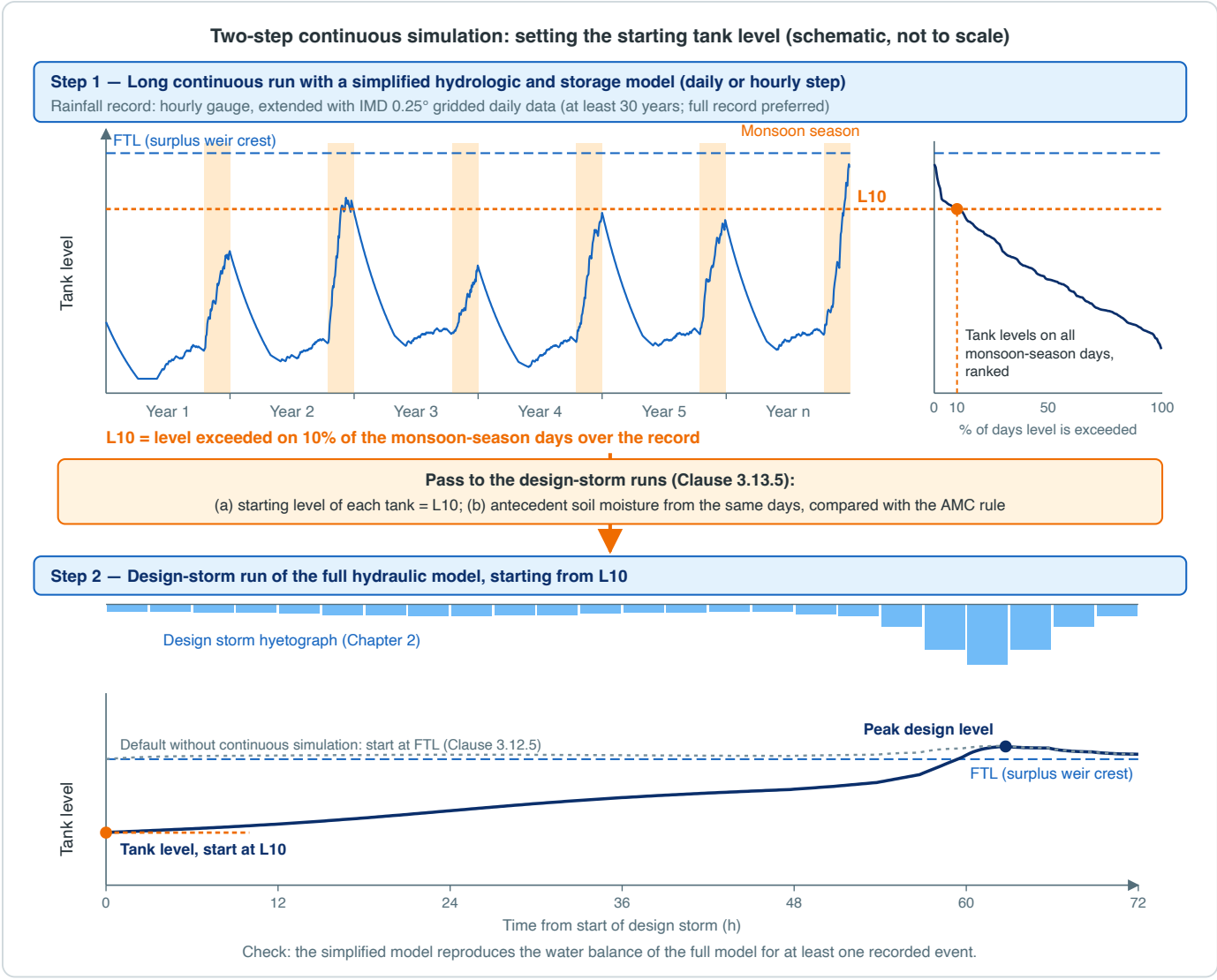

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 July to 15 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place of the default start at FTL of Clause 3.12.5. Schematic, not real data. Original drawing for this Manual, illustrating the two-step approach set by this Manual in Clause 3.13.5.

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

were in September 1988, when Ludhiana PAU recorded 668.5 mm in the month, 338.0 mm of it on 24 September, and October 1955, when Ludhiana recorded 587.5 mm in the month, 354.3 mm of it on 4 October (IMD, *Extremes*).

3.14 Pre- vs post-development comparison procedure

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

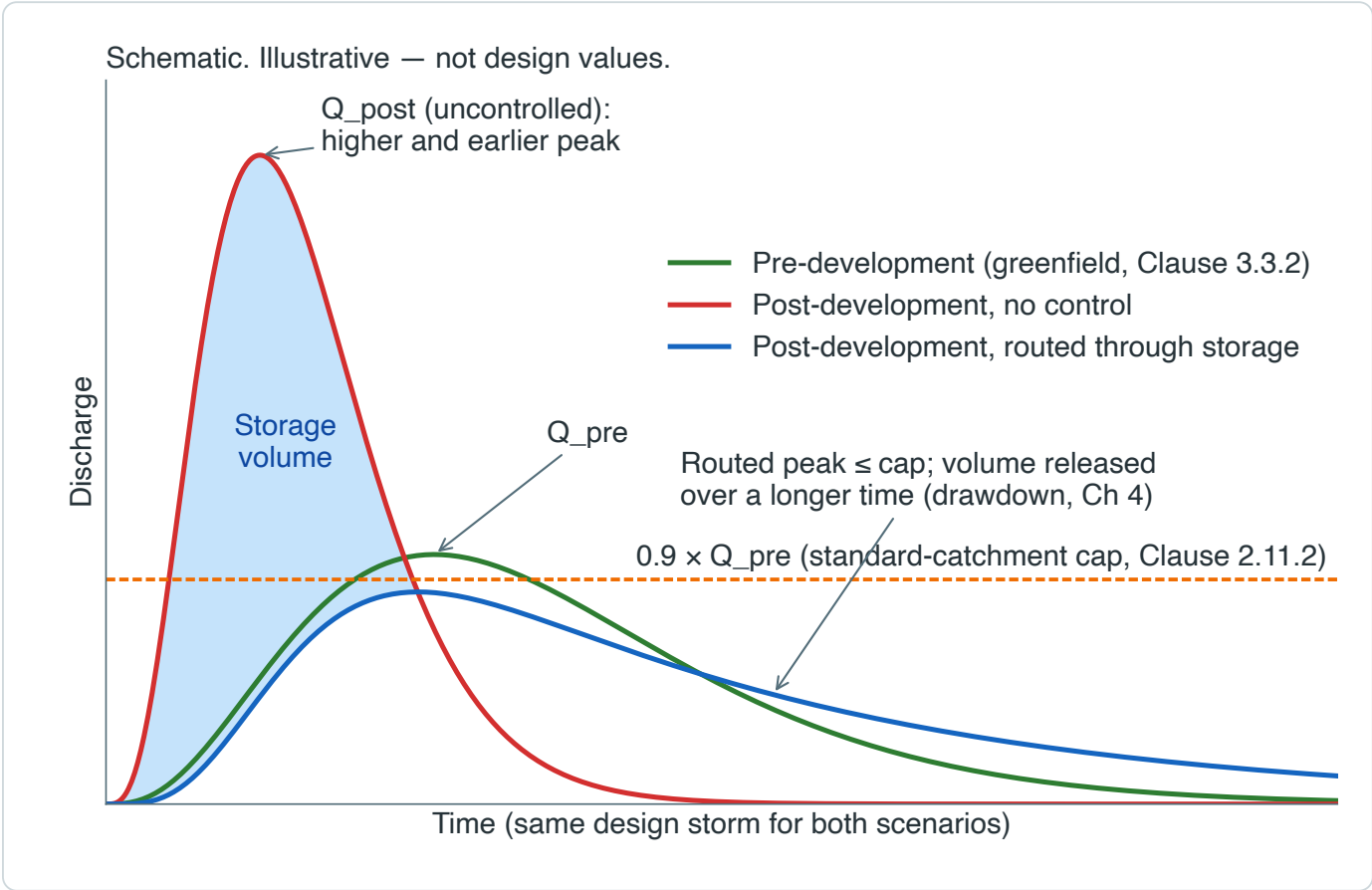

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

> Commentary. The step sequence follows the standard event-based workflow: delineate; set pre-development CN and Tc; set post-development CN and shorter Tc; run identical storms through a unit hydrograph or kinematic model; compare peaks and volumes; and size storage by modified Puls routing. It adds the Punjab elements: the 48–72 h storms, AMC III, and tailwater. Figure 3.5 shows why the long-duration runs matter: the routed peak can

meet the cap while the storage holds the volume difference between the post- and pre-development hydrographs, which must then drain within the Chapter 4 limits. The ban on diverting runoff between catchments in 3.14.2(b) stops a site meeting the rule at one POC by moving flow to a neighbour's drain.

3.15 Model calibration and validation

3.15.1 **When required.** Calibration and validation are required for:

- (a) catchment models of 25 km² or more;
- (b) regional facilities and continuous simulation under Clause 3.13;
- (c) city or basin drainage master plans; and
- (d) any model whose parameters differ from the defaults of this chapter (for example a Clark transform or a lower peak rate factor).

3.15.2 **Data.** Calibration shall use observed rainfall (gauges, and radar where available) and observed flows or water levels (WRD gauging sites, MC Ludhiana or PSDMA 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 Rupnagar, SAS Nagar and Patiala (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD press release, and 302.2 mm at Chandigarh on 9 July, IMD), the storm of 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala in 24 hours, IMD), or the storm of 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 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	Punjab soil series to HSG lookup; seasonal high water table map
3B	Punjab CN calibration and supplementary land covers (choe beds and Kandi scrub, paddy fields, saline-sodic fields, dune sand, chhappar 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) and zone 7, with worked example
Form 3-1	Hydrologic Calculation Summary
Form 3-2	Pre- vs Post-Development Comparison

CHAPTER 4

Site Runoff Control: Retention and Detention

4.1 Purpose and scope

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

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

4.1.2 This chapter applies to land disturbance of **0.1 ha or more**, or new or replaced impervious area of **500 m² or more**, as set in Chapter 1. Single dwellings below that threshold, and road resurfacing that adds no impervious area, are exempt. The existing RWH mandate of the building rules (a complete rainwater harvesting proposal with the building plans for every plot of 100 m² or more, and for group housing, public, commercial and industrial buildings of every size, in municipal areas under PMBBL 2018 (as amended), cl. 10.1 and Table 10.1, with recharge for plots of more than 500 m² (cl. 10.5); and rainwater harvesting for residential plotted and public or institutional buildings above 250 m², for commercial, mixed-use and industrial buildings above 100 m² and for group housing of every size, outside municipal limits and in development-authority schemes, under PUDBR 2021 (as amended), r.40; 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 Punjab 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". Punjab controls building through two instruments, divided by territory. Inside the limits of every Municipal Corporation, Municipal Council and Nagar Panchayat the Punjab Municipal Building Bye-Laws 2018 (PMBBL) apply, made by DLG (notification No. CTP(LG)/2018/3548 of 22 November 2018) under section 201(1) of the Punjab Municipal Act 1911 and section 399(2) of the Punjab Municipal Corporation Act 1976 (PMBBL 1.3), and amended on 31 December 2019 and, for independent floors, on 9 August 2023 (as listed by DLG). Outside municipal limits, and in the urban estates and other schemes of the development authorities, the Punjab Urban Planning and Development Building Rules 2021 (PUDBR, an abbreviation set by this Manual) apply, made by HUD under section 180 read with section 43(2) of the Punjab Regional and Town Planning and Development Act 1995 (G.S.R. 144 of 31 August 2021), except within the Lal Lakir of village abadi, Cantonment Boards and protected archaeological sites (PUDBR r.1(3)); they were corrected on 16 March 2022 and amended on 29 March 2022, and the amendments reported for 2026 were not read, none of them being reported to touch rainwater harvesting, the plinth, basements or drainage [TBC]. The Punjab Unified Building Rules 2025, which would have replaced both, were withdrawn on 27 April 2026, restoring

the two instruments (as reported), and are not cited. The drainage provisions of both protect the building and the drain, not the catchment. The building plan shows "methods of disposal of waste water, sewerage and storm water" and the surroundings up to fifteen metres (PUDBR r.11); open parking is kept level with the crown of the road "except for the slopes required for natural drainage of the area" (PMBBL, definition of parking); the plinth is sited "that adequate drainage of the site is assured", at least 450 mm above the surrounding ground (PMBBL 5.2.1.1), or 900 mm "from the crown of adjoining road in front" on residential plots and "450mm or as specified by competent authority" for other buildings (PUDBR r.3(A) and r.30(1)); roof water is carried away from the building, and the municipality may require the rain-water pipes to be led to a covered channel and the road gutter (PMBBL 5.16.1); rainwater harvesting is required (Commentary to Clause 4.11); and for buildings of 5,000–20,000 m² of built-up area the environmental conditions 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" and that the unpaved area be at least 20% of the recreational open space (PMBBL 11.2.1(iv) and Table 15.1; PUDBR r.43, by reference to MoEFCC S.O. 3999(E) of 9 December 2016). PMBBL 10.4 comes nearest to detention: public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites". None of these sets a design storm, a release rate, a storage volume or an overflow path, and neither instrument sets any setback from a river, nallah, choe, pond or canal (PUDBR r.26 sets setbacks by building height only). The parent municipal Acts were not read, and their sections on drains and drain connections are not known to this Manual [TBC]. The lines that do exist come from a statute and the courts. Under section 38 of the Punjab Canal and Drainage Act 2023 (Punjab Act 11 of 2023), as under section 55 of the Northern India Canal and Drainage Act 1873 that it repeals in Punjab (section 61), the State may notify limits within which no obstruction of a river, stream or drainage channel may be formed, and the reach "shall be held to be a drainage-work"; whether the 2023 Act has been brought into force was not confirmed [TBC]. WRD computes such lines from the 100-year flood by Gumbel's method and the waterway by Lacey's formula, and states that in the 100-year area "no construction is to be allowed" (Chief Engineer, Drainage-cum-Mining & Geology, to CWC, 2 May 2024); the Sutlej floodplain zone of Ferozepur and Tarn Taran districts, notified on 4 March 2024, was declared as the land between the embankments, about 4.5 km apart, although the Lacey waterway was 0.58 km (WRD affidavit in NGT O.A. 303/2023). The Patiala ki Rao has a section 55 notification of 4 March 2013 and pillars marking a 200-ft width set in the High Court's proceedings, a case-specific width and not a WRD norm (CWP 5901/2017). The Master Plan Jalandhar report proposes no construction within at least 200 m of the Chitti Bein "untill concrete bandh is constructed", except a 30 m buffer zone from the bank, and a 30 m plantation strip along the Black (Kala Sanghian) Bein (13.8.6–13.8.7), the only numeric river setback found in a Punjab plan text, a plan proposal whose notified form was not seen [TBC]. A drainage-wing NoC for projects within 150 m of a water body was announced by the Water Resources Minister on 20 September 2023 (as reported), but no notification or order was found, and this Manual does not apply it. 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, to be superseded by a notification under section 38 where one exists; the notified limits and the court lines apply where they bind and are wider. The design norms in use are history, to be replaced. No State or municipal storm-drain standard was found. The Amritsar Smart City bid of 2018 adopted for the walled-city trunk sewers "a return period of once in two years", a minimum time of concentration of 15 minutes and surcharge in the manholes "(without flooding)" (bid 07/ASCL/2018-19); the Buddha Nallah was designed for a 2-year return period "with reduced run-off within the city reach due to active storm water detention" (PMIDC, 2020); WRD sizes the recharge structures of government roofs for 40 mm/h, with runoff coefficients of 0.8–0.9 for roofs, 0.6–0.7 for paved areas and 0.1–0.2 for green areas, which is a recharge-structure figure and not a design storm for drains (WRD, rooftop rainwater harvesting proposal); and under AMRUT, "Storm Water Drainage — No work was done … due to shortage of funds" up to September 2020 (CAG Report 7 of 2021). These are project choices, not State standards, and this Manual uses none of them. Basements are regulated, and more firmly than in most States, but not for flooding. "Adequate arrangement shall be made that surface drainage does not enter the basement" (PUDBR r.30(5)(iv)(e); PMBBL 4.23(vii)); the basement's waste water is pumped to the sewer, not connected directly, "to avoid any risk of the sewerage or sludge heading back into the basement" (PMBBL 4.23(viii)); its structural safety is certified "in relation to underground water table/spring level" (PMBBL 4.23(vi)); the ceiling of a first basement stands 0.9–1.2 m above the average surrounding ground (PUDBR r.30(5)(iv)(d)); and no basement is allowed in a "No construction Zone" or "Master Plan Green area" or any other restricted zone

"under the provision of any other Act" (PUDBR r.30(5)(iii)), under which a reach notified under section 38 could, by NEER's reading, count. No rule sets the level of a basement ramp or opening against a flood level. 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). The same rule sets the lowest habitable floor and every opening at least 0.5 m above the 1% AEP flood level (Clause 6.11.1). These levels are stricter than the plinth of either instrument, which is measured from the road crown or the surrounding ground and not from any flood level, and the difference is disclosed: a PMBBL plinth of 450 mm above the surrounding ground meets Clause 6.11.1 only where the 1% AEP level stays at least 50 mm below the ground beside the building, and a PUDBR plinth of 900 mm above the crown of the road meets it only where that level is no more than 0.4 m above the crown (NEER's arithmetic); on a street that floods 0.5 m deep, neither does. In the flood-sensitive catchments of Clause 4.5.3.2 and in any catchment notified under Clause 4.5.4, this Manual recommends that no basement be permitted where the 1% AEP flood level stands above the plinth that the applicable instrument requires; and in the waterlogged south-west (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda), the Sirowal belt below the Kandi, and the bet (floodplain) lands of the Sutlej, Beas, Ravi and Ghaggar, where the water table is within 3 m of the surface, that a basement be permitted only as a watertight structure checked against flotation with the groundwater at ground level (Clauses 4.12.1 and 4.12.3). These are the Manual's proposals, not rules of PMBBL or PUDBR. This chapter is written so that it can supply, as a technical companion to the two instruments, the sizing for the storm-water disposal that PUDBR r.11 already requires to be shown on the plans and the "adequate size of channel" that Table 15.1 leaves open; a competent authority (for example DLG for municipal building approvals or HUD for PUDBR) could adopt it for either purpose, and none has. In practice the storm drains carry sewage. The Buddha Nallah, before its confluence with the Sutlej, measured BOD 161 mg/l, COD 456 mg/l and TSS 328 mg/l in April 2024, against general discharge standards of 30, 250 and 100 mg/l (CPCB reply in NGT O.A. 327/2025); the roadside drains of Amritsar's walled city are joined to the sewers (Amritsar Smart City bid, 2018); and the rain in Jalandhar "is largely discharged in to the sewer network" (Master Plan Jalandhar report, 9.3), although the Canal and Drainage Act excludes "removal of sewage from towns, villages or any other habitat" from its drainage works (section 2(7)). 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.

Term	Meaning in this Manual
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 Municipal Corporation, Municipal Council or Nagar Panchayat that sanctions building plans under PMBBL 2018 within its municipal limits; PUDA, GMADA, GLADA or the other development authority in its urban estates and schemes under PUDBR 2021; and the competent authority under PUDBR 2021 elsewhere outside municipal limits, whose definition in the Rules was not read [TBC], as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Municipal Corporation Ludhiana (MC Ludhiana), with GLADA and every other approving authority within GLADA's area; the Municipal Corporation SAS Nagar (Mohali), with GMADA and every other approving authority within GMADA's area, among them the local bodies of Zirakpur and Kharar and the authority for New Chandigarh; every other Municipal Corporation constituted under the Punjab Municipal Corporation Act 1976, among them those of Amritsar, Jalandhar and Patiala (13 at March 2023 by the CAG, with Barnala reported as the fourteenth; list [TBC]), with every other approving authority within its limits; and, wherever they lie, PUDA and the development authorities in their urban estates and schemes. Tier B: Municipal Councils and Nagar Panchayats.

4.3 Order of measures

4.3.1 Every site runoff-control design shall apply measures in the following order, and shall document in the submittal why each earlier step could not do more:

1. **Preserve.** Keep existing waterbodies, chhappars, natural drainage lines, wetlands, and permeable soils and vegetation. Avoid fill in flood storage (Chapter 7).
2. **Retain.** Retain the RRV on site by infiltration, reuse or evapotranspiration (Clause 4.4).
3. **Detain.** Detain the remaining runoff so that the release-rate criteria of Clause 4.5 are met for every design storm and duration (Clauses 4.6 to 4.9).
4. **Convey.** Convey the 1% AEP (100-yr) flow safely through the site to the receiving system on a defined overland path (Chapter 6), and check the receiving system downstream (Chapter 5).

4.3.2 Preservation and retention reduce the detention required (Clauses 4.4.6 and 4.4.7). They do not relieve the site of the release-rate criteria of Clause 4.5 or of the downstream analysis of Chapter 5.

> Commentary. This order follows the "layers of stormwater management" adopted in the Kansas City Metro APWA Section 5600 Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet; MARC Supplement, Nov 2025). Maintenance is the fifth layer and is set in Chapter 10. The 2025.01 manual credits

> retention and natural-area preservation against detention size (MARC Supplement, Nov 2025). Clause 4.4.6 adopts that credit, and defines it so that it cannot be claimed twice.

4.4 Retention

4.4.1 Requirement

The site shall retain the RRV. Retention shall be achieved by one or more of the following:

- infiltration practices (soakaways, infiltration trenches, permeable pavement with an infiltration base, bioretention);
- rainwater reuse that is drawn down by a demonstrated non-potable demand;
- green roofs and landscape areas that do not drain to the outfall in the retention-depth storm.

The limits of Clause 4.4.4 apply.

4.4.2 Computation of the RRV

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

where:

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

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

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

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

4.4.3 Verification

Retention by infiltration shall be supported by:

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

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

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

4.4.4 Limits on retention

4.4.4.1 Infiltration practices shall not be used:

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

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

4.4.5 Drawdown of retention

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

4.4.6 Retention credit: definition and computation

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

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

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

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

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

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

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

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

> **Commentary.** "Credited against detention" (APWA 5600 2025.01) can be read in two ways. One reading subtracts the retained volume from the detention volume, cubic metre for cubic metre. The other routes the storms with retention in place and sees what detention is still needed. The two readings give very different answers in Punjab, 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) **Ludhiana on the Buddha Nallah**: the catchment of the Buddha Nallah and of the city drains that join it, through its city reach to its outfall to the Sutlej at Walipur Kalan;
- (b) **SAS Nagar–Zirakpur–Kharar–Dera Bassi–New Chandigarh on the Shivalik choes**: the land of those towns that drains to the choes and raos that come from the Shivaliks and from Chandigarh, among them the N-Choe, the Patiala ki Rao (Patiali-ki-Rao), the Sukhna Choe, the Jayanti Devi ki Rao and the Lakhnaur choe, and to the Ghaggar at Bhankharpur;
- (c) **Patiala–Rajpura–Samana on the Nadis and the Ghaggar**: the land of those towns that drains to the Badi and Chhoti Nadi of Patiala and to the Ghaggar, including the land held up behind the canal crossings of their drains;
- (d) **the Ghaggar towns of Sangrur and Mansa**: Moonak, Khanauri, Makraud Sahib and Sardulgarh, and the land that drains from them to the Ghaggar;
- (e) **Jalandhar–Kapurthala–Phagwara on the Beins and the Sutlej**: the land of those towns that drains to the Kali Bein, the Chitti Bein and the Kala Sanghian drain, and the land along the Sutlej at Phillaur and Shahkot;
- (f) **Amritsar on the Tung Dhab–Hudiara outfall**: the walled city and the land of the city that drains to the Tung Dhab drain and the City Outfall drain and through them to the Hudiara drain;
- (g) **Pathankot–Gurdaspur–Dera Baba Nanak on the Ravi**: the land of those towns that drains to the Ravi, the Chakki Khad and the other khads, including the land behind the dhussi bandh of the Ravi;
- (h) **the Kandi towns of Hoshiarpur, Garhshankar, Mukerian and Talwara**: the land of those towns that drains to the Kandi choes, and the land along the Beas below Pong;
- (i) **Rupnagar–Nangal–Anandpur Sahib on the Sutlej and the Swan**: the land of those towns that drains to the Sutlej below Bhakra and to the Swan;
- (j) **Ferozepur and the Harike–Hussainiwala reach**: the land of Ferozepur and of the towns along the Sutlej from Harike to Hussainiwala that drains to the river through outfalls in its dhussi bandhs;
- (k) **the waterlogged south-west**: Bathinda, Sri Muktsar Sahib, Fazilka, Abohar and Faridkot, and the land that drains from them to the WRD drains or to pumped outfalls; and
- (l) any catchment notified under Clause 4.5.4.

The boundaries shall be those mapped in Annex 4A.

4.5.4 Notification of further flood-sensitive catchments

4.5.4.1 The Authority may propose that a catchment be notified as flood-sensitive where one or more of the following is documented:

- (a) buildings or arterial roads flooded in an event of 1% AEP or more frequent, on at least two occasions in the previous 20 years;
- (b) receiving drains or channels with capacity below the 10% AEP flow under existing conditions;
- (c) an outfall that is closed by a flap gate or regulator in a dhussi bandh when the receiving river is high, as on the Sutlej at Rupnagar, Ludhiana, Phillaur, Shahkot and Ferozepur, the Beas at Mukerian and the Ravi at Dera Baba Nanak, that is held up by the Ghaggar in flood, as at Dera Bassi, Patiala, Samana, Moonak, Khanauri and

Sardulgarh, that depends on pumping, as in the depressions of the waterlogged south-west, or that discharges to a WRD drain that runs full, such as the Buddha Nallah, the Tung Dhab and Hudiara drains or the Chitti Bein, for part of the SW monsoon (Chapter 5);

- (d) loss of more than a quarter of the mapped tank and chhappar 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 list of Clause 4.5.3.2 is this Manual's proposal; no Punjab body has named any of these catchments as flood-sensitive, and each entry follows the evidence below. The Ludhiana entry follows the Buddha Nallah, the State's largest urban drainage problem: a channel of 47.55 km that leaves the city for the Sutlej at Walipur Kalan, whose rehabilitation was designed "considering 2 year return period with reduced run-off within the city reach due to active storm water detention" (PMIDC, feasibility report, January 2020), with no design discharge found [TBC]; it carries about 700 MLD of treated and untreated wastewater (River Rejuvenation Committee, 28 October 2025, in the PPCB reply in NGT O.A. 413/2025), and a road built along it is alleged to have cut its width "from 58 feet to 35 feet" (NGT O.A. 327/2025). Ludhiana holds the State's storm of record, 354.3 mm on 4 October 1955, and recorded 286.8 mm on 5 September 1995, while Ludhiana PAU recorded 338.0 mm on 24 September 1988 (IMD, *Extremes*); flash floods were reported in Ludhiana, SAS Nagar, Jalandhar and Amritsar on 1–3 September 2025, with no depths recorded (as reported). The SAS Nagar entry follows the choes. They rise in the Shivaliks and in Chandigarh, where 302.2 mm fell in 24 hours on 9 July 2023 (IMD), and cross the sectors to the Ghaggar: Phase 11 of SAS Nagar floods when the Lakhnaur choe is not cleared (as reported); the villagers of Chappar Chiri Khurd and Landran told GMADA's social impact assessment for the storm sewer of sector roads 92 and 92-Alpha that "the village Abadi area is seven feet lower than the level of stream (Nadi)" (GMADA, 2021); a notification of 4 March 2013 under section 55 of the Northern India Canal and Drainage Act 1873 authorised WRD's Executive Engineer at Rupnagar to prevent any construction in the Patiala ki Rao or covering of it, yet the Punjab reach was "heavily encroached", and the pillars that the High Court's proceedings require to mark its 200-ft width were in place in Chandigarh but pending in Punjab in January 2024 (Local Commissioner's report of 8 January 2024 in CWP 5901/2017); and WRD lists the re-alignment and channelisation of the N-Choe over RD 4,943–8,128 m in IT City (Sector 101) among its projects, at ₹22.43 crore (WRD, Drainage Administration). The Ghaggar at Bhankharpur is reported with a "full capacity" of 70,000 cusecs, against a flow of about 1.22 lakh cusecs reported for July 2023 (as reported; the two figures conflict). The Patiala entry follows the storm of 11 July 1993, 356.5 mm at Patiala (IMD), and the Nadis, whose revamp of 8.3 km of the Badi Nadi and 4.9 km of the Chhoti Nadi at ₹208.33 crore was discussed in 2025 (as reported); the recording gauge at Patiala measured 93 mm in one hour on 21 July 1982 and 153 mm in three hours (CWC zone 7 report, Annex 4.4); breaches of the SYL canal and the Narwana branch flooded Rajpura in 2023, and the Hansi–Butana siphon on the Ghaggar is blamed for ponding at Samana (as reported). The Ghaggar entry for Sangrur and Mansa follows July 2023, when the river at Khanauri reached 753 ft on 13 July, "the highest-

ever", and 754.2 ft on 15 July, against a danger mark reported as 748 ft (752 and 753 ft are also reported, and the gauge datum was not found [TBC]), and breached at Moonak, Khanauri, Banarasi, Makraud Sahib and Phullad and, in Mansa district, at Budhlada and Sardulgarh (as reported); the channel is reported as "588 ft wide from Khanauri to Makraud Sahib", narrowing to 190 ft from Makraud Sahib to Kadail (as reported), and in 1993 Mansa and Sangrur were flooded by "congested" drainage (as reported). The Jalandhar entry follows the Beins and the river. Only "about 5% of the city area is covered under the storm water network" and the rain "is largely discharged in to the sewer network" (Master Plan Jalandhar report, Vision 2031, 9.3); the same report puts the high flood level of the Chitti Bein at the Chaheru railway bridge at "generally 12'", with water spreading about 200 m, and proposes to widen the Bein from 40–60 ft to "atleast 80'-100'" (13.8.7); Kapurthala, 19 km from Jalandhar by NEER's reading, recorded 284.2 mm on 24 September 1988 (IMD); and in August 2019 the Sutlej breached the dhussi bundh at Shahkot (Janian and Janian Chahal), at Gidderpindi near Sultanpur Lodhi and at Mandala, flooding more than 150 villages in Kapurthala and Jalandhar districts (as reported). The Amritsar entry follows the walled city, 3.55 km² at 300–550 persons an acre, whose trunk storm sewers were designed for "a return period of once in two years", with a minimum time of concentration of 15 minutes and surcharge in the manholes "allowed (without flooding)", and whose road-side drains "are connected to the sewerage system typically at the road junctions, thus making the sewerage system as combined system" (Amritsar Smart City bid 07/ASCL/2018-19, 2018); the city drains by the Tung Dhab and City Outfall drains of WRD to the Hudiara drain, which runs into Pakistan, so its outfall level is set outside Indian control (same source; Chapter 5); Amritsar recorded 308.4 mm on 22 September 1962 (IMD). The Pathankot–Gurdaspur entry follows August 2025, when gates of the Madhopur headworks on the Ravi jammed on 27 August and one was washed away on 28 August, under a flow reported as "less than 2 lakh cusec", and the Ravi breached the dhussi bundh in the Ajnala–Ramdass area and submerged Kartarpur Sahib across the border (as reported); the recording gauge at Madhopur measured 100 mm in one hour on 16 September 1975 and 329 mm in 24 hours on 23–24 July 1974 (CWC zone 7 report, Annex 4.4). The Kandi entry follows the choes: Hoshiarpur district has "more than 100 choes", which "originate from Shivalik slopes and take shape of wide channels after entering the foothill plains" and leave "thick deposits of sand and silt" (Hoshiarpur District Environment Plan), and Garhshankar recorded 470.0 mm on 31 July 1976 (IMD, *Climate of Punjab*); below Pong, the reservoir took a record inflow of about 7.3 lakh cusecs on 14 August 2023 and stood at 1,399.65 ft on 15 August (as reported; the reservoir's full, permissible and technical levels are reported variously as 1,390, 1,394 and 1,410 ft). The Rupnagar entry follows July 2023, when Ropar recorded 35 cm in the 24 hours to 08:30 on 10 July and Nangal 28 cm in the 24 hours to 08:30 on 9 July (IMD press releases), the Ropar figure above the district's heaviest day of 310.4 mm in 1951 (IMD, *Climate of Punjab*), and the Ropar headworks passed about 1.79 lakh cusecs, against 2.4 lakh in 1988 (as reported); WRD lists flood-management works on the Swan, down to its confluence with the Sutlej near Anandpur Sahib, at ₹284.98 crore (WRD, Drainage Administration). The Ferozepur entry follows the river: at Harike "discharge above 3,00,000 cusecs falls under the High Flood category", and 3,35,030 cusecs passed it on 3 September 2025, with 3,02,508 cusecs at Hussainiwala (as reported); the Sutlej floodplain zone of Ferozepur and Tarn Taran districts, notified on 4 March 2024 on a 100-year flow of 5,34,441 cusecs, was declared as the land between the embankments, about 4.5 km apart (WRD affidavit in NGT O.A. 303/2023); and in the floods of 1988 Ferozepur was reported as the worst-hit district, with 2,054 km² flooded (as reported; the draft State Disaster Management Plan's table gives a much smaller area for that year, and the two are not reconciled). The south-west entry follows the water table and the outfalls: the shallowest wells in the State were at Abohar (0.79 m, June 2019) and Kot Bhai in Sri Muktsar Sahib district (0.53 m, October 2019) (CGWB and WRD, 2020); Bathinda's storm-water pumping stations are reported to be "connected to the existing sewer system" and its waterlogging is chronic (as reported); and the Bhatinda rain gauge recorded 256.1 mm on 18 August 1964 (IMD, *Climate of Punjab*). Moga, Barnala, Malerkotla, Batala, Khanna and Tarn Taran, and the towns on the Kali Bein at Sultanpur Lodhi, 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 chhappar or tank flood storage identified in the basin stormwater master plan (Chapter 11); and

- (c) recorded in the public ledger of Clause 4.13.4, which shall show the volume owed and the volume delivered in each basin.

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

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

> Commentary. Greenfield is the target for all redevelopment, because a dense city only reduces its runoff as it rebuilds. On small, fully built plots in areas such as the walled city of Amritsar, the old cores of Ludhiana, Jalandhar, Patiala and Bathinda, or the village abadis inside the sectors of SAS Nagar, 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 15 June to 30 September under paddy or other ponded fields in sub-areas PB-B to PB-F and on the bet lands of the Sutlej, Beas, Ravi and Ghaggar, from 1 July to 31 October in PB-F and the Sirowal belt where the October water table is within 3 m, 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 a choe in SAS Nagar (Mohali). 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.

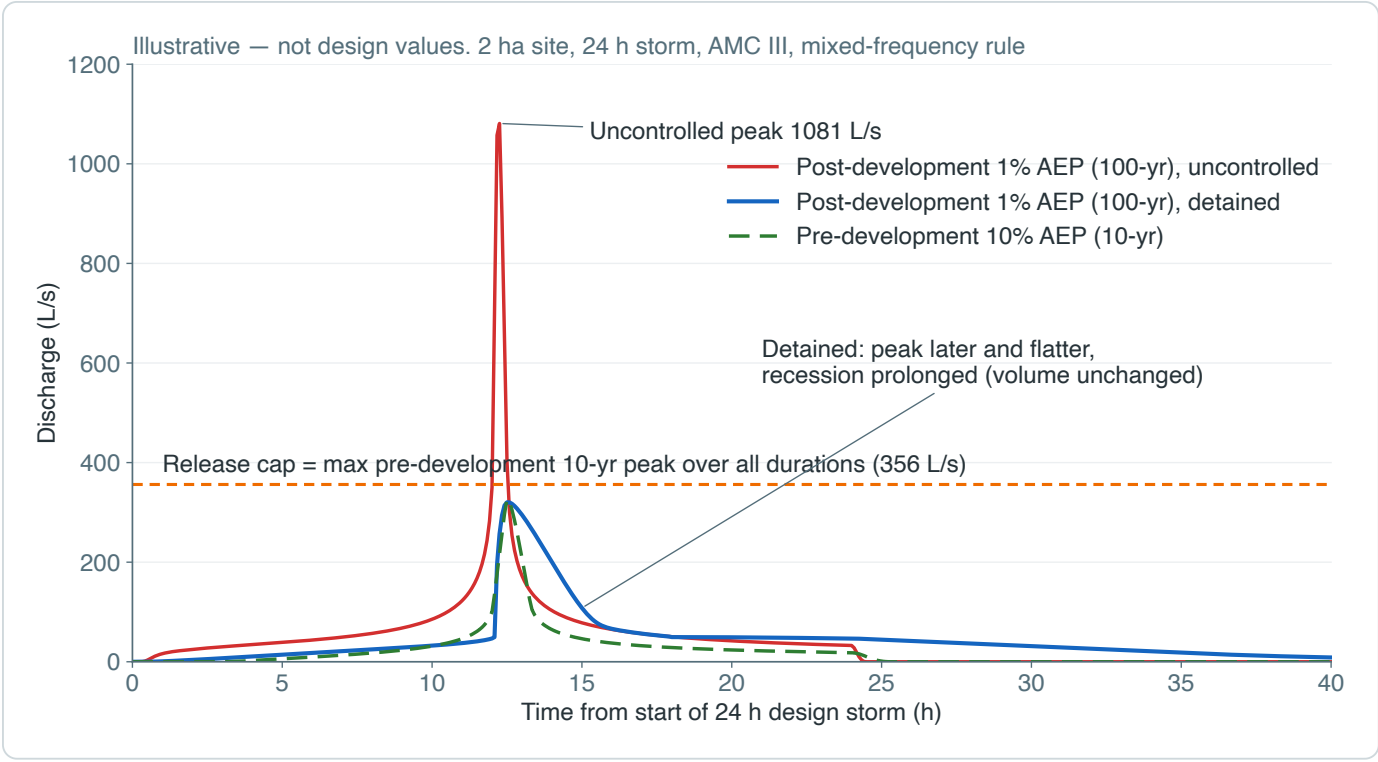


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA 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 Punjab 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 July 2023 at Ropar (27 cm in the 24 hours to 08:30 on 9 July and 35 cm in the 24 hours to 08:30 on 10 July, IMD press releases) followed within days.

4.8 Outlet structures

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

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

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

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

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

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

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

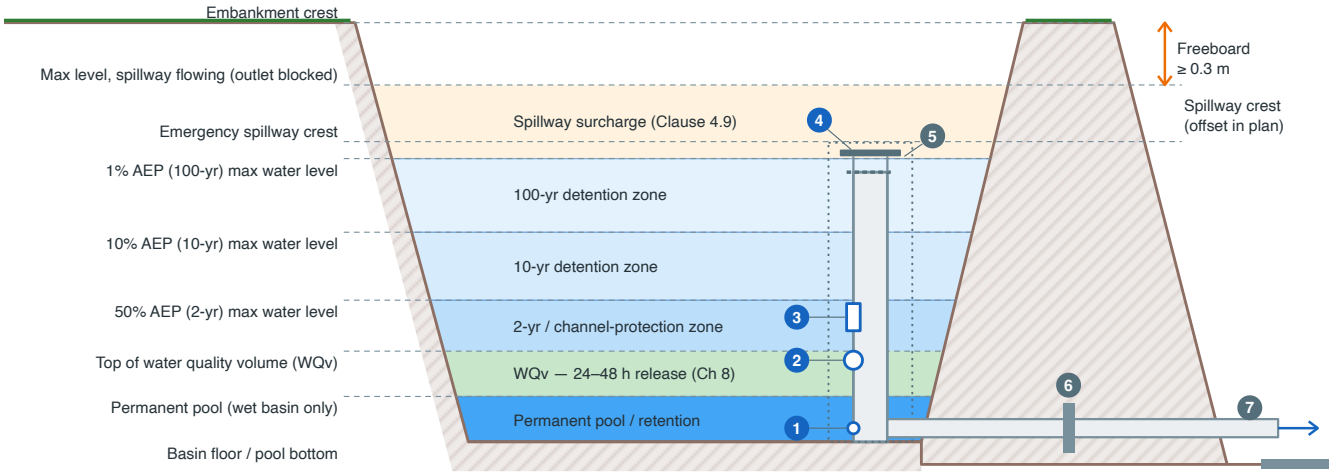
- be at least 300 mm in diameter (Chapter 6);
- have watertight joints;
- have a filter diaphragm or seepage collars over the length within the embankment; and

- have an energy-dissipating outfall (Chapter 9).

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

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

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



Key

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

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

4.9 Emergency spillway, freeboard and embankment safety

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

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

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

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

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

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

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

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

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

4.9.6 **Embankments.**

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

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

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

4.10 Facility types

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

4.10.2 **Underground tanks and vaults.**

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

4.10.3 **Rooftop detention.**

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

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

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

4.10.5 **Parking-lot detention.**

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

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

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

4.10.7 **Ponds and wet basins.**

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

Commentary.

- The rooftop depth (150 mm) and parking depths (200 and 300 mm) have no direct precedent. This Manual sets them so that a blocked outlet is noticed before it becomes dangerous.
- The 1.2 m pool depth equals the 4 ft minimum permanent pool of KC APWA 5600 (2006). This Manual adopts it mainly for weed and mosquito control.
- Pumped detention tanks need maintenance declarations in Singapore (PUB Addendum No. 3, April 2025). This Manual adopts the same approach through Chapter 10.
- Using open space for multi-use detention fits the building instruments. PMBBL 10.4 requires public open spaces of more than 500 m² to have "arrangements for complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites"; PMBBL 10.5 makes recharge mandatory for parks, parking, plazas and playgrounds; and for buildings of 5,000–20,000 m² of built-up area at least 20% of the recreational open space is to be unpaved (PMBBL 11.2.1(iv) and Table 15.1; PUDBR r.43). It also fits the recommendation of GMADA's social impact assessment for the storm sewer of sector roads 92 and 92-Alpha that the authority "not disturb the natural passage of 'Nadi' or allied tributaries" (GMADA, 2021). 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 chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond), toba or dhab on or beside the land is Panchayat common land (shamlat) under the Punjab Village Common Lands (Regulation) Act 1961, protected against encroachment by the Supreme Court in *Jagpal Singh v. State of Punjab* (2011) and by the High Court's order of 2020 to remove encroachments from village ponds (as reported); it 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 overflow level (Clause 3.12.5), so only its flood storage above that level can count, only as Chapter 7 allows and only with the Gram Panchayat's consent. And land within the limits of a reach notified under section 38 of the Punjab Canal and Drainage Act 2023 (or section 55 of the 1873 Act), such as the Patiala ki Rao and its pillared 200-ft width, the Sutlej floodplain zone of Ferozepur and Tarn Taran, the bet land between a river and its dhussi bandh, and land in the hydraulic corridor of a drain, choe 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 Chapter X (cl. 10.1–10.6) and Table 10.1 of PMBBL 2018 (as amended) in municipal areas, r.40 of PUDBR 2021 (as amended) outside them and in development-authority schemes, the environmental conditions of PMBBL Chapter 15 and of PUDBR r.43 (MoEFCC S.O. 3999(E) of 9 December 2016), any condition of a building plan, completion certificate or occupation certificate, any direction of PWRDA under section 15(2)(ix) of the Punjab Water Resources (Management and Regulation) Act 2020, or any rainwater harvesting rule or direction of an approving authority.

Commentary. RWH in Punjab is required by two instruments, with different thresholds, and each number belongs to its instrument; there is no single "Punjab threshold". In municipal areas, "All buildings having a plot size of 100 sq.m. or more, while submitting the building plans for sanction, shall mandatorily include the complete proposal of rainwater harvesting" (PMBBL 2018 (as amended), cl. 10.1); Table 10.1 applies this to residential plots of 100 m² and above, with the emphasis on storage and reuse, and to group housing, public, commercial, mixed-use and industrial buildings of every plot size; public open spaces of more than 500 m² are to capture and use their storm water (cl. 10.4); recharge is to be mandatory for every building on a plot of more than 500 m² and for parks, parking, plazas and playgrounds (cl. 10.5); and each municipality is to constitute a Rainwater Harvesting Cell, inspect the structures "before issuing Completion Certificates or NOCs for service connections", verify every building above 1,000 m² each year and survey 10% of the smaller ones at random (cl. 10.6). The bye-laws add that rainwater "can be harvested to the extent of 55,000 liters per 100sq. meters area per year from rooftops" (cl. 10.1), about 550 mm a year by NEER's arithmetic, a description and not a sizing rule, and the amendment of 31 December 2019 makes buyers of additional FAR comply with "Rain Water Harvesting and requirements of National Building Code (NBC)-2016". Outside municipal limits and in the schemes of the development authorities, PUDBR 2021 (as amended), r.40 requires rainwater harvesting for residential plotted and for government, semi-government and institutional buildings "Above 250 sq.mt.", for commercial, mixed-use and industrial buildings "Above 100 Sq.mt.", and for group housing of "All plot sizes", with industrial units "not to inject contaminated water into recharge structures" and recharge structures kept away from sewer lines, septic tanks, soak pits and landfill; the design "shall be prepared and certified by an Engineer dealing with civil work". Earlier thresholds of 400 m² (a 2010 amendment of the PUDA rules) and 500 square yards (the 2013 rules) are reported (as reported), and a Lok Sabha reply quotes "above 200 sq. yds." for the municipal bye-laws (as quoted, [TBC]); none of them is current. Both instruments also say, for group housing, that "Concrete paving to be avoided and permeable materials are to be used [for] all open parking spaces", which is Punjab's only rule on permeable paving. Neither instrument sets a storage volume, a design storm, an infiltration test or a depth to the water table, so the RWH Cell's inspection and the engineer's certificate have no stated standard; the tests of Clauses 4.4.3 and 4.11.4 can supply one. WRD's own design for the recharge structures of government roofs uses 40 mm/h ("Hourly Rainfall Intensity is typically 25 to 30 mm/hr for Punjab and Haryana. For safer side we assumed it to be 40 mm/hr"), with one injection well and filter chamber "safe for a roof top area of 900 sqm" (WRD, rooftop rainwater harvesting proposal); that is a figure for sizing a recharge structure, not a design storm for a drain, and this Manual does not use it as one. PWRDA's Directions of 2023 make rainwater harvesting voluntary for the users they cover and reward it: a user with an approved scheme earns water-conservation credits, one for each cubic metre conserved, worth a rebate of ₹2.50 against the groundwater charges of ₹4–22/m³ (Directions 2.7, 4.6 and 4.7), and the Act empowers PWRDA to direct "water conservation and groundwater recharge, including rain water harvesting" (Punjab Water Resources (Management and Regulation) Act 2020, section 15(2)(ix)). A design under this chapter therefore states the recharge volume of each practice in m³ a year, so that the owner can use it in an application for credits; this is a link, not a mandate, and this Manual gives no credit of its own for it. This Manual credits these structures against its own retention requirement (Clause 4.4) as follows:

- An RWH storage tank or sump is RWH storage. It is not detention (Clause 4.11.1), and it is assumed full at the start of every storm (Clause 4.11.2). 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 if it holds at least 20 litres for every square metre of the roof that drains to it, and then only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or garden watering, demonstrated under Clause 4.4.3; it is then modelled under Clause 4.4.6 like any other retention practice. The 20 L/m² minimum, about 20 mm over the roof, is set by this Manual, because neither PMBBL nor PUDBR sets a volume; it follows the minimum capacity of 20 litres per square metre of roof-top area set for roof-top storage by the Himachal Pradesh Town and Country Planning Rules 2014 (Appendix 6), the nearest precedent found. 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 PMBBL Table 10.1 and PUDBR r.40 and the recharge bores of the environmental conditions, 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, read from the October (post-monsoon) record (Clause 3.10.2), and the credit is found by routing under Clause 4.4.6, not by deducting their volume.
- **Recharge depends on the ground, and Punjab has three kinds.** The State draws far more groundwater than is recharged, at a stage of extraction of 156.87% in 2024, with 115 of its 153 assessment units over-exploited (CGWB, *Dynamic Ground Water Resources of Punjab* 2024), and the area where the water lay deeper than 10 m in June grew from 14.9% in 1989 to 68% in 2019; yet in the south-west the water was within 1.5 m of the surface at Abohar and Kot Bhai in 2019, and "Water logging conditions exist in some parts of south-western districts" (CGWB and WRD, 2020). The credit for recharge therefore follows the ground and the seasonal high (October) water table at the site, from Clause 3.10.2 or Clause 4.12.1, under three rules, all set by this Manual:
    - (a) **the Kandi recharge belt: recharge first, with sediment control.** On the boulder–gravel fans and choe beds of sub-area PB-A, where "deep water levels are recorded in Kandi belt" (CGWB and WRD, 2020) and the stage of extraction is lower than in the central districts (Hoshiarpur 102%, Ropar 100% and Pathankot 53%, against 211% at Ludhiana and 301% at Sangrur, by district in GWRA-2020), retention shall be provided by recharge before reuse or detention wherever site infiltration tests allow, through pre-treatment, a silt trap ahead of every pit, shaft or well, and the 1.0 m separation above the October water table, and with the sand and silt of the choes kept out of every recharge structure by the sediment control of Chapter 8; the Kandi low dams and WRD's 410 check dams on rivers and nallahs are recharge structures of the same kind at basin scale (WRD reply in NGT O.A. 694/2023). On the Shivalik slopes themselves the hill infiltration rule below applies instead;
    - (b) **the central over-exploited plains: recharge encouraged, with quality protection.** In sub-areas PB-B, PB-C, PB-D and PB-E, and in the parts of PB-F where the water table is deep, recharge is the default where the October water table is deeper than 10 m below ground, and earns credit with: first-flush diversion and a filter ahead of every structure; roof water only to an injection well, bore or shaft; road, parking, yard and industrial runoff only through a surface infiltration practice with a filter, such as a vegetated basin or trench, and never directly into a well, bore or shaft (following PUDBR r.40's "not to inject contaminated water into recharge structures"); no runoff from a drain that carries sewage; every recharge structure away from sewers, septic tanks, soak pits and landfill (PUDBR r.40), and outside the 30 m within which PUDBR r.45(7) keeps septic tanks and absorption pits from wells, sources and streams used for drinking; and a quality screen: where the groundwater at the site, from a sample or the nearest CGWB or WRD well, exceeds 30 ppb of uranium, 45 mg/L of nitrate, 1.5 mg/L of fluoride, 10 ppb of arsenic or an EC of 3,000 µS/cm, the limits used in GWRA-2024, recharge earns credit only after a check by a hydrogeologist that it will not spread the contaminant towards a drinking-water well. Uranium above 30 ppb was found in 32.6% of the samples of the 2024 assessment, nitrate above 45 mg/L in 12.58%, fluoride above 1.5 mg/L in 13.77%, arsenic above 10 ppb in 4.85% and EC above 3,000 µS/cm in 6.72% (CGWB, GWRA-2024), and the CGWB notes that "Groundwater at Shallow depth is largely contaminated caused by surface water pollution" (CGWB and WRD, 2020). **Between 3 m and 10 m below ground**, recharge earns credit only after a site check

of the water table, by a piezometer read in October or 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;
    - (c) **the south-west waterlogged belt, the Sirowal and the bet lands: no infiltration.** In sub-area PB-F wherever the October water table is within 3 m of the surface, as in parts of Sri Muktsar Sahib, Fazilka, Faridkot, Bathinda and Ferozepur, in the Sirowal belt below the Kandi, and on bet land within the seasonal flood level of the Sutlej, Beas, Ravi or Ghaggar, the soil is HSG D for design (Clause 3.7.2), no recharge or infiltration practice earns retention credit whatever a test shows, and no soakaway, recharge pit, shaft or well, or permeable paving with an exfiltrating base, shall be built for the purposes of this chapter; RWH there is storage and reuse, saline groundwater (EC up to 8,320 µS/cm at Abohar; CGWB and WRD, 2020) is not a recharge target, and detention, conveyance and pumped outfalls carry the design, with the design groundwater level at ground level (Clause 4.12.1). Where PMBBL or PUDBR requires a recharge well on such a site, it is built as the instrument requires, lined above the water table and fed only with filtered roof water, but it is not counted. The maps are those of the CGWB and WRD for October, not June.
- **Hill infiltration rule (Clause 4.11).** No deliberate infiltration practice (soakaway, soak pit, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited on natural ground sloping more than 10° in the Shivalik hills of sub-area PB-A (the Pathankot–Dhar Kalan hills, the Mukerian–Dasuya, Hoshiarpur and Garhshankar Shivaliks, the Anandpur Sahib–Nangal Shivaliks and the Kharar–Mullanpur hills), or upslope of a cut slope or retaining wall within a distance of twice the height of the cut or wall, unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope. On such sites roof runoff goes to rainwater storage, with overflow to a lined drain that discharges through a sediment trap to a stable natural channel or choe, never onto an unprotected slope. The 10° trigger is set by this Manual; the Shivalik slopes are of sandstone and clay, and runoff from them reaches the choes within minutes.
- Permeable paving on the open parking of group housing, which both instruments require, is pervious area in the post-development run (Clause 3.9.2). It earns credit as retention only where it is built and tested as an infiltration practice under rule (a) or (b); under rule (c), and under the hill rule, it is built with a lined, non-exfiltrating base and an underdrain.
- The unpaved area of the environmental conditions (at least 20% of the recreational open space) 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 waterlogged belt, the Sirowal and the bet lands, 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 three recharge rules, the 10 m and 3 m thresholds, the site check in between, the quality screen, the 20 L/m² minimum for reuse credit, the hill infiltration rule and the pre-treatment and road-runoff rules are set by this Manual; no Punjab 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 waterlogged south-west of sub-area PB-F of Annex 2A (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda and Ferozepur), the land along the Rajasthan and Sirhind feeders, the Sirowal belt below the Kandi in sub-area PB-A, the bet (floodplain) lands of the Sutlej, Beas, Ravi and

Ghaggar, and the beds and margins of chhappars, 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 WRD (or PWRDA) record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, choe, bein, drain, canal or chhappar.

For the flotation check of 4.12.3 at sites in the waterlogged south-west (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda), the Sirowal belt below the Kandi, and the bet (floodplain) lands of the Sutlej, Beas, Ravi and Ghaggar, 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. Punjab 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 in the south-west it often is: the EC of groundwater exceeded 3,000 µS/cm in 6.72% of the samples of the 2024 assessment, with hot spots in Bathinda, Faridkot, Fazilka, Ferozepur, Mansa, Sri Muktsar Sahib, Nawanshahr, Patiala and SAS Nagar (CGWB, GWRA-2024); "About 15-25% of the groundwater is saline/alkaline" in Sri Muktsar Sahib, Bathinda, Mansa and Sangrur districts, and the EC reached 8,320 µS/cm at Abohar (CGWB and WRD, 2020). The State's groundwater runs to both extremes. Depths ranged from 0.79 m to 65.10 m below ground in June 2019 and from 0.53 m to 67.27 m in October 2019, and about 21–22% of the State had water deeper than 30 m (same source). Where it is deep, infiltration is the best retention and should be used, subject to the three recharge rules of the Commentary to Clause 4.11, the 1.0 m separation of Clause 4.4.3 and Chapter 8. The waterlogged south-west, the Sirowal and the bet lands are the opposite case. There the water table is within a few metres of the surface and rises through the monsoon, fed in the south-west by seepage from the Rajasthan and Sirhind feeders (as reported), so an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when the Sutlej or the Ghaggar is high and the river raises the water table of the bet land beside it. The design groundwater level of 4.12.1(b) therefore takes the design flood level of the

adjacent river, choe, bein, drain, canal or chhappar where that is higher than the well record, and in the waterlogged south-west (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda), the Sirowal belt below the Kandi, and the bet (floodplain) lands of the Sutlej, Beas, Ravi and Ghaggar 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 CGWB and WRD read their wells in June and October, the October reading is the shallowest in the waterlogged belt (0.53 m at Kot Bhai in October 2019, against 0.79 m at Abohar in June), and the share of the State with water within 1.5–5 m rose from about 14% in June to about 17% in October (CGWB and WRD, 2020), so a reading taken in June understates the design level. No monsoon water-table depths for individual town sites in Bathinda, Sri Muktsar Sahib, Fazilka or Faridkot were obtained [TBC]. The factor of 1.2, the 0.5 m allowance and the "ground level" default for the waterlogged south-west, the Sirowal and the bet lands have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Punjab 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 chhappar 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.

Punjab has no pond Act, no pond authority and no working tank cascade [N; unverified]. Its regional storage is of three kinds: the village chhappars (ਛੱਪੜ; toba ਟੋਭਾ; pond), tobas and dhabs, which are Panchayat commons; the low dams and check dams of the Kandi; and the drains, embankments and canals of WRD. Village ponds are shamlat land under the Punjab Village Common Lands (Regulation) Act 1961; the Supreme Court ordered illegally occupied pond land restored to the Gram Panchayat in *Jagpal Singh v. State of Punjab* (28 January 2011), and the High Court directed in July 2020 that encroachments on village ponds be removed within six months and that PPCB monitor their water (as reported); restoration is a programme of the Department of Rural Development and Panchayats, on the Seechewal, Thapar and PPCB models (as reported). No spatial-plan or building approval in Punjab was found to require the consent of any pond body. Three points follow:

- A pond on a list may not be what the list says. About 15,000 ponds in about 13,500 villages are in the cleaning programme of April 2025 (as reported); the first census of water bodies counted 16,012 in Punjab, 1,578 of them encroached (as reported); and many chhappars are combined basins that take the village sullage all year, so that the Comptroller and Auditor General found that a choked screening chamber at the pond-treatment works of the Gram Panchayats of Punnawal and Bhalwan, in Dhuri block, had led to the "discharge of untreated wastewater into the drain" (CAG Report 1 of 2026). A chhappar is credited only after a survey shows its bed, bank and outlet, only for the storage above its overflow level, only where its sullage is intercepted and treated ahead of it (Chapter 8), and only with the Gram Panchayat's consent.
- The Kandi dams are regional detention only where they are run as such. WRD reports 12 low dams completed in the Kandi, with "Flood attenuation" among their benefits, and 410 check dams on rivers and nallahs (WRD, Kandi Area Development; WRD reply in NGT O.A. 694/2023), and the Kandi choes, "prone to flashy floods", fill them with sand and silt. A low dam or check dam is the kind of regional storage that Clause 4.13 can credit once it is identified in a basin master plan (Chapter 11), surveyed for its present capacity, given an operating rule under Chapter 7 and desilted on a schedule; until then it starts full (Clause 3.12.5) and gives no credit.
- A drain or canal of WRD, or the bet land of a river, is not regional storage. The Buddha Nallah was designed for a 2-year storm and already carries about 700 MLD of wastewater (PMIDC, 2020; River Rejuvenation Committee, 2025), the Tung Dhab and Hudiara drains end in Pakistan, the Ghaggar has breached its banks in 1993, 2010 and 2023 (as reported), the bet land between a river and its dhussi bandh is the river's own flood land, and a canal is a barrier, not a receiving system. 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 consent of WRD, for a stated flow and level (Chapter 5).

The first point is the basis of condition 4.13.2(c) in Punjab. A chhappar gives flood storage only above its overflow 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
PB-Z1 Shivalik–Kandi: PB-A Shivalik foothills and Kandi (Pathankot–Talwara–Hoshiarpur–Garhshankar–Nangal–Anandpur Sahib–Rupnagar–Mullanpur)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
PB-Z2 Northern and central plains: PB-B Majha–Doaba north (Gurdaspur–Batala–Jalandhar–Kapurthala–Phagwara–Nawanshahr)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
PB-Z2 Northern and central plains: PB-C Central Sutlej–Ghaggar belt (Ludhiana–Khanna–SAS Nagar–Zirakpur–Rajpura–Patiala–Fatehgarh Sahib)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
PB-Z3 Western and Malwa plains: PB-D Majha west and the border (Amritsar–Tarn Taran–Patti–Ferozepur–Zira)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
PB-Z3 Western and Malwa plains: PB-E Malwa centre (Sangrur–Barnala–Malerkotla–Moga–Mansa)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
PB-Z4 South-west: PB-F South-west sands, waterlogging and salinity (Bathinda–Sri Muktsar Sahib–Malout–Fazilka–Abohar–Faridkot)	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 over d of [10 × C_v × P_100(d) × A − 1.8 × Q_cap,10 × d]

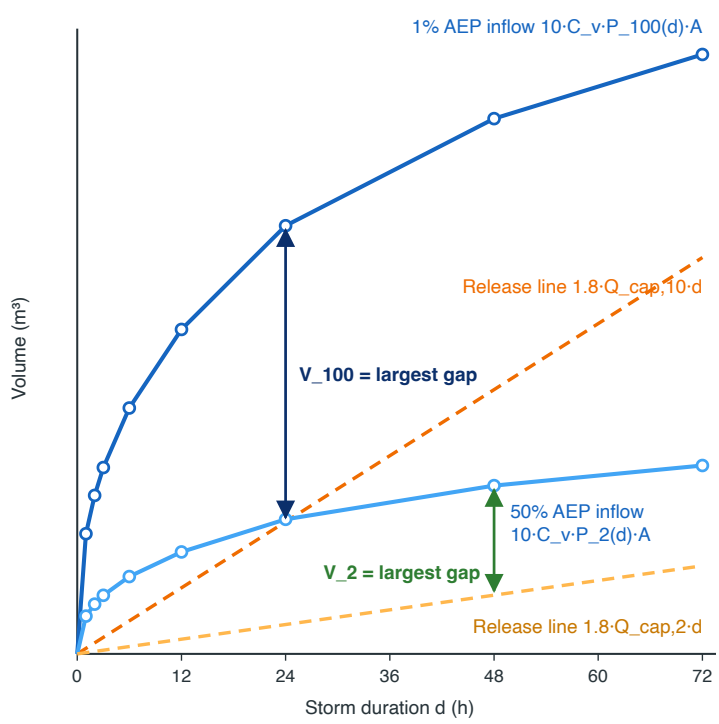
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

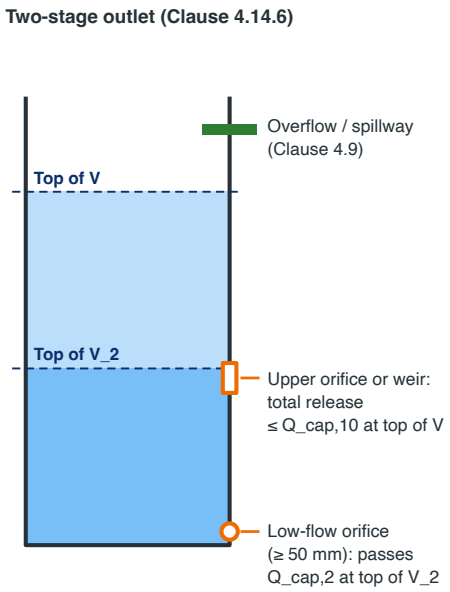
where P_100(d) and P_2(d) are the 1% and 50% AEP rainfall depths (mm) for duration d (hours), with the climate factor; and C_v is the post-development volumetric coefficient: the composite C of Table 3.2 (upper half of each range), multiplied by Cf of Table 3.3 for the 1% AEP. For durations of 12 hours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

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

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

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





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

Q_cap,10 = 2.78 × C_10 × i_10 × A ; Q_cap,2 = 2.78 × C_2 × i_2 × 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 × C_v × P_T(d) × A – 1.8 × Q_cap × d] (m³) ; 1.8 = 3.6 × 0.5 (average release of half the cap)

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

> **Commentary.** The fixed-coefficient route follows Singapore, which caps the peak runoff from every development of 0.2 ha or more with one runoff coefficient, C = 0.55, applied to the 10-yr storm (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5, Addendum No. 3, 2025). It is quick to apply and quick to check: the cap needs only the site area, the soil group and two intensities. PUB's 0.55 is not used here, because Singapore's baseline is the existing urban drainage system, while this Manual's baseline is greenfield land (Clause 4.5.1.2). The coefficients of Table 4.3A are set by this Manual from the greenfield curve numbers of Clause 3.3 (CN 39, 61, 74 and 80 for soil groups A to D). They are the ratios of runoff to rainfall that those curve numbers give for 1-hour depths typical of the Ludhiana–Patiala 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 Punjabi 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 Punjab, the governing failure is volume with no outlet when the receiving water is high. The towns of the plains drain through outfalls in the dhussi bandhs of the Sutlej, the Beas, the Ravi and the Ghaggar, or to WRD drains that end in them, and a flap gate closes when the river rises. The rivers rise for days, not hours: at Harike "discharge above 3,00,000 cusecs falls under the High Flood category", and the headworks passed about 2.73 lakh cusecs on 26 August 2025 and 3,35,030 cusecs on 3 September 2025 (as reported); the Ghaggar at Khanauri stood above its danger mark, reported as 748 ft, from 13 to 15 July 2023, reaching 754.2 ft, with breaches left open after it (as reported); and the Pong reservoir took a record inflow of about 7.3 lakh cusecs on 14 August 2023 and then released for weeks (as reported). The dams give warning of the river but none of a local burst: BBMB's release notices from Bhakra and Pong come hours to days ahead, and a local storm can coincide with a high river, as when the storm of 8–10 July 2023 put 35 cm on Ropar in the 24 hours to 08:30 on 10 July (IMD press release) while the Ropar headworks passed about 1.79 lakh cusecs (as reported). The Central Water Commission has no flood site in Punjab, and the gauges used are WRD's and BBMB's, in feet, with gauge zeros not found [TBC]. The Buddha Nallah ends in the Sutlej at Walipur Kalan, and its rehabilitation was designed for a 2-year storm (PMIDC, 2020), so

when the river is high the storm runoff of the city backs up in the city reach. Amritsar drains by the Tung Dhab and City Outfall drains of WRD to the Hudiara drain, which enters Pakistan, so the level at its outfall is outside Indian control (Amritsar Smart City bid, 2018). In the waterlogged south-west many depressions have no gravity outlet at all and drain only by pumping. And the canals are a barrier, not an outlet: a canal, distributary or minor takes no storm water without WRD's written consent, and the siphons and culverts that carry the drains under the canals control the flood level upstream of them (Chapter 5). A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.

The response in this Manual is layered:

- release below pre-development (Clause 4.5);
- retain the frequent storms (Clause 4.4);
- route long SW monsoon storms (Clause 4.6.3);
- prefer regional storage in the chhappar 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 Punjab.** Punjab 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 Punjab: 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 Punjab the receiving water is one of four kinds: a river, the Sutlej, the Beas, the Ravi or the Ghaggar, reached through a sluice or flap gate in a dhussi bandh or through a pumping station, whose level is set by the releases of the dams and headworks upstream and, at the border, by reaches outside the State's control; a drain of WRD, such as the Buddha Nallah, the Tung Dhab and Hudiara drains or a notified drain, or a sector or trunk drain that leads to one; a choe, rao or nadi of the Kandi and the Shivalik fringe, ungauged and sand-laden; or a depression or chhappar that may have no outlet at all, or may be emptied only by pumping, as in the waterlogged south-west; and the canals cross all of them. In Punjab:

- (a) the 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 choe, a canal or a pumped sump, with the river locks of Clause 5.8.5(a) to (e), the drain lock of Clause 5.8.5(i) and the closures of Clause 5.8.5(f) and (g) in place of the tidal lock windows; and
- (d) where there is no defined outfall, Clause 5.8.5(g) 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 Punjab's towns fail in places that site design does not see, and in four different ways. The first is the river. The Sutlej, the Beas and the Ravi are held between dhussi bandhs, about 1,800 km of them (WRD), below the Bhakra, Pong and Ranjit Sagar dams and the Ropar, Harike, Hussainiwala and Madhopur headworks, and the towns along them drain through the bandhs. In 2025 the Sutlej passed 3,35,030 cusecs at Harike and the Madhopur headworks on the Ravi lost gates (as reported); in 2023 the Ghaggar rose to 754.2 ft on the Khanauri gauge and breached its banks at Moonak, Khanauri and Makraud Sahib (as reported); and no river in the State has a CWC gauge (SANDRP, 2018 and 2022, as reported), so the only levels are those of WRD's and the district gauges, in feet, read in the press. The second is the receiving drain. Ludhiana drains to the Sutlej through the Buddha Nallah, 47.55 km long and rebuilt on a 2-year return period (PMIDC, 2020), which carries about 700 MLD of wastewater before it reaches the river at Walipur Kalan (River Rejuvenation Committee, 2025); Amritsar drains through the Tung Dhab and City Outfall drains of WRD to the Hudiara drain and on into Pakistan (Amritsar Smart City bid, 2018); and no design discharge is stated for any of these drains. The third is the choe. The Kandi below the Shivaliks is "traversed by numerous small and big seasonal streams called choes and is prone to flashy floods" (WRD, Kandi Area Development), Hoshiarpur alone has "more than 100 choes" that leave "thick deposits of sand and silt" (District Environment Plan, Hoshiarpur), and the choes of SAS Nagar carry the runoff of Chandigarh and the Shivaliks to the Ghaggar. The fourth is the land with nowhere to drain to. In the south-west the canals and feeders cut across the land's drainage, the water table stands near the surface, and low villages drain only by pumping to the drains of WRD. The outfalls also belong to one body while the drains above them belong to others: the rivers, choes, notified drains and dhussi bandhs are held by WRD, the canals by WRD's canal wing, the dams on the Sutlej and the Beas by BBMB, the sector drains by PUDA or a development authority, the street drains by the Municipal Corporations, Councils and Nagar Panchayats and the chhappars by the Gram Panchayats, 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, if its outfall is buried in choe sand, or if there is nowhere for the water to go. This chapter makes all four failure modes part of the design. Punjab has no tidal outfall, so Clause 5.1.4 says which of the chapter's coastal provisions fall away and what takes their place.

5.2 Definitions

Term	Meaning in this Manual
Analysis point	A location on the downstream system where pre- and post-project conditions are compared (Clause 5.3.3).
Contributing catchment	The whole area draining to an analysis point, on and off site.
Major drain	A channel listed as a major drain in the basin plan or Annex 5B, or any river, WRD canal, the Buddha Nallah, the Tung Dhab and City Outfall drains and the Hudiara drain, the Kala Sanghian drain and the Chitti and Kali Beins, the Sakki/Kiran, Patti and Kasur nallahs, the Chand Bhan drain and its diversion drain, every choe, rao and nadi, every drain notified under section 38 of the Punjab Canal and Drainage Act 2023 or section 55 of the Northern India Canal and Drainage Act 1873, any drain of WRD, and any drain maintained by PUDA, GMADA, GLADA or another development authority, a Municipal Corporation, a Municipal Council or a Nagar Panchayat with an internal width of 1.0 m or more, or a tidal creek.
Chart datum (CD)	The datum of the published tide tables and nautical charts, to which tidal heights are referred.
Mean sea level (MSL)	Average sea level over a long period at a tide gauge.
MHWS	Mean high water springs: the average of high waters at spring tides.
HAT	Highest astronomical tide: the highest level predicted under average meteorological conditions over a full tidal cycle (18.6 years).

Term	Meaning in this Manual
Storm surge	The rise in sea level above the astronomical tide caused by wind and low pressure, mainly during cyclones.
Still-water level	Astronomical tide plus surge, excluding individual waves.
Sea-level allowance (SLA)	The allowance added to present-day tidal levels for sea-level rise over the design life (Clause 5.7.4).
Tailwater	The water level at the downstream end of a drain, outlet or storage.
Tide-lock	The condition in which the tailwater is at or above the upstream water level, so a gravity outfall cannot discharge.
Lock window	A period during which the outfall-closed check of Clause 5.10 sets gravity discharge to zero.
Sand bar	A bar of beach sand that partly or fully closes a river mouth or creek inlet.
Project datum	The levelling datum used on the project drawings. It must be tied to a Survey of India benchmark (Clause 5.7.2).

5.3 Extent of the downstream analysis

5.3.1 The downstream analysis shall start at each site or project outfall. It shall continue downstream to the **first** of:

- (a) the point at which the project area is **10% or less** of the contributing catchment;
- (b) the next **tank, chhappar** 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 chhappar 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, MC Ludhiana, PSDMA or WRD; and
- (e) each building or road segment lying within the 1% AEP flood extent along the route. Representative points may be used where buildings are closely spaced.

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

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

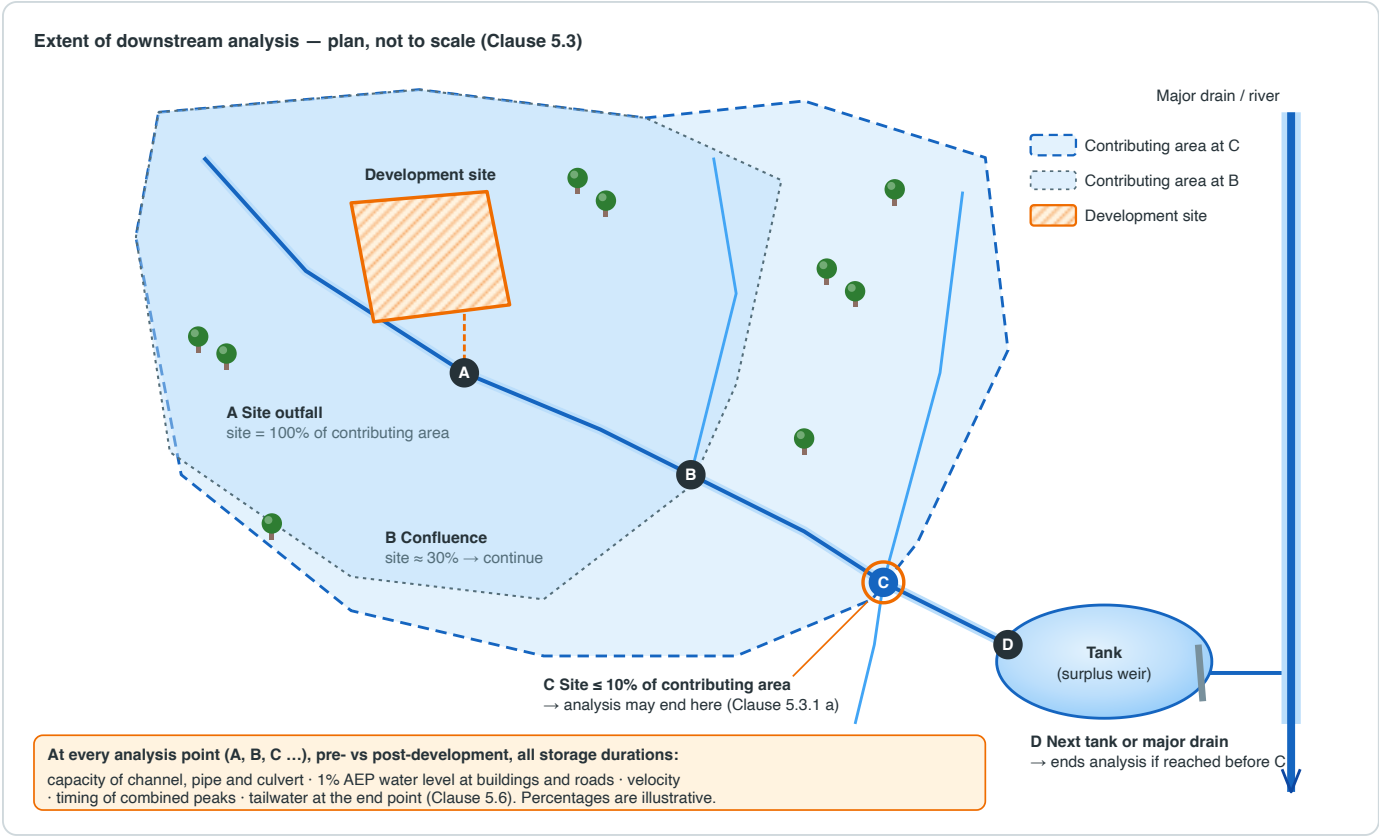

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next chhappar or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Punjab. In Ludhiana, where the city's drains reach the Sutlej through the Buddha Nallah, which runs 47.55 km from the confluence of the Kum Link and Neelon drains near Ghumait to the river at Walipur Kalan (PMIDC, 2020), in Amritsar, where the city's storm water travels by the Tung Dhab and City Outfall drains to the Hudiara drain and on into Pakistan (Amritsar Smart City bid, 2018), and in SAS Nagar, where the N-Choe leaves Chandigarh and runs through the sectors of Mohali and the Pachisdhara drain to the Ghaggar at Sarala Khurd, about 70 km in all (CPCB, 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 south-west of Punjab: the Sutlej at Harike was reported at 2.73 lakh cusecs on 26 August 2025 and at 3,35,030 cusecs on 3 September 2025, above the 3 lakh cusec band that WRD calls "High Flood" (as reported); the Ghaggar at Khanauri crossed its danger mark on 13 July 2023 and stood at 754.2 ft on 15 July, with breaches at Moonak, Khanauri and Makraud Sahib (as reported); and in the south-west, where the water table stands within 1.5 to 5 m of the surface over about 15% of the State (ground water resource assessment of 2020, CGWB and WRD), low villages drain only by pumping and by pipelines to the drains of 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 Punjab, 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, a development authority 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.

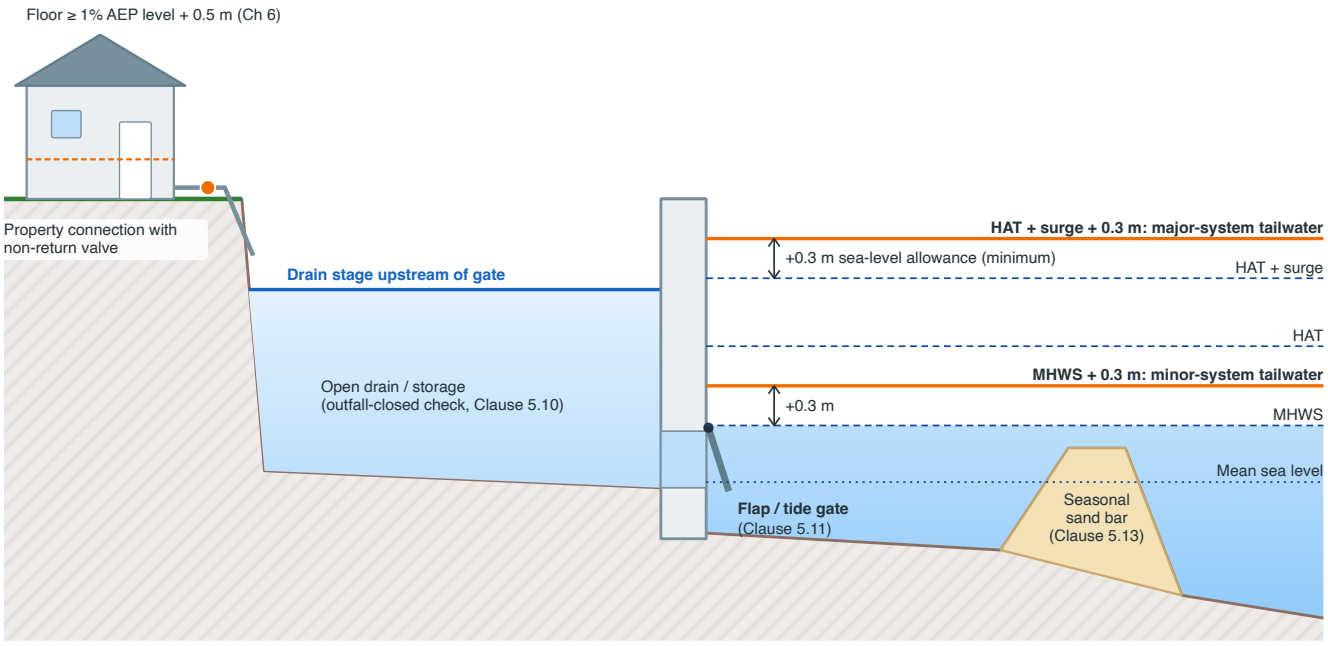

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater 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; Punjab 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 Punjab, 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 **Sutlej** from the **Bhakra** dam past **Nangal**, **Anandpur Sahib** and the **Ropar** headworks at **Rupnagar**, along **Ludhiana**, **Phillaur** and **Shahkot** to the **Harike** headworks, and on past **Ferozepur** to the **Hussainiwala** headworks and the border, with the releases of Bhakra, behind the dhussi bandhs, and the drains that lead to it, among them the **Buddha Nallah** at **Walipur Kalan** and the **Kala Sanghian** drain and **Chitti Bein** of Jalandhar, and the **Swan** below **Anandpur Sahib** (Clauses 5.8.3 and 5.8.5(a), (c) and (i));
- the **Beas** from the **Pong** dam past **Talwara** and **Mukerian** to **Harike**, with the releases of Pong, and the **Kali Bein** that joins it (Clauses 5.8.3 and 5.8.5(c) and (i));
- the **Ravi** below the **Ranjit Sagar** and **Shahpur Kandi** dams and the **Madhopur** headworks, at **Pathankot**, **Gurdaspur** and **Dera Baba Nanak** to the border, with the **Chakki Khad** at **Pathankot** (Clauses 5.8.3 and 5.8.5(c) and (e));
- the **Ghaggar** from the boundary with Haryana at **Mubarakpur** and **Bhankharpur**, along **Dera Bassi** and **Zirakpur** in **SAS Nagar** district, past **Patiala** and **Samana** districts to **Moonak**, **Khanauri** and **Makraud Sahib** and on to **Sardulgarh**, for which no CWC gauge exists, with the choes and nadis that reach it from **SAS Nagar** and **Chandigarh**, among them the **N-Choe**, the **Sukhna Choe**, the **Patiali-ki-Rao** and the **Jayanti Devi ki Rao**, and the **Badi** and **Chhoti Nadi** of **Patiala** (Clause 5.8.5(b) and (e));
- the **Tung Dhab** and **City Outfall** drains of **Amritsar** and the **Hudiara** drain, which enters Pakistan near village **Lalo** (Clause 5.8.5(d));
- the choes of the **Kandi**, among them those of **Hoshiarpur**, **Garhshankar** and **Balachaur**, the **Sirhind** choe, the **Lakhnaur** choe at **SAS Nagar** and the other choes, raos and nadis of sub-area PB-A (Clause 5.8.5(e));
- the **Sakki/Kiran**, **Patti** and **Kasur** nallahs, the **Chand Bhan** drain and its diversion drain, and the other drains of WRD and those notified under section 38 of the Punjab Canal and Drainage Act 2023 or section 55 of the 1873 Act (Clause 5.8.5(i));
- the pumped drains and depressions of the south-west, at **Bathinda**, **Sri Muktsar Sahib**, **Fazilka**, **Abohar** and **Faridkot**, and the chhappars that receive storm water (Clause 5.8.5(g));
- the **Sirhind** canal, the **Bhakra Main Line**, the **Sirhind** and **Rajasthan** feeders, the **SYL** canal and the **Narwana** branch, and every siphon or culvert that carries a drain or choe under a canal (Clause 5.8.5(f)); and
- elsewhere: any river or WRD channel listed in Annex 5B.

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

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

5.8.3 **Reservoir and tank releases.** Where a reservoir or tank upstream can release to the river (for example the Bhakra dam on the Sutlej and the Pong dam on the Beas, operated by BBMB, the Ranjit Sagar and Shahpur Kandi dams on the Ravi, the Ropar, Harike and Hussainiwala headworks on the Sutlej and the Madhopur headworks on the Ravi, and the

low dams of the Kandi), 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 **Outfalls to the Sutlej, the Ghaggar, the Ravi and the Beas, the Hudiara drain, choes and nallahs, canals, the south-west depressions and the drains of WRD.** In Punjab no river level is published by CWC: **CWC has no flood-forecasting, level-monitoring or inflow site in the State** (SANDRP, 2018 and 2022, as reported), so no level in this clause is a CWC level, and no "CWC danger level" exists for any Punjab river. The levels below are readings of the gauges of WRD at its headworks, of BBMB at its dams, or of district gauges, mostly in feet and mostly known from the press. Every level used under this clause shall name its gauge, its unit (feet or metres) and its gauge zero, and shall be tied to the project datum and a Survey of India benchmark by levelling, with WRD's or BBMB's confirmation of the reading; the gauge zeros were not found during research [TBC], and a level in feet shall not be converted to metres above mean sea level until its datum is confirmed (set by this Manual).

- (a) **Sutlej-front towns.** For an outfall to the Sutlej, directly, through a sluice or flap gate in a dhussi bandh (flood embankment), through a pumping station, or through a drain that discharges in one of those ways, at Rupnagar, Ludhiana, Phillaur, Shahkot, Ferozepur or elsewhere between the Ropar headworks and the Hussainiwala headworks:
  - **Operator and levels.** 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 dhussi bandh, the installed pumping capacity and the operating levels, including the river level at which each gate is closed.
  - **Design river level (1% AEP).** The river level of Clause 5.8.2 at the outfall for the major-system cases (Clause 5.8.4(b)) shall be the higher of: (i) the 1% AEP level from a hydraulic model under Clause 5.8.2(b), carrying the 100-year flood of a flood-frequency study by Gumbel's method of the gauge record, which is the method WRD uses for its floodplain zoning (Chief Engineer, Drainage-cum-Mining & Geology, to CWC, 2 May 2024), and, on the Ferozepur–Tarn Taran reach, not less than **5,34,441 cusecs**, the 100-year discharge on which WRD based the Sutlej floodplain zone notified there on 4 March 2024 (WRD affidavit in NGT OA 303/2023); and (ii) the highest flood level surveyed at the outfall from the flood marks of **2019, 2023 and 2025** and from the records of WRD, the local body or the Deputy Commissioner, **plus 0.5 m** (set by this Manual). The 0.5 m is added to the marks because the floods that left them breached the dhussi bandhs upstream, and a mark left by a flood that spilled out of the river is lower than the level the same flood would have reached between intact embankments.
  - **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 headworks record, and shall be not less than the level for a flow of **3,00,000 cusecs** at Harike, routed to the outfall: WRD classes a discharge above 3,00,000 cusecs at Harike as "High Flood" (as reported), and the river passed **3,35,030 cusecs** at Harike on 3 September 2025, at a reading of **686.50 ft** on the upstream gauge (as reported). On the reach above Harike, the 10% AEP level shall be not less than the level of the highest flow recorded at the Ropar headworks, about **2.4 lakh cusecs** in 1988 (as reported), routed down the river with the flows of the tributaries that joined it in the same event, until a frequency analysis of the headworks record is accepted (set by this Manual) [TBC].
  - **Tailwater behind the bandh.** The tailwater at the outfall shall be the higher of the river level beyond the gate or bandh 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 its whole catchment, 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, with gravity discharge through the gate only while the river is lower than the level behind it (set by this Manual). 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). Portable dewatering pumps brought in for an event, pumps lent for a flood, and capacity sanctioned or proposed but not commissioned shall not be counted.

- **River lock.** 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 headworks gauge in the flood that set the highest recorded level or in a comparable flood, and **not less than 7 days (168 hours)** on the Sutlej below the Bhakra dam (set by this Manual). The lock covers the whole of the 48- and 72-hour storms of Clause 5.10.2, so that storage and pumping handle the full storm volume (Clause 5.9.4), and the drawdown of Clause 5.10.5 is met by pumping until the lock ends. A shorter lock may be used only where the outfall invert is above the design river level of this item, or where a gauge analysis under Clause 5.10.6, including the releases of item (c), shows it and the Authority approves it.
- **Release notices.** BBMB's notices of releases from the Bhakra and Pong dams, and WRD's flood warnings for the reach, give hours to days of warning, which the operation and maintenance plan of Chapter 10 shall use as the trigger to close the gates on the dhussi-bandh outfalls and to bring standby pumps into service. They give no warning of a local storm, and the design shall not assume that a gate is opened, a pump started or a drain lowered before the storm on the strength of a notice.
- **The Buddha Nallah.** For an outfall to the Buddha Nallah, or to a drain that ends in it, the level of the Nallah shall be computed under item (i) for the design AEP of the outfall, with all the storm water it receives and its dry-weather flow (Clause 8.9), and with its downstream boundary at the level of the Sutlej at **Walipur Kalan**, where it joins the river (PMIDC, 2020), from this item: the 1% AEP Sutlej level for the major-system cases and the 10% AEP level for the others. The Nallah's rejuvenation design, on a **2-year** return period "with reduced run-off within the city reach due to active storm water detention" (PMIDC feasibility report, January 2020), is a project choice and not a capacity this Manual accepts as a bound: the outfall shall be checked against the minor and major storms of Table 6.1 with the Sutlej at Walipur Kalan as above, and no detention that the project assumes upstream shall be counted unless it is built, maintained and documented (Clause 5.4.4).
- **Gate failure and breach.** Floor levels and pumped outfalls behind a gate or dhussi bandh shall also be checked for the failure of the gate and for a breach of the bandh, with the land and drains behind it filled to the river level beyond it (item (c) gives the 2025 stress case).

- (b) **Ghaggar towns.** For an outfall to the Ghaggar or to a drain that ends in it, at SAS Nagar, Zirakpur and Dera Bassi, Patiala, Samana, Moonak, Khanauri, Makraud Sahib, Sardulgarh or elsewhere, the rules of item (a) on operators, the tailwater behind a bandh, release notices, gate failure and breach apply, and:
  - **Design river level (1% AEP).** Until WRD gives the gauge zero, the danger level and the highest flood level for each gauge on the river [TBC], the design river level shall be the higher of: (i) the 1% AEP level from a hydraulic model under Clause 5.8.2(b), whose inflow at the outfall shall be not less than **2.40 m³/s per km²** of the catchment above it, the 50-year flood of the Ghaggar at MoST road bridge No. 2 in the worked example of the CWC Flood Estimation Report for subzone 1(e) (2,706 m³/s from 1,126 km²), used here as a yardstick for catchments of the same order of size and not as a 1% AEP flood; and (ii) the highest flood level surveyed at the outfall from the flood marks of **July 2023** and of 2025, plus 0.5 m, transferred under item (a). At Khanauri, on the boundary with Haryana, the river stood at **753 ft** on 13 July 2023, described as "the highest-ever so far", and at **754.2 ft** on 15 July 2023, about 6 ft above its danger mark (as reported); the design level there shall be not less than 754.2 ft on that gauge plus 0.5 m. The danger mark at Khanauri is reported as **748 ft**, and also as 752 ft and 753 ft (as reported): the sources conflict, and none is cited here as the danger level.
  - **10% AEP level.** For the cases of Clause 5.8.4(a), the level shall be not less than the highest of the danger marks reported for the nearest gauge, transferred: **753 ft** at Khanauri, the highest of the three reported values, until WRD confirms one; about **16 ft** at Sarala Kalan in Patiala district, reported to correspond to

27,195.94 cusecs; and **20 ft** at the Sardulgarh bridge (all as reported). Where no danger mark has been found, as at Bhankharpur and on the choes, the 10% AEP case shall use the design river level of this item until a frequency analysis is accepted (all set by this Manual).
    - **Capacity.** No reach of the Ghaggar shall be assumed to carry more than it has carried without breaching. At Bhankharpur the river is reported to have carried 1.22 lakh cusecs, against a stated "full capacity" of 70,000 cusecs (both as reported), and below Khanauri the channel is reported to narrow from 588 ft wide to 190 ft between Makraud Sahib and Kadail (as reported); the widening and embankment works on the river recommended by CWPRS (Case 2-D, RD 14,000 to 182,000 m; WRD) shall not be counted until they are complete.
    - **The Haryana reach.** Below Khanauri the Ghaggar runs through Haryana, past Guhla and on to the Ottu weir, and above Mubarakpur it comes from Panchkula, where Haryana has notified a floodplain zone on a 100-year flood of 2,933.45 m³/s (Haryana edition of this Manual, Clause 5.8.5(b)). The level at an outfall near the boundary therefore cannot be set by a Punjab body alone: the designer shall obtain it through WRD, which may coordinate it with the Irrigation and Water Resources Department of Haryana, and shall state on Form 5-1 the level used and its source; until a level is agreed, the level of this item governs (set by this Manual).
    - **River lock.** The single lock of item (a) applies, **not less than 7 days** on the Ghaggar below the Patiala district boundary, at Samana, Moonak, Khanauri, Makraud Sahib and Sardulgarh, and **not less than 72 hours** on the Ghaggar at and above Bhankharpur, in SAS Nagar, Zirakpur and Dera Bassi, and on its choes (set by this Manual).
- (c) **Ravi and Beas towns, and rivers below dams and headworks.** For an outfall to the Ravi, at Pathankot, Gurdaspur or Dera Baba Nanak, to the Beas, at Talwara, Mukerian or elsewhere above Harike, or to the Sutlej between the Bhakra dam and the Ropar headworks, at Nangal and Anandpur Sahib, the rules of item (a) apply, with the river lock of **not less than 7 days** on the Ravi below the Madhopur headworks, on the Beas below the Pong dam and on the Sutlej below the Bhakra dam, at Nangal, Anandpur Sahib and Rupnagar, and of **72 hours** on the Chakki Khad and the Swan (set by this Manual), and:
    - **Dam-spill tailwater.** 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 dam or headworks above, routed to the outfall, with the flow of the catchment below it as it occurred in the same event, until the operator publishes an operating rule that bounds the release [TBC] (set by this Manual). The largest releases found during research, all as reported, are: from **Pong**, about 1.40 to 1.50 lakh cusecs over the days after the record inflow of 7.3 lakh cusecs on 14 August 2023, BBMB stating that the dam "has never released beyond 1.49 lakh cusecs"; below **Bhakra**, no release record was found [TBC], and the largest flow found is about 2.4 lakh cusecs at the Ropar headworks in 1988, most of it reported to come from streams below the dam, which applies at Ropar and below until BBMB gives the record; and from **Ranjit Sagar** in August 2025, between 77,027 cusecs and 1.01 lakh cusecs in one set of reports and 2.12 to 2.21 lakh cusecs in another, which conflict. Where two releases are reported for the same event, the larger applies until the operator gives the record (set by this Manual).
    - **Reservoir and pond levels.** For an outfall to the reservoir or pond of a dam or headworks, the tailwater shall be the higher of its highest recorded level and its highest stated limit, plus 0.5 m, and the outfall shall be treated as closed for the whole storm wherever its invert is below that level: for **Ranjit Sagar**, the full reservoir level of **527.91 m**, which is also reported as 1,731 ft (527.61 m at 0.3048 m to the foot, so the two figures do not agree), the higher governing; for **Shahpur Kandi**, its maximum of **405 m**; and for **Pong**, whose full reservoir level is **1,390 ft**, a "permissible limit of 1,394 feet" and a "technical limit up to 1,410 feet" were both reported in 2025 against a recorded level of **1,399.65 ft** on 15 August 2023 (all as reported), so **1,410 ft** governs (all set by this Manual) [TBC]. The datum of each level is to be confirmed with the operator [TBC].
    - **Madhopur stress case.** On 27 August 2025 gates of the **Madhopur headworks** on the Ravi jammed, and on 28 August a gate was washed away, under a flow described by the State as "less than 2 lakh cusec", with the river "just 2 feet below" the level of the floods of 1988, and the dhussi bandh then breached at three places in the Ajnala and Ramdass areas of Amritsar district and near Dera Baba Nanak (as reported). Every outfall, pumping station and floor level on the Ravi below Madhopur, and on the drains and canals

that the headworks commands, shall also be checked for that event: the river at the 2025 flow with the headworks gates failed open and no regulation at the headworks, and a breach of the bandh under item (a). The check is a stress case: where it floods a building or disables a pumping station that the design cases do not, the designer shall report it on Form 5-1 and state the measures taken (set by this Manual).
    - **No early opening.** No dam, headworks or barrage gate shall be assumed to open earlier or wider than the operator's records show, and a release shall be placed before, during and after the site storm; the travel time of a release from the dam to the outfall may be used to place it, but not to lower it. A river level shall not be reduced on the ground that the flood comes from rain that falls outside the town, outside the State or above a dam.
- (d) **Amritsar, the Tung Dhab and City Outfall drains, and the Hudiara drain.** For an outfall that reaches the **Tung Dhab drain** or the **City Outfall drain** of Amritsar, which are maintained by WRD's drainage division and carry the city's storm water to the **Hudiara drain** (Amritsar Smart City bid 07/ASCL/2018-19, 2018), the Hudiara drain entering Pakistan at RD-138 near village Lalo (as reported):
    - the rules of item (i) apply to both drains;
    - the downstream boundary of the model shall be the level at the junction of the Tung Dhab and Hudiara drains, the higher of the level computed with the Hudiara drain running full at the border and the highest flood level surveyed at the junction plus 0.5 m (set by this Manual). The level of the Hudiara drain beyond the border, and of the river it joins there, is outside the control of any Indian body, and no record of it was found [TBC]; no lowering of it shall be assumed;
    - the river lock of item (a), **not less than 7 days**, applies to an outfall to the Hudiara drain and to every outfall whose drain is backed up by it (set by this Manual).
- (e) **Choes, raos, nadis and nallahs.** For an outfall to a choe, rao, nadi or nallah, such as the choes of Hoshiarpur and the Kandi, the N-Choe, the Patiali-ki-Rao, the Sukhna Choe, the Jayanti Devi ki Rao and the Lakhnaur choe in and around SAS Nagar, the Badi and Chhoti Nadi of Patiala, the Sirhind choe, the Swan and the Chakki Khad, none of which has a gauge whose level was found:
    - the level at the outfall shall be the higher of the 1% AEP level of a hydraulic study of the choe under Clause 5.8.2(b), with the design flow of Clause 2.3.6(i) multiplied by the bulking factor of Clause 6.3.6(b) and the crossings below the outfall blocked under Clause 6.3.6(c), and the highest flood level surveyed at the outfall from the flood marks of 2023 and 2025 and from the records of WRD, the local body or the Deputy Commissioner, plus 0.5 m, with the level of the river or drain the choe ends in under items (a), (b) or (i) as its downstream boundary (set by this Manual);
    - the outfall invert shall be at least **0.5 m above the highest bed level surveyed within 50 m downstream**, because a choe's bed rises and falls with the sand each flood brings and leaves, and its foundation shall be below the scour depth of Chapter 9 (Clause 9.6); no outfall structure shall stand in the active channel of the choe (Clause 6.3.6(f));
    - the outfall-closed check applies with a lock of **not less than 72 hours**, or the lock of the river the choe ends in, where the outfall is closed by the river (set by this Manual);
    - a choe notified under section 38 of the Punjab Canal and Drainage Act 2023, or under section 55 of the Northern India Canal and Drainage Act 1873 before it, such as the Patiala ki Rao in Kharar tehsil (notification of 4 March 2013), is a drainage-work within the notified limits, and item (h) applies to any structure in it.
- (f) **Canals: a barrier, not a receiving system.** A canal, branch, feeder, distributary, minor, kassi or watercourse of WRD carries supply water and is not a drainage outfall. **Storm water shall not be discharged to any of them without the written consent of WRD**; where WRD consents, the tailwater is the higher of the channel's full supply 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 (set by this Manual). No procedure for WRD's consent, and no policy of WRD on canal escapes taking storm water, was found during research [TBC]. In addition:
    - **Crossings as controls.** Every siphon, aqueduct, culvert and super-passage that carries a choe, nallah or drain under or over a canal, and every canal bank across the line of the drainage, shall be modelled as a control on the upstream flood level, with its waterway as surveyed in its present condition, net of silt, and the blockage of Clause 6.12.4 (or of Clause 6.3.6(c) in sub-area PB-A); the canal bank shall be taken as a

weir only at its surveyed crest and only where WRD confirms that the bank may be overtopped. Examples are the siphon that carries the **Sirhind choe** under the Bhakra Main Line canal (WRD lists the lining of the choe from the "BML Syphon D/s"), the siphon of the **Hansi–Butana** canal on the Ghaggar, blamed for ponding at Samana, and the **SYL** canal and the Narwana branch, whose breaches flooded Rajpura in 2023 (as reported).
    - **Breach.** Where water ponds against a canal bank in the design case, floor levels and pumped outfalls on the other side shall also be checked for a breach of the bank, with the land behind it filled to the ponded level.
    - **Feeders in the south-west.** The Sirhind and Rajasthan feeders and the other canals of the south-west cut across the natural drainage of the land and their seepage feeds its waterlogging (as reported); no cross-drainage capacity shall be assumed under them that is not surveyed, and item (g) applies to the land behind them.
- (g) **South-west depressions, pumped outfalls and catchments with no outfall.** In sub-area PB-F of Annex 2A, and wherever 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, or reaches one only by pumping:
    - **No outfall.** 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 (where Clause 4.11 allows infiltration), 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, nallah or road (set by this Manual).
    - **Shared depressions.** Where the site drains to a public depression, chhappar or low ground that also receives other land, the downstream analysis of Clauses 5.3 to 5.5 shall end there and report its maximum water level in the 1% AEP 72-hour storm, with and without the project; it 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 chhappar that receives sullage shall start full (set by this Manual). The overflow path shall be traced to where it ends, within the limits of Table 6.3, and shall not end on a neighbour's land or in another catchment; a pump or pipe that moves the water onto a road, a neighbour's land or another catchment is not an outfall.
    - **Pumped outfalls.** Where a town's or village's drains reach a WRD drain only by pumping, as WRD's pumped drainage and its RCC pipelines from low-lying villages do in the south-west (WRD), the tailwater of the drain or sump shall be its routed level under item (a), with the permanent pumps less the largest one and no portable pumps, with the receiving drain at its level under item (i), and with pumping credited only at the rate that 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).
    - **No infiltration where the water table is high.** Where the October water table is within 3 m of the surface, 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 ground level (Clauses 4.11 and 4.12.1); low ground, fields and depressions 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.
- (h) **WRD consent, section 38 limits, and court and plan lines.** No outfall structure, gate, pumping station or drain shall be built in the bed, bank or floodplain of a river or choe, or in a drain, dhussi bandh or canal of WRD, without the written consent of WRD; WRD has stated that no notified drain may be realigned "without prior permission/NOC from competent authority of Water Resources Department" (report of the Executive Engineer, Drainage-cum-Mining & Geology, SAS Nagar, in NGT OA 279/2024). Within the limits of a notification under section 38 of the Punjab Canal and Drainage Act 2023 (Punjab Act 11 of 2023), or under section 55 of the Northern India Canal and Drainage Act 1873 for a notification issued before the 2023 Act came into force, the notified reach "shall be held to be a drainage-work", the Divisional Canal Officer may have an obstruction removed (s.39), and to construct or alter a drainage work is an offence (s.52); an outfall there shall not be built without WRD's written permission. WRD reports **393 of 869** drains, choes and rivers notified under section 55 (WRD

website), and the press **514 of 935** under the 2023 Act (as reported); no list or notification text giving widths was found [TBC], and the designer shall state whether the outfall lies within notified limits. The designer shall also check the outfall against the lines that bind at the time of design (Chapter 7): the **Sutlej floodplain zone** in Ferozepur and Tarn Taran districts (notification of 4 March 2024), the land between the embankments; the **Patiala ki Rao**, where the High Court has had pillars fixed **200 ft** apart in Chandigarh and the same is pending in Punjab (Local Commissioner's report of 8 January 2024 in CWP 5901/2017), a court-monitored line for that choe only; and the lines proposed for the **Chitti Bein** and the Black Bein in the Master Plan Jalandhar report, which are plan proposals whose notified status was not seen. The NoC of the drainage wing for projects "within the 150-metre radius" of a water body was announced by the Water Resources Minister on 20 September 2023 (as reported); no order was found, and it is not applied in this Manual [TBC]. Whether a drain outfall is permitted within each line is to be confirmed with the authority concerned before design [TBC].

- (i) **Receiving drains of WRD and of other bodies.** For an outfall to a drain of WRD, such as the Buddha Nallah, the Tung Dhab, City Outfall and Hudiara drains, the Kala Sanghian drain and the Chitti and Kali Beins, the Sakki/Kiran, Patti and Kasur nallahs and the Chand Bhan drain, to a drain notified under section 38 (or section 55), to a sector or trunk drain of PUDA, GMADA, GLADA or another development authority or of a Municipal Corporation, Municipal Council or Nagar Panchayat, or to a drain that ends in any of them:
    - **Consent.** Storm water shall not be discharged to a drain of WRD without the written consent of WRD, or to another body's drain without the written consent of that body. 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 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 and dry-weather flow it receives, including the drains of other bodies, with its downstream boundary at the level of the river, drain or depression it ends in under items (a) to (g). No design discharge or design basis was found for any WRD drain [TBC]; until one is published for a drain, the computed level governs.
    - **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, with its narrowest section as surveyed. Where the owner's records give different capacities or widths for the same reach, the lowest applies until the owner confirms one in writing; on the Buddha Nallah, where a road is alleged before the NGT to have cut the channel's width "from 58 feet to 35 feet" (OA 327/2025), the width as surveyed governs. A widening, lining, remodelling or new drain that has been proposed but not completed, including the works of the Buddha Nallah rejuvenation project until each reach is commissioned, shall not be counted (set by this Manual).
    - **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; where the drain is itself backed up by a river under items (a) to (d), the lock is the river lock of that item (set by this Manual).
    - **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.
    - **Sewage.** Many of these drains carry sewage and industrial effluent: the Buddha Nallah about 700 MLD (River Rejuvenation Committee, 2025, as reported to the NGT). The Punjab Canal and Drainage Act 2023 excludes from a "drainage work" the "removal of sewage from towns, villages or any other habitat" (s.2(7)); the interception of dry-weather flow is the subject of Clause 8.9, not of this clause, but the dry-weather flow is part of the flow that sets the drain's level.

No pump, gate, sluice, regulator, headworks or dam operation that helps drainage, such as pumping a drain down before a storm, lowering a chhappar before a storm, closing a gate late or opening dam or headworks 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 or the river (Clause 5.12.3). Pumping shall not be used to move water out of a catchment with no outfall (item (g)).

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. Punjab's rivers break that assumption, because the monsoon spells that fill them fall on the Shivaliks, on the dam catchments and on the towns of the plains together. In the 24 hours to 08:30 on 9 July 2023 Nangal recorded 28 cm, and in the 24 hours to 08:30 on 10 July Ropar 35 cm (IMD press releases); Chandigarh recorded 302.2 mm on 9 July (IMD); and the Sutlej passed 1.79 lakh cusecs at the Ropar headworks and the Ghaggar rose to its highest-ever reading at Khanauri in the same week (as reported). On 24 September 1988 Ludhiana PAU recorded 338.0 mm and Kapurthala 284.2 mm in a day (IMD) while the Sutlej passed about 2.4 lakh cusecs at Ropar and the Bhakra gates were opened (as reported). In August 2025 Pong, Bhakra and Ranjit Sagar were all releasing while the rain went on over the plains, and the towns of SAS Nagar, Ludhiana, Jalandhar and Amritsar flooded in the first days of September (as reported). The two cannot be treated as independent, and a local storm can fall before, during or after the river peak. Clause 5.8.4 therefore pairs a design event on one side with a 10-yr event on the other, in the same way as Clause 2.12(b). This pairing has no direct precedent. It is more severe than an independence assumption would give.

Clause 5.8.3 reflects the dams and headworks above the State's towns, on which no operating rule or release record was obtained during research [TBC], so every figure below is a level or release reported in the press. **Bhakra** (Gobind Sagar), operated by BBMB on the Sutlej, has a permissible level of 1,680 ft, reduced from 1,685 ft after the floods of 1988, and a "technical limit up to 1,690 feet"; its spillway capacity is reported as "four lakh cusecs" and also as 8,212 m³/s, about 2.9 lakh cusecs, which conflict; in 1988 its gates were opened by 22 ft in one report and 20 ft in another, and the Sutlej passed about 2.4 lakh cusecs at the Ropar headworks, most of it from streams below the dam; in July 2023 the flow at Ropar reached 1.79 lakh cusecs (all as reported). **Pong**, operated by BBMB on the Beas, has a full reservoir level of 1,390 ft; it took a record inflow of 7.3 lakh cusecs on 14 August 2023 and rose to 1,399.65 ft, and then released about 1.4 to 1.5 lakh cusecs, BBMB stating that it "has never released beyond 1.49 lakh cusecs"; in 2025 its outflow "was capped at one lakh cusecs" against inflows of 2 to 2.5 lakh cusecs, with the level "four feet above the permissible limit of 1,394 feet" and a "technical limit up to 1,410 feet" (all as reported). On the Ravi, **Ranjit Sagar** has a full reservoir level of 527.91 m, also reported as 1,731 ft, and stood at 527.14 m on 27 August 2025; its releases that week are reported as 77,027 cusecs to 1.01 lakh cusecs and also as 2.12 to 2.21 lakh cusecs, which conflict; **Shahpur Kandi**, about 7 km upstream of Madhopur, has a maximum level of 405 m and stood at 399.60 m on 28 August 2025; and the **Madhopur** headworks lost gates on 27 and 28 August 2025 under "less than 2 lakh cusec" (all as reported). Its discharge capacity is reported as "17,750" in a unit given in the same source both as cumecs and as cusecs [TBC]. Below the dams, the **Harike** headworks at the confluence of the Sutlej and the Beas passed 3,35,030 cusecs, 686.50 ft on its upstream gauge, and **Hussainiwala** 3,02,508 cusecs, 646.50 ft, on 3 September 2025 (as reported), with the Rajasthan feeder taking off at Harike. The Kandi has 12 low dams completed by WRD and others in progress (WRD, Kandi Area Development), whose spillways reach the choes; no operating level or spill record for any of them was found [TBC]. The releases give warning to close gates and move pumps, but they do not lower the river. Until operating rules and release records are obtained, the largest recorded release applies, with the flow of the catchment below it as it occurred in the same event, and the higher of two conflicting reports (Clause 5.8.5(c)).

Clause 5.8.5 is set by this Manual. In Punjab the tailwater at a town outfall is set not by the tide but by a river held behind dhussi bandhs and headworks whose stage the dams upstream and the border downstream decide, by a drain of WRD that may already be full of sewage and storm water, by a choe that brings sand as well as water, by a canal that crosses the line of the drainage, or by a depression in the south-west with nowhere else to go. No document found during research gives a design water level for any of them, and none of the State's building instruments sets one: the Punjab Urban Planning and Development Building Rules 2021 require the plans to show the "methods of disposal of waste water, sewerage and storm water" (PUDBR 2021, r.11), and the Punjab Municipal Building Bye-Laws 2018 require a large project to keep "The inlet and outlet point of natural drain system" with a channel of adequate size (PMBBL 2018, Table 15.1, item 1), with no level in either.

The first is the river, and its gauges. **CWC has no flood-forecasting, level-monitoring or inflow site in Punjab** (SANDRP, 2018 and 2022, as reported), so there is no CWC highest flood level or danger level to transfer to an outfall. The levels that exist are readings of WRD's headworks gauges and of district gauges, in feet, reported in the press, with no gauge zero found: the Sutlej at Harike at 686.50 ft and Hussainiwala at 646.50 ft on 3 September 2025, and the Ghaggar at Khanauri at 754.2 ft on 15 July 2023 (as reported). That is why item (a) requires every level to name its gauge, unit and zero and to be levelled to the project datum, and why it builds the design level from a model and from the flood marks rather than from a gauge reading alone. WRD's own method for its floodplain zoning is a 100-year discharge by Gumbel's method with a waterway by Lacey's formula (Chief Engineer, Drainage-cum-Mining & Geology, to CWC, 2 May 2024), and its 100-year discharge on the Ferozepur–Tarn Taran reach of the Sutlej is 5,34,441 cusecs (WRD affidavit in NGT OA 303/2023); item (a) uses both as the State's precedent for a 1% AEP river. The flood marks of 2019, 2023 and 2025 are raised by 0.5 m, the freeboard this Manual uses for floor levels (Clause 6.11.1), because each of those floods breached the dhussi bandhs (at Janian Chahal near Shahkot, at Gidderpindi and at Mandala in August 2019, and in the Ajnala and Ramdass areas and near Dera Baba Nanak in 2025; as reported), and a flood that spills through a breach leaves a lower mark downstream than it would have left between intact banks. The "High Flood" band at Harike, above 3,00,000 cusecs (as reported), is used as the floor of the 10% AEP level because the river crossed it in 2025 and passed 2.35 lakh cusecs at Harike in 2019 (as reported), so a flow reached about once in ten years is unlikely to lie below it; it is to be replaced by a frequency analysis of the headworks record [TBC].

The second is the length of a river flood. A Punjab river in flood is high for days, not hours, because the dams release for days after the inflow peaks and the plains drain slowly behind the embankments. The flow at Harike was reported at 2.73 lakh cusecs on 26 August 2025 and at 3,35,030 cusecs on 3 September 2025 (as reported); Pong, after a record inflow of 7.3 lakh cusecs on 14 August 2023, released about 1.4 to 1.5 lakh cusecs over the following days, and in 2025 its outflow "was capped at one lakh cusecs" while its inflows ran at 2 to 2.5 lakh cusecs (BBMB, as reported); and the Ghaggar at Khanauri crossed its danger mark on 13 July 2023 and was still rising on 15 July, with breaches at Moonak, Khanauri, Makraud Sahib and Phullad (as reported), while in Mansa the river was reported to be running at levels not seen "since 1993". A single river lock of 7 days on the main rivers below the dams and on the lower Ghaggar covers those spells, and matches the lock that the Haryana edition of this Manual sets on the Ghaggar below Guhla, the reach that continues from Khanauri. The Ghaggar above Bhankharpur, the choes, the Chakki Khad and the Swan 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, as it does in the Haryana and Himachal Pradesh editions on the same streams. Neither lock is a substitute for the stage record of the flood that set the highest level, from which each is to be lengthened. BBMB's release notices are useful for operation, not for design: they give hours to days of warning before a release reaches a town, which is enough to close a gate and move a pump, but a local storm gives none, and the storm and the release come from the same monsoon spell (see the Commentary to Clause 5.8.4).

The third is the dams and headworks. Item (c) runs the design storm with the river at the largest recorded release because the storage of the dams does not bound the river below them. In 2023 Pong took a record inflow of 7.3 lakh cusecs and rose to 1,399.65 ft, about 10 ft above its full reservoir level of 1,390 ft (as reported), before its releases were raised; in 2025 the Madhopur headworks on the Ravi lost gates under a flow the State put at "less than 2 lakh cusec", with the river close to its level of 1988 (as reported), and the dhussi bandh breached below it. The levels and limits of the dams are themselves reported in conflicting forms: Bhakra's permissible level is 1,680 ft, reduced from 1,685 ft after 1988, with a "technical limit up to 1,690 feet"; Pong's full reservoir level is 1,390 ft but a "permissible limit of 1,394 feet" and a "technical limit up to 1,410 feet" were stated in 2025; and the releases of Ranjit Sagar in August 2025 are reported as about 1 lakh cusecs in one set of reports and more than 2 lakh in another (all as reported). Item (c) takes the higher value in each case until the operator gives the record, and treats the Madhopur failure as a stress case rather than a design case because a gate failure is not an event with a return period; it is checked so that a pumping station or floor level that would fail in it is known.

The fourth is the Ghaggar. The Ghaggar crosses the State boundary twice, from Panchkula into SAS Nagar and from Khanauri into Haryana, and no CWC gauge exists anywhere in its basin (SANDRP, 2018). Its levels are known only as readings in feet, its danger mark at Khanauri is reported as 748 ft, 752 ft and 753 ft (as reported), and its

capacity is reported as 70,000 cusecs at Bhankharpur, where 1.22 lakh cusecs was also reported (as reported). Item (b) therefore names no danger level as fact, takes the highest reported mark as the floor of the 10% AEP case, and sets a floor on the model inflow from the only Ghaggar flood in a CWC report, the 50-year flood of 2,706 m³/s from 1,126 km² at the border bridge (CWC Flood Estimation Report, subzone 1(e), worked example), about 2.40 m³/s per km². The level at the boundary depends on Haryana's reach downstream, which is why item (b) asks WRD to coordinate it.

The fifth is the drains, the border and the canals. The city drains of Amritsar reach the Tung Dhab and City Outfall drains of WRD and then the Hudiara drain, which crosses into Pakistan (Amritsar Smart City bid, 2018; as reported); the level beyond the border cannot be obtained or influenced, so item (d) bounds it from the Indian side and gives it the long lock. Ludhiana's drains reach the Sutlej through the Buddha Nallah, which is being rebuilt on a 2-year return period (PMIDC, 2020) and carries about 700 MLD of wastewater (River Rejuvenation Committee, 2025), so item (a) checks every outfall to it against this Manual's storms with the Sutlej high at Walipur Kalan, and item (i) counts its dry-weather flow in its level. No design discharge was found for any WRD drain, and WRD's own counts of its drains differ (7,200 km of drains, and 393 of 869 notified, on its website; 514 of 935 notified in the press; as reported), which is why item (i) computes each drain's level and takes the lowest reported capacity. The canals are the State's largest structures across the line of the land's drainage. No policy of WRD on canal escapes taking storm water was found; the Sirhind canal was reported stopped after villagers put rainwater into it, the SYL canal and the Narwana branch breached and flooded Rajpura in 2023, the Hansi–Butana siphon on the Ghaggar was blamed for ponding at Samana, and about 35 breaches in canals and minors were reported in a single storm in June 2026 (all as reported). Item (f) therefore treats a canal as a barrier, not as an outfall, and models every siphon and canal bank as a control on the level upstream of it.

The sixth is the land with no outfall. In the south-west the water table stands within 1.5 to 5 m of the surface over about 15% of the State, mostly in the south-west, while elsewhere the area deeper than 10 m grew from 14.9% of the State in June 1989 to 68% in June 2019 (ground water resource assessment of 2020, CGWB and WRD), the canals and feeders block the natural drainage and feed the waterlogging, and WRD drains low villages by pumping and by pipelines (WRD). Item (g) applies the 72-hour design volume where there is no outfall, gives no infiltration credit where the October water table is within 3 m, counts only permanent pumps, and limits credited pumping to what WRD's consent allows when its drain is full, because a pump that discharges into a full drain only moves the flood downstream.

The seventh is the body that owns the receiving water. The rivers, choes, notified drains and dhussi bandhs are WRD's, the canals are WRD's canal wing's, the dams on the Sutlej and the Beas are BBMB's, the sector drains are PUDA's or a development authority's until they are transferred, the street drains are the local body's, and the chhappars are the Gram Panchayat's; no rule divides them (Chapter 6, Clause 6.9). Items (h) and (i) ask for the owner's consent and design level because a design that discharges to a channel cannot be checked without them. Section 38 of the Punjab Canal and Drainage Act 2023 lets the State notify limits along a river, stream or drainage-channel within which obstruction is barred, and WRD reports notifying several hundred drains under it and under section 55 of the 1873 Act before it; no list giving the limits was found, and item (h) asks the designer to state whether the outfall lies in notified limits. The lines of item (h) 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:

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

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

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

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

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

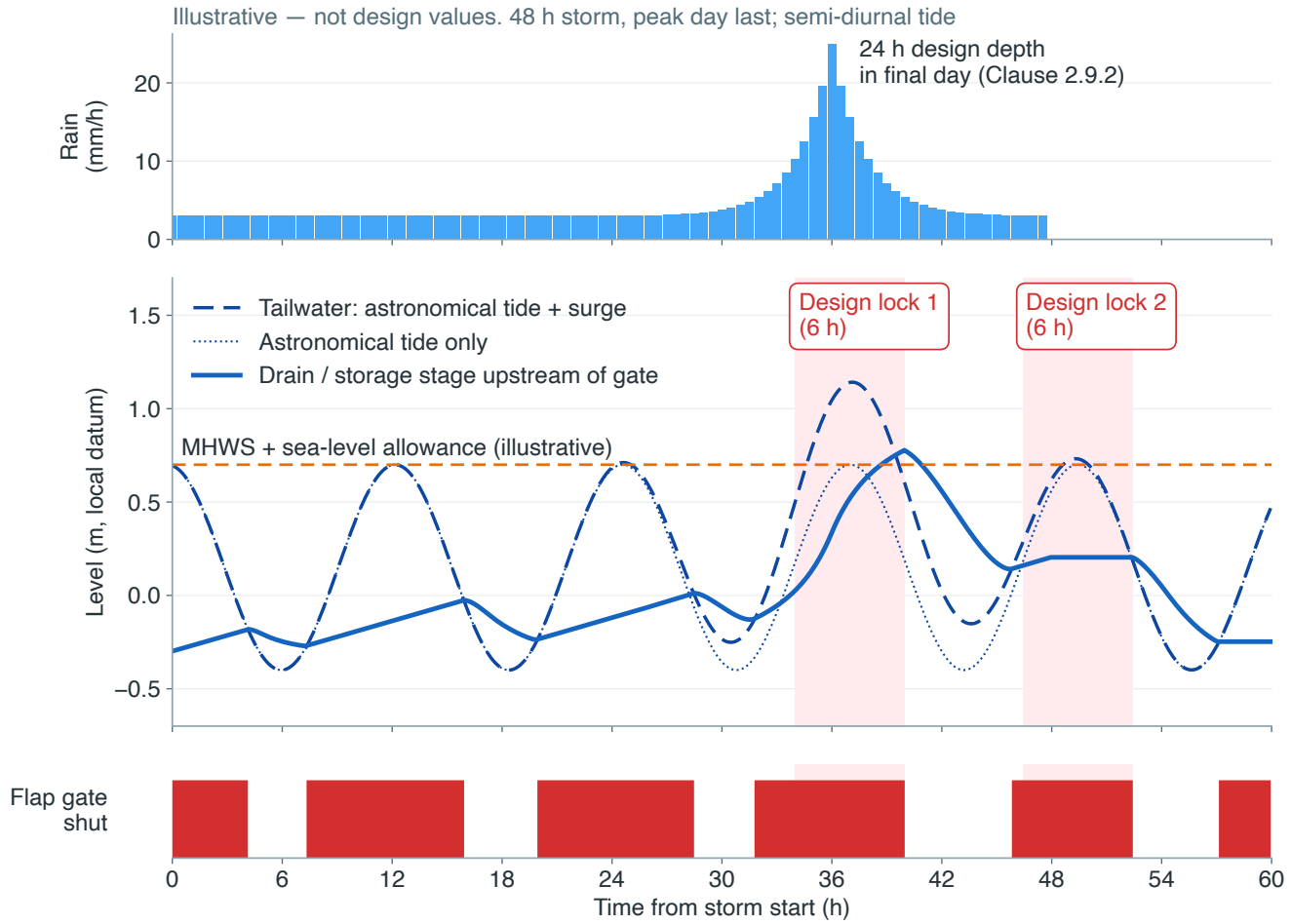

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal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

Commentary. The outfall-closed check is the distinctive Punjab requirement in this Manual. In Punjab it applies where an outfall is shut not by the tide but by a river that stays high for days behind its dhussi bandhs, by a receiving drain that is already full, by a choe or a canal, or by a depression with no outlet. The Sutlej at Harike was reported at 2.73 lakh cusecs on 26 August 2025 and at 3,35,030 cusecs on 3 September 2025, above the band that WRD calls "High Flood" (as reported). The Ghaggar at Khanauri crossed its danger mark on 13 July 2023 and was still higher on 15 July (as reported). Pong released about 1.4 to 1.5 lakh cusecs for days after its record inflow of August 2023, and kept releasing into September in 2025 (as reported). 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 with no outlet empties only by infiltration and evaporation, and the low ground of the south-west 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 7 days on the Sutlej, the Beas and the Ravi below the dams, on the lower Ghaggar and on the Hudiara drain, of at least 72 hours on the upper Ghaggar and the choes, 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 Punjab the outfalls do not cross a beach, but many of them pass through a sluice or flap gate in a dhussi bandh, or reach a river below headworks whose gates can fail, and the bandhs breach. On 27 August 2025 gates of the Madhopur headworks on the Ravi jammed, and the next day a gate was washed away, under a flow the State described as "less than 2 lakh cusec" (as reported); the dhussi bandh on the Ravi then breached at three places in the Ajnala and Ramdass areas of Amritsar district, and near Dera Baba Nanak (as reported). In August 2019 the Sutlej breached the dhussi bandh near Shahkot, flooding Janian and Janian Chahal, and at Gidderpindi near Sultanpur Lodhi and at Mandala in Jalandhar district; the breach at Janian Chahal was reported as 500 feet wide in one account and as about 130 m wide and 13 m deep in another (as reported). A gate that is jammed or left open lets the river or the receiving

> drain back into the drains behind it, and a bandh that breaches fills the land behind it to the river level. The dhussi bandhs, the sluices in them and the headworks are held by WRD, and the dams upstream by BBMB or the operator of the dam, while the drains that reach them belong to the Municipal Corporations, Councils and Nagar Panchayats, to PUDA and the development authorities or to the Gram Panchayats, 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 Punjab: 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 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 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. Punjab 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 sand and silt that the choes of the Kandi leave at an outfall, and the silt, solid waste and dumped material that block the drains below them. The choes of Hoshiarpur "originate from Shivalik slopes and take shape of wide channels after entering the foothill plains", leaving "thick deposits of sand and silt" (District Environment Plan, Hoshiarpur); the Phase 11 area of SAS Nagar is reported to flood when the Lakhnaur choe is not cleared (as reported); and the NGT has recorded that debris in the N-Choe is "shrinking size of drain causing serious apprehension of flood" (OA 736/2022, as quoted by CPCB, 2024). A flap gate held open or shut by sand, a sluice in a dhussi bandh whose gates cannot be moved, or a headworks gate that jams, as at Madhopur in 2025, turns a designed outfall into a dead end or a back-flow path. No written gate-operation rule for

> any sluice in a dhussi bandh, or for any regulator on a WRD drain, was found during research [TBC]. Clauses 5.8.5(e) and 6.3.6 deal with the sand, and Clause 5.8.5 gives 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 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.

References (chapter)

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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 choe draining to the Ghaggar in SAS Nagar (Mohali)
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) Punjab 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. Punjab's drains have been designed to no stated standard, or to a low one, and with no plan for floods larger than the drain. No storm-drain design standard of the State, of PWSSB, PMIDC, PUDA, GMADA or GLADA, or of any Municipal Corporation was found during research. The two design return periods found are project choices: the trunk storm sewers of the walled city of Amritsar were designed for "a return period of once in two years", with a "Minimum time of concentration … 15 mins", and "the surcharging inside the manhole has been allowed (without flooding)" so that pipe sizes could be kept small enough for the narrow lanes (Amritsar Smart City bid 07/ASCL/2018-19, 2018); and the rejuvenation of the Buddha Nallah in Ludhiana was designed "considering 2 year return period with reduced run-off within the city reach due to active storm water detention" (PMIDC feasibility report, 2020). Under AMRUT, "No work was done" on storm water drainage in the State up to September 2020 "due to shortage of funds and priority to cover water supply and sewerage" (CAG Report No. 7 of 2021). In Jalandhar "only about 5% of the city area is covered under the storm water network", 11.53 of 93.41 km², and "the rain water is largely discharged in to the sewer network", choking it (Master Plan Jalandhar report). The storms these drains face are far larger than a 2-year storm: Patiala recorded 356.5 mm in a day on 11 July 1993 and Ludhiana 354.3 mm on 4 October 1955 (IMD), and on 1 to 3 September 2025 SAS Nagar, Ludhiana, Jalandhar and Amritsar flooded within the city in rain for which no depths were reported (as reported). Where the drains overflow, the water runs along the roads and collects in the low streets and village abadis, because the roads are the only path left, and the natural channels that should carry the overflow have been narrowed or built over: the Punjab portion of the Patiala ki Rao was found "heavily encroached by squatters" with "rampant illegal

construction even deep inside the Nadi/Choe" (Local Commissioner's report of 8 January 2024 in CWP 5901/2017), a road along the Buddha Nallah is alleged before the NGT to have cut its width "from 58 feet to 35 feet" (OA 327/2025), and villagers told GMADA that "the village Abadi area is seven feet lower than the level of stream (Nadi) area" beside a new sector road in SAS Nagar (GMADA, social impact assessment for sector roads 92 and 92-Alpha, 2021). The drains are also divided among owners: the Municipal Corporations, Councils and Nagar Panchayats, PUDA and the development authorities, the Smart City companies, PWSSB and PMIDC as builders, PWD (B&R) and NHAI, the Gram Panchayats and WRD all build or hold drains and receiving waters in the same town, and no rule divides them (see the Commentary to Clause 6.9). Fixing the rainfall (Chapter 2) is only half the answer. The other half is a second, surface-level system that carries the flows the pipes cannot, without flooding buildings. That is the dual drainage concept of this chapter, taken from Kansas City Metro APWA Section 5600 (5601.8, Levels of Service), which requires every element to have a 1% AEP overflow path.

6.2 Definitions

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

6.3 The dual drainage concept

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

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

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

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

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

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

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

6.3.6 **Choe crossings and Kandi drains (sub-area PB-A).** This clause applies to every element of the minor and major systems that receives runoff from the Shivalik hills or the Kandi, which in this Manual means land in sub-area PB-A of Annex 2A, any catchment whose natural ground slopes more than 10% on average, and any choe, rao, nadi, khad or other seasonal stream that comes down from the Shivaliks, wherever it runs, including the choes that cross SAS Nagar, Kharar, Zirakpur, Dera Bassi and New Chandigarh on their way to the Ghaggar. Such elements shall meet Clauses 6.4 to 6.14 and, in addition (all set by this Manual):

- (a) **Debris racks and sediment traps.** Every inlet, drain or pipe entrance and culvert that receives flow from **1 ha or more** of unbuilt Shivalik or Kandi land (forest, scrub, grassland, bare or eroded slope, a quarried surface or a choe bed), or from a choe, rao or nadi whatever its catchment, shall have a debris rack or a sediment trap upstream of it, designed under Chapter 9 (Clause 9.8), with machine access and a place to stockpile what it catches that is not a slope, a choe bed or a drain. With 50% of the rack blocked, the element it protects shall still pass its design flow, and the overflow route shall not send the flow onto a building or an unprotected slope. Racks and traps shall be cleared by 15 June and, in sub-area PB-A, again after the monsoon by 31 October (Chapter 10). The volume of a sediment basin is to be set in Chapter 9 [TBC].
- (b) **Bulking factor.** The design flow of every channel, drain, pipe, culvert and crossing that receives flow from such a catchment shall be the clear-water peak flow of Chapters 2 and 3, with Clause 2.3.6(i) for the Kandi and Shivalik catchments, multiplied by a bulking factor of **1.25**, for the minor design flow, the check event and the 1% AEP flow; elsewhere the factor is 1.0. The factor applies to capacity, freeboard and velocity; it does not apply to the runoff volume used for storage (Chapter 4). A larger factor shall be used where a sediment study of the catchment gives one.
- (c) **Blockage.** The blockage check of Clause 6.12.4 shall assume 50% of the inlet area blocked for every culvert and pipe entrance with a span or diameter below **3.0 m**, and 20% for larger ones, whether or not a debris rack is provided. Grate inlets keep the clogging factor of Table 6.5, and kerb openings on grade take the sag value of 20%.
- (d) **Sediment and minimum velocity.** Drains and pipes that receive flow from such a catchment, or that run across the Kandi fans of sub-area PB-A, shall reach a velocity of at least **1.0 m/s** at the minor design flow, in place of the minimum of Clause 6.7.3(a). Where the gradient does not allow it, a sediment trap shall be provided upstream and the sediment allowance of Clause 6.7.8 doubled (Clause 6.7.4). Every town drain that takes the flow of a choe, or of a catchment under item (a), shall have a sediment trap where it takes it, so that the sand the choe carries settles where it can be removed and not in the drain.

- (e) **Steep drains and steep streets.** Where the gradient of a drain gives a velocity above the limits of Clause 6.7.3(b), or a Froude number above 0.8, at the design flow, the drain shall be a lined chute, a stepped channel or a series of drop structures designed under Chapter 9 for the bulked flow of item (b), with the freeboard of Table 6.7 for steep channels and an energy dissipator at every change to a flatter gradient and at the outlet. On a street steeper than 5%, grate-only inlets shall not be used, and inlets shall be placed by the calculation of Clause 6.6.4 with the bypass flows of a steep gutter; on a street steeper than 10%, the flow shall be intercepted by transverse grated channels or kerb inlets at a spacing that keeps the street flow within the limits of Table 6.3 in the check and 1% AEP events.
- (f) **Choe beds and choe crossings.** No choe, rao or nadi bed shall be narrowed, filled, covered, decked, built over or diverted by a development, a road, a drain or a boundary wall, and no structure shall be placed in it, other than a crossing, outfall or protection work designed under this clause with the written consent of WRD (Clause 5.8.5(h)); where the choe is notified under section 38 of the Punjab Canal and Drainage Act 2023, or under section 55 of the Northern India Canal and Drainage Act 1873, the notified limits apply as well. Every culvert, causeway and bridge on a choe shall pass the bulked 1% AEP flow of item (b) with the blockage of item (c) without raising the upstream level above the floor levels of Clause 6.11, and a causeway shall be treated as closed to traffic whenever it is overtopped. Every outfall to a choe shall have its invert at least **0.5 m above the highest bed level surveyed within 50 m downstream**, shall enter in the direction of flow, and shall have an erosion-resistant apron and scour protection designed under Chapter 9 (Clause 5.8.5(e)).
- (g) **Foothill roads as the minor system.** In sub-area PB-A, and on any road elsewhere that crosses a choe or a Kandi catchment, the drainage of a road is the minor system for the land above it as well as for the road. Every road and street there shall have, as works of the road's owner, PWD (B&R), NHAI or the local body:
  - (i) a lined catch-water drain above every cut slope where the land above drains towards the road, discharging to a natural channel or a cross-drainage work and not over the cut;
  - (ii) lined side drains on the hill side (IRC:SP:42-2014, cl. 8.5.1);
  - (iii) a cross-drainage work at every choe, rao and nadi, and culverts or scuppers at intervals such that no side drain exceeds its capacity at the design AEP of Table 6.1 with the factors of items (b) and (c);
  - (iv) at the outlet of every scupper, culvert and side drain on the valley side, a lined chute, cascade or pipe carrying the flow to a stable natural channel, with an energy dissipator, so that road runoff is **never discharged onto an unprotected slope**, fill, retaining wall or the land of a building below;
  - (v) culverts of at least the size of Clause 6.12.5, designed under Clause 6.12 and not less than IRC:SP:42-2014 cl. 7.1.4 requires for the road; where the drainage provisions of IRC:SP:48-1998, the Hill Road Manual, which were not read for this Manual [TBC], are stricter than this item, they apply; and
  - (vi) no muck, spoil, quarry waste or excavated material from the construction, widening or maintenance of the road placed in or beside a choe, rao, nadi or other line of natural drainage, or on a slope from which a storm can carry it into one.
- (h) **Sloping sites.** On a site where the land above drains towards a building, its cut or its retaining wall, the runoff of that land shall be intercepted above them by a lined diversion drain sized for the minor design flow of Table 6.1 from the land above it, with the factors of items (b) and (c), with a 1% AEP flow path that does not pass through or against the building. It shall discharge to a public drain or a stable natural channel as item (g)(iv) requires, not onto the slope below. Roof and paved-area runoff on such a site follows the hill infiltration rule of Clause 4.11.

> **Commentary.** The CPHEEO (2019) manual defines major and minor systems in its glossary but gives no return period for the major system. APWA 5600 (2006, 5601.8) requires the system to convey the 1% peak and, where in-system capacity is less, an overflow system to carry the remainder. Clause 6.3.3 subtracts only the *clogged* inlet capacity, not the full pipe capacity, because in practice the pipes cannot take more water than the inlets admit. The fully-blocked check at sags has no direct precedent; this Manual sets it because of the Amritsar experience that drains under footpaths are often silted or blocked by solid waste when the heaviest rain arrives (CPHEEO 2019 Part A, Ch 1 and 2, Figures 1.2 and 2.1 on solid waste dumping in drains). The prohibition on inter-catchment transfer follows the DID Malaysia 2008 submission checklist, which prohibits inter-catchment diversion. Clause 6.3.6 is set by this Manual for the Shivalik fringe and the Kandi of Punjab, on the model of the clause that the Himachal Pradesh edition sets for its hills, because the criteria of this chapter assume clear water on gentle ground, and the water of a choe is not clear. The Kandi below the Shivaliks "is traversed by numerous small and

big seasonal streams called choes and is prone to flashy floods", and "About 40% of this rain water gets wasted in floods" (WRD, Kandi Area Development); the plain there slopes about 16 m per kilometre, decreasing westwards (CGWB, Hoshiarpur district report). Hoshiarpur district alone has "more than 100 choes", which "originate from Shivalik slopes and take shape of wide channels after entering the foothill plains" and leave "thick deposits of sand and silt" (District Environment Plan, Hoshiarpur). The same choes cross the sectors of SAS Nagar and Chandigarh on their way to the Ghaggar: the Phase 11 area of SAS Nagar is reported to flood when the Lakhnaur choe is not cleared (as reported); villagers beside a new sector road told GMADA that "the village Abadi area is seven feet lower than the level of stream (Nadi) area", and the assessment recommended that GMADA "not disturb the natural passage of 'Nadi' or allied tributaries" and recalculate the nadi's runoff "as per proposed landuse" (GMADA, social impact assessment for sector roads 92 and 92-Alpha, 2021); the NGT has recorded that debris in the N-Choe is "shrinking size of drain causing serious apprehension of flood" (OA 736/2022, as quoted by CPCB, 2024); and the Punjab portion of the Patiala ki Rao was found "heavily encroached by squatters" with "rampant illegal construction even deep inside the Nadi/Choe" (Local Commissioner's report of 8 January 2024 in CWP 5901/2017). That is why item (f) forbids narrowing, filling or covering a choe bed, whatever the choe is called and whoever maintains it: the rule matches the notification of 4 March 2013 on the Patiala ki Rao, which authorises action against any construction in, or covering of, the nadi, and the Punjab Land Preservation (Chos) Act 1900, under which the State may regulate the clearing, quarrying and cultivation of notified Kandi land (s.4, as quoted). The clause does not ask for the concrete channelisation of choes, and it does not forbid it: WRD has channelised and lined choes, among them the Sirhind choe below the siphon of the Bhakra Main Line and the N-Choe in IT City (WRD), and Hoshiarpur's choes have been channelised "to avoid any disaster caused by over flooding" (District Environment Plan, Hoshiarpur); such a work is a work of WRD under Clause 5.8.5(h), and item (f) requires only that what a development puts across or beside a choe passes the choe's bulked flood. No Indian guidance on bulking factors, debris racks or sediment basins was found during research [TBC], so each number in Clause 6.3.6 is an interim value with a stated reason, the same as in the Himachal Pradesh edition. The 1 ha trigger for a rack or trap reflects the short time of concentration on the Shivalik slopes and the Kandi fans, so that even a small unbuilt slope delivers sand, gravel and leaves to an inlet in the first burst of a storm. The bulking factor of 1.25 is the factor for a flow that carries a fifth of its volume as sediment (bulking factor = 1 / (1 − sediment fraction by volume)): about the most that a drain can carry and still behave as a water flood; it is to be replaced by a sediment study of the Kandi choes as soon as one is made [TBC]. The 3.0 m limit in item (c) doubles the core's 1.5 m because sand, gravel and branches block openings that leaves and plastic do not. The 1.0 m/s minimum in item (d) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm, because the choes carry coarse sand and gravel, and the sediment trap where a town drain takes a choe keeps that sand out of the town's drains. The 0.5 m clearance of an outfall invert above the highest surveyed bed in item (f) allows for the bed to rise in a single flood, which is how an outfall to a choe is buried. Few streets in the State are steep, but those of Pathankot, Dhar Kalan and the Shivalik townships are, and on a 10% street the hazard limit of 2.0 m/s is reached when sheet flow on a concrete surface is only about 30 mm deep, which is why item (e) takes the flow off steep carriageways. IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently: their side drains are lined because "rolling stones cause high friction", and "culverts are required at closer intervals compared to those in plain areas"; item (g) applies the same to the foothill roads of PWD (B&R), NHAI and the local bodies, and adds that their runoff shall never be discharged onto an unprotected slope, because water discharged onto a slope raises its pore pressure (Chapter 4, Clause 4.11). The clearance of sand and debris after the monsoon, by 31 October, follows from the same evidence: a choe that has left its sand at a crossing in September has blocked it for the next storm, and a storm can come in October, as in 1955.

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: Ludhiana, Amritsar, Jalandhar, Patiala and SAS Nagar (Mohali) core and other high-density areas	10% (10-yr)	1% (100-yr) overland path	This Manual (see Commentary)
Minor system: other Class I areas	20% (5-yr)	1% overland path	This Manual; CPHEEO Table 4.1
Minor system: other areas	50% (2-yr)	1% overland path	This Manual; CPHEEO Table 4.1
Arterial road drainage and crossings	2% (50-yr) for arterials that are notified evacuation or emergency routes; 4% (25-yr) for other arterials	Next higher AEP: 1% for a 2% design; 2% for a 4% design	This Manual (25–50-yr); split set by this Manual
Collector road drainage and crossings	4% (25-yr)	2% (50-yr)	This Manual
Local road drainage and crossings	10% (10-yr)	4% (25-yr)	This Manual
Road underpasses and other trapped sags on public roads	2% (50-yr)	1% (100-yr)	This Manual (Clause 6.10.5)
Airports, railway stations, power stations and other critical infrastructure	1% (100-yr) in Class I areas; 2% (50-yr) elsewhere	—	CPHEEO 2019 Table 4.1
Major (overland) system, every element	1% (100-yr)	—	This Manual
Building floor levels	1% level + 0.5 m freeboard	—	This Manual (Clause 6.11)

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

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

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

- (a) the walled city of Amritsar, about 877 acres (3.55 km²) at a density of 300 to 550 persons per acre (Amritsar Smart City bid 07/ASCL/2018-19, 2018), and the old cores of Ludhiana, Jalandhar, Patiala and Bathinda: the older, densely built area within each Municipal Corporation that the applicable master plan identifies as the walled city, old city or core, outside the urban estates and sectors planned since, with the boundary of each to be confirmed by the Municipal Corporation, DLG and HUD [TBC]; and the village abadis (the Lal Lakir) that lie inside the sectors of SAS Nagar (Mohali), with the boundary to be confirmed by GMADA and the Municipal Corporation SAS Nagar [TBC];
- (b) in every other Municipal Corporation, Municipal Council or Nagar Panchayat, the area that the applicable master plan identifies as the old town, walled city, core or central bazaar, and the abadi (Lal Lakir) of every village that has 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:

> $Q = (Ku / n) \cdot Sx^{(5/3)} \cdot SL^{(1/2)} \cdot T^{(8/3)}$

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

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

Table 6.2 — Street flow limits

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

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

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

Location	Required hazard class (Table 6.4)	Limits
Carriageways of all roads	H2 or better	D·V ≤ 0.6 m²/s; D ≤ 0.35 m (Table 6.2); V ≤ 2.0 m/s
Footpaths, pedestrian crossings, school, hospital and transit-stop frontages	H1	D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s
Notified evacuation and emergency routes	H1	D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s
Overland flow paths in public open space or easements, away from roads	H3 or better, with warning signs	D·V ≤ 0.6 m²/s; D ≤ 1.2 m; V ≤ 2.0 m/s

Table 6.4 — Combined flood hazard vulnerability classes (reproduced for reference)

Class	Description	D·V limit (m²/s)	Depth limit D (m)	Velocity limit V (m/s)
H1	Generally safe for vehicles, people and buildings	≤ 0.3	0.3	2.0
H2	Unsafe for small vehicles	≤ 0.6	0.5	2.0
H3	Unsafe for vehicles, children and the elderly	≤ 0.6	1.2	2.0
H4	Unsafe for vehicles and people	≤ 1.0	2.0	2.0
H5	Unsafe for vehicles and people; buildings vulnerable to structural damage	≤ 4.0	4.0	4.0
H6	Unsafe for vehicles and people; all buildings vulnerable to failure	> 4.0	—	—

Source: AIDR Guideline 7-3, *Technical flood risk management guideline: Flood hazard* (2014), Tables 1 and 2, modelled after Smith and Wasko (2012).

6.5.4 Depth and velocity for Clause 6.5.3 shall be taken from the gutter-flow calculation for simple sections, or from a 1D or 2D hydraulic model where flow leaves the kerb-and-gutter section.

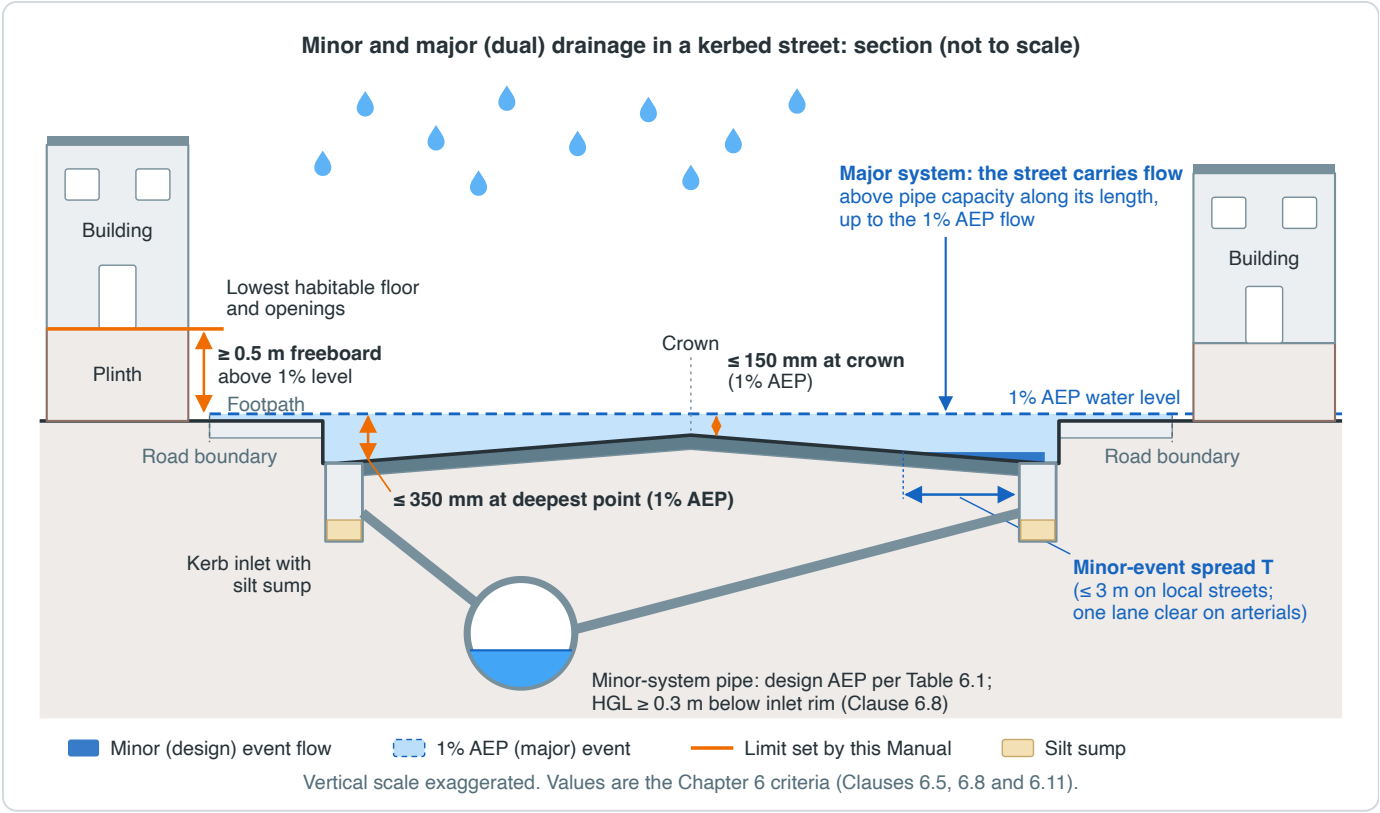


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

> **Commentary.** The Izzard form of Manning's equation with Ku = 0.376 is used both in FHWA HEC-22 and in the CPHEEO (2019) manual (Part A, Example 5.5, where the constant is written Kc = 0.376). The arterial spread rule (one lane clear) and the 3 m spread for local and collector streets are close to the APWA 5600 (2006, 5604.2) limit of 12 ft (3.66 m) from the back of kerb in each outside lane. The cross-flow limit of 0.03 m³/s is the SI equivalent of the APWA limit of 1.0 cfs at intersection sumps and superelevation transitions, with no cross-flow at mid-block sumps. The 150 mm and 350 mm depth limits are close to the APWA 5600 limits for 1% overflow at road crossings (7 in, about 180 mm, at the crown; 14 in, about 360 mm, at the deepest point). Mumbai's criterion of no flooding above 15 cm (IRC:SP:50-2013, §6.4.1) is a local precedent for the 150 mm crown value.
>
> The hazard classes of Table 6.4 are the combined hazard curves published by the Australian Institute for Disaster Resilience (AIDR Guideline 7-3, 2014), which are modelled after Smith and Wasko (2012). Requiring H2 or better on carriageways means the 1% depth limit of 350 mm (Table 6.2) governs the depth, and the D·V product controls fast, shallow flow on steep streets. H2 is described as "unsafe for small vehicles". Two-wheelers are the dominant vehicles on Punjab streets, so the 1% event must be treated as a road-closure event on all roads except notified evacuation routes, which must meet H1. The assignment of hazard classes to locations in Table 6.3 has no direct precedent and is set by this Manual.

6.6 Inlets

6.6.1 **Inlet types.** Inlets may be kerb-opening inlets, grate inlets, combination inlets (a grate with a kerb opening) or slotted and trench drains. On public streets:

- (a) kerb-opening or combination inlets shall be used, unless the approving authority accepts grate-only inlets for a specific location;

- (b) inlet openings shall be set at road level, with a gutter depression where practicable, so that water is not held on the carriageway by a raised kerb or footpath;
- (c) grates in carriageways, cycle lanes and footpaths shall be of a bicycle- and pedestrian-safe pattern (Chapter 9, Clause 9.11).

6.6.2 **Inlet capacity.** The clean capacity of inlets on grade and in sags shall be computed by the methods of FHWA HEC-22 (4th edition, 2024), or from tested ratings published by the manufacturer for the exact grate and kerb-opening geometry. The empirical kerb-inlet equations of CPHEEO (2019) Part A §5.6.2 may be used as a cross-check only.

6.6.3 **Clogging factors.** The design capacity of every inlet shall be its clean capacity reduced by the clogging factors of Table 6.5:

Table 6.5 — Inlet clogging factors (share of clean capacity assumed lost)

Inlet type	On grade	In a sag
Grate	50%	50%
Kerb opening	10%	20%
Combination	Apply the grate and kerb factors to each part separately	Apply the grate and kerb factors to each part separately

Design capacity = (1 − clogging factor) × clean capacity.

6.6.4 **Inlet spacing.** Inlets shall be located by a sequential calculation that starts at the top of each gutter run. At each inlet, the intercepted flow is computed, and the bypass flow is added to the gutter flow arriving at the next inlet. Spacing shall be such that the spread limits of Table 6.2 are met everywhere in the minor design event. In addition:

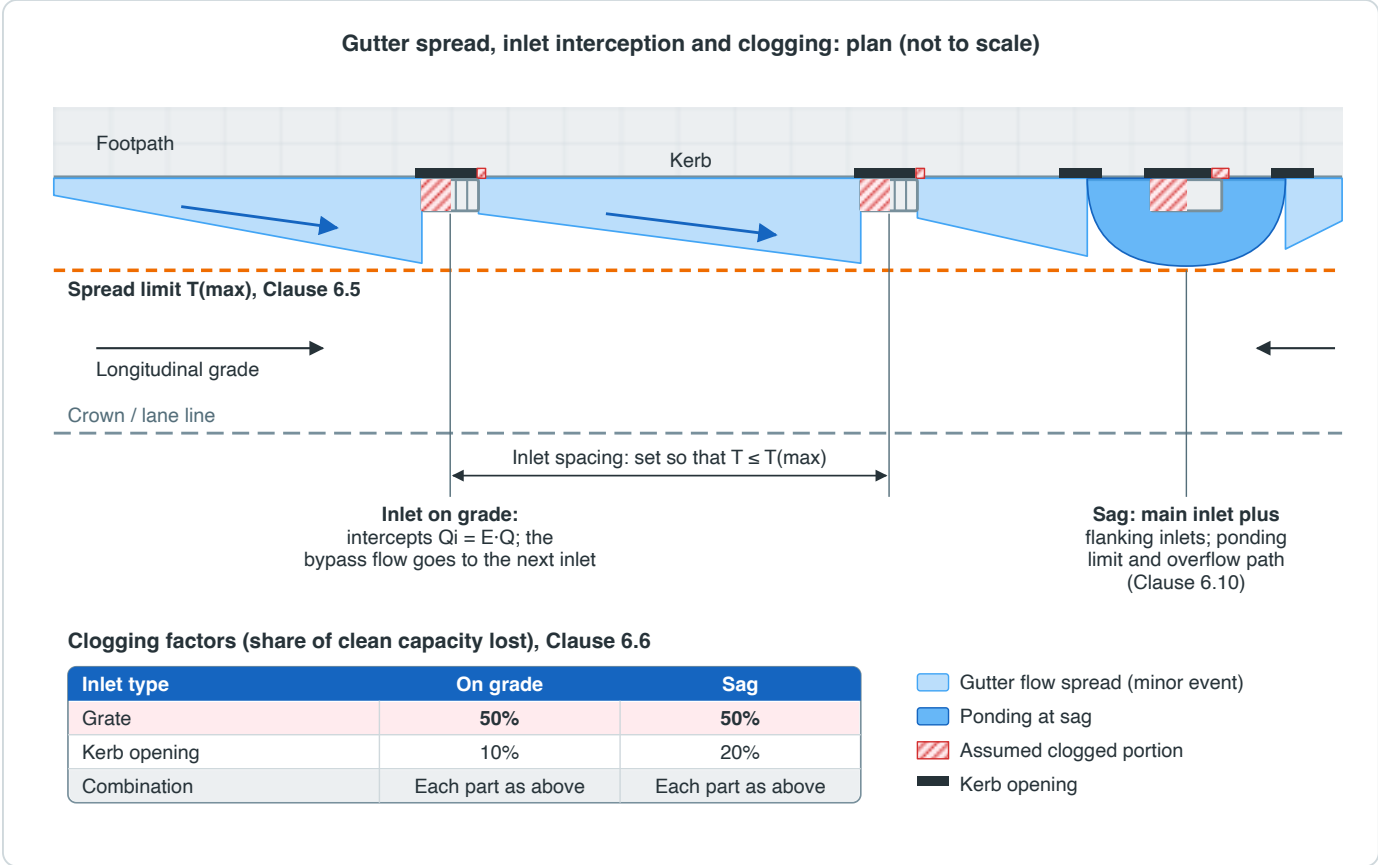
- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass flow from the last inlet of a run shall not be passed onto a road of a higher class or into private land.

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

- (a) the sag inlet's design capacity (after clogging) shall be not less than the total minor design flow arriving at the sag;
- (b) flanking inlets shall be placed on each side of a sag on any road where ponding could spread beyond the Table 6.2 limits, and at every underpass;
- (c) the ponding at the sag shall comply with Clause 6.10.

6.6.6 **Inlet connections.** The pipe connecting an inlet to the main drain shall have a diameter of at least 300 mm and shall be laid at a gradient that gives at least 0.9 m/s at the inlet's design flow.

6.6.7 **Silt sumps.** Every inlet chamber on a public road shall have a silt sump at least 300 mm deep below the invert of its outlet pipe, accessible for cleaning from the surface.



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

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

> Commentary. The clogging factors are more severe than the APWA 5600 (2006, 5604.2) rating of sump inlets at 80% of theoretical capacity (a 20% reduction), because grates in Punjab streets are routinely blinded by plastic and leaves. CPHEEO (2019) Part A shows solid waste dumped in drains as a primary cause of drain failure (Figures 1.2 and 2.1). APWA 5600 (2006) allows only kerb-opening inlets on public streets; Clause 6.6.1(a) is less strict because combination inlets are useful on flat roads. The 30 m maximum spacing and the treatment of combination inlets in Table 6.5 have no direct precedent and are set by this Manual. Roads on the Punjab plains, where the river slopes "seldom exceed 0.38 m per km" (CWC, Flood Estimation Report for subzone 1(e)), are flat, which shortens the calculated spacing anyway; on the steep streets of the Shivalik fringe gutter flow runs fast and passes inlets by, which Clause 6.3.6(e) deals with. A fixed cap stops a single blocked inlet from leaving a long dry gutter run. The 300 mm silt sump is set by this Manual. It matches the 0.3 m sump shown on the CPHEEO catch-basin detail (CPHEEO 2019, Figure 5.9).

6.7 Pipes and open and covered drains

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

$$V = \frac{1}{n} \cdot R^{2/3} \cdot S^{1/2}; \quad Q = A \cdot V$$

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

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

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

Material	Condition	n (CPHEEO)	Minimum design n in this Manual
Cement concrete pipe (collar joints)	Good / fair	0.013 / 0.015	0.015
Spun concrete pipe (RCC, PSC) with S/S joints	Manufacturer's design value	0.011	0.013
HDPE / uPVC pipe	—	0.010	0.011
Plastic (smooth), asbestos cement	—	0.011	0.011
Concrete drain, steel trowelled / wood trowelled	—	0.014 / 0.015	0.015
Sand and cement plaster	—	0.015	0.015
Brick masonry	Good / rough	0.015 / 0.017	0.017
Masonry	Bad condition	0.020	0.020
Rubble set in cement	—	0.017	0.017
Earth channel	Regular, good / ordinary	0.020 / 0.025	0.025
Earth channel	With stones and weeds / poor	0.030 / 0.035	0.035
Earth channel	Partly obstructed by debris or weeds	0.050	0.050
Gutter: concrete	—	0.013	0.013
Gutter: hot-mix asphalt	—	0.015	0.015
Gutter: sprayed seal	—	0.018	0.018

Source of the CPHEEO column: CPHEEO (2019) Part A, Table 5.1 (itself from the CPHEEO Manual on Sewerage and Sewage Treatment Systems, 2013) and Table 5.8 (gutters).

6.7.3 **Velocity limits.** At the minor design flow:

- (a) minimum (self-cleansing) velocity: **0.6 m/s** in open and covered drains and **0.9 m/s** in pipes;
- (b) maximum velocity: **3.0 m/s** in lined drains and in pipes, unless the drain or pipe is designed as a chute under Chapter 9. CPHEEO permits up to 6.0 m/s in plastic or plastic-lined pipes in hilly regions; this may be used in Pathankot and Dhar Kalan on the Shivalik fringe, Talwara, Nangal and Anandpur Sahib and other hill towns with the approving authority's agreement;
- (c) maximum velocity in unlined and vegetated channels: Chapter 9, Table 9.2;

- (d) the Froude number of flow in open and covered drains shall not exceed 0.8 at the design flow, unless the drain is designed for supercritical flow under Chapter 9.

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

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

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

6.7.6 **Minimum sizes.**

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

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

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

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

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

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

Table 6.7 — Minimum freeboard in open and covered drains

Drain	Minimum freeboard	Source
Bed width up to 300 mm	100 mm	CPHEEO 2019 Table 5.3 (from IRC:SP:50-2013)
Bed width 300–900 mm	150 mm	CPHEEO 2019 Table 5.3
Bed width 900–1,500 mm	300 mm	CPHEEO 2019 Table 5.3
Wider drains and engineered channels, Q < 3 m³/s	450 mm	CPHEEO 2019 Table 5.12 (from IS 7784 (Part 1): 1993)
Q 3 to < 30 m³/s	600 mm	As above
Q 30 to < 300 m³/s	900 mm	As above
Q 300 to < 3,000 m³/s	1,200 mm	As above
Q ≥ 3,000 m³/s	1,500 mm	As above
Any roadside drain	Not less than 150 mm	IRC:SP:42-2014
Steep (supercritical) channels	Equal to the flow depth	CPHEEO 2019 §5.3.2

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

6.7.10 **Bends and junctions.**

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

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

Table 6.8 — Maximum spacing of manholes on straight pipe runs

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

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

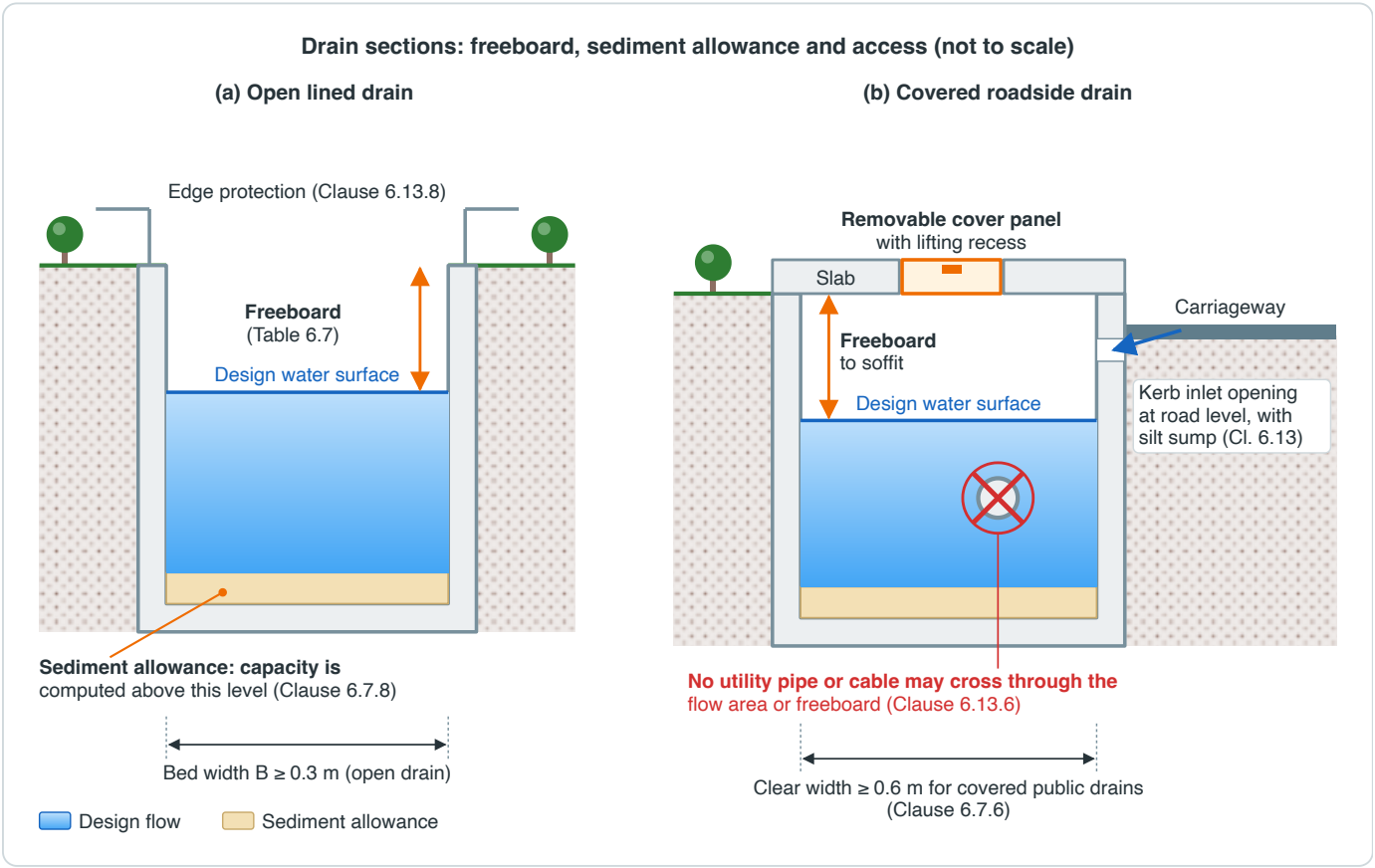


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

Commentary. The n values are those of CPHEEO (2019) Table 5.1. The higher minimum design values have no direct precedent; this Manual sets them because CPHEEO notes that the 0.011 value for spun pipes "may be taken as given by the manufacturer". That is a clean-pipe value, and Punjab drains carry heavy silt and solid waste. The 0.6 m/s minimum velocity is CPHEEO's (Table 5.2), based on carrying 0.09 mm sand (§5.3.1). The 0.9 m/s value for pipes is stricter, because a silted pipe cannot be cleaned as easily as an open drain. The 3.0 m/s maximum is from CPHEEO Table 5.2 (WPCF/ASCE 1982). The Froude limit of 0.8 is from CPHEEO §5.3, which advises avoiding critical flow because the water surface becomes unstable.

The 0.6 m × 0.6 m minimum for covered drains has no direct precedent and is set by this Manual. A covered drain narrower than this cannot be desilted by hand or by small machines through a cover opening, and silted, inaccessible drains were a recurring finding after the floods of Punjab's older cities: in Amritsar the open Ganda Nallahs were converted to double-barrel pipes, and a 2011 PWSSB report found the south-east storm sewer of the walled city "75%" silted with garbage (as quoted in the Amritsar Smart City bid, 2018); and in Jalandhar, where storm drains serve about 5% of the city, the rain is "largely discharged in to the sewer network", resulting in "choking of the pipes" and "back flow of the sewerage water" (Master Plan Jalandhar report). 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. Amritsar'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 Punjab most town drains end in a drain of WRD, in a river held high for days behind a dhussi bandh, in a choe, or in a pumped sump (Clause 5.8.5). In Amritsar the city's storm sewers end in the Tung Dhab and City Outfall drains of WRD, which end in the Hudiara drain (Amritsar Smart City bid, 2018), and the walled-city sewers were designed to surcharge in their manholes in the 2-year storm; in Ludhiana the city's drains end in the Buddha Nallah, whose level is set by its own narrowed reaches and by the Sutlej at Walipur Kalan; and in Jalandhar the rain is "largely discharged in to the sewer network", which chokes and backs up (Master Plan Jalandhar report). A drain whose HGL is started from a free outfall, or computed one length at a time without the receiving drain, its narrowest reach 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 a WRD channel, the reserve is transferred to 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.

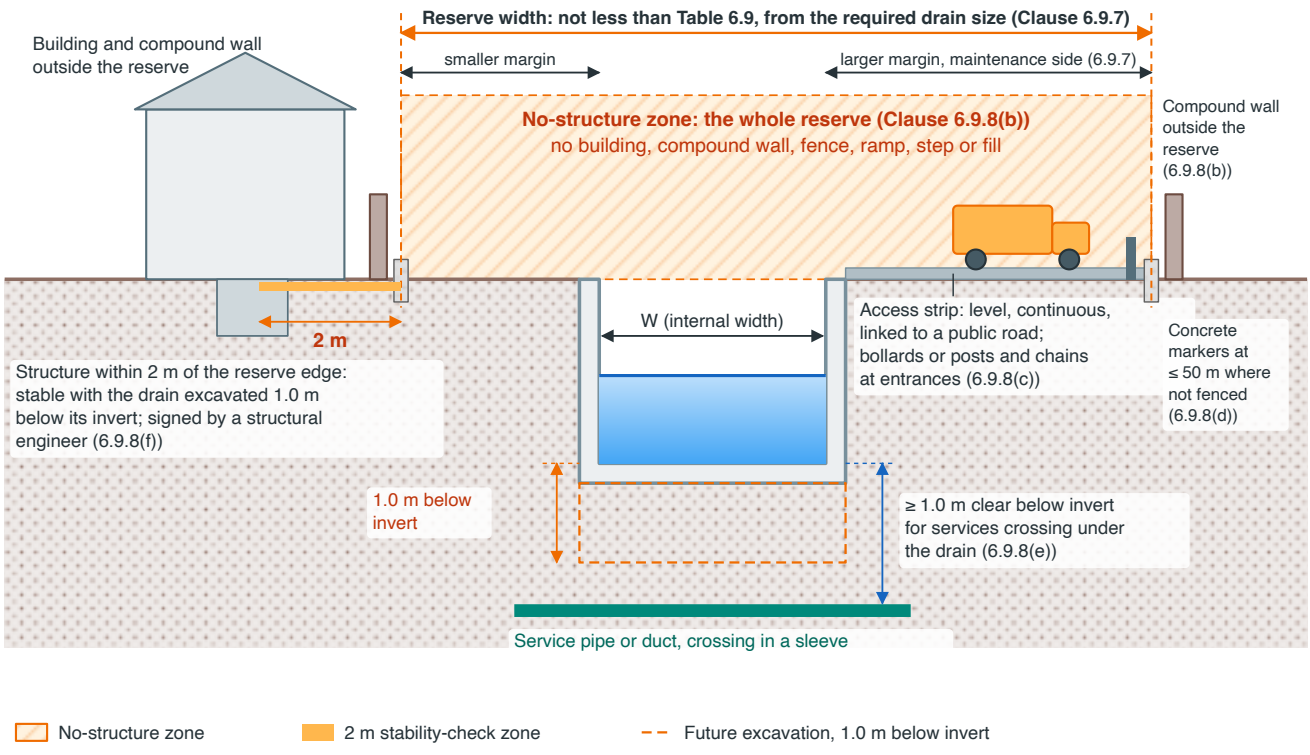


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Punjab, 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. Punjab has no statutory reserve width along a drain, choe or nala. Neither building instrument sets a setback from any river, nallah, choe, pond or canal: the Punjab Urban Planning and Development Building Rules 2021 set setbacks by the height of the building and the Uniform Zoning Plan only (PUDBR 2021 (as amended), r.26), and require the plans to show the "methods of disposal of waste water, sewerage and storm water" and the "surroundings up to a distance of fifteen metres" (r.11); the Punjab Municipal Building Bye-Laws 2018 require only that, on a large project, "The inlet and outlet point of natural drain system should be maintained with adequate size of channel" (PMBBL 2018 (as amended), Table 15.1, item 1). The sections of the Punjab Municipal Corporation Act 1976 and the Punjab Municipal Act 1911 that vest drains in a municipality or bar building over them were not read [TBC]. The only instrument found that draws a line along a channel is section 38 of the Punjab Canal and Drainage Act 2023 (Punjab Act 11 of 2023), which carries over section 55 of the Northern India Canal and Drainage Act 1873: the State may notify limits along "any river, stream or drainage-channel" within which an obstruction is prohibited or is to be removed, and the reach so notified "shall be held to be a drainage-work", from which the Divisional Canal Officer may have an obstruction removed (s.39), and to construct or alter a drainage

work, or to alter the flow of a river or stream so as to endanger one, is an offence punishable with a fine of ₹5,000 to ₹50,000 or imprisonment of up to six months (s.52). WRD reports 393 of 869 drains, choes and rivers notified under section 55 (WRD website), and the press 514 of 935 notified under the 2023 Act (as reported); no list of the notified drains and no notification giving a width was found [TBC]. WRD's method, which it described to CWC in 2024, is to compute the 100-year flood by Gumbel's method and the waterway by Lacey's formula and to notify that area, in which "no construction is to be allowed" (Chief Engineer, Drainage-cum-Mining & Geology, 2 May 2024); but the one floodplain zone found, on the Sutlej in Ferozepur and Tarn Taran districts (4 March 2024), was declared as the land between the embankments, about 4.5 km apart, although the Lacey width of the 100-year flood of 5,34,441 cusecs is 0.58 km (WRD affidavit in NGT OA 303/2023), and the NGT found "no material … indicating the exercise for demarcating the flood plain zone" (order of 14 March 2024, as quoted). Two lines have been drawn on particular channels. Along the Patiala ki Rao, notified under section 55 on 4 March 2013 against construction in or covering of the nadi, the High Court's Local Commissioner reported pillars "measuring 200 Ft." apart fixed in Chandigarh and still pending on the Punjab side (report of 8 January 2024 in CWP 5901/2017): a court-monitored width for one choe, not a norm of WRD. Along the Buddha Nallah, a road built by the Municipal Corporation Ludhiana is alleged before the NGT to have cut the channel's width "from 58 feet to 35 feet" (OA 327/2025): an allegation, cited as one, not a finding. The Master Plan Jalandhar report proposes that no construction be allowed within at least 200 m of the Chitti Bein "untill concrete bandh is constructed", except for a 30 m buffer zone from its bank, and a 30 m strip of plantation along the Black (Kala Sanghian) Bein (13.8.6 and 13.8.7): plan proposals, whose notified status was not seen. The NoC of the drainage wing for projects "within the 150-metre radius" of a water body was announced by the Water Resources Minister on 20 September 2023 (as reported), but no order was found, and this Manual does not apply it [TBC]. WRD has stated that no notified drain may be realigned "without prior permission/NOC from competent authority of Water Resources Department" (NGT OA 279/2024). 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 choe, rao, nadi, bein or natural drain, or a drain of 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 38 (or section 55), a floodplain zone or a court has set a wider line, such as the Sutlej floodplain zone in Ferozepur and Tarn Taran districts or the 200 ft pillared width of the Patiala ki Rao, that line applies for as long as it binds (Chapter 7). The corridor is to be superseded by a notification under section 38 of the Punjab Canal and Drainage Act 2023 where one exists. For this Manual, every nala, choe, rao, nadi and bein 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 (khasra) records as a nala, choe, rao, chhappar, toba or dhab 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 master plans under the Punjab Regional and Town Planning and Development Act 1995, in the layouts of PUDA, GMADA, GLADA and the other development authorities and in the plans sanctioned under PMBBL and PUDBR, with the khasra map and WRD's list of notified drains overlaid, rather than made a new NoC.

The reserve matters because the drains of Punjab's towns are divided among owners, and no rule divides them. WRD's Drainage-cum-Mining & Geology wing holds the rivers, choes, notified drains and dhussi bandhs, among them the Buddha Nallah in Ludhiana and the Tung Dhab and City Outfall drains in Amritsar, which are "maintained by drainage division of Irrigation department" (Amritsar Smart City bid, 2018); WRD's canal wing holds the canals, distributaries and watercourses; PUDA and the development authorities build the sector drains of their urban estates and schemes, as GMADA does with the storm sewer under the sector roads 92 and 92-Alpha of SAS Nagar (GMADA, 2021); the Municipal Corporations, Councils and Nagar Panchayats, under DLG, hold the street drains and sewers within their limits; PWSSB and PMIDC build drains and sewers for the local bodies, PMIDC as the State's nodal agency for AMRUT and for the Buddha Nallah project (CAG Report No. 7 of 2021; PMIDC, 2020); the Smart City companies of Ludhiana, Jalandhar and Amritsar build storm-drain works in their areas (CAG Report No. 7 of 2021); PWD (B&R) and NHAI hold the drains of their roads; the chhappars belong to the Gram Panchayats as shamlat land, under the Department of Rural Development and Panchayats; the Department of Soil and Water Conservation builds check dams in the Kandi; and land closed under the Punjab Land Preservation (Chos) Act 1900 is administered by a department not confirmed during research [TBC]. The Punjab Canal and Drainage Act

2023 excludes from a "drainage work" the "removal of sewage from towns, villages or any other habitat" (s.2(7)). No rule dividing the drains of WRD from those of the local bodies or the development authorities 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, choes, raos, nadis and beins, every drain notified under section 38 (or section 55), every drain that WRD maintains, including the Buddha Nallah, the Tung Dhab, City Outfall and Hudiara drains, the Kala Sanghian drain, the Sakki/Kiran, Patti and Kasur nallahs and the Chand Bhan drain, and the dhussi bandhs, flood embankments and river-training works, to WRD's Drainage-cum-Mining & Geology wing; canals, branches, feeders, distributaries, minors, kassis and watercourses, with their siphons and escapes, to WRD's canal wing; the sector and scheme drains of an urban estate or scheme to PUDA or the development authority (GMADA, GLADA or another) until they are transferred to the local body; the public drains, street drains and sewers within a Municipal Corporation, Municipal Council or Nagar Panchayat to that body, under DLG; drains built by PWSSB, PMIDC or a Smart City company to the body for which they were built, on completion; road drains, culverts and cross-drainage works to PWD (B&R) or NHAI on their roads; chhappars and village drains to the Gram Panchayat; check dams in the Kandi to the Department of Soil and Water Conservation, and the Kandi low dams to WRD; and land closed under the Punjab Land Preservation (Chos) Act 1900 to the department that administers it [TBC], with the choes through it under WRD (set by this Manual). Under Clause 6.9.8(a), the reserve along a WRD drain is transferred to WRD. Where a channel's status is disputed, the corridor follows the channel and not its name: the Buddha Nallah is both a seasonal tributary of the Sutlej and the trunk drain of Ludhiana, the N-Choe leaves Chandigarh as a choe and reaches the Ghaggar as the Pachisdhara drain (CPCB, 2024), and a complaint about the "N-Choe" near Manauli was found by WRD to concern the Jagatpura drain (NGT OA 279/2024). No design return period was found for any drain in the State other than two project choices, both of 2 years: the trunk storm sewers of the walled city of Amritsar (Amritsar Smart City bid, 2018) and the rejuvenated Buddha Nallah (PMIDC, 2020); and under AMRUT no storm-drain work was done up to 2020 (CAG Report No. 7 of 2021). 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 Punjab and are one of the most common ways that overland flow paths get blocked. The 50% blockage assumption for wall openings is set to match the grate clogging factor of Clause 6.6.3. The 3.5 m access width is set by this Manual, sized for a small excavator or desilting vehicle. For comparison, APWA 5600 (2006, 5608.4) requires a 15 ft (about 4.6 m) maintenance access strip for detention facilities.

6.10 Ponding at sags and low points

6.10.1 **Minor event.** At every sag, the minor design flow shall be removed by inlets (after clogging) with ponded spread within Table 6.2.

6.10.2 **1% AEP event.** At every sag:

- (a) the ponded depth shall not exceed 350 mm at the deepest point of the carriageway;
- (b) a surface overflow route shall be provided (for example over a lowered kerb and footpath into a designated overland flow path), so that the ponding level cannot rise above the overflow level; and
- (c) building floor levels around the sag shall comply with Clause 6.11.

6.10.3 **Fully-blocked check.** At sags, the 1% AEP ponding level shall also be computed with the minor system fully blocked and all flow leaving by the surface overflow route. Floor levels around the sag shall be set from the higher of the two ponding levels.

6.10.4 **Trapped sags.** Where a sag has no surface overflow route, the inlets and conduits (after clogging) shall carry the 1% AEP flow, and the approving authority shall agree the arrangement.

6.10.5 **Road underpasses.** Underpasses and other trapped sags on public roads shall:

- (a) be drained by a minor system (with pumping under Chapter 9, Clause 9.9, where gravity drainage is not possible) designed for the 2% AEP (50-yr) flow, checked at the 1% AEP flow;
- (b) have flanking inlets at both approaches to intercept flow before it reaches the low point;
- (c) be protected from inflow from surrounding streets by raised approach crests where practicable; and
- (d) have depth markers and automatic warning or closure signals that operate at 150 mm depth on the carriageway.

> Commentary. The fully-blocked check, the trapped-sag rule and the underpass requirements have no direct precedent and are set by this Manual. No record of a flooded underpass in a Punjab city, with its depth and duration, was found during research [TBC]. Jalandhar's master plan report lists only two underpasses in the city, one under the main railway line and one on the bypass road, and proposes more under the same railway (Master Plan Jalandhar report), and the urban floods of 1 to 3 September 2025 in SAS Nagar, Ludhiana, Jalandhar and Amritsar were reported without depths (as reported). The requirements are set so that the underpasses now being built under the railways and highways of the State do not repeat the failures recorded in the cities of other States. 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.

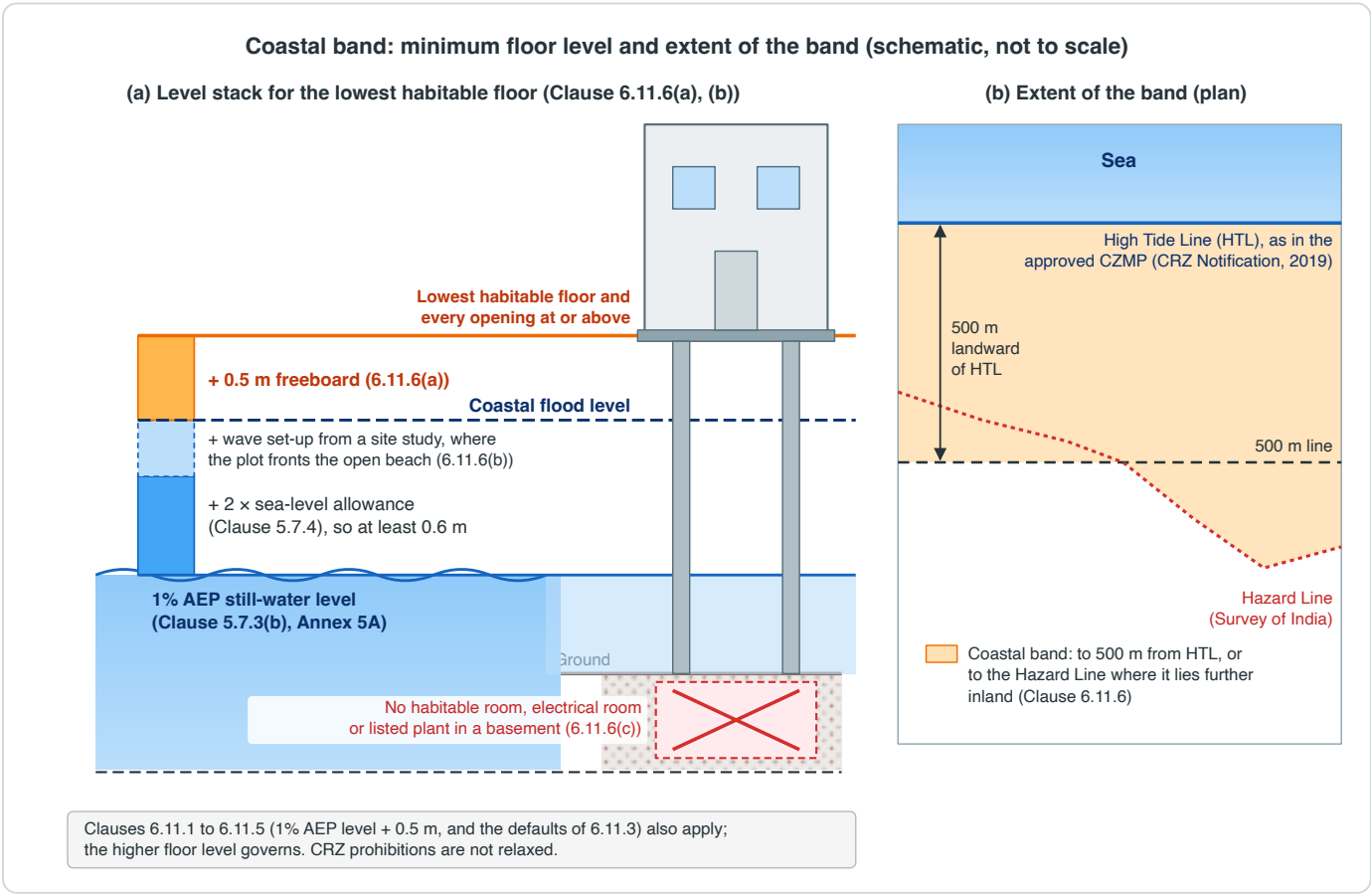


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Punjab 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 two building instruments of the State set different plinths. In municipal areas the plinth shall be "not less than 450 mm from the surrounding ground level", and the building sited so "that adequate drainage of the site is assured" (PMBBL 2018 (as amended), cl. 5.2.1.1); outside them and in the schemes of PUDA and the development authorities, a residential plot's plinth is 900 mm "from the crown of adjoining road in front", and other buildings' "450mm or as specified by competent authority" (PUDBR 2021 (as amended), r.3(A)). Both keep surface water out of basements in words only: PMBBL requires that "surface drainage does not enter the basement", that the basement be safe "in relation to underground water table/spring level", and that a basement's sewage be pumped "to avoid any risk of the sewerage or sludge heading back into the basement" (PMBBL 2018, cl. 4.23(vi) to (viii)); PUDBR bars a basement in a "No construction Zone" or "Master Plan Green area", sets the ceiling of a first basement 0.9 m to 1.2 m above the average surrounding ground, and requires that "Adequate arrangement shall be made that surface drainage does not enter the basement" (PUDBR 2021, r.30(5)(iii) and (iv)). Neither sets a level related to a flood, and no amendment touching these provisions 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. The PUDBR plinth of 900 mm above the road crown meets the 0.65 m of Clause 6.11.3; the PMBBL plinth of 450 mm is measured from the surrounding ground, not the road, and can be lower than it, so in municipal areas Clause 6.11.3 is the stricter and the two can be met together by building to it. In the waterlogged south-west, the Sirowal belt and the bet lands a basement also lies in the groundwater, and the flotation check of Clause 4.12.3 applies to it. Within limits notified under section 38 of the Punjab Canal and Drainage Act 2023 (or section 55 of the 1873 Act), in the Sutlej floodplain zone of Ferozepur and Tarn Taran districts and along the Patiala ki Rao, 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 Punjab 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 Punjab 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 Punjab the south-west monsoon normally sets in at Jalandhar on 26 June, at Patti on 28 June and at Ludhiana on 1 July, and normally withdraws from all three on 21 September; by 1 October it has withdrawn from most of the State (IMD, new normals, Pai et al., 2020). Paddy is transplanted from 1 to 9 June, district by district (as reported), so the plains are wet before the monsoon arrives, and large storms fall in June: Patiala recorded 160.6 mm on 8 June 2000 (IMD). So Clause 6.13.10 refers to the south-west monsoon, and Chapter 10 requires the desilting of drains, choes and chhappars to be complete by 15 June; the gates, flap gates on the dhussi-bandh outfalls, pumps, siphon crossings, inlets and choe crossings 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 15 October, because the State's storm of record fell on 4–5 October 1955, after the normal withdrawal, and the dams were still spilling into September in 2023 and 2025. In sub-area PB-A the sand and debris that the choes leave at crossings, culverts and inlets are cleared again after the monsoon, by 31 October (Clause 6.3.6(a)). No State order fixes a date for drain cleaning (as reported): the customary target is 30 June, set in 2023 by the Chief Minister for "cleansing of waterways" and in 2026 by the Minister for Local Government for sewer desilting in Ludhiana and by the Deputy Commissioner of Kapurthala for drains, sewers and storm systems (all as reported), and 30 June is later than the normal onset at Jalandhar and Patti. These dates are therefore set by this Manual.

Neither building instrument protects a drain, choe or nala from being covered or built over. The Punjab Municipal Building Bye-Laws 2018 require only that, on a large project, "The inlet and outlet point of natural drain system should be maintained with adequate size of channel" (PMBBL 2018, Table 15.1, item 1), and the Punjab Urban Planning and Development Building Rules 2021 require the plans to show the "methods of disposal of waste water, sewerage and storm water" (PUDBR 2021, r.11); the sections of the Punjab Municipal Corporation Act 1976 and the Punjab Municipal Act 1911 on municipal drains were not read [TBC]. Natural drains, choes and the drains of WRD are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over; within limits notified under section 38 of the Punjab Canal and Drainage Act 2023 the Divisional Canal Officer may have an obstruction removed (s.39), and the 2013 notification on the Patiala ki Rao authorises action against any construction in, or "covering" of, the nadi. Covered drains silt: in Amritsar the Ganda Nallahs were converted to double-barrel pipes, and a 2011 PWSSB report found the south-east storm sewer "75%" silted with garbage (as quoted in the Amritsar Smart City bid, 2018). Where a drain is covered, Clause 6.13.2 applies to it in full.

Clause 6.13.7 is not yet the practice. Punjab's largest urban drains carry sewage and industrial effluent: the Buddha Nallah takes about 700 MLD of treated and untreated wastewater to the Sutlej (River Rejuvenation Committee, 2025), and before its confluence its BOD was 161 mg/l, its COD 456 mg/l and its suspended solids 328 mg/l in April 2024, against the general standards of 30, 250 and 100 mg/l (CPCB reply in NGT OA 327/2025); in Amritsar the road-side drains "are connected to the sewerage system typically at the road junctions, thus making the sewerage system as combined system" (Amritsar Smart City bid, 2018). The Punjab Canal and Drainage Act 2023 excludes the "removal of sewage from towns, villages or any other habitat" from a drainage work (s.2(7)), so sewage has no lawful place in a drain of WRD, and the Building Rules forbid an absorption pit from having an outlet into "any sewer, storm water, drain or surface drain" (PUDBR 2021, r.45(8)). 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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- Department of Housing and Urban Development, Punjab. *Punjab Urban Planning and Development Building Rules, 2021*, G.S.R. 144/P.A.11/1995/Ss.180 and 43/2021 of 31 August 2021 (Punjab Government Gazette, 10 September 2021), r.1(3), r.3(A), r.11, r.26, r.30(5) and r.45, with the corrigendum of 16 March 2022 and the Amendment Rules 2022 (G.S.R. 23, 29 March 2022), read through the PPCB copy; the amendments of 2026 were reported and not read, and none was found to touch these rules [TBC]. "PUDBR" is an abbreviation set by this Manual. http://web.archive.org/web/20221222012900id_/https://ppcb.punjab.gov.in/sites/default/files/2022-07/Building%20Rules-2021.pdf
- *The Punjab Canal and Drainage Act, 2023* (Punjab Act No. 11 of 2023), ss.2(7), 38, 39, 52 and 61, PRS copy; commencement notification not found [TBC]. https://prsindia.org/files/bills_acts/acts_states/punjab/2023/Act11of2023-Punjab.pdf ; and the *Northern India Canal and Drainage Act, 1873*, s.55, for notifications issued before the 2023 Act came into force.
- Department of Irrigation, Punjab. Notification No. 4/8/2013-iw(3)26573/1 of 4 March 2013 under section 55 of the Northern India Canal and Drainage Act 1873 (the Patiala ki Rao), as annexed to the reply of the Nagar Panchayat Naya Gaon in NGT O.A. 180/2026; and the Sutlej floodplain zone in Ferozepur and Tarn Taran districts, notified on 4 March 2024, as described in WRD's affidavit in NGT O.A. 303/2023 (the Gazette text was not read [TBC]).
- *The Punjab Municipal Corporation Act, 1976* (Punjab Act 42 of 1976) and *the Punjab Municipal Act, 1911* (Punjab Act 3 of 1911): their sections on municipal drains were not read [TBC].
- Water Resources Department, Punjab. Report of the Executive Engineer, Drainage-cum-Mining & Geology Division, SAS Nagar, of 11 October 2024 in NGT O.A. 279/2024 (drain realignment and the NoC of WRD).
- Press report on the NoC of the drainage wing within 150 m of a water body, announced on 20 September 2023 (The Tribune, "Now, get NoC for construction near water bodies", 20 September 2023); no order was found.
- Government of India. *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.

Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Punjab with capacity curves (on grade and sag)
6B	Sediment yield for silt-trap sizing and calibration of the sediment allowance
6C	Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump
Form 6-1	Conveyance Design Report checklist

CHAPTER 7

Waterbodies, Chhappars (Village 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 (chhappar) 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 Punjab, with no coast and no tidal water, means the six Ramsar sites (Harike, Kanjli, Ropar, Keshopur-Miani, the Beas Conservation Reserve and Nangal Wildlife Sanctuary), any wetland that the Punjab State Wetlands Authority notifies under the 2017 Rules (none was found notified; it recommended 72 water bodies for notification in September 2025, as reported), the wetlands of the national atlas, the dhabs and other natural depressions that hold water through the monsoon, the marshy reaches of the beins, and the village ponds (chhappars and tobas) 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 Punjab Canal and Drainage Act, 2023, the Punjab Village Common Lands (Regulation) Act, 1961, the Punjab Land Preservation Act, 1900, the Punjab Municipal Corporation Act, 1976, the Punjab Municipal Act, 1911, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Punjab has no pond Act and no pond authority. Its village ponds, the **chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond)** of every village of the plains, stand on shamlat, the common land of the village, under the Punjab Village Common Lands (Regulation) Act, 1961 (not read for this Manual), and the courts have protected them as commons: the Supreme Court upheld the order that those who had occupied the land of a village pond in Punjab vacate it and restore it to the Gram Panchayat (*Jagpal Singh v. State of Punjab*, 28 January 2011, as reported), and the Punjab and Haryana High Court directed in July 2020 that encroachments on village ponds in Punjab be removed within six months, with the PPCB to monitor their water (as reported; the order was not read). Their restoration is a programme of the Department of Rural Development and Panchayats: ₹4,573 crore for cleaning some 15,000 chhappars in about 13,500 villages, announced in April 2025 (as reported), of which about 1,062 had been dewatered and about 400 desilted by the Minister's account (as quoted). The first census of water bodies counted 16,012 in Punjab, 1,578 of them encroached (as reported). No statute sets out what a pond includes, whether its

catchment, its feeder inlets or its overflow, and no authority keeps a register of the State's ponds (none was found for this Manual). The rivers, choes and drains have their own tool: under section 38 of the Punjab Canal and Drainage Act, 2023 (Punjab Act 11 of 2023), as under section 55 of the Northern India Canal and Drainage Act, 1873 before it, the State may notify limits along a river, stream or drainage channel within which no obstruction may be formed, and the notified reach "shall be held to be a drainage-work" (Clause 7.4, Disclosure). The Act came into force on a date to be notified (s. 1(3)); no commencement notification was found for this Manual [TBC], and notifications issued under section 55 of the 1873 Act are cited as such.

Punjab's waterbodies are of more kinds than its ponds. The Sutlej, the Beas and the Ravi, and the seasonal Ghaggar, run between the dhussi bandhs, WRD's flood embankments, which enclose the bet, the low riverine land that the river floods. The beins, the Kali (Holy) Bein, the Chitti (East) Bein and the Black Bein, or Kala Sanghian drain, are slow streams of the Doaba with clay beds. In the Kandi, the foothill belt below the Shivaliks, "numerous small and big seasonal streams called choes" make the area "prone to flashy floods" (WRD, Kandi Area Development), and "more than 100 choes" cross Hoshiarpur district alone, leaving "thick deposits of sand and silt" (District Environment Plan, Hoshiarpur); the raos, such as the Patiala ki Rao at the edge of SAS Nagar, are streams of the same kind. WRD maintains about 7,200 km of drains, among them the Buddha Nallah at Ludhiana and the Tung Dhab and Hudiara drains at Amritsar, and it has notified 393 of 869 drains, choes and rivers under section 55 of the 1873 Act by the count on its own page, or 514 of 935 by a press report of November 2024 (the counts differ, and no list was found [TBC]). The canals, distributaries and minors of WRD's canal wing form a separate class: they carry irrigation water, they are not a receiving water for storm runoff, and no drain under this Manual discharges into one without WRD's written consent (Chapter 5). The dhabs are the larger natural depressions and lakes, and six wetlands are Ramsar sites (Clause 7.12, Commentary).

This Manual treats every recorded chhappar, toba and dhab, with its catchment and the flow paths that feed it, as drainage infrastructure. No Punjab law says how a pond's 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 chhappar" and "Catchment and flow paths" in the definitions after Clause 7.2, the setbacks of Clause 7.4 and Figure 7.3) answer 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, and any buffer around a chhappar, are this Manual's proposal. No department, Gram Panchayat, court or other body of the State has adopted or endorsed them**, and the 1961 Act, the orders of the courts and any later statute or notification govern wherever they say more. No design under this Manual shall assume or rely on the filling of a recorded chhappar, 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. Neither the Punjab Municipal Building Bye-Laws 2018 nor the Punjab Urban Planning and Development Building Rules 2021 sets a setback from water; their 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" (PMBBL 2018, Table 15.1, item 1; PUDBR 2021, r.43, by reference to the Ministry of Environment, Forest and Climate Change notification S.O. 3999(E) of 9 December 2016). This chapter gives the design rules that protect waterbody storage and conveyance. It does not replace the revenue, panchayat, municipal, 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 Sutlej, the Beas, the Ravi and the Ghaggar, and the choes and raos of the Kandi and the Shivalik foothills, such as the Patiala ki Rao, the N-Choe, the Lakhnaur choe and the choes of Hoshiarpur district), bein (such as the Kali Bein, the Chitti Bein and the Black Bein, or Kala Sanghian drain), natural drain or nala, WRD drain (such as the Buddha Nallah, the Tung Dhab and Hudiara drains, the Sakki/Kiran nallah and the Chand Bhan drain), canal, distributary, minor or kassi (which carries irrigation water and does not receive storm water, Chapter 5), pond (chhappar, toba), whether or not it holds water, dhab or other natural depression or lake, marsh or other wetland (such as the Ramsar sites of Harike, Kanjli, Ropar and Keshopur-Miani), bet land (the low riverine land between a river and its dhussi bandh), the pondage of a Kandi low dam or check dam, abandoned borrow or mining pit, supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (chhappar)	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, spill point 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 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, khal or watercourse)	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).

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

Term	Meaning in this Manual
Chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond)	A natural or excavated village pond that stores rainfall runoff from its own catchment, and often the village's sullage: in Maya Singh's *Panjabi Dictionary* (1895), "A pond; a puddle" (Annex 7E). Toba is its synonym, common in Malwa. Not ਛੱਪਰ, a thatched roof, which is spelt alike in Roman letters. A chhappar is a tank or pond under Clause 7.2. Most chhappars have no surplus weir or sluice, only a low point in the rim over which they spill; where a chhappar has none, its FTL is the level at which it spills to the village nala, a drain or low ground, found by survey. A chhappar need not hold water to be a chhappar: one that is dry, or kept full only by sullage, keeps its bed, its rim, its catchment and its flow paths.
Recorded chhappar	A chhappar, toba, dhab or other pond shown in the Revenue records and khasra maps, the lists of the Department of Rural Development and Panchayats, the census of water bodies, a municipal record, a master plan or layout, or a survey made under a court's or the Tribunal's directions. A recorded chhappar 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 Punjab Village Common Lands (Regulation) Act, 1961, a court order or another law that forbids the filling.
Catchment and flow paths	The catchment of a chhappar is the land that drains to it, and its flow paths are the nalas, khals, feeder inlets and depressions by which that runoff reaches it, recorded or not. 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 chhappar keeps its inflow; and (d) the catchment boundary shall be marked on the approved layout plan. This is this Manual's proposed method; no Punjab body has adopted it.
Monsoon water line	The outer edge of a chhappar's, dhab's, bein'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 such as 1988, 1993, 2019, 2023 and 2025, the edge recorded in the Revenue records, and the spill level (FTL) contour; where none is available, the MWL contour. The boundary of a chhappar, dhab 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.
Dhab	A larger natural pool, lake or depression: in Maya Singh, "An unwalled tank or pond, a natural pool, a lake, a deep depression in the earth" (Annex 7E). A dhab is a lake under Clause 7.2 and, where Clause 7.12.1 lists it, a wetland; where it is recorded, it is a recorded chhappar for this chapter.
Choe; rao	A choe (cho) is a seasonal torrent of the Shivalik foothills and the Kandi, dry for most of the year and in spate in the monsoon, with a wide bed of sand and boulders, such as the choes of Hoshiarpur district, the N-Choe and the Lakhnaur choe; a rao is a stream of the same kind from the hills, such as the Patiala ki Rao (Annex 7E). Every choe and rao is a river or seasonal stream under Clause 7.2, and its whole active bed, from the toe of one bank to the toe of the other, is part of the waterbody: Zone 1 is measured from the top of bank, never from the edge of the low-flow channel, and a choe bed is the receiving system, not a drain to be narrowed (Clause 6.3.6).
Bein	A slow, irregular stream with a clay bed, such as the Kali (Holy) Bein, the Chitti (East) Bein and the Black Bein, or Kala Sanghian drain (Annex 7E). A bein is a river or seasonal stream under Clause 7.2 whoever maintains it and however much drain water it now carries; where WRD has notified it, it is also a section 38 reach.

Term	Meaning in this Manual
Bet; dhussi bandh	Bet is the low alluvial land along a river and in its bed (Annex 7E), such as the bet of the Sutlej and the Beas; a dhussi bandh is a flood embankment of WRD along a river, an administrative term with no dictionary source (Annex 7E). Bet land on the river side of a dhussi bandh is within the 1% AEP extent until a hydraulic study under Clause 7.3.4 shows otherwise, and bet land behind a bandh is checked for the breach and outfall-closed cases of Chapter 5. A dhussi bandh is a flood embankment for Clause 7.14, not a tank bund.
WRD drain; section 38 reach	A WRD drain is a drain maintained by WRD's Drainage-cum-Mining & Geology wing, notified or not, such as the Buddha Nallah, the Tung Dhab drain, the Hudiara drain, the Sakki/Kiran nallah and the Chand Bhan drain. A section 38 reach is a river, stream or drainage channel within limits notified under section 38 of the Punjab Canal and Drainage Act, 2023, or under section 55 of the Northern India Canal and Drainage Act, 1873 before it, which "shall be held to be a drainage-work", such as the Patiala ki Rao in Kharar tehsil (2013) and the Sutlej floodplain in Ferozepur and Tarn Taran districts (2024). Each is a waterbody under Clause 7.3; a section 38 limit governs where it is wider than the setback of Clause 7.4 (Clause 7.4.5).
Canal; kassi	A canal, branch, distributary or minor of WRD's canal wing, and a kassi, a small distributary channel from a canal (Annex 7E). Each is a waterbody for Clause 7.3 and its setback, but it is **not** a receiving water: no storm drain shall discharge into a canal, distributary, minor, kassi or watercourse without WRD's written consent (Chapter 5), and every siphon or culvert that carries a drain or choe under a canal is a hydraulic control on the upstream flood level (Chapter 9).
Sullage-fed chhappar	A chhappar 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; it is a combined sullage-and-storm basin, whose sullage is intercepted, screened and treated ahead of it under Clause 8.9.5, and whose starting level for Clause 7.7.3 is FTL in every season.
Kandi; Sirowal	The Kandi is the belt of boulder-gravel fans, 10 to 15 km wide, immediately south-west of the Shivalik hills, with deep water levels; the Sirowal is the belt below it where the fans give way to the plain and the water table is shallow, with seepage (CGWB). Both are administrative or hydrogeological terms, not dictionary terms (Annex 7E). In this chapter a choe's setback and its 1% AEP extent are found over its whole run across the Kandi and the Sirowal, where it may spread and change course.

7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with WRD and the Department of Revenue, Rehabilitation and Disaster Management, 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 (WRD (its Drainage-cum-Mining & Geology wing for the rivers, choes, raos and beins, the drains it maintains, the dhussi bandhs and other flood embankments, and the reaches notified under section 38 of the Punjab Canal and Drainage Act, 2023, or under section 55 of the Northern India Canal and Drainage Act, 1873, before it; its canal wing for the canals, distributaries, minors and watercourses; and its Kandi Area Development wing for the Kandi low dams), a Municipal Corporation, Municipal Council or Nagar Panchayat (for the street and public drains in its area; the sections of the Punjab Municipal Corporation Act, 1976 and the Punjab Municipal Act, 1911 that vest drains and tanks were not read for this Manual [TBC]), PUDA or a development authority such as GMADA or GLADA (for the drains and waterbodies of its urban estates and schemes until they are transferred), the Gram Panchayat (for village chhappars and other shamlat land, under the Punjab Village Common Lands (Regulation) Act, 1961, with the Department of Rural Development and Panchayats), the Department of Soil and Water Conservation (for the Kandi check dams it built), the Forests and Wildlife department and the Punjab State Wetlands Authority (for the Ramsar sites, the conservation and community reserves and any notified wetland, and the Forests department for land closed under the Punjab Land Preservation Act, 1900 [TBC]), BBMB (for the headworks and reservoirs it operates), 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 Department of Revenue, Rehabilitation and Disaster Management, in which village ponds stand on shamlat land (the common land of the village under the Punjab Village Common Lands (Regulation) Act, 1961) and ponds, choes, nalas and bet parcels are entered under their local names (the entries used for chhappars, tobas and dhabs were not checked for this Manual [TBC]); the pond lists of the Department of Rural Development and Panchayats for its programme for some 15,000 chhappars, and the first census of water bodies, which counted 16,012 in Punjab, 1,578 of them encroached (both as reported); WRD's list of drains notified under section 55 of the Northern India Canal and Drainage Act, 1873 or section 38 of the Punjab Canal and Drainage Act, 2023 (393 of 869 drains, choes and rivers on WRD's page; 514 of 935 as reported in November 2024; the counts differ and no list was found [TBC]) and its notifications, such as those for the Patiala ki Rao (4 March 2013) and the Sutlej floodplain in Ferozepur and Tarn Taran (4 March 2024); the alignments of WRD's dhussi bandhs, canals and minors; the drains, green belts and waterbodies shown in master plans and plan reports, such as the Ludhiana Master Plan (2007–2031) and the Master Plan Jalandhar report (Vision 2031), and in the layouts of PUDA and the development authorities; the boundaries of the six Ramsar sites and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was confirmed for this Manual), with the 72 water bodies recommended for notification in September 2025; the areas of the Kandi notified under the Punjab Land Preservation Act, 1900; and the wetlands of the national atlas;
- (b) 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 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 Punjab city was found, and no design return period was found for any of the State's urban drains except two project choices: the trunk storm sewers of the walled city of Amritsar, designed for "a return period of once in two years" (Amritsar Smart City, bid of 2018), and the Buddha Nallah, whose proposed design considers a "2 year return period with reduced run-off within the city reach due to active storm water detention" (PMIDC, feasibility report, 2020). WRD has a method for flood lines: it computes the 5-, 25- and 100-year floods by Gumbel's method, takes the 100-year flood as the one "in which no construction is to be allowed", finds the waterway by Lacey's formula, and notifies that area under the drainage law (Chief Engineer, Drainage-cum-Mining & Geology, to the CWC, 2 May 2024). The one floodplain zone found that was drawn under it is the Sutlej in Ferozepur and Tarn Taran districts, notified on 4 March 2024 for a reach of 47 km: the 100-year flood was taken as 5,34,441 cusecs and the Lacey waterway computed as 0.58 km, but because the permanent embankments stand about 4.5 km apart, the land between them was declared the floodplain zone, on embankment sections of 1976 and Survey of India sheets of 1984 (WRD, affidavit in O.A. 303/2023); the National Green Tribunal found "no material … indicating the exercise for demarcating the flood plain zone as per the applicable zone" (order of 14 March 2024, as quoted). No zone was found for the Ghaggar, the Beas, the Ravi or any choe of the Kandi, and Punjab has no floodplain zoning Act (as reported). The only other notified line found is that of the Patiala ki Rao, notified under section 55 of the 1873 Act on 4 March 2013 by khasra in villages of Kharar tehsil, among them Karoran and Nada, against any construction in or covering of the "Nadi/Choe" (notification No. 4/8/2013-iw(3)26573/1), with no width stated. This Manual uses WRD's method as the State's precedent, but in the order that the Tribunal's criticism implies: **the flood line is computed first, from the 1% AEP flood of Chapters 2 and 3 with the climate factor, and only then compared with the embankment alignment**; where the embankments stand outside the computed line, the land between them stays a waterbody and a floodplain for this chapter, and where the computed line lies outside an embankment, as behind a breach or a low reach, it governs. The State's records of its rivers are kept in feet at WRD's headworks and BBMB's gauges, and the gauge zeros were not found [TBC]: the Chitti Bein's high flood level "at Railway Bridge Chaheru is generally 12'", with a spread "up to a distance of about 200 metres" at about 2 ft deep (Master Plan Jalandhar report), and the Ghaggar reached 754.2 ft at Khanauri on 15 July 2023 (as reported); each such level shall be tied to a surveyed datum before use (Clause 7.3.5), and no "danger level" of the CWC exists for any Punjab river. The length of the dhussi bandhs is itself uncertain, 1,365 km by one count (as reported) and "about 1800 Kms." of flood embankments by WRD's page (as quoted). The records of the ponds are no better: the counts of the pond programme (about 15,000) and of the census of water bodies (16,012) differ, and the Revenue entries for chhappars, tobas and dhabs were not checked for this Manual [TBC]. Every site plan under this Manual shall therefore overlay the khasra map and show each chhappar, toba and dhab, each choe, rao, bein and nala, each bet parcel and each WRD drain, canal and dhussi bandh, with its notified limits where they exist, on the Waterbody Sheet (Form 7-1); PUDBR 2021 already requires building plans to show the "methods of disposal of waste water, sewerage and storm water" and the "surroundings up to a distance of fifteen metres on all sides" (r.11). 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 38 or section 55 limit, where one has been notified, is a minimum that the 1% AEP extent of this Manual 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 river, choe, bein, drain, nala, chhappar or canal in Punjab; 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 WRD for a work on or next to one of its rivers, choes, drains, dhussi bandhs, canals or headworks, including its permission or no-objection certificate for the realignment of a notified drain, or within limits notified under section 38 of the Punjab Canal and Drainage Act, 2023 (or under section 55 of the Northern India Canal and Drainage Act, 1873, for notifications issued before the 2023 Act came into force), such as the Patiala ki Rao in Kharar tehsil (2013) and the Sutlej floodplain in Ferozepur and Tarn Taran districts (2024); WRD's written consent to any discharge to a canal, distributary or minor; the permission of the Punjab State Wetlands Authority for a regulated activity in a notified wetland; a master-plan buffer in force; or a direction of the Supreme Court, the Punjab and Haryana High Court or the National Green Tribunal (such as the 200 ft width of the Patiala ki Rao being marked with pillars under CWP 5901 of 2017; the no-objection certificate of WRD's drainage wing for projects within 150 m of a water body, announced by the Water Resources Minister on 20 September 2023, is not one, as no notification or order giving it effect was found) 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. Punjab has no general statutory distance from water: neither the Punjab Municipal Building Bye-Laws 2018 nor the Punjab Urban Planning and Development Building Rules 2021 sets a setback from a river, nallah, choe, pond or canal, and no WRD instruction barring construction within a stated distance of a drain or canal was found. The lines that exist are tied to a notification or to one channel: within limits notified under section 38 of the Punjab Canal and Drainage Act, 2023 (section 55 of the Northern India Canal and Drainage Act, 1873, before it), no obstruction may be formed, and the notified reach becomes a drainage work; WRD draws such limits from the 100-year flood found by Gumbel's method and the waterway found by Lacey's formula, but the one floodplain zone found, on the Sutlej in Ferozepur and Tarn Taran districts (2024), was declared as the land between the existing embankments, about 4.5 km apart, where the computed waterway was 0.58 km; on the Patiala ki Rao, pillars marking a width of 200 ft are being fixed under the High Court's supervision, a width for that one channel; and the Master Plan Jalandhar report proposes a 30 m buffer along the Chitti Bein and the Black Bein, a plan proposal and not a statutory buffer. This Manual's 15 m gives every choe, bein, nala, drain and chhappar a hydraulic corridor where nothing wider binds, and is this Manual's proposal, not a statutory width, to be superseded by a notification under section 38 where one exists (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 Punjab flood maps are mostly coarser than US maps, the alluvial plains of Punjab, where river slopes seldom exceed 0.38 m per km (CWC), the bet lands behind the dhussi bandhs and the waterlogged south-west 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).
>
> Punjab's building instruments give no distance in metres from water. The Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 were searched for river, nallah, choe, pond, canal and flood, and neither sets a setback from any of them: the setbacks of PUDBR 2021 run by building height (r.26) and by the Uniform Zoning Plan Drawing No. 01/2020 CTP(Pb) of 28 July 2020. Their only distance near water concerns sewage: a septic tank or absorption pit is not to be "within thirty meters of any percolation well, water sources or stream used or likely to be used for drinking", and an absorption pit has no outlet into "any sewer, storm water, drain or surface drain" (PUDBR 2021, r.45(7) and (8)); recharge structures are to be kept away from sewer lines, septic tanks and soak pits, with no distance (r.40). No instruction of WRD barring construction within a stated distance of a drain, choe or canal was found; WRD's report to the National Green Tribunal says only that no drain may be realigned "without prior permission/NOC from competent authority of Water Resources

Department" (O.A. 279/2024). The lines that exist are tied to a notification, to a court or to one plan. Within limits notified under section 38 of the Punjab Canal and Drainage Act, 2023, or under section 55 of the 1873 Act before it, no obstruction may be formed, any obstruction may be ordered removed by the Divisional Canal Officer (s. 39), no compensation is paid for an illegal structure (s. 45), and damaging, altering or building on a drainage work is an offence punishable with a fine of ₹5,000 to ₹50,000 or imprisonment of up to six months (s. 52); WRD draws such limits on the 100-year flood and Lacey's waterway (Clause 7.3, Commentary), but no width is set by the Act. On the Patiala ki Rao, where the Punjab reach is "heavily encroached by squatters", the fixing of pillars on both sides "measuring 200 Ft." was done in the Union Territory and was still pending on the Punjab side in January 2024 (Local Commissioner, fourth periodic report in CWP 5901/2017 before the High Court): a width fixed for one channel under a court's supervision, not a WRD norm. The Master Plan Jalandhar report (Vision 2031) proposes that "No construction activity should be allowed on both sides of the Bein up to a distance of atleast 200 metres untill concrete bandh is constructed … except 30 metre buffer zone from the bank of Chitti Bein", and a plantation "buffer strip of 30 m width" along the Black (Kala Sanghian) Bein (13.8.6–13.8.7): the only numeric river or bein setback found in a Punjab plan text, a plan proposal whose notification was not seen [TBC]. On 20 September 2023 the Water Resources Minister announced that projects "within the 150-metre radius" of a water body would need the approval of WRD's drainage wing (as reported); no notification or order giving it effect was found, and this Manual does not apply it. 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)), but no wetland in Punjab was confirmed as notified under the Rules for this Manual. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

Disclosure. Punjab has **no statutory setback in metres from a river, choe, bein, drain, nala, chhappar or canal**: neither PMBBL 2018 nor PUDBR 2021, and no other statute or rule read for this Manual, sets one, and **the only floodplain zone found under the State's drainage law is the Sutlej in Ferozepur and Tarn Taran districts**, declared as the land between the embankments. 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 chhappars, any buffer around a chhappar, and the reading of the monsoon water line (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule, to be superseded by a notification under section 38 of the Punjab Canal and Drainage Act, 2023 where one exists**, and no department, authority, Gram Panchayat or court of the State has adopted or endorsed them. The setback is applied as **the larger of the corridor and any statutory, court or plan line in force**, so the Manual is **stricter than statute** along choes, beins, nalas, drains and chhappars, 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, and it is computed before it is compared with any embankment. What does exist, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **Rivers, choes and drains (section 38).** Limits notified under section 38 of the Punjab Canal and Drainage Act, 2023, or under section 55 of the Northern India Canal and Drainage Act, 1873 for notifications issued before the 2023 Act came into force, within which no obstruction may be formed and any obstruction may be removed, the notified reach becoming a drainage work: the Patiala ki Rao in Kharar tehsil (4 March 2013) and the Sutlej floodplain in Ferozepur and Tarn Taran districts (4 March 2024; 100-year flood 5,34,441 cusecs; Lacey waterway 0.58 km; zone declared between embankments about 4.5 km apart). WRD's method, the 100-year flood by Gumbel's method with Lacey's waterway, is the State's precedent; no zone was found for the Ghaggar, the Beas, the Ravi or a Kandi choe, and the lists of notified drains (393 of 869, or 514 of 935) were not found.
- **Court-fixed widths.** The 200 ft width of the Patiala ki Rao, marked with pillars under the High Court's supervision in CWP 5901/2017 (done in the Union Territory, pending in Punjab in January 2024): a width for that channel only, not a general rule.
- **Plan proposals.** The Master Plan Jalandhar report (Vision 2031): a 30 m buffer from the bank of the Chitti Bein, with no construction within at least 200 m until a concrete bandh is built, and a 30 m plantation buffer along the Black (Kala Sanghian) Bein. They govern only as far as a notified master plan carries them [TBC].
- **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 six Ramsar sites, Harike, Kanjli, Ropar, Keshopur-Miani, the Beas Conservation Reserve and Nangal Wildlife Sanctuary, to their designated boundaries. No wetland notified under rule 7, and no eco-sensitive zone or buffer distance for any of them, was found.

- **Sewage near water.** No septic tank or absorption pit within 30 m of a well, water source or stream used or likely to be used for drinking (PUDBR 2021, r.45(7)). This protects drinking water, not a flood corridor.
- **WRD drains, dhussi bandhs, canals and headworks.** Works on or next to them, and the realignment of a notified drain, need WRD's approval; a discharge to a canal needs its written consent.
- **Announced only.** The no-objection certificate of WRD's drainage wing for projects within 150 m of a water body, announced on 20 September 2023 (as reported). No order was found; it is not applied by this Manual and is shown in Figure 7.1 only as announced.

This Manual sets 15 m as the floor because no width exists in Punjab for choes, beins, nalas, drains or chhappars outside a notified reach; 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 the desilting machinery that the drains and choes need. The reasons for the corridor and the catchment rules are the record: the Punjab reach of the Patiala ki Rao is "heavily encroached by squatters" with "rampant illegal construction even deep inside the Nadi/Choe" (Local Commissioner, 2024); a road along the Buddha Nallah is alleged to have cut its width "from 58 feet to 35 feet" (O.A. 327/2025, the allegation as recorded); the Chitti Bein is to be widened from 40–60 ft to "atleast 80'-100'" (Master Plan Jalandhar report); the village abadi beside a nadi in SAS Nagar "is seven feet lower than the level of stream (Nadi)" (GMADA, social impact assessment, 2021); and 1,578 of Punjab's 16,012 water bodies were counted as encroached (as reported). Until a statute, rule, notification or master plan adopts them, the 15 m minimum and the catchment rules are this Manual's recommended standard, and the statutory, court and plan lines above remain the only lines with legal force. Approving authorities should state in each approval which was applied.

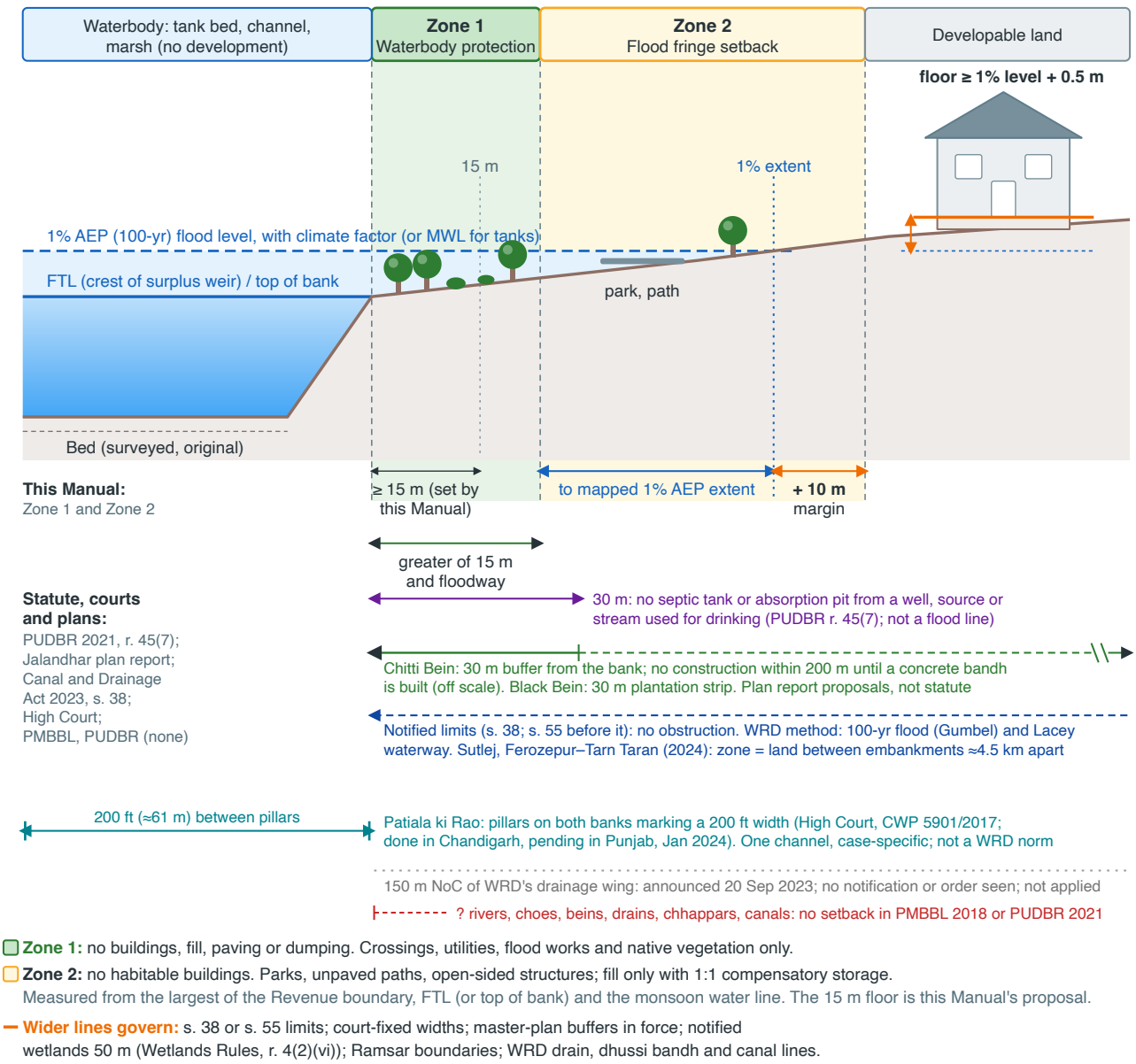

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021, 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 Punjab 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 alluvial plains of Punjab, where river slopes seldom exceed 0.38 m per km, the bet lands behind the dhussi bandhs and the waterlogged depressions of the south-west, 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 Punjab the lines that exist around waterbodies are drawn from a high level or a flood, not from the dry-season water line: WRD's floodplain method starts from the 100-year flood, the Wetlands Rules, 2017 measure their 50 m from the mean high flood level, and the High Court's pillars on the Patiala ki Rao mark the width of the "Nadi/Choe", not of its low-flow channel. The difference matters because most of the State's waterbodies are full only in the monsoon. The choes of the Kandi are dry for most of the year and in spate in the monsoon, "most of the rainfall occurs in 2½ months only" (WRD, Kandi Area Development), and their beds of sand and boulders look like spare land in the dry months; the Chitti Bein, whose channel is 40 to 60 ft wide, spreads "up to a distance of about 200 metres" in flood (Master Plan Jalandhar report); and the chhappars of the plains fill with the monsoon and stand full on sullage in the villages that feed them. A line drawn from the edge of the dry months would leave the foreshore that the monsoon floods, and that the chhappar, dhab or bein needs in order to store it, open to building. This Manual gives the same rule a level for every chhappar, dhab, bein and wetland: 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 of Ludhiana along the Buddha Nallah, the sectors and village abadis of SAS Nagar along the choes, such as Phase 11 beside the Lakhnaur choe and the abadis of Nayagaon, Karoran and Nada along the Patiala ki Rao, the low parts of Patiala along the Badi and Chhoti Nadi, the land along the Chitti Bein at Jalandhar, and the towns on the Ghaggar, such as Khanauri, Moonak and Sardulgarh, and on the bet lands of the Sutlej and the Beas (each reported to have flooded, or recorded as low-lying, in the documents cited in this chapter; no 1% AEP map of any of them exists) 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.

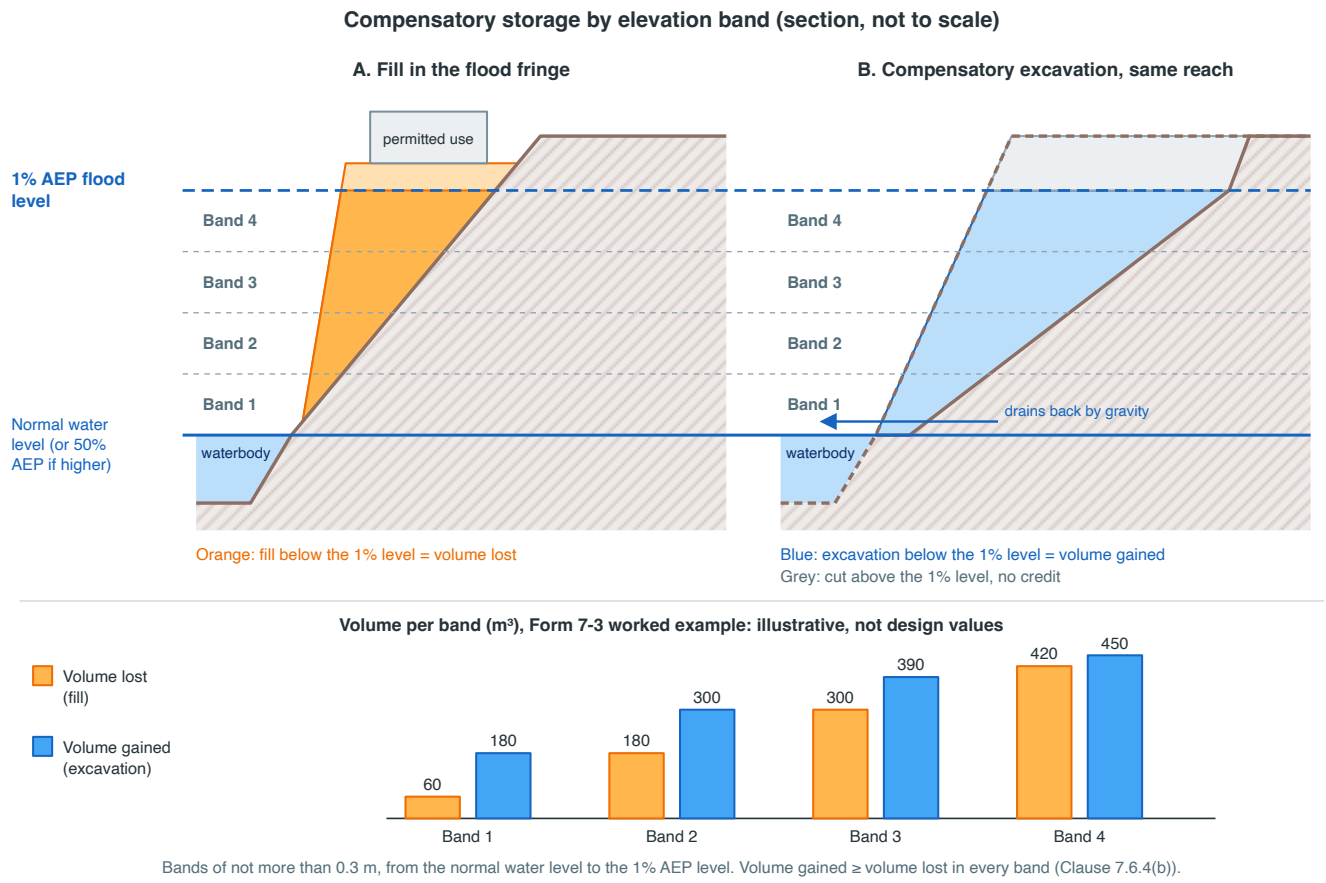

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation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

Punjab has neither a tank Act nor a pond Act, and its storages range from the village chhappar to the dams on its rivers. The storages that matter for urban drainage are of six kinds. The first is the village chhappar or toba on shamlat land, in the care of the Gram Panchayat, usually with no outlet structure and often fed by the village's sullage as well as its catchment; some 15,000 are in the State's cleaning programme of 2025 (as reported). The second is the chhappar that now lies inside a town, a sector or a colony, vested in a municipal body or a development authority or privately owned, and the low-lying collection areas around the towns, many of them filled or built on; no register of them was found. The

third is the dhabs and other natural depressions of the plains, and the waterlogged depressions of the south-west, which hold water through and after the monsoon. The fourth is the low dams and check dams of the Kandi: WRD reports "12 Low Dams" completed under its Kandi Area Development programme, with the Nara dam in Hoshiarpur district one of nine more, and lists "Flood attenuation" among their benefits, and it counts 410 check dams on rivers and nallahs (WRD, reply in O.A. 694/2023); no operating rule, level record or flood-cushion rule for any of them was found. The fifth is the dams and headworks of the rivers, such as the Ranjit Sagar and Shahpur Kandi dams on the Ravi, BBMB's reservoirs on the Sutlej and the Beas, and WRD's headworks at Ropar, Harike, Hussainiwala and Madhopur; 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 six Ramsar sites among them, which are wetlands under Clause 7.12; Harike, at the confluence of the Sutlej and the Beas, is both a Ramsar site and a headworks pond. Clauses 7.7 and 7.8 apply to any of these whose storage is counted; a Kandi low dam, check dam or dhab whose storage is to be counted is subject to Clause 7.7.1 in full, with WRD, the Department of Soil and Water Conservation, the Gram Panchayat or other custodian, and the custodian of each low dam and check dam 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.** 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 chhappar and the flow paths that feed it, the chhappar with its FTL and its overflow to the village nala or a WRD drain, and the drain, with its crossings under canals and its outfall through a dhussi bandh to the river, whose design water level and stage are the tailwater of the chhappar's overflow (Chapter 5), and, in the Kandi, the choe from the Shivalik hills to the Sirowal with its low dam or check dam and its crossings, as shown in Figure 7.3.

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

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

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

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

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

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

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

> Commentary. This Manual allows tank cascades to be used as design storage subject to three basic conditions (surveyed FTL, a documented operating rule and maintained surplus weirs). Clause 7.7.1 adds the stage–storage survey and the custodian's concurrence, because the storage a tank actually offers depends on its silt level and on who controls the sluices. The 5-year survey interval is set by this Manual.
>
> The FTL starting level follows Clause 3.12.5. Punjab's chhappars and depressions are fullest, and its water table highest, when its worst storms come. Paddy is transplanted from 1 to 9 June, by districts (Punjab Preservation of Subsoil Water Act, 2009, schedule for 2025, as reported), so that the fields of the central and south-western plains are ponded through the monsoon; the water table is shallowest in October (CGWB and WRD); and the largest daily falls of record came late in the season, 354.3 mm at Ludhiana on 4 October 1955 and 338.0 mm at Ludhiana (PAU) on 24 September 1988 (IMD), after weeks of rain. The drains and rivers that take the overflow run full at the same time: Harike carried 3,35,030 cusecs on 3 September 2025, above the 3,00,000 cusecs at which a flow "falls under the High Flood category", and the Ghaggar stood at 754.2 ft at Khanauri on 15 July 2023 (both as reported), so that a WRD drain whose outfall passes through a dhussi bandh may be closed by its flap gate for days (Chapter 5). Many village chhappars are also fed by sullage, which keeps them at or near FTL in every season; the State's programme of 2025 had to dewater them, about 1,062 by the Minister's account (as quoted), before they could be desilted. No record of how long Punjab's chhappars and dhabs stay at or above FTL in a wet spell was obtained for this Manual. An empty chhappar 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.

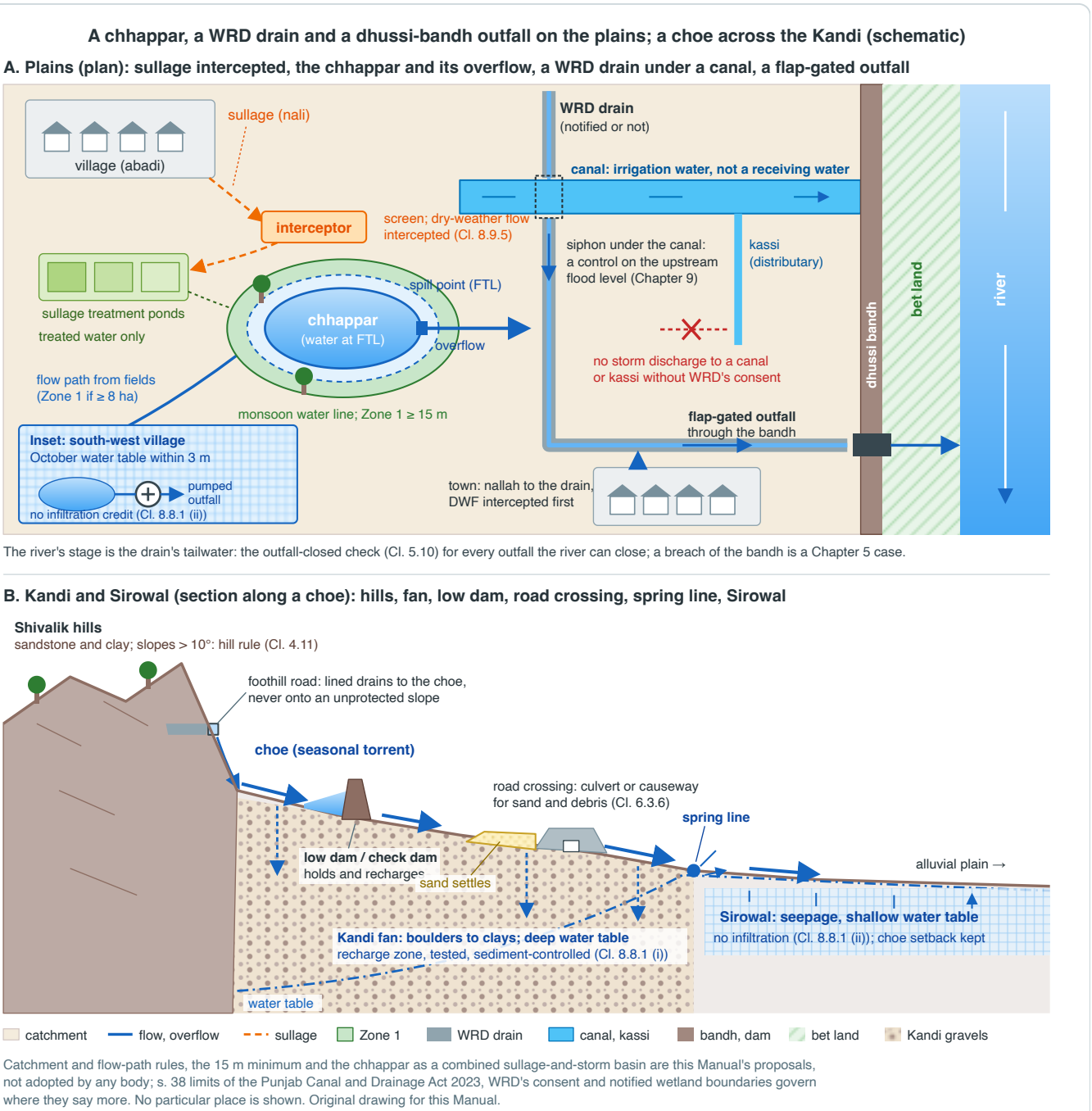

Figure 7.3 — A village chhappar, a WRD drain, a canal crossing and a dhussi-bandh outfall on the plains, and a choe across the Kandi and the Sirowal (schematic, not to scale; no particular place is shown). A (plains, in plan): the village's sullage is intercepted and treated ahead of the chhappar (Clause 8.9.5), so that only storm runoff and treated water reach it; the chhappar spills at its FTL to a WRD drain, which passes under a canal by a siphon and never discharges into the canal or its kassi without WRD's written consent (Chapter 5); a town nallah joins the drain; and the drain reaches the river through a flap-gated outfall in the dhussi bandh, behind which lies the bet land, so that the river's stage is the drain's tailwater and the outfall-closed check of Clause 5.10 applies. The inset shows a village of the south-west where the October water table is within 3 m: there no infiltration is credited and the outfall is pumped (Clause 8.8.1, class (ii)). B (Kandi and Sirowal, in section): a choe leaves the Shivalik hills and crosses the Kandi fan, where its bed of sand and boulders is the recharge zone and a low dam or check dam holds and recharges its flow (Clause 8.8.1, class (i)); sand settles at the road crossing, which is designed for sand and debris (Clause 6.3.6); below the fan the spring line marks the Sirowal, where seepage and a shallow water table bar infiltration (class (ii)); and the foothill road carries its runoff in lined drains to the choe, never onto an unprotected slope. The catchment and flow-path rules, the 15 m

minimum and the treatment of a chhappar as a combined sullage-and-storm basin are this Manual's proposals, not adopted by any body; limits notified under section 38 of the Punjab Canal and Drainage Act, 2023, WRD's consent and a notified wetland boundary govern where they say more. Original drawing for this Manual.

7.8 Operating rules and pre-monsoon flood cushion

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

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

> **Commentary.** No operating rule for a Punjab chhappar, dhab or Kandi low dam that keeps a flood cushion was found, and most chhappars have no controllable outlet, so Clause 7.8.3 applies to them. WRD lists "Flood attenuation" among the benefits of its Kandi low dams (Kandi Area Development), but no rule, level record or release record for any of them was found. The controlled flows that matter in the State are those of the dams and headworks on its rivers: BBMB's releases from Bhakra and Pong, which in 2023 and 2025 kept the Sutlej and the Beas high for weeks (as reported); the Ranjit Sagar and Shahpur Kandi dams on the Ravi; and WRD's headworks at Ropar, Harike, Hussainiwala and Madhopur, where in August 2025 the gates jammed and one was washed away at a flow reported as less than 2 lakh cusecs (as reported). No current State disaster management plan or urban flood plan was found, only a draft State plan of about 2011, and no warning protocol tied to a headworks setting or a dam release that reaches the drains and chhappars of the towns was found. Without an agreed rule with dates, levels, release rates and a named operator, storage in a chhappar or low dam 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 when a late-season storm, such as those of 24 September 1988 and 4–5 October 1955, arrives after weeks of rain. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.

Most chhappars have other users. A village chhappar 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 water of the Kandi low dams irrigates their commands (WRD, Kandi Area Development). Drawing a chhappar or a low dam 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 Punjab Pollution Control Board (PPCB) 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. No standing order of the State fixes a date for the desilting of drains, choes or ponds. In practice the date is set each year by ministers or Deputy Commissioners, usually 30 June: in 2023 the State Flood Control Board, under the Chief Minister, ordered the cleaning of waterways by 30 June, and in 2026 the Local Government

Minister and the Deputy Commissioner of Kapurthala set 30 June for sewers and drains (all as reported); the draft State disaster management plan of about 2011 asks only that streams be desilted "before the onset of monsoons every year". The date of 15 June in this Manual is set by this Manual: the monsoon now sets in at Jalandhar on about 26 June, at Patti on about 28 June and at Ludhiana on about 1 July (IMD, new normal dates, 2020), so that 30 June comes after the onset in the Doaba and Majha; storms of June are real, such as 160.6 mm at Patiala on 8 June 2000 (IMD); and the plains are wetted from 1 to 9 June by the transplanting of paddy. Village chhappars are dewatered and desilted under the programme of the Department of Rural Development and Panchayats, about 1,062 dewatered and about 400 desilted by the Minister's account in 2025 (as quoted), with treatment on the Seechewal and Thapar models; some 1,450 ponds prepared on those models are reported to lie empty (as reported), and the CAG found a choked screening chamber at the pond works of Punnawal and Bhalwan (Report No. 1 of 2026). No published measure of their effect on storage or recharge was found. In the Kandi the choes leave "thick deposits of sand and silt" (District Environment Plan, Hoshiarpur), so their crossings and the drains they feed are cleared after the monsoon as well as before it (Chapter 10). Excavation to "increase capacity" is governed by Clause 7.9.3; in the waterlogged south-west deepening that cuts into the groundwater gives no storage at all, and in the over-exploited centre it can let polluted water reach an aquifer that is already contaminated at shallow depth (Clause 8.8.1). 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 Punjab 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 Punjab the rivers, choes and the drains it maintains lie with WRD's Drainage-cum-Mining & Geology wing, the canals with its canal wing, the street drains with the Municipal Corporations, Municipal Councils and Nagar Panchayats, and the sector drains of the urban estates with PUDA and the development authorities until they are transferred, but no rule or order dividing them was found for this Manual, and the sections of the Punjab Municipal Corporation Act, 1976 and the Punjab Municipal Act, 1911 that would vest drains in a municipal body were not read [TBC]. This Manual's working split of drain ownership (Chapter 1 and Chapter 6) is its own, not a statement of law. The drainage law protects the channels it reaches: under the Punjab Canal and Drainage Act, 2023 a notified reach is a drainage work (s. 38), WRD may remove an obstruction (s. 39), and damaging, altering or building on a drainage work, or altering the flow of a river or stream so as to endanger one, is an offence (s. 52); but a "drainage work" excludes the "removal of sewage from towns, villages or any other habitat" (s. 2(7)), so the town drains that carry sewage fall outside it. WRD told the National Green Tribunal that no drain may be realigned "without prior permission/NOC from competent authority of Water Resources Department" (O.A. 279/2024), and it has itself realigned and channelised the N-Choe in IT City, Sector 101, SAS Nagar, and lined the Sirhind choe below the Bhakra Main Line siphon (WRD, Drainage Administration). The record shows what is lost when the natural channels are treated as spare land: the Punjab reach of the Patiala ki Rao is "heavily encroached by squatters" (Local Commissioner, 2024); a road along the Buddha Nallah is alleged to have narrowed it "from 58 feet to 35 feet" (O.A. 327/2025, the allegation as recorded); the Chitti Bein is 40 to 60 ft wide where the Master Plan Jalandhar report asks for "atleast 80'-100'"; and in SAS Nagar a social impact assessment for a storm sewer under a sector road recorded villagers saying that "the village Abadi area is seven feet lower than the level of stream (Nadi)" and asked GMADA "not [to] disturb the natural passage of 'Nadi' or allied tributaries" (GMADA, 2021). The only existing rule on channel width is the environmental 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" (PMBBL 2018, Table 15.1, item 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 chhappar 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 Punjab no shared form of storage is required by either building instrument: rainwater harvesting under PMBBL 2018 (Chapter X) and PUDBR 2021 (r.40) is plot-level, and neither has a detention, peak-flow or "zero runoff" rule. The nearest existing forms of shared storage are the village chhappars restored under the State's pond programme of 2025; the Kandi low dams, whose listed benefits include "Flood attenuation" (WRD, Kandi Area Development); WRD's 410 check dams and 33 Amrit Sarovar works (WRD, reply in O.A. 694/2023); the condition of PMBBL 2018 that public open spaces of more than 500 m² provide for the "complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (cl. 10.4); and the "active storm water detention" assumed in the city reach of the Buddha Nallah (PMIDC, feasibility report, 2020). 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 Punjab State Wetlands Authority;
- (b) the six Ramsar sites of Punjab (Harike, designated in 1990; Kanjli and Ropar, in 2002; and Keshopur-Miani Community Reserve, the Beas Conservation Reserve and Nangal Wildlife Sanctuary, on 26 September 2019), each to its boundary as designated, any wetland notified under the 2017 Rules, the 72 water bodies that the Punjab State Wetlands Authority recommended for notification in September 2025, and the wetlands of the national atlas, until each is notified or found not to be a wetland;
- (c) the dhabs and other natural depressions that hold water through the monsoon, the marshy reaches of the Kali, Chitti and Black Beins, and the low wet bet land of the Sutlej, Beas, Ravi and Ghaggar, within the 1% AEP extent of Clause 7.3.4 or any limit notified under section 38 of the Punjab Canal and Drainage Act, 2023 (or section 55 of the Northern India Canal and Drainage Act, 1873), whichever is larger (the river and bein channels themselves are waterbodies under the rest of this chapter); and
- (d) any other marsh, wetland, dhab or chhappar 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. Punjab's wetlands are the concern of the Punjab State Wetlands Authority, constituted under rule 5 of the Wetlands (Conservation and Management) Rules, 2017 and chaired by the minister in charge of wildlife preservation (as reported; the notification constituting it was not seen [TBC]). No wetland notified by it under rule 7 of the Rules was found for this Manual. After its District Wetland Committees had ground-truthed 1,143 sites under the Supreme Court's directions (*Anand Arya*, W.P.(C) 304/2018), the Authority recommended 72 water bodies across 14 districts for notification on 25 September 2025, the largest numbers in Fatehgarh Sahib, Mansa, Barnala and Fazilka, and approved a management plan of ₹38.45 crore over five years for the Beas Conservation Reserve (as reported; the district counts given sum to 72 over 13 named districts). The State has six Ramsar sites: Harike, designated in 1990, and Kanjli and Ropar, designated in 2002, which together cover about 56.48 km² (as reported); and Keshopur-Miani Community Reserve (344 ha), the Beas Conservation Reserve (6,429 ha) and Nangal Wildlife Sanctuary (116 ha), all designated on 26 September 2019 (Rajya Sabha reply of 13 February 2025, as quoted; the Ramsar Information Sheets were not read). Harike lies at the confluence of the Sutlej and the Beas, at WRD's headworks, and Kanjli on the Kali Bein. A meeting of the Authority in 2024 listed seven of these sites for a "zone of influence" (as reported), but no eco-sensitive zone, zone of influence or buffer distance for any Punjab wetland was found. A drain outfall, desilting, diversion or regulator operation in or near a Ramsar site or a notified wetland therefore needs the Authority's permission where a notification or the Rules regulate it, and compliance with the directions of the courts and the Tribunal, as well as compliance with this chapter; for the chhappars, dhabs and depressions that are not notified, including the 72 recommended in 2025 until they are, this chapter, the commons law and the drainage and municipal law are the only controls, and Clause 7.12.1(b) treats the recommended sites as wetlands. 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 Punjab's beins, rivers and wetlands through its drains (Clause 8.9, Commentary). The Buddha Nallah carries "A quantum of 700 MLD discharge of treated effluent" to the Sutlej at Walipur, turning the river from Class B to Class E, from which it recovers to D and C by Harike, a Ramsar site (River Rejuvenation Committee, 28 October 2025); its water before the confluence had a BOD of 161 mg/l in April 2024 (CPCB). The Kala Sanghian drain carries the treated effluent of the Leather Complex CETP at Jalandhar to the Chitti Bein, which joins the Sutlej above Harike (as reported), and the National Green Tribunal ordered nineteen tanneries at Jalandhar closed in December 2017 for discharging into drains (as reported). The Kali Bein, on which Kanjli lies, was removed from the CPCB's list of polluted stretches in 2025 (PPCB, reply in O.A. 413/2025). In the villages the chhappars take sullage, and pond-based treatment works can fail, as at Punnawal and Bhalwan (CAG, Report No. 1 of 2026). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by many existing outfalls. In Punjab they apply in full to every new outfall, and every existing outfall to a chhappar, bein, river, wetland or 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. Punjab's main controls on filling and building in chhappars, choes and drains are the commons law, the drainage law and the courts. Village ponds are shamlat land under the Punjab Village Common Lands (Regulation) Act, 1961 (not read for this Manual), and the Supreme Court upheld the order that those who had occupied a village pond in Punjab vacate it and restore it to the Gram Panchayat (*Jagpal Singh v. State of Punjab*, 28 January 2011, a case under section 7 of the 1961 Act, as reported); in July 2020 the High Court directed that all encroachments and unauthorised constructions on village ponds in Punjab be removed within six months (as reported). The first census of water bodies counted 1,578 of the State's 16,012 water bodies as encroached (as reported). Within a reach notified under section 38 of the Punjab Canal and Drainage Act, 2023, the Divisional Canal Officer may order an obstruction removed (s. 39), no compensation is paid for a structure built without approval (s. 45), and damaging, altering or building on a drainage work is punishable with a fine of ₹5,000 to ₹50,000 or imprisonment of up to six months, or both (s. 52). The courts have had to enforce the channels one by one: on the Patiala ki Rao, notified in 2013, the High Court appointed a Local Commissioner in *Shamsher Singh v. State of Punjab* (CWP 5901/2017), who reported in January 2024 "rampant illegal construction even deep inside the Nadi/Choe" on the Punjab side, with the pillars marking its 200 ft width still to be fixed there, and contempt proceedings remain pending (COCP 1105/2023); a further petition seeks an embankment along it against seasonal flooding in Khuda Lahora, Nada, Nayagaon and Karoran (CWP-PIL 79/2025); and before the National Green Tribunal a road along the Buddha Nallah is alleged to have cut its width "from 58 feet to 35 feet" (O.A. 327/2025). In the Kandi, the Punjab Land Preservation Act, 1900 lets the State notify erosion-prone areas (s. 3) and regulate, restrict or prohibit clearing, quarrying, cultivation and tree-cutting in them (s. 4), and one such notification is reported to cover 21,944 acres in 15 villages near Chandigarh (as reported; the Punjab text and the list of notified areas were not read [TBC]). The announcement of 20 September 2023 that projects within 150 m of a water body would need the approval of WRD's drainage wing was meant "to regulate the construction activities in the vicinity of natural water bodies" (as reported), but no order giving it effect was found. This Manual treats a recorded chhappar, with its catchment and flow paths, as drainage infrastructure (definitions after Clause 7.2), and land recorded as a chhappar, toba or dhab as a waterbody under Clause 7.3 whatever its present state. 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 rims of most chhappars are low and are not expected to make them specified dams, but each shall be screened under Clause 7.14.1. The low dams of the Kandi are higher, and their heights were not found for this Manual [TBC]; each, and every check dam whose storage is counted, shall be screened. The dhussi bandhs and other flood embankments of WRD are excluded from the Act's definition of a dam, and the dams of the rivers, such as Ranjit Sagar and Shahpur Kandi on the Ravi, and WRD's headworks are not tanks under this chapter (Clause 7.7, scope note). Where the storage of a chhappar, dhab or low dam is counted under Clause 7.7, its rim, bund or dam 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

> Punjab the embankments that matter to the towns are WRD's dhussi bandhs along the rivers and the banks of its drains and canals. They have breached in most great floods: in August 2019 the Sutlej breached the Shahkot dhussi bandh, flooding Janian and Janian Chahal, and broke through at Gidderpindi and Tibbi near Sultanpur Lodhi and at Mandala; in July 2023 the Ghaggar breached at Moonak, Khanauri, Banarasi, Makraud Sahib and Phullad and in Mansa district, and breaches of the SYL canal and the Narwana branch flooded Rajpura; and in 2025 a dhussi bandh breached in the Ajnala–Ramdass area and the gates of the Madhopur headworks on the Ravi failed (all as reported). No breach map or emergency action plan for a chhappar rim, a Kandi low dam, a dhussi bandh or a drain embankment was found, and no current State disaster management plan was found. A failed or overtopped bank floods the villages, 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, and why the breach of a dhussi bandh is a case of Chapter 5 for the outfalls behind it. The hazard classes, the breach analysis and the emergency action plan for high-hazard tanks are set by this Manual. They extend the Chapter 4 requirement for detention basins (1% AEP spillway with outlet blocked, 0.2% AEP for high-hazard basins) to tanks that are counted as design storage.

7.15 Submittal requirements

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

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

7.16 Review and update

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

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

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Annexes and forms

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

8.4 Water quality volume and design flow

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

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

where:

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

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

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

where:

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

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

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

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

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

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

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

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

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

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

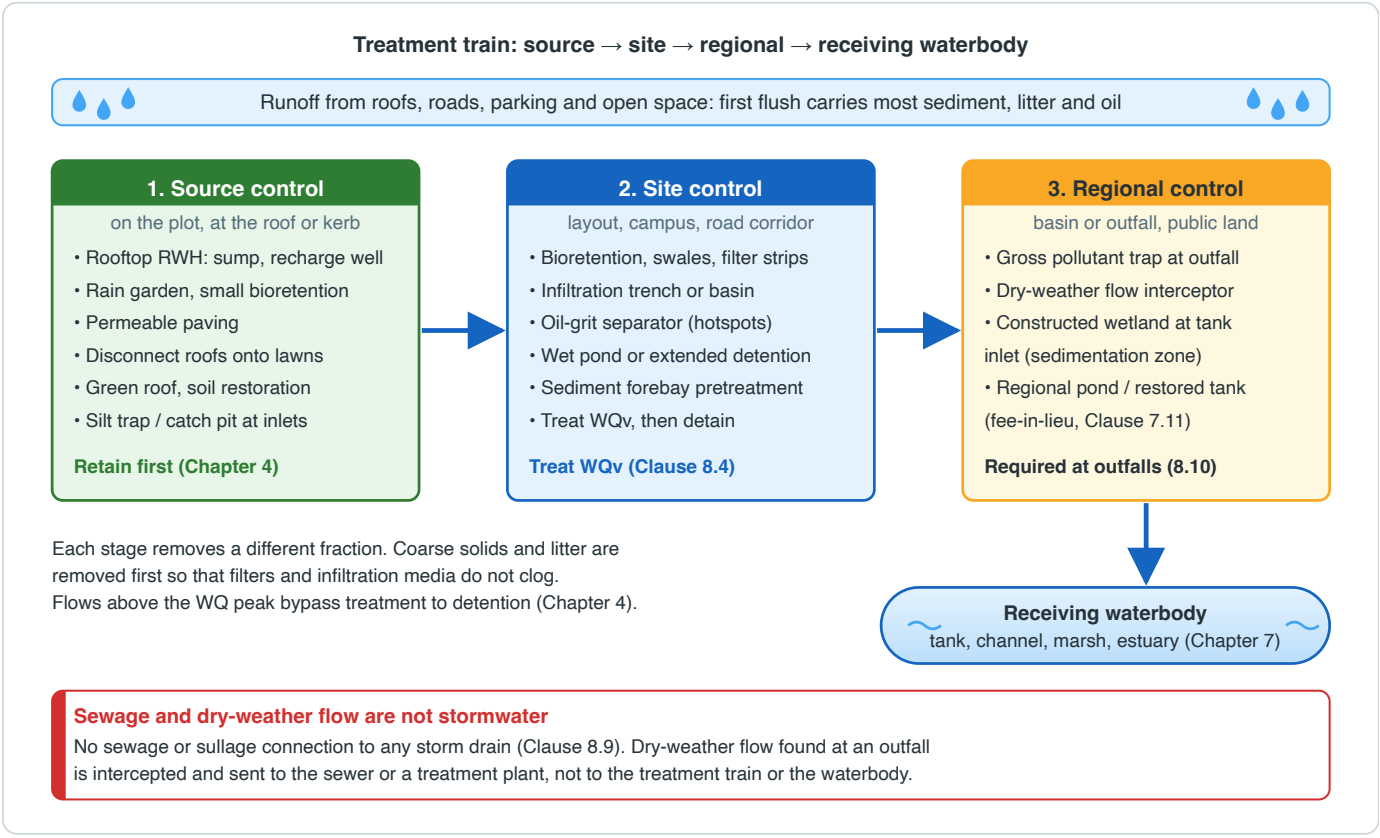


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater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

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Kandi fans, dune sands and alluvium	Laterite / hard rock	Sirowal, sodic soils / water table within 3 m	Punjab 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	Kandi fans, dune sands and alluvium	Laterite / hard rock	Sirowal, sodic soils / water table within 3 m	Punjab 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 Punjab 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. Punjab 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.**

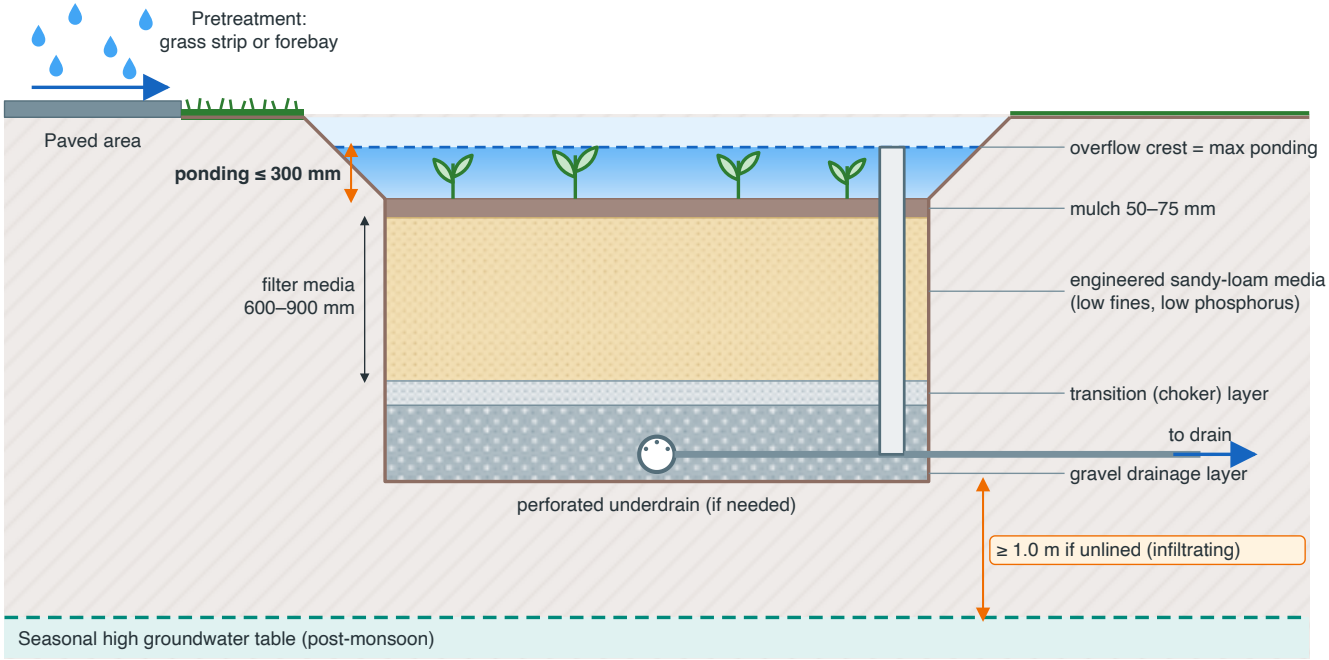
- (a) At every inlet that receives runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody.
- (b) A sump at least 300 mm below the outlet invert.
- (c) Silt traps are pretreatment only and earn no VR.

> **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 Punjab. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Punjab. 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 Punjab's rain falls in the south-west monsoon, whose normal for June to September is 439.8 mm (ICAR-CRIDA), and the State is wet in the north-east and dry in the south-west: the district normals range from 388.6 mm a year at Ferozpur, 429.8 mm at Bhatinda and 433.0 mm at Faridkot to 660.3

mm at Ludhiana, 818.8 mm at Hoshiarpur and 1,106.1 mm at Gurdaspur (IMD, *Climate of Punjab*, normals of 1901–1980). The monsoon now sets in at Jalandhar on about 26 June, at Patti on about 28 June and at Ludhiana on about 1 July, withdraws from all three by about 21 September, and leaves most of the State by 1 October (IMD, new normal dates, 2020); the western disturbances of winter add rain, and falls of more than 100 mm in a day have been recorded at Ludhiana in January, March and December (IMD). For eight or nine months of the year the chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond) and the dhab fall or dry out unless they are fed, and in the villages and towns the feed is 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-area PB-F) the dry forms of Clause 8.7 (bioretention, swales and extended dry detention) are the practical choice, lined and with no infiltration where the October water table is within 3 m (Clause 8.8.1, class (ii)); and in the Kandi (PB-A) a wet pond or wetland on a choe fills with sand, so that dry forms with a sediment forebay are preferred there too. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; chhappars, tobas, dhabs and the Kandi low dams are waterbodies under Chapter 7 and are not to be used as treatment for a development, even where the State's pond programme treats the sullage reaching a village chhappar on the Seechewal or Thapar model. 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 Punjab 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

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 Punjab, which has no coastal sand areas (Clause 8.8.9). **Depth to water decides.** Punjab's groundwater runs to both extremes: in the assessment of 2024 the stage of extraction was 156.87%, and 115 of the 153 assessment units (112 blocks and 3 urban areas) were over-exploited (CGWB); in June 2019 the water table lay deeper than 10 m over about 68% of the State, against 14.9% in 1989, with "deep water levels" in the Kandi belt, yet within 1.5 m of the ground over about 1% of the State, in Faridkot, Fazilka and Sri Muktsar Sahib, and within 5 m over about 5,723 km², mainly in the south-west, where "Water logging conditions exist" (CGWB and WRD, assessment as on 31 March 2020). For this Clause the seasonal high groundwater table is the post-monsoon level of October, the State's shallowest, read from the CGWB and WRD October maps, not the pre-monsoon level, and the 1.0 m separation above is measured from it. Each site falls in one of three classes, which are those of Clause 4.11. (i) **Deeper than 10 m** (the over-exploited plains of sub-areas PB-B, PB-C, PB-D and PB-E and the deep-water parts of PB-F, and the Kandi fans and choe beds of PB-A): recharge, with pretreatment and a first-flush diversion, is the first means of meeting retention wherever this Clause is met; no runoff from roads, parking, service yards or industrial premises is led directly to any recharge well, borewell or shaft (Clause 8.11.3(b); PUDBR 2021, r.40, already requires industrial units "not to inject contaminated water into recharge structures"); only filtered roof water goes to an injection well; recharge structures are kept away from sewer lines, septic tanks, soak pits and landfill (r.40, which sets no distance); and no septic tank or absorption pit is placed within 30 m of a well, water source or stream used or likely to be used for drinking (r.45(7)). In the Kandi, recharge is preferred on the boulder-gravel fans and in the choe beds, on site infiltration tests and with sediment control ahead of every facility, because the choes carry sand and silt; the Kandi low dams and WRD's 410 check dams on rivers and nallahs are recharge structures of this kind. On the Shivalik slopes themselves (natural ground of sandstone and clay sloping more than 10°, in the Pathankot–Dhar Kalan hills, the Mukerian–Dasuya, Hoshiarpur and Garhshankar Shivaliks, the Anandpur Sahib–Nangal Shivaliks and the Kharar–Mullanpur hills) the hill infiltration rule of Clause 4.11 applies, and no infiltration is built or credited there without the geotechnical certificate it requires. (ii) **Within 3 m** (the waterlogged south-west, sub-area PB-F where the October water table is within 3 m, including parts of Sri Muktsar Sahib, Fazilka, Faridkot, Bathinda and Ferozepur; the Sirowal belt below the Kandi; the bet lands within the seasonal flood level; and the beds and foreshores of chhappars and dhabs): no infiltration facility, soakaway, recharge pit, recharge well, recharge shaft or exfiltrating paving 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; rainwater harvesting there is storage for use, saline groundwater is not a recharge target, and retention is met by storage for use, by evaporation from shallow lined storage and by detention under Chapter 4, with conveyance and pumped outfalls carrying the design. (iii) **Between 3 m and 10 m**: infiltration or recharge is credited only on a check at the site of the October water table and its trend over at least the past five years, which shows that this Clause is met and that the water table is not rising. **Quality.** Before a recharge well or shaft is designed, the groundwater at the site is tested against the limits of the State's assessment of 2024 (uranium above 30 ppb, found in 32.6% of the samples; nitrate above 45 mg/L, 12.58%; fluoride above 1.5 mg/L, 13.77%; arsenic above 10 ppb, 4.85%; and an electrical conductivity above 3,000 µS/cm, 6.72%, with up to 8,320 µS/cm at Abohar; CGWB), and where any of them is exceeded at the site, recharge through a well or shaft is not credited unless a hydrogeologist shows that it will not worsen the aquifer or the wells it supplies; the State's own assessment records that "Groundwater at Shallow depth is largely contaminated caused by surface water pollution" (CGWB and WRD). **Credits.** A user who implements an approved rainwater harvesting scheme earns water-conservation credits under the Punjab Groundwater Extraction and Conservation Directions, 2023, one credit for each cubic metre conserved, with a rebate of ₹2.50 (Directions 2.7 and 4.7); the drainage report states each recharge structure's design volume in m³ a year so that a user can claim them, which is a link to that regime and not a mandate. The classes, the 3 m and 10 m limits, the October reading and the quality screen 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. Punjab 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 and loamy sands of the south-west (Bathinda, Fazilka, Abohar and Sri Muktsar Sahib), the boulder-gravel fans and choe beds of the Kandi and the sands of the river beds and bet lands 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 sandstone and clay of the Shivalik hills, in the Pathankot–Dhar Kalan hills, the Mukerian–Dasuya, Hoshiarpur and Garhshankar Shivaliks, the Anandpur Sahib–Nangal Shivaliks and the Kharar–Mullanpur hills, where water moves through joints and the weathered mantle; Punjab has no laterite, and on any slope in these hills the hill rule of Clause 4.11 and the limits of Clause 8.8.1 apply first):

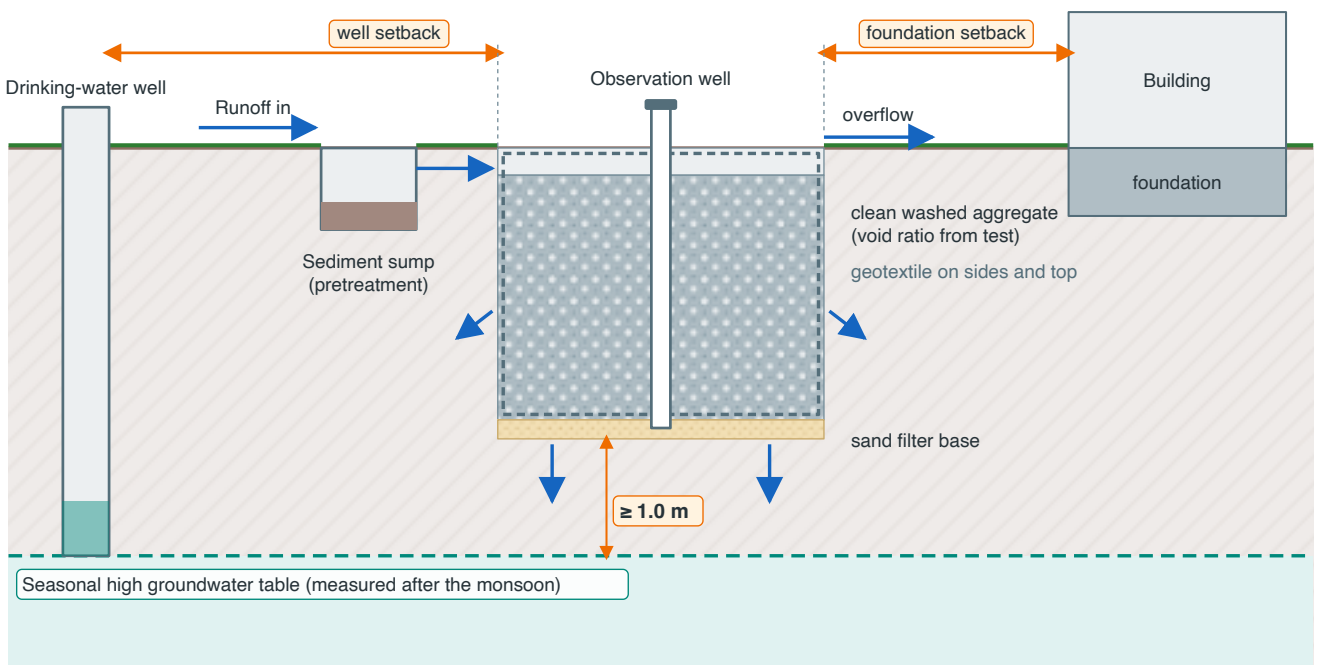
- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes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

8.8.11 **Delta clays and black cotton soils.** In the Sirowal belt below the Kandi, where the water table is shallow and seepage comes out, the waterlogged and saline-sodic ground of the south-west (sub-area PB-F) where the October water table is within 3 m, the sodic patches of the old alluvium between Patiala, Sangrur and Mansa, the bet lands of the Sutlej, Beas, Ravi and Ghaggar, the clay beds of the beins, the silted beds of chhappars, tobas and dhabs, the Shivalik clays, the puddled paddy fields of the plains in the paddy season, 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 Punjab precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Punjab 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 Punjab was found, and no measured basic infiltration rates by soil group for the Kandi or the central plains; every infiltration design needs the tests of Clause 8.8.3. The only measured rates found are from the dry south-west, where double-ring tests on rainfed soils near Bathinda gave final intake rates of 0.26, 0.09 and 0.05 cm/min, about 156, 54 and 30 mm/h, on sand, loamy sand and sandy loam (Singh, Singh and Chaudhary, 1995): upper bounds on dry, recently cultivated soil, not design values. The State's ground falls into six broad kinds. Immediately south-west of the Shivalik hills, the Kandi belt, 10 to 15 km

wide, is made of fans whose deposits grade "from boulders to clays", sloping at about 16 m per km and less to the west, with deep water levels; below it the Sirowal "imperceptibly merges with the alluvial plain", with a shallow water table and seepage (CGWB). The recent alluvium of the upper Ravi, Beas, Sutlej and Ghaggar, sandy loams and loams in the Doaba and around Ludhiana, is open, though puddled paddy fields behave as tight soil in season; calcareous alluvium covers the middle reaches, and old alluvium lies between the Sutlej and the Ghaggar, with saline and alkaline patches (CWC, Flood Estimation Report for subzone 1(e)); the bet lands of the rivers have seasonally high water tables; and the south-west has dune sands and loamy sands, with desert and grey-brown soils near the boundary (CWC; CGWB). This Manual's interim soil groups follow from these: Kandi boulder-gravel fans and choe beds A; the Shivalik slopes, of sandstone and clay, C or D; south-west dune sands and loamy sands A, or A/B on loamy sand, but D where the water table is within 1.5 m; the sandy loams and loams of the central plains and the Doaba B, behaving as C or D under ponded paddy; the old alluvium with kankar between Patiala, Sangrur and Mansa B or C, with sodic patches D; bet soils B, with a seasonally high water table; the Sirowal C or D; and made ground C unless tested, D if compacted. **Groundwater runs to both extremes.** In the assessment of 2024 the stage of groundwater extraction was 156.87%, and 115 of 153 assessment units were over-exploited, 4 critical, 12 semi-critical and 22 safe (CGWB); by district in 2020 the stage ranged from 301% in Sangrur, 257% in Jalandhar and 211% in Ludhiana to 53% in Pathankot and 43% in Sri Muktsar Sahib, and the water table fell by up to 36.15 m at Rajpura between 1984 and 2019 while it rose by up to 20.70 m at Talwara (CGWB and WRD). In June 2019 it lay deeper than 10 m over about 68% of the State and deeper than 30 m over about 21%, but within 5 m over about 5,723 km², mainly in the south-west, where "Water logging conditions exist in some parts" (CGWB and WRD); the waterlogged area itself is uncertain, with reported figures ranging from about 52,500 ha in 2009 to "around 2 lakh hectares" in Sri Muktsar Sahib, Ferozepur, Fazilka and Faridkot, part of it alongside the Rajasthan and Sirhind feeder canals (all as reported). The quality of the groundwater limits what recharge can do: of the samples of 2024, 32.6% had uranium above 30 ppb, 13.77% fluoride above 1.5 mg/L, 12.58% nitrate above 45 mg/L, 4.85% arsenic above 10 ppb and 6.72% an electrical conductivity above 3,000 µS/cm (CGWB); about 15 to 25% of the groundwater is saline or alkaline, in Sri Muktsar Sahib, Bathinda, Mansa and Sangrur, and "Groundwater at Shallow depth is largely contaminated caused by surface water pollution" (CGWB and WRD). The State recharges as well as draws: WRD reports 129 recharge schemes along its canals and 60 more, 410 check dams on rivers and nallahs and 33 Amrit Sarovar works (reply in O.A. 694/2023), and of the Kandi's rain "About 40% … gets wasted in floods" (WRD, Kandi Area Development). The Punjab Water Regulation and Development Authority regulates extraction under the Punjab Water Resources (Management and Regulation) Act, 2020, which lets it issue directions on "water conservation and groundwater recharge, including rain water harvesting" (s. 15(2)(ix)), and charges for groundwater by block and slab under its Directions of 2023, with credits for approved rainwater harvesting (Directions 2.7 and 4.7). **The State therefore needs recharge in most places and must avoid it in others.** Where the October water table is deeper than 10 m, recharge comes first, with pretreatment and a quality check; where it is within 3 m, in the waterlogged south-west, the Sirowal, the bet lands and the beds of chhappars and dhabs, no recharge or infiltration is credited, and storage, detention and drainage carry the design; in between, a check at the site 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 uranium, nitrate, fluoride, arsenic and salinity. Clause 8.8.9 has no effect in Punjab, 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 Punjab Pollution Control Board (PPCB) 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 Punjab. 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 Punjab the law keeps drainage and sewage apart, but the drains carry both. A "drainage work" under the Punjab Canal and Drainage Act, 2023 excludes the "removal of sewage from towns, villages or any other habitat" (s. 2(7)), so WRD's drains are not sewers in law; an absorption pit may have no outlet into "any sewer, storm water, drain or surface drain" (PUDBR 2021, r.45(8)(ii)); and the waste water of a basement is pumped into the sewer, not connected to it directly, "to avoid any risk of the sewerage or sludge heading back into the basement" (PMBBL 2018, cl. 4.23(viii)). The sections of the Punjab Municipal Corporation Act, 1976 and the Punjab Municipal Act, 1911 on drains and sewer connections were not read for this Manual [TBC]. In practice the large drains are wastewater channels. The Buddha Nallah at Ludhiana, a seasonal tributary of the Sutlej 47.55 km long that WRD lists among its drains, receives "A quantum of 700 MLD discharge of treated effluent", including that of three dyeing CETPs of 15, 40 and 50 MLD to which 211 of about 345 dyeing units are connected, and turns the Sutlej from Class B, at which it enters the State, to Class E below the confluence at Walipur (River Rejuvenation Committee, 28 October 2025); before the confluence in April 2024 its water had a BOD of 161 mg/l, a COD of 456 mg/l and TSS of 328 mg/l, against the general discharge standards of 30, 250 and 100 mg/l (CPCB, reply in O.A. 327/2025), so that much of what it carries is not treated. At Jalandhar the Kala Sanghian drain, which takes the treated effluent of the Leather Complex CETP of 5 MLD (State of Punjab, report in E.A. 35/2023), runs to the Chitti Bein and on to the Sutlej (as reported). In the walled city of Amritsar the road-side drains "are connected to the sewerage system typically at the road junctions, thus making the sewerage system as combined system" (Amritsar Smart City, bid of 2018); at Jalandhar "only about 5% of the city area is covered under the storm water network" and the rain "is largely discharged in to the sewer network" (Master Plan Jalandhar report); and at Bathinda the storm-water pumping stations are reported to be connected to the sewers (as reported). The State's 166 towns generated 2,212 MLD of sewage in September 2023, with a treatment gap of 326.58 MLD (State of Punjab, E.A. 35/2023). The polluted river stretches listed in 2023 were the Sutlej from Roopnagar to Harike and the Ghaggar from Sardulgarh to Mubarakpur, both Priority I, with the Kali Bein (Priority V) and others (PPCB, letter of 5 September 2023); in September 2025 the CPCB kept only two Priority I stretches in the State, the Ghaggar from Mubarakpur to Sardulgarh and the Sutlej from Ludhiana to Harike, and removed the Kali Bein, the Sirsa and the Swan from its list (PPCB, reply in O.A. 413/2025). In the villages the chhappar takes the village's sullage as well as its storm runoff, and the State's pond programme treats the sullage on the Seechewal and Thapar models (as reported; their specifications were not read); the CAG found that at the pond-based treatment works of Punnawal and Bhalwan, in Dhuri block, a choked screening chamber resulted in the "discharge of untreated

wastewater into the drain" (Report No. 1 of 2026). This Manual therefore treats a chhappar as a combined sullage-and-storm basin: the drawings show both its sullage inflow and its storm overflow route; the sullage is intercepted, screened and treated ahead of the chhappar; and only the storm flow above the interceptor's capacity reaches the chhappar and passes over its overflow. A DWF interceptor with a screen is likewise placed, under Clause 8.9.5, ahead of every outfall that carries dry-weather flow to a chhappar, to a bein (the Kali, Chitti and Black Beins), to the Ghaggar or to the Buddha Nallah, until its sources are removed (set by this Manual). Clause 8.9.5(b) applies to every one of 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 chhappar'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 Punjab 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 (in municipal areas, PMBBL 2018 (as amended), cl. 10.1, for all buildings on plots of 100 m² or more and for group housing, public, commercial and industrial buildings

of every plot size, with recharge for plots of more than 500 m² (cl. 10.5), complete capture of storm water in public open spaces of more than 500 m² (cl. 10.4), and inspection by the municipal Rainwater Harvesting Cell before a completion certificate or service connection is given (cl. 10.6); outside municipal limits and in the schemes of PUDA and the development authorities, PUDBR 2021 (as amended), r.40, for residential plotted and public or institutional buildings above 250 m², commercial, mixed-use and industrial buildings above 100 m² and group housing of every plot size, with a design certified by an engineer; and, under both, permeable materials for all open parking in group housing) 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. Punjab's two building instruments make rainwater harvesting mandatory on different thresholds, and neither sets a detention rule. In municipal areas, "All buildings having a plot size of 100 sq.m. or more, while submitting the building plans for sanction, shall mandatorily include the complete proposal of rainwater harvesting" (PMBBL 2018, cl. 10.1), with residential plots of 100 m² and above (where storage and reuse are emphasised) and group housing, public, commercial, mixed-use and industrial buildings of every plot size (Table 10.1); recharge is to be "made mandatory" for plots of more than 500 m² and for parks, parking, plazas and playgrounds (cl. 10.5); public open spaces of more than 500 m² are to provide for the "complete utilization and capture of storm water" (cl. 10.4); and each municipality is to constitute a Rainwater Harvesting Cell, inspect the structures "before issuing Completion Certificates or NOCs for service connections", and verify every building above 1,000 m² each year and a 10%

random sample below it (cl. 10.6). Outside municipal limits and in the schemes of PUDA and the development authorities, PUDBR 2021 requires harvesting for residential plotted and public or institutional buildings "Above 250 sq.mt.", for commercial, mixed-use and industrial buildings "Above 100 Sq.mt." and for group housing of all plot sizes, with the design "prepared and certified by an Engineer dealing with civil work", industrial units "not to inject contaminated water into recharge structures", and recharge structures kept away from sewer lines, septic tanks, soak pits and landfill (r.40). Group housing under both instruments is to avoid concrete paving, "permeable materials are to be used [for] all open parking spaces", and its plans are to show the storm water drainage, the harvesting structure and the recharging well, Punjab's only permeable-paving rule. The thresholds therefore differ by instrument, and earlier ones differed again: 400 m² in a 2010 amendment of the PUDA rules and 500 square yards in 2013 (as reported), and "above 200 sq. yds." in a Lok Sabha reply (as quoted); this Manual cites the instrument with each number and never a single "Punjab threshold". Neither instrument sets a volume, a sizing method or a storage to be empty before a storm: PMBBL 2018 says only that rain "can be harvested to the extent of 55,000 liters per 100sq. meters area per year from rooftops" (cl. 10.1), a description of about 550 mm a year, not a design rule. WRD's own scheme for the roofs of government buildings sizes a 40 m injection well with a filter chamber for 900 m² of roof on an intensity of 40 mm/h ("Hourly Rainfall Intensity is typically 25 to 30 mm/hr … For safer side we assumed it to be 40 mm/hr") and runoff coefficients of 0.8 to 0.9 for roofs, 0.6 to 0.7 for paved areas and 0.1 to 0.2 for green areas (WRD, Proposal RWH); that is a recharge-structure figure, never a design storm for drains. Enforcement is reported to be weak, with MC Ludhiana "not serious about rainwater harvesting" (as reported). The Punjab Water Regulation and Development Authority rewards approved harvesting with water-conservation credits under its Directions of 2023 (2.7 and 4.7), but its charges fall on non-exempt users, mainly industry, not on households. Because Punjab's water table is deep in the centre and the Kandi and shallow in the south-west (Clause 8.8.1), the function of harvesting depends on where the building is: recharge is its main function where the October water table is deeper than 10 m, over most of the central plains, with the quality limits of Clause 8.8.1 (Clause 8.11.2(b)); in the waterlogged south-west, the Sirowal and the bet lands, where it is within 3 m, the instruments' 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 late-season storm, such as those of 24 September 1988 and 4–5 October 1955, 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 15 October has sediment controls in place before it is cleared.

8.12.3 **Measures.**

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

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

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

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

> Commentary. The 0.1 ha threshold is the applicability threshold of Chapter 1. The sediment basin volume of 250 m³/ha is the US EPA Construction General Permit minimum of 3,600 ft³ per acre drained, converted to SI (US EPA, 2022 CGP); the CGP allows the alternative of the 2-year, 24-hour runoff. This Manual requires the greater of the two, because Punjab'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 Punjab sediment takes the storage of the chhappars, the drains and, above all, the choes: the Kandi is "traversed by numerous small and big seasonal streams called choes and is prone to flashy floods" (WRD, Kandi Area Development), and the choes of Hoshiarpur district "originate from Shivalik slopes" and leave "thick deposits of sand and silt" where they reach the plains (District Environment Plan, Hoshiarpur), in the culverts, siphons and town drains that they cross (Clause 6.3.6). In the Kandi and on the Shivalik slopes the outlet of a sediment basin or trap under Clause 8.12 discharges to a lined drain or a stable channel and never onto an unprotected slope; no sediment basin or trap is designed to infiltrate where Clause 8.8.1 bars infiltration, which includes the Sirowal; no spoil, sand or debris from a site is placed in a choe, rao, bein, nala, drain or chhappar or within its Zone 1; and in an area notified under the Punjab Land Preservation Act, 1900, clearing and quarrying are regulated by that Act before this Clause applies. The reason given above for the larger basin volume, that the 2-year 24-hour depths are high, holds in the Kandi and the north-east of the State, where the 50-year 24-hour depths of the CWC plates are about 255 to 320 mm and the annual normal reaches 1,106.1 mm at Gurdaspur; it holds less in the south-west, where the plates give about 150 to 180 mm and the normal is 388.6 mm at Ferozpur, and there the minimum of 250 m³ per hectare is likely to govern over the 2-year runoff, so the rule of Clause 8.12.3(c) is kept unchanged (set by this Manual).

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 Punjab 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	Punjab 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 or choe of WRD, to a bein, to a canal (with WRD's written consent, Chapter 5) or to a chhappar (ਛੱਪੜ; toba ਟੋਭਾ; 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 by BBMB from Bhakra on the Sutlej and Pong on the Beas, the releases from Ranjit Sagar and Shahpur Kandi on the Ravi, the stage held at the Ropar, Harike,

Hussainiwala and Madhopur headworks, 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 through the dhussi bandhs to the Sutlej, from Rupnagar and Ludhiana to Phillaur, Shahkot and Ferozepur, to the Beas and the Ravi, from Pathankot, Gurdaspur, Dera Baba Nanak and Mukerian, and to the Ghaggar, from SAS Nagar, Zirakpur and Dera Bassi to Patiala, Samana, Moonak, Khanauri and Sardulgarh, for the drains of Ludhiana that reach the Buddha Nallah, which meets the Sutlej at Walipur Kalan, and for the drains of Amritsar that reach WRD's Tung Dhab and City Outfall drains and, through the Hudiara drain, Pakistan; for an outfall to a WRD drain, the design water level of that drain at the outfall, with WRD's consent, or, where none is published, the level of the drain running at its design capacity (set by this Manual; Clause 5.8.5(i)); for an outfall to a river, the design river level of Clause 5.8.5(a)–(c), referred to the nearest gauge of WRD's headworks or of BBMB, read in feet on a gauge zero that is to be confirmed [TBC] and converted at 0.3048 m per foot to a named datum, and never a CWC danger level, since CWC has no flood-forecasting or level-monitoring site in Punjab (as reported); for an outfall to a choe, rao or nallah with no gauge, the level of the 1% AEP flood in the reach, computed with the sediment bulking and blockage of Clause 6.3.6 and checked against surveyed flood marks, with the outfall invert above the highest surveyed bed (Clauses 5.8.5(e) and 6.3.6(f)); the level held in a drain by any siphon or culvert under a canal, regulator, sluice, bund, low dam or pumping station downstream of the outfall, taken as a fixed control at the level that passes the drain's design flow through it, its gate-closed level, its crest or the start level of its pumps; and the joint case of Clause 2.12. Where a catchment has no gravity outfall and ends in a depression, as in the waterlogged south-west, the tailwater is the level reached in that storage when it holds the 72-hour design volume with no outflow other than pumping and evaporation, since no infiltration is credited where the October water table is within 3 m (Clauses 4.12.7 and 5.8.5(g)). A canal, distributary or minor is never a receiving water without WRD's written consent (Clause 5.8.5(f)). No document found sets a design river or drain level at any outfall in Punjab; until one is published, the levels of Chapter 5 apply.

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

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

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

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

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

9.3 Pipes and box drains

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

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

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

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

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

9.3.5 **Changes of size and direction.**

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

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

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

9.4 Culverts

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

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

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

> HWo = ho + H − L·S

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

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

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

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

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

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

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

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

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

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

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

> Qr = Cd · L · h^1.5

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

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

9.4.8 **Barrels and debris.**

- (a) Multi-barrel culverts shall be avoided in debris-prone urban drains. Where they are used, one barrel shall carry the dry-weather flow, and the inlet shall have a debris fin or deflector.

- (b) Culverts shall meet the minimum size and blockage checks of Chapter 6, Clauses 6.12.4 and 6.12.5.
- (c) Culvert inverts shall match the bed of the drain. They shall not be set above the bed, which traps silt and water upstream.

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

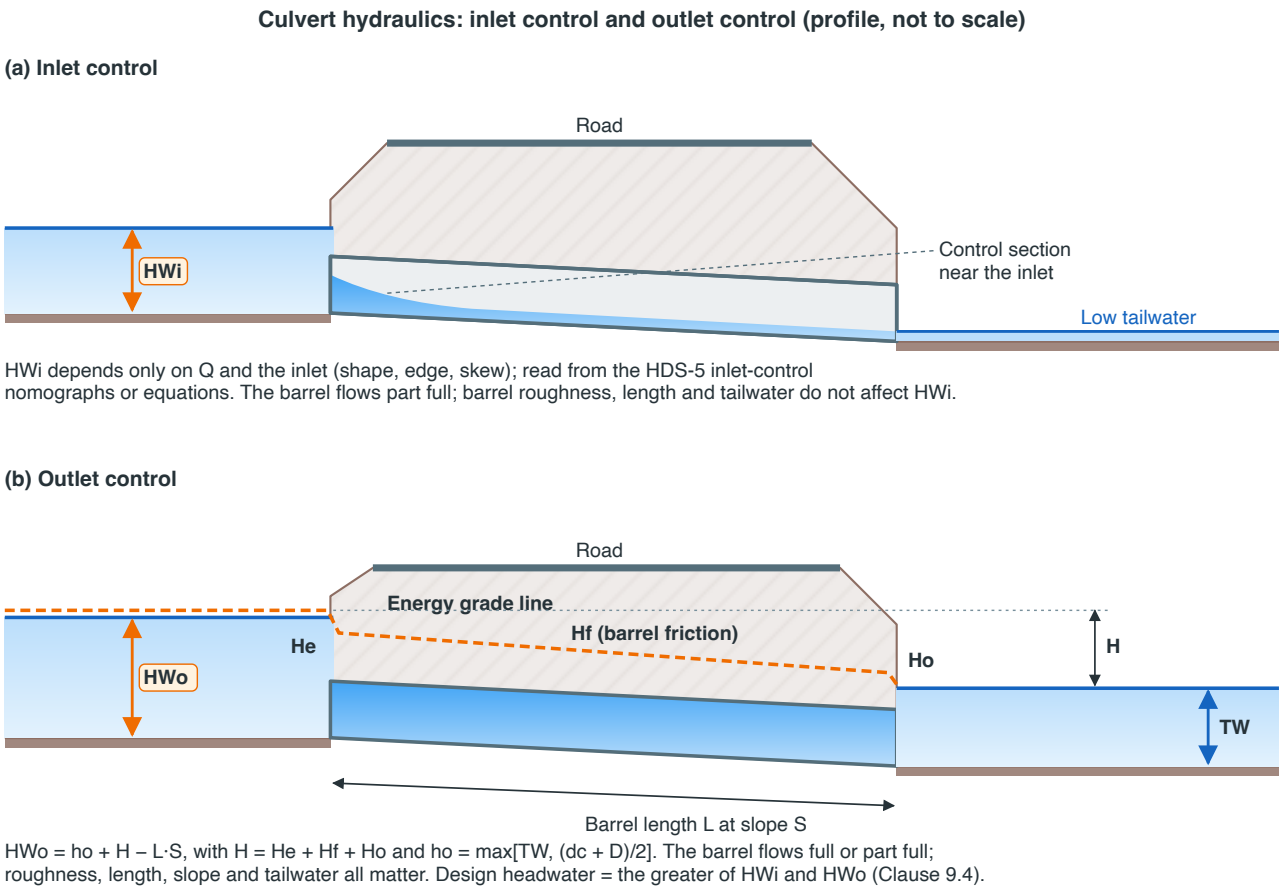

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

Commentary. HDS-5 (3rd ed., FHWA-HIF-12-026, April 2012) merged the culvert design material of HEC-5, HEC-10 and HEC-13 and is the current FHWA culvert manual. The outlet-control equation in Clause 9.4.3 is the HDS-5 energy equation in SI units: the friction coefficient 19.63 equals 2g. The ke values in Table 9.1 are reproduced from HDS-5. The weir coefficient cap of 1.66 (SI) is the conversion of the APWA 5600 (2006) limit of C ≤ 3.0 (US units) for overtopping calculations. The headwater limits of Clause 9.4.5 are set by this Manual: HW/D ≤ 1.2 keeps the inlet from operating far into submerged-orifice flow at the design event, where small increases in flow give large increases in headwater. Clause 9.4.8(c) has no direct precedent; it is included because raised culvert inverts are common in Punjab 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 through the dhussi bandhs to the Sutlej, the Beas, the Ravi and the Ghaggar, whose levels BBMB's releases from Bhakra and Pong and the headworks at Ropar, Harike, Hussainiwala and Madhopur set, on the Buddha Nallah, the Tung Dhab and the other WRD drains with little fall, on drains held back by siphons and culverts under canals, such as the Sirhind choe below the siphon of the Bhakra Main Line, and on the flat drains of the plains and the waterlogged south-west, where river slopes seldom exceed 0.38 m per km (CWC Flood Estimation Report, subzone 1(e)), 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 Punjab (the recent and old alluvium of the Punjab plains, with kankar and sodic patches between Patiala, Sangrur and Mansa, the sandy loams of the bet floodplains, the boulder–gravel fans and choe beds of the Kandi, the clays of the Sirowal below them and of the Shivalik slopes above, and the dune sands, loamy sands and saline-sodic soils of the south-west). 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 Punjab urban channels carry sewage-mixed dry-weather flow until the cross-connections of Chapter 8 are removed. A wide flat bed then deposits sludge across its whole width, and a low-flow channel keeps the dry-weather flow concentrated.

9.6 Energy dissipators, outlet protection and drop structures

9.6.1 **When required.** Outlet protection or an energy dissipator shall be provided at every pipe, culvert and channel outlet where the outlet velocity at the design AEP or the 1% AEP exceeds the permissible velocity of the receiving channel in Table 9.2, and at every outlet to an unlined channel, tank or waterbody.

9.6.2 **Method.** Energy dissipators and outlet protection shall be designed by the methods of FHWA HEC-14, *Hydraulic Design of Energy Dissipators for Culverts and Channels*, 3rd edition (2006), selecting the dissipator type by its range of application.

9.6.3 **Riprap aprons.** For a circular outlet discharging to a flat apron, the median riprap size shall be computed with the HEC-14 apron equation:

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

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

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

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

Class	D50 (mm)	Apron length	Apron thickness
1	125	4D	3.5 D50
2	150	4D	3.3 D50

Class	D50 (mm)	Apron length	Apron thickness
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.

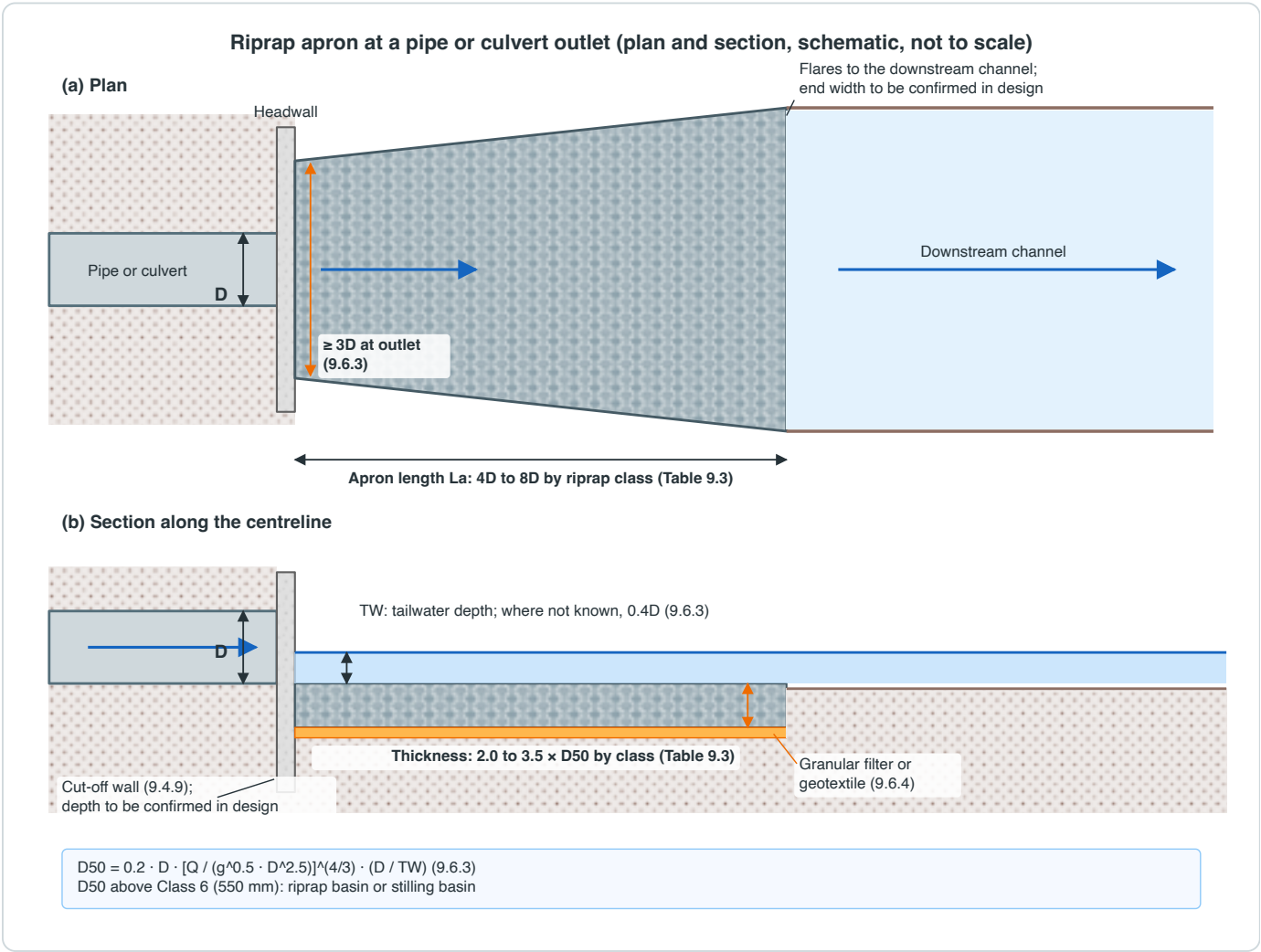

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design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

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

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

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

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

Submerged weirs shall be corrected for submergence from published relationships.

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

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

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

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

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

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

9.8 Trash racks and screens

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

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

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

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

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

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

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

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

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

9.8.6 **Pump sump screens.** Bar screens at pump-station inlets shall have a clear spacing smaller than the largest solid the pumps can pass, as stated by the pump manufacturer. Screens shall be built in removable modules, and a mechanically raked screen shall be used where the design inflow exceeds 1 m³/s.

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

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

9.9 Pumps and sumps

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

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

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

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

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

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

9.9.4 **Duty and standby.**

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

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

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

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

9.9.8 **Controls and monitoring.**

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

9.9.9 **Power supply.**

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

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

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

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

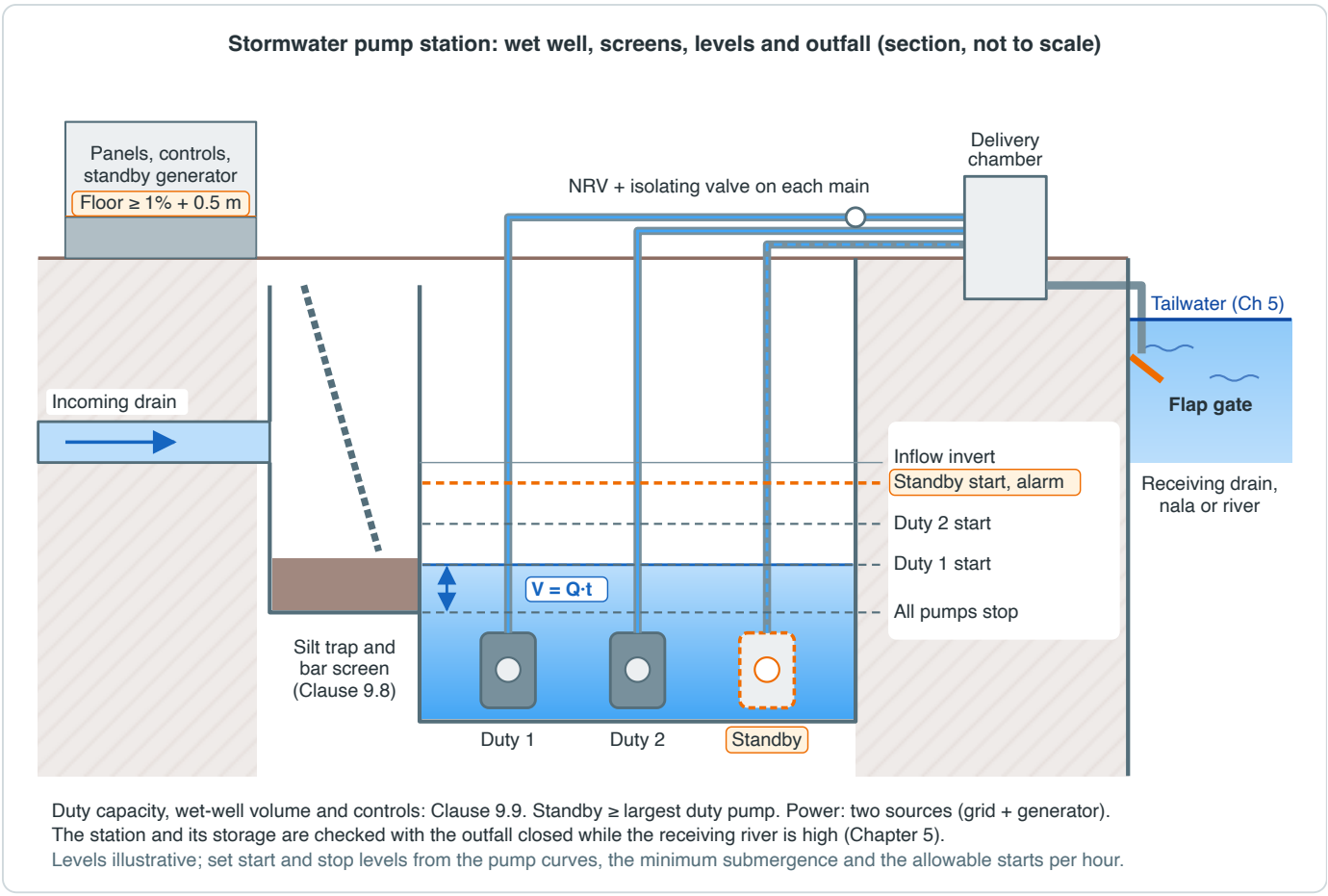

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

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

9.10 Tide gates, flap gates and non-return valves

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

9.10.2 **Types.** Acceptable devices are:

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

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

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

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

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

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

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

> Commentary. CPHEEO (2019, §6.3.10.1) describes flap gates and flood gates at outfalls to tidal waters. It notes that "adequate storage may be necessary if pumping is to be avoided during the closure of the gate" and that hinge pins and links "should be of corrosion-resistant materials". Punjab 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 as written; in Clause 9.9.2(c) the highest tailwater is the highest river, drain or choe 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 found electrical conductivity above 3,000 µS/cm in 6.72% of its samples (2024), up to 8,320 µS/cm at Abohar, and describes 15–25% of the groundwater as saline or alkaline in Sri Muktsar Sahib, Bathinda, Mansa and Sangrur. Gates are still required below the 1% still-water level, because the State's town drains outfall through the dhussi bandhs to rivers whose stage the dams, the headworks and the border set. CWC has no flood-forecasting or level-monitoring site in Punjab (SANDRP, 2018 and 2022, as reported), so the levels are WRD's headworks gauges and BBMB's reservoir levels, published in feet on gauge zeros that have still to be confirmed. On the Sutlej the Ropar headworks passed 2.4 lakh cusecs in 1988 and 1.79 lakh cusecs in July 2023, and Harike, where a discharge above 3,00,000 cusecs is classed as "High Flood", passed 3,35,030 cusecs at 686.50 ft upstream on 3 September 2025, with Hussainiwala at 3,02,508 cusecs and 646.50 ft the same day (all as reported); on the Beas, Pong (full reservoir level 1,390 ft) took a record inflow of 7.3 lakh cusecs on 14 August 2023 and rose to 1,399.65 ft (as reported); on the Ghaggar the gauge at Khanauri stood at 754.2 ft on 15 July 2023 against a danger mark given as 748 ft, with 752 and 753 ft also reported (as reported). Dhussi bandhs have breached in these floods, at Shahkot (Janian), Gidderpindi and Mandala on the Sutlej in August 2019 and in Ajnala and Ramdass on the Ravi in 2025 (as reported), so a gated outfall through a bandh is part of the flood defence and is built and inspected as one. BBMB's release notices give the towns below the dams hours to days of warning, but a local storm gives none, so a gate must close by itself and the storage or pumps behind it must work without notice. Pumping stations under Clause 9.9 are needed in two cases. The first is an outfall that fails the outfall-closed check of Chapter 5, as on the Sutlej front from Rupnagar and Ludhiana to Ferozepur and on the Ghaggar from SAS Nagar to Sardulgarh, where a river at its flood level can stand above the invert for longer than any storm, for the river lock of Clause 5.8.5 (at least 7 days on the Sutlej below the Ropar headworks and on the Ghaggar from Samana to Sardulgarh). The second is the depressions of the waterlogged south-west, where the water table stood as little as 0.79 m below ground at Abohar in June 2019 and within 5 m over about 5,723 km² (CGWB and WRD, 2020), the land is flat and many low villages have no gravity outfall at all: WRD lays RCC pipelines of 600 mm to drain flood water from low-lying villages in the Sri Muktsar Sahib and Fazilka area (WRD Drainage Administration). The town drains of Bathinda, Sri Muktsar Sahib, Fazilka, Abohar and Faridkot therefore need storage and pumped outfalls sized under Clause 9.9 and the outfall-closed check of Chapter 5, with no infiltration credited. Bathinda's storm-water pumping stations have been reported as "connected to the existing sewer system" (as reported); under Clause

9.9.11 a storm pump delivers to a storm outfall, never to a sewer. Canals cross the drainage of the plains and act as controls on it. The Sirhind choe passes under the Bhakra Main Line by a siphon (WRD), the Hansi–Butana canal siphon on the Ghaggar has been blamed for ponding at Samana, the SYL canal and the Narwana branch breached and flooded Rajpura in July 2023, the Sirhind canal was stopped after villagers put rainwater into it, and a storm in June 2026 caused about 35 breaches in canals and minors (all as reported). In Punjab, therefore, set by this Manual: (a) every siphon, culvert or aqueduct that carries a drain or choe under or over a canal downstream of an outfall is a fixed control under Clause 9.2.1 (Clause 5.8.5(f)), and its head loss at the drain's design flow, clear and with the blockage of Clause 6.3.6 where the drain carries choe sediment, sets the tailwater upstream; (b) no structure of this chapter discharges to a canal, distributary or minor without WRD's written consent; and (c) a new road or layout that crosses a drain on the line of a canal crossing does not reduce the waterway of the crossing. The Kandi is crossed by "numerous small and big seasonal streams called choes" and "is prone to flashy floods" (WRD, Kandi Area Development); Hoshiarpur district alone has "more than 100 choes", which "originate from Shivalik slopes" and leave "thick deposits of sand and silt" on the plains (District Environment Plan, Hoshiarpur), and the Kandi plain of Hoshiarpur slopes at about 16 m per km, less towards the west (CGWB). Towns stand on these fans and beds: Phase 11 of SAS Nagar floods when the Lakhnaur choe is not cleared (as reported), and villagers told a GMADA impact study that their abadi is "seven feet lower than the level of stream (Nadi)" (2021). In sub-area PB-A, and on any drain with an undeveloped Shivalik catchment, the following are set by this Manual: (a) a culvert or causeway on a choe shall be designed for the sediment bulking and blockage of Clause 6.3.6(b) and (c), with a single barrel where possible (Clause 9.4.8(a)), an invert that follows the bed (Clause 9.4.8(c)), an armoured headwall, apron and cut-off wall against scour, and an outlet protected under Clause 9.6; a causeway shall be marked with depth gauges and closed to traffic when overtopped; (b) where a choe-fed drain enters a pipe, covered drain or culvert, a sediment trap with a ramp for the machines that empty it shall stand upstream of the inlet, with a rack under Clause 9.8 (Clause 6.3.6(a) and (d)), cleared by 15 June and again by 31 October (Chapter 10); (c) an outfall to a choe shall have its invert above the highest surveyed bed, as Clause 6.3.6(f) sets, and a flap gate there shall be housed in a chamber with surface access or replaced by an elastomeric check valve, as in Clause 9.10.5(a), because sand can hold it open; (d) no structure shall narrow or cover a choe bed (Chapters 6 and 7); and (e) a lining in a drain that carries choe sand and gravel shall be designed for their abrasion as well as for the velocity of Table 9.2. On the Shivalik roads of PWD (B&R) and NHAI, side drains are lined and outlets are led to a stable channel, never onto an unprotected slope, as IRC:SP:42-2014 (§8.5.1) says of hill roads. No Punjab gauge in the records read has exceeded 100 mm in an hour (the largest, at Madhopur on 16 September 1975, is 100 mm; CWC Flood Estimation Report, zone 7), so no cloudburst or debris-flow rule is set for the State. Screens matter as much as gates, because the drains carry sewage and solid waste: the Buddha Nallah takes about 700 MLD of treated and untreated effluent to the Sutlej, which leaves it in Class E below Walipur (River Rejuvenation Committee, 28 October 2025, in PPCB's reply before the National Green Tribunal, OA 413/2025), and the State's treatment gap was 326.58 MLD in September 2023 (State of Punjab before the National Green Tribunal), so a rack on a Punjab town drain is checked in the blocked case of Clause 9.8.4. The 12 low dams of the Kandi and the 410 check dams built by WRD on rivers and nallahs fix the level upstream of them and are taken as fixed controls in Clause 9.2.1 at their crests. No inventory of the regulators, sluices, flap gates and pumping stations on the drains of any Punjab town, with their capacities and operating rules, no operating rule linking a town outfall to a BBMB release or a headworks gauge, no gauge zero for a WRD gauge 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, sand, 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 Punjab carry silt, solid waste and sewage to their outfalls, and the choes carry sand: the Buddha Nallah, before it meets the Sutlej, had a BOD of 161 mg/l, a COD of 456 mg/l and suspended solids of 328 mg/l in April 2024, against the 30, 250 and 100 mg/l required for discharge (CPCB reply before the National Green Tribunal, OA 327/2025), a PWSSB report of 2011 found the south-east storm sewer of Amritsar's walled city "75%" silted with garbage (Amritsar Smart City bid, 2018), and the choes of the Kandi leave "thick deposits of sand and silt" where they enter the plains (District Environment Plan, Hoshiarpur), so a gate, its screen and the sewage interception beside it are exposed to the same load and must be kept clear together; gates on the rivers have failed in flood: two gates of the Madhopur headworks on the Ravi jammed on 27 August 2025 and one was washed away the next day, under a flow given as less than 2 lakh cusecs at a level 2 feet below that of 1988 (as reported); and because the Sutlej

can stand in the "High Flood" band at Harike for days, as at 3,35,030 cusecs on 3 September 2025 (as reported), and BBMB's reservoirs can spill for weeks, as Pong did after its record inflow of 7.3 lakh cusecs on 14 August 2023 (as reported), 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 Punjab 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 Punjab 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 Punjab locations

Location	Minimum IS 456 exposure class
Inland drains and structures	Moderate

Location	Minimum IS 456 exposure class
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 Punjab 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 Punjab the failure is one of missing criteria, and of conditions checked only for rainwater harvesting. No document of HUD, DTCP, DLG, PUDA, GMADA, GLADA, PWSSB, PMIDC or a Municipal Corporation stating a design return period for urban storm drains was found; the only urban figures on record are the 2-year choices of two projects (Clause 10.4, Commentary). The approval route shapes this chapter, and it runs through two instruments by territory. In the municipal areas of the Municipal Corporations, Municipal Councils and Nagar Panchayats, PMBBL 2018 (DLG notification No. CTP(LG)/2018/3548 of 22 November 2018, under s.201(1) of the Punjab Municipal Act 1911 and s.399(2) of the Punjab Municipal Corporation Act 1976) requires the plinth to be at least 450 mm above the surrounding ground and the building sited "that adequate drainage of the site is assured" (cl. 5.2.1.1), a complete rainwater harvesting proposal with the building plans of every plot of 100 m² or more (cl. 10.1), and inspection by a municipal Rainwater Harvesting Cell before a completion certificate or a service connection is given (cl. 10.6). Outside municipal limits, and in the urban estates and schemes of PUDA and the development authorities, PUDBR 2021 (HUD, G.S.R. 144 of 31 August 2021, under ss.180 and 43(2) of the PRTPD Act 1995) requires the plans to show "methods of disposal of waste water, sewerage and storm water" and the surroundings to 15 m (r.11), a rainwater harvesting design "prepared and certified by an Engineer dealing with civil work" (r.40), a certificate in Form H before drainage is brought into use (r.44(5)) and an application in Form L to connect to a public sewer (r.45), before the completion and occupation certificates (r.14 and r.23). In both instruments the open parking of group housing is to be of permeable materials, basements are to be built so that surface drainage does not enter them (PUDBR r.30(5)(iv)(e); PMBBL cl. 4.23(vii)), and the larger projects keep the inlet and outlet points of the natural drainage (PMBBL Table 15.1; PUDBR r.43, by reference to MoEFCC S.O. 3999(E)). Outside the building instruments, an obstruction within limits notified under s.38 of the Punjab Canal and Drainage Act 2023 needs WRD's permission, a notified drain may not be realigned "without prior permission/NOC" of WRD (OA 279/2024), and a rainwater harvesting scheme earns PWRDA's water-conservation

credits only once PWRDA approves it (Directions 2023, cl. 2.7); a no-objection of WRD's drainage wing for projects within 150 m of a water body was announced by the Water Resources Minister on 20 September 2023 (as reported), but no order making it was found, and this Manual does not treat it as a rule. Village chhappars (ਛੱਪੜ; toba ਟੋਭਾ; ponds) are the common land of the Gram Panchayats, and no rule ties a building approval to them. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a setback from a drain, choe, river, canal or pond: PUDBR's setbacks run by building height only (r.26). 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, at the Form H and Form L stages and at the completion and occupation certificates. 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 (Table 10.1):

Table 10.1 — Submittal stages and linked approvals

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

Stage	Submittal	When	Linked approval
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.

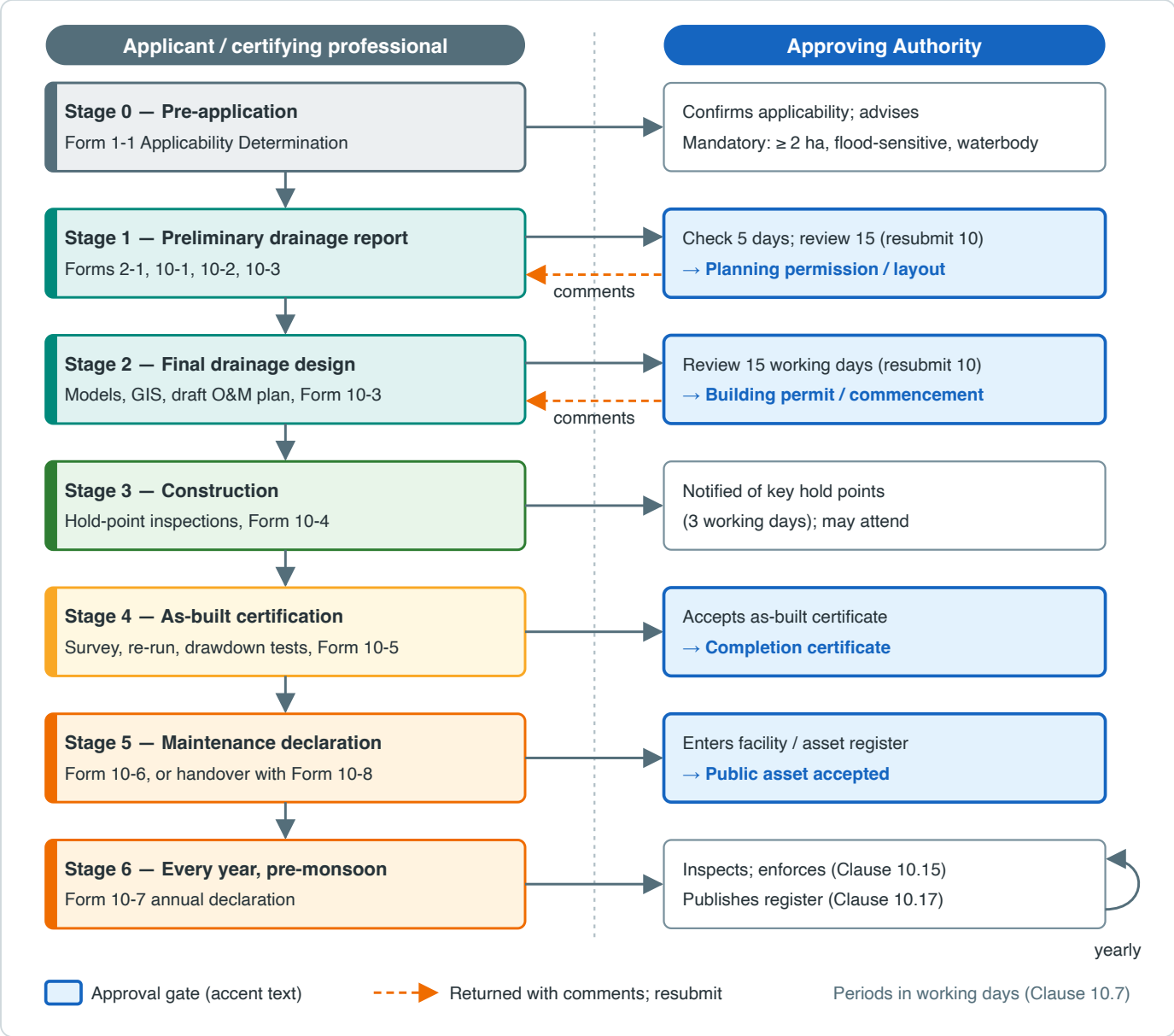

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **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 PMBBL/PUDBR steps a Punjab 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, which contains the whole State, from 29°33' to 32°32' N and from 73°53' to 76°56' E), 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 WRD's headworks and drain gauges and of BBMB's reservoir levels for Bhakra and Pong (published in feet, on gauge zeros to be confirmed [TBC], and converted at 0.3048 m per foot), of the Ranjit Sagar and Shahpur Kandi levels published in metres, and of the flood marks surveyed on ungauged choes, raos and drains 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

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

Commentary. Runnable models and GIS data cost the applicant little and let the Authority check the work, and later build a city-wide picture of private storage. Punjab has no notified design return period or design storm for its urban drains: no standard of PWSSB, PMIDC, PUDA, GMADA, GLADA, a Municipal Corporation or a Smart City company was found. Two project choices are on record. Amritsar Smart City Ltd's bid for the trunk storm sewers of the walled city (No. 07/ASCL/2018-19, November 2018) adopted "a return period of once in two years", a minimum time of concentration of 15 minutes and surcharge "inside the manhole … (without flooding)", and PMIDC's feasibility report for the Buddha Nallah (January 2020) designed the channel "considering 2 year return period with reduced run-off within the city reach due to active storm water detention"; neither states a design intensity or a design discharge in the sections read. WRD's own numbers serve other purposes: it zones floodplains on the 100-year flood computed by Gumbel's method, with the waterway by Lacey's formula (Chief Engineer Drainage to CWC, 2 May 2024), and it sizes rooftop rainwater harvesting on government buildings for 40 mm/h with runoff coefficients of 0.8–0.9 for roofs, 0.6–0.7 for paved and 0.1–0.2 for green areas, which is a recharge figure and not a drain design storm. Under AMRUT, Punjab did no storm-water drainage work up to September 2020, "due to shortage of funds and priority to cover water supply and sewerage" (CAG, Report No. 7 of 2021). These figures are history, not a design basis; the return periods of Table 2.1 apply instead. In IMD's national IDF study (Das et al. 2022) the only Punjab panel, Amritsar, repeats a generic curve and is not used, and no station IDF has been published for any Punjab station. The State's sub-daily design values are therefore those of the CWC Flood Estimation Reports for subzone 1(e) and zone 7, with the interim short-storm floors and the 24-hour record check of Clause 2.3.6, which raises the 24-hour depths near Ludhiana, Patiala, Amritsar and Bathinda well above the plates. 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 Punjab 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 DLG:

- (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 DLG 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 PMBBL/PUDBR 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 DLG 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 prior permission or no-objection of WRD for an outfall to, or a work on or across, one of its rivers, choes, drains, dhussi bandhs or regulators, among them the realignment of a notified drain (WRD report before the National Green Tribunal, OA 279/2024), or for an obstruction within limits notified under s.38 of the Punjab Canal and Drainage Act 2023, or under s.55 of the Northern India Canal and Drainage Act 1873 for a notification made before the 2023 Act came into force, such as the Patiala ki Rao in Kharar tehsil (2013) and the Sutlej floodplain zone in Ferozepur and Tarn Taran (2024), the written consent of WRD for any discharge to a canal, distributary or minor, the consent of BBMB for a work that drains to a reservoir or channel in its charge, the approval of PWRDA for a rainwater harvesting scheme that is to earn water-conservation credits (PWRDA Directions 2023, cl. 2.7), the permission needed under the Punjab Land Preservation (Chos) Act 1900 for clearing, quarrying or cultivation in an area regulated under its s.4 (the administering department to be confirmed [TBC]), the views of the Punjab State Wetlands Authority for a work in or next to a Ramsar site such as Harike, Kanjli, Ropar or Keshopur-Miani, the consent of the Gram Panchayat for a work that drains to, or encroaches on, a chhappar on its common land, the consent of PWD (B&R) or NHAI for a discharge to a drain or culvert of one of their roads, the consent of the body that owns the receiving drain where that body is not the Authority (for example GMADA, GLADA, PUDA or another development authority in its scheme), 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.

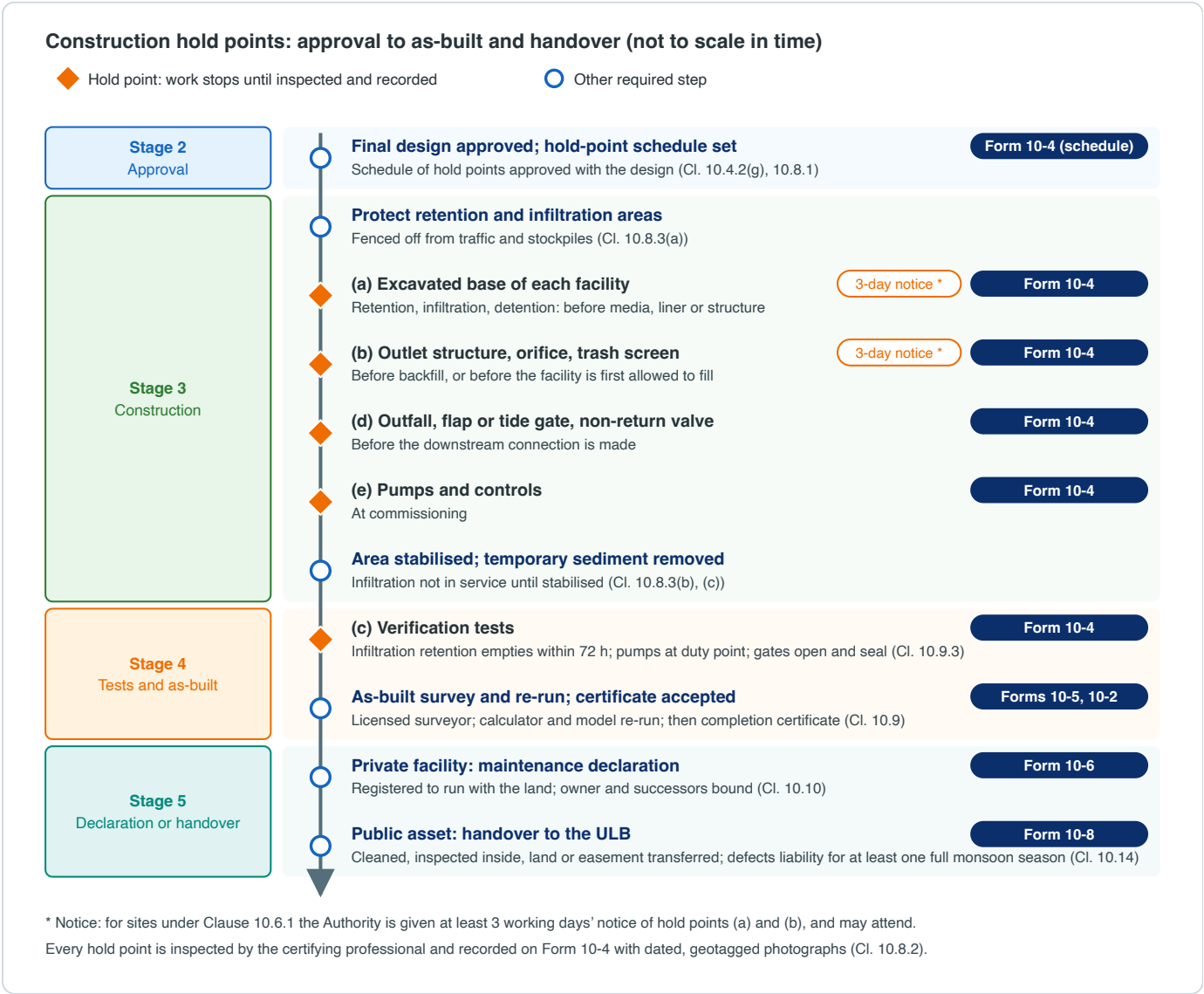

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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 Punjab 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 Punjab 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. Punjab runs its monsoon season through the State Flood Control Board, chaired by the Chief Minister, which reviews drain cleaning and embankment works and in 2023 ordered flood-protection works and the cleaning of waterways finished by 30 June (as reported), and through district flood works under the Deputy Commissioners. The draft State Disaster Management Plan (c. 2011) says that streams "should be desilted properly before the onset of monsoons every year" but sets no date, and no current State plan or urban flood plan of PSDMA was found. On the rivers, choes and drains the works are WRD's: its Drainage Administration reports about 1,800 km of flood embankments, 3,800 river-training works and 7,200 km of drains; in 2025 it reported 601 of 850 drains cleaned over 4,766 km (as reported); and for the 2024 monsoon its SAS Nagar division listed 19 flood-protection works costing ₹1,091.40 lakh (public notice of 26 June 2024). For the town drains the orders found are local and dated by ministers and Deputy Commissioners: a target of 30 June 2026 for Ludhiana's sewers, 47% of 220 km being desilted by mid-June, and the same date in Kapurthala (as reported). The rivers are run by the dams and headworks: BBMB sets the releases from Bhakra and Pong, whose permissible levels are given as 1,680 ft and 1,390 ft (with higher "technical" limits also quoted), Harike's discharge above 3,00,000 cusecs is classed as "High Flood", and the gates of the Madhopur headworks failed on 27–28 August 2025 (all as

reported). No operating rule for any regulator, sluice, flap gate or pumping station in a Punjab town, linking it to a river stage, a BBMB release or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

10.12 Inspection frequencies

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

Table 10.3 — Minimum owner inspection frequencies

Facility type	Routine	Pre-monsoon (by 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 Punjab, the pre-monsoon inspection of regulators, sluices, flap gates on the outfalls through the dhussi bandhs, non-return valves, siphons and culverts under canals, choe crossings and pumped facilities, including the pumps at underpasses and in the depressions of the south-west, with the desilting of drains, choes and chhappars and 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 Jalandhar (26 June) and Patti (28 June), with every gate on an outfall to a river or a 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 **15 October**, and at an outfall to the Sutlej, the Beas, the Ravi or the Ghaggar until BBMB's releases from Bhakra and Pong have ended and the river at the governing WRD gauge has fallen below its danger mark, if that is later. In sub-area PB-A, and on every drain with an undeveloped Shivalik catchment, every public culvert, causeway, choe crossing, inlet and sediment trap shall be cleared a second time, of the sand, gravel and debris of the monsoon, by **31 October**.

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).

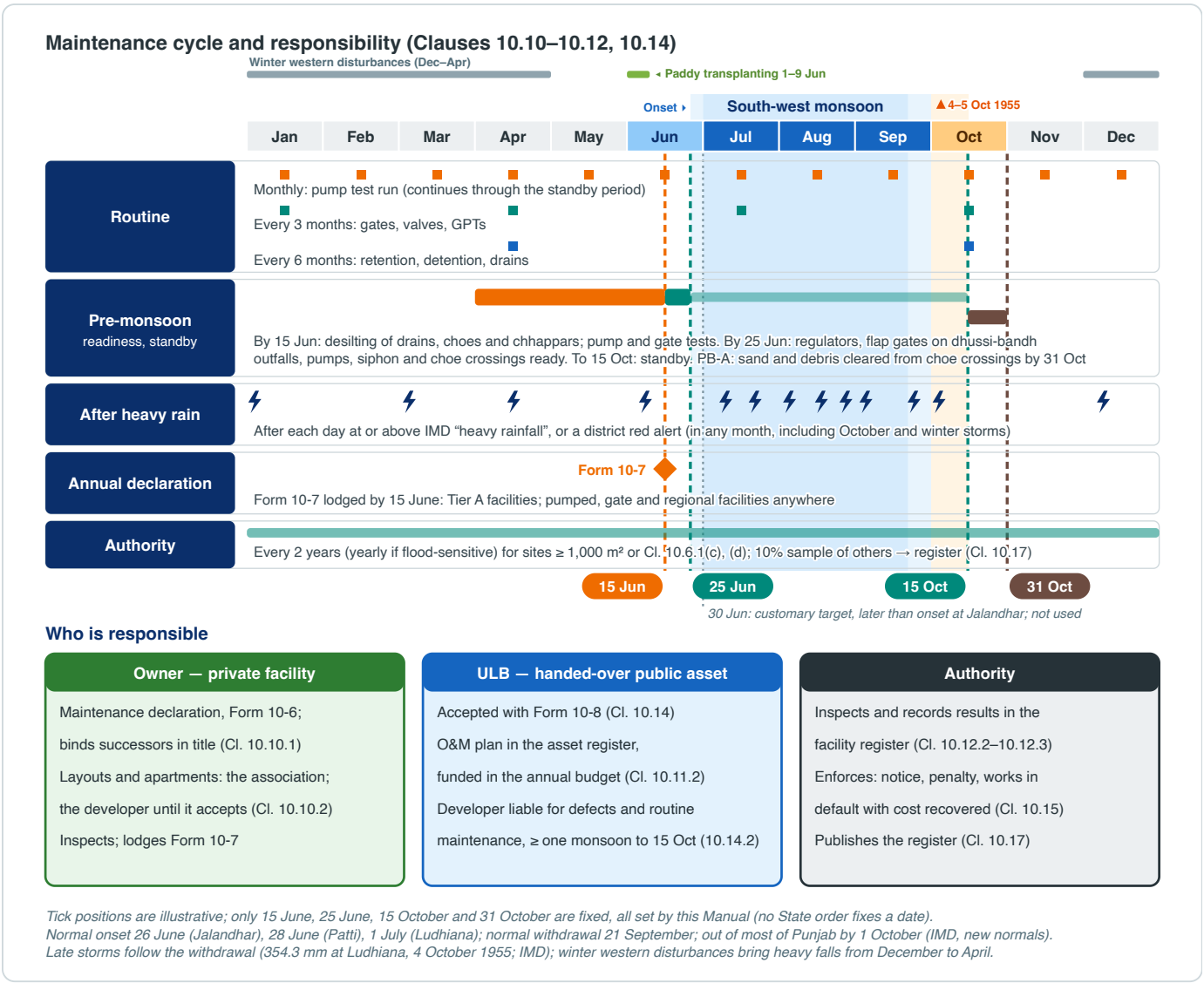

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 15 June) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the south-west monsoon (June–September); 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: under IMD's new normals the monsoon reaches Jalandhar on 26 June, Patti on 28 June and Ludhiana on 1 July (Pai et al., IMD, 2020), so the onset lies inside the calendar season of June–September rather than at its start, and heavy falls come before it, such as 160.6 mm at Patiala on 8 June 2000 (IMD). The plains are wetted before the monsoon too, because paddy is transplanted from 1, 5 or 9 June by district under the Punjab Preservation of Subsoil Water Act 2009 (2025 schedule, as reported). No State order fixing a date for drain cleaning was found: ministers and Deputy Commissioners set 30 June in most years, as for the flood works of the State Flood Control Board in 2023 and the sewer desilting of Ludhiana and the drain cleaning of Kapurthala in 2026, and WRD's desilting of river sites missed a 30 June deadline in 2026 and was extended to 30 September (all as reported). 30 June falls after the normal onset at Jalandhar and Patti, so this Manual does not use it and takes 15 June for the desilting of drains, choes and chhappars, the pre-monsoon inspection, the annual declaration and the BSMP report. 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, flap gates on the outfalls through the dhussi bandhs, pumps, siphon crossings, inlets and choe crossings must in addition be

certified ready by 25 June, before the onset reaches Jalandhar. The normal withdrawal is 21 September at all three stations, and "By 1st October, monsoon withdraws from most areas of … Punjab" (IMD), but the storm of record came after it, on 4–5 October 1955, with 354.3 mm at Ludhiana (IMD), as did the September storms of 1950, 1958, 1962, 1988 and 1995, and BBMB's reservoirs were still spilling in late August and September of 2023 and 2025 (as reported); pumps and gates are therefore kept on standby to 15 October (Figure 10.3), and at an outfall to the Sutlej, the Beas, the Ravi or the Ghaggar until the releases have ended. The choes of the Kandi leave "thick deposits of sand and silt" (District Environment Plan, Hoshiarpur), so in sub-area PB-A culverts, causeways, inlets and choe crossings are cleared of sand and debris a second time, by 31 October. Western disturbances bring large falls in winter and before the monsoon, 119.6 mm at Ludhiana on 4 January 1911, 115.0 mm there on 9 December 1997 and 144.2 mm at Patiala on 16 April 1983 (IMD), and the post-event inspections of Table 10.3 cover storms at any time of year. The reporting year of Forms 10-7 and 11-1 runs from 1 June to 31 May, so that each report covers one monsoon and the dry-season works after it (set by this Manual). All these dates are this Manual's; none is a State order.

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 Punjab 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 15 October,** after handover. The ULB may hold a security deposit for this period.

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

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

> **Commentary.** NDMA (2010) calls for a GIS inventory of drains. Requiring the developer's GIS data at handover builds that inventory as the city grows, at no cost to the ULB. The defects period spans one monsoon because many defects in Punjab 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 are made and from the municipal Acts. The graduated steps are set by this Manual. In Punjab the courts have become the working regulators of choes, ponds, floodplains and drains. The Punjab and Haryana High Court directed the clearing and demarcation of the Patiala ki Rao (*Shamsher Singh v. State of Punjab*, CWP 5901/2017, 2 June 2017), and its Local Commissioner found the Punjab portion "heavily encroached" and the pillars marking a width of "200 Ft." still pending on the Punjab side in January 2024, though fixed in Chandigarh; contempt proceedings are pending (COCP 1105/2023), and an embankment along the same rao is sought in *Ram Lal v. State of Punjab* (CWP-PIL 79/2025). The High Court ordered encroachments on village ponds removed within six months and PPCB to monitor their water (suo motu, 2020, as reported), after the Supreme Court held village commons protected (*Jagpal Singh v. State of Punjab*, 28 January 2011, as reported). The National Green Tribunal found "no material … indicating the exercise for demarcating the flood plain zone" of the Sutlej in Ferozepur and Tarn Taran (OA 303/2023, order of 14 March 2024, as quoted), has heard that a road built by MC Ludhiana cut the width of the Buddha Nallah "from 58 feet to 35 feet" (OA 327/2025), and has been told by WRD that no notified drain may be realigned without its permission (OA 279/2024). The statutes carry real powers: within limits notified under s.38 of the Punjab Canal and Drainage Act 2023 the Divisional Canal Officer may remove an obstruction (s.39) and no compensation is due for an illegal structure (s.45), and damaging, altering or building a drainage work, or altering the flow of a river or stream, is an offence punishable with a fine of ₹5,000 to ₹50,000 or imprisonment of up to six months (s.52); under PMBBL 2018 the municipal Rainwater Harvesting Cell inspects before a completion certificate or a service connection is given and verifies every building of more than 1,000 m² each year, with a 10% random survey below that (cl. 10.6); under PUDBR 2021 drainage may not be brought into use without the certificate in Form H (r.44(5)); and PWRDA may penalise the non-maintenance of a recharge structure with ₹10,000 to ₹1,00,000, by the size of the unit (Directions 2023). The enforcement sections of the Punjab Municipal Corporation Act 1976, the Punjab Municipal Act 1911 and the PRTPD Act 1995 were not read, and are to be confirmed [TBC]. CAG found that no storm-water drainage work had been done under AMRUT in Punjab up to September 2020 (Report No. 7 of 2021), and an excess release of ₹1.33 lakh of performance security on four works of the Municipal Council Amloh, two of them for "Laying storm water drain", which it called "record tampering and fraud" (Report No. 1 of 2026); no CAG audit of urban storm drainage, of WRD's drainage works or of flood control in Punjab 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 at the nearest gauge of WRD's headworks or of BBMB (for the Sutlej at Ropar, Harike or Hussainiwala; for the Ravi at Madhopur; for the Beas below Pong; for the Ghaggar at Bhankharpur, Sarala Kalan, Khanauri or Sardulgarh), or of the receiving WRD drain, and, where it is gauged, at the outfall, each with its gauge zero and a named datum, levels read in feet converted at 0.3048 m per foot, and never a CWC danger level; for an ungauged choe, rao or nallah, the flood marks surveyed after the event and the sand and debris deposited at crossings; the state of every regulator, sluice, flap gate, siphon or culvert under a canal and pumping station on the outfall and on the drain upstream of it, including those on the dhussi bandhs, with the

hours each pump ran and any loss of power; any breach of a dhussi bandh or canal bank; and the releases from Bhakra, Pong, Ranjit Sagar and Shahpur Kandi and the gate operations at the headworks 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), PSDMA, 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. Punjab's floods have been counted in figures that do not agree, and examined by the courts and the press rather than by technical reviews. On 4–5 October 1955, after the monsoon's normal withdrawal, a single storm put 300–500 mm in a day on many stations of Majha, Doaba and central Malwa, 354.3 mm at Ludhiana (IMD), and the draft State Disaster Management Plan records 6,27,000 houses damaged that year. Ludhiana PAU recorded 338.0 mm and Kapurthala 284.2 mm on 24 September 1988, and Patiala 356.5 mm on 11 July 1993 (IMD); the area flooded in those years is given as 9,221.2 and 9,757.4 km² in the press, quoting official data, but as 741 and 7,977 km² in the table of the draft State plan, figures that conflict. On 8–10 July 2023 Ropar recorded 35 cm in the 24 hours to 08:30 on 10 July (IMD press release), and the Ghaggar rose to 754.2 ft at Khanauri against a danger mark given as 748 ft, with 752 and 753 ft also reported, and breached in Sangrur and Mansa (as reported); the State reported 41 deaths in July (as reported), while the Union's provisional figure for all the year's hydro-meteorological events is 77 (MHA). In August–September 2025 the Ravi, the Beas, the Sutlej and the Ghaggar flooded together, Harike passed 3,35,030 cusecs on 3 September, the Madhopur gates failed, dhussi bandhs breached in Ajnala and Ramdass, and SAS Nagar, Ludhiana, Jalandhar and Amritsar flooded on 1–3 September (all as reported); the deaths are given as 56 (State bulletin of 16 September 2025, as reported), 40 (Rajya Sabha reply of 3 December 2025, as reported) and 28 (MHA, provisional). The station falls of August–September 2025, the deaths and area of 1955 and the official figures for 2019 were not found. No technical review of any of these events, no post-disaster needs assessment for 2023 or 2025, and no record of flood extents, depths or durations kept by any Municipal Corporation or development authority 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 Punjab's drainage records are public: PUDBR 2021 with its corrigendum and 2022 amendment (in PPCB's circular copy), PMBBL 2018 and its 2019 amendment (in archived copies of the DLG website), the Punjab Canal and Drainage Act 2023 and the Punjab Water Resources (Management and Regulation) Act 2020 (in PRS copies), the PWRDA Directions 2023, the replies and reports that WRD, HUD, PPCB, CPCB and the local bodies have filed before the National Green Tribunal, CAG's Reports No. 7 of 2021 and No. 1 of 2026, the draft State Disaster Management Plan, WRD's archived Drainage Administration and Kandi Area Development pages, PMIDC's feasibility report for the Buddha Nallah, Amritsar Smart City's bid for its walled-city storm sewers, GMADA's impact study for the storm-sewer road of Sectors 92 and 92-Alpha, the Jalandhar master plan report and CGWB's groundwater assessments. Much else could not be found in the public domain: the notification bringing the 2023 Act into force and any rules under it; the list of notified drains (393 of 869 by WRD's page, 514 of 935 by a press report) and the text, with widths, of any notification under s.38 or s.55; any order on the 150 m drainage-wing no-objection announced in 2023; any urban drain design standard of PWSSB, PMIDC, PUDA, GMADA or GLADA; GMADA's "City Drainage Plan"; the drainage chapters of the Ludhiana and other master plans; the gauge zeros, danger marks and rating curves of WRD's gauges; the operating rules of the headworks and of the town gates and pumps; an inventory of the regulators, sluices, flap gates and pumping stations of any town; a current State Disaster Management Plan; any wetland notified under the Wetlands Rules 2017; and the texts of the Punjab Municipal Corporation Act 1976, the Punjab Municipal Act 1911 and the PRTPD Act 1995 as applied to drains, which were not read. 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

Annex / Form	Content
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, chhappar 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. Punjab's cities are spending on their drains, but no city drainage master plan with a design storm has been published. The Master Plan Ludhiana (2007–2031) was notified on 12 September 2008 under s.70(5) of the PRTPD Act 1995 (HUD reply before the National Green Tribunal, OA 1295/2024); its drainage chapter was not read. The Jalandhar master plan report (Vision 2031) found that "only about 5% of the city area is covered under the storm water network" (11.53 of 93.41 km²) and that rain is "largely discharged in to the sewer network"; it proposes widening the Chitti Bein, whose high flood level at the Chaheru railway bridge "is generally 12'", from 40–60 ft to "atleast 80'-100'", no construction within 200 m of it until a concrete bandh is built, except a 30 m buffer from the bank, and storm drainage as an "integral part of road development plans" (13.8.7 and 13.9.3; the notification status of the plan was not seen). GMADA's impact study for the 200-ft sector road of Sectors 92 and 92-Alpha, built "for Disposal of Storm Sewer" (2021), asks GMADA to "calculate / recalculate the 'Proposed Runoff Water of the Nadi Catchment Area'" and to make "strong provisions … in the 'City Drainage Plan'", a plan that was not found. The Buddha Nallah, 47.55 km from the Kum Link and Neelon drains near Ghumait to the Sutlej at Walipur Kalan, is being rebuilt on a 2-year design "with reduced run-off within the city reach due to active storm water detention" (PMIDC feasibility report, 2020), in a project sanctioned at ₹650 crore and awarded at ₹839.79 crore with its operation and maintenance (as reported); no design discharge for it was found. Amritsar Smart City's walled-city storm sewers (2018) were designed for a 2-year storm and outfall through WRD's Tung Dhab and City Outfall drains to the Hudiara drain, which flows on into Pakistan. Patiala's Badi Nadi (8.3 km) and Chhoti Nadi (4.9 km) are to be revamped for ₹208.33 crore (as reported). Under AMRUT, Punjab did no storm-water drainage work up to September 2020 (CAG, Report No. 7 of 2021). WRD zones the floodplains of rivers, choes and drains on the 100-year flood by Gumbel's method and Lacey's waterway, but its first zone, on the Sutlej in Ferozepur and

Tarn Taran (4 March 2024), was drawn as the land between the embankments, about 4.5 km apart, against a computed Lacey width of 0.58 km (WRD affidavit, OA 303/2023). No published document sets a design return period for the storm drain network of any Punjab city; the only design floods found are WRD's 100-year river floods and the two 2-year project choices. 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 HUD, DTCP, DLG, PUDA, GMADA, GLADA, any Municipal Corporation, WRD or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, town drains that outfall through the dhussi bandhs to the Sutlej, the Beas, the Ravi and the Ghaggar when the rivers are high, the Buddha Nallah and other WRD drains that carry sewage and industrial effluent, choes from the Shivaliks that carry sand onto the towns built on their fans and beds, as at SAS Nagar, drains that must pass under canals by siphons and culverts, village chhappars (ਛੱਪੜ; toba ਟੋਭਾ; ponds) filled, encroached or turned into sullage ponds, the depressions of the waterlogged south-west with no gravity outfall, single drains split between a Municipal Corporation, a development authority, WRD and a Gram Panchayat, 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 Punjab: to town outfalls through the dhussi bandhs to the Sutlej, the Beas, the Ravi and the Ghaggar, whose stage BBMB's releases from Bhakra and Pong, the dams on the Ravi and the headworks at Ropar, Harike, Hussainiwala and Madhopur set, and on which CWC has no flood sites; to the Buddha Nallah and the other WRD drains that receive the towns and carry their sewage and industrial effluent; to Amritsar, whose drains reach Pakistan through the Hudiara drain; to choes from the Shivaliks that carry sand onto the towns built on the Kandi fans, among them the choes that SAS Nagar shares with Chandigarh (Supplement S01); to canals that cross the drainage of the plains and are not receiving waters; to aquifers over-exploited across the centre of the State but standing near the surface in the south-west, the Sirowal and the bet lands; to street drains vested in the Municipal Corporations, Municipal Councils and Nagar Panchayats, sector drains in the schemes of PUDA, GMADA, GLADA and the other development authorities, rivers, choes and notified drains held by WRD and village chhappars on the common land of the Gram Panchayats, without an order that divides the drains between them; to a State whose floodplain lines are notifications under the Canal and Drainage Acts and widths fixed under court orders; to a State with no published design return period for the drains of any city; and to storms far beyond the 50-year depths of the CWC plates, 354.3 mm at Ludhiana on 4 October 1955 and 356.5 mm at Patiala on 11 July 1993 (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).

Term	Meaning in this Manual
Flood hazard map	A map of flood extent, depth, velocity and hazard class (H1–H6, Chapter 6) for a stated AEP and scenario.
Regional facility	A storage, conveyance or outfall work serving more than one development, identified in a BSMP.
Capital Improvement Programme (CIP)	The ranked, costed list of works in a BSMP (Clause 11.8.4).

11.3 Planning unit: the basin, not the ward

11.3.1 BSMPs shall be prepared **by hydrological basin**, not by ward, zone or local-body boundary. Where a basin crosses local-body boundaries, one BSMP shall cover the whole basin.

11.3.2 Basin boundaries shall be delineated from the digital elevation model of Clause 11.5.2, checked against the drain network, road embankments, canals and tank supply channels. Diversions between basins, whether by canal, drain or surplus course, shall be mapped and represented in the model.

11.3.3 No basin delineation has been published for any Punjab city. For the urban areas where the evidence identifies them, the basins are at least the following:

- **Ludhiana, Buddha Nallah:** the catchment of the **Buddha Nallah** from the **Kum Link** and **Neelon** drains near Ghumait through its upper reach, the 14 km city reach (RD 55,000–99,620 ft) and the outer reach to the **Sutlej at Walipur Kalan**, with the discharges of the city's STPs and the dyeing CETPs and the sewage interceptions mapped (Clause 8.9.5), the width disputed before the National Green Tribunal (OA 327/2025) surveyed, and the Sutlej level at the outfall, behind the dhussi bandh, as the boundary condition;
- **SAS Nagar–Zirakpur–Kharar–Dera Bassi–New Chandigarh, the Ghaggar choes:** the catchments of the **N-Choe**, the **Patiala ki Rao** (Patiali-ki-Rao), the **Sukhna Choe**, the **Jayanti Devi ki Rao** and the **Lakhnaur choe** from the Shivaliks and Chandigarh to the **Ghaggar** at and below Bhankharpur, with the reaches in the Union Territory, the releases from Sukhna Lake and the cross-boundary rules of Supplement S01 as inflows and partners, the limits notified on the Patiala ki Rao in 2013 and its pillared width shown, GMADA's storm sewer on the sector road of Sectors 92 and 92-Alpha in the 1D network, sand bulking at every choe crossing, and the Ghaggar level as the boundary condition;
- **Patiala, the Nadis:** the catchments of the **Badi Nadi** and the **Chhoti Nadi** through the city and of the **Patiala Nadi** to the **Ghaggar**, with the siphons and culverts that carry them under the canals as controls and the outfall-closed case a design case;
- **The Ghaggar towns of Patiala, Sangrur and Mansa districts:** for **Samana**, **Moonak**, **Khanauri**, **Makraud Sahib** and **Sardulgarh**, the catchments that drain to the Ghaggar, with the river's narrowing from 588 ft to 190 ft below Makraud Sahib (as reported), the Hansi–Butana canal siphon on the Ghaggar near Samana as a control, the WRD gauges at Khanauri and Sardulgarh as boundary conditions, the breaches of 1993 and 2023 as calibration, and the Haryana reach downstream agreed through WRD;
- **Jalandhar–Kapurthala–Phagwara, the Beins:** the catchments that drain to the **Kali Bein**, the **Chitti Bein** and the **Kala Sanghian drain**, with the Chitti Bein level at the Chaheru railway bridge, the Leather Complex CETP and the sewage interceptions mapped, and the Sutlej at **Phillaur–Shahkot** as the boundary condition;
- **Amritsar, Tung Dhab–Hudiara:** the catchments of the walled city and the town that drain through the **Tung Dhab** and **City Outfall** drains to the **Hudiara drain**, with the joint level at the Tung Dhab–Hudiara junction as the boundary condition and the transboundary reach, whose levels are outside Indian control, treated as an uncertain boundary;
- **Pathankot, Chakki Khad:** the catchments that drain to the **Chakki Khad**, which rises in Himachal Pradesh, and to the **Ravi**, with the releases from Ranjit Sagar and Shahpur Kandi and the level at the Madhopur headworks as boundary conditions and the gate failure of 2025 as a stress case;

- **Hoshiarpur and the Kandi towns, the choes:** the catchments of the **Hoshiarpur choes** and of the choes that cross the Kandi at Garhshankar, Mukerian and Talwara, split at the break of slope above the Sirowal, with the Kandi low dams and check dams as storage, channel losses on the fans, and the Beas below Pong as the boundary condition where the choes reach it; and
- **The south-west drains:** for **Bathinda**, **Sri Muktsar Sahib**, **Fazilka**, **Abohar** and **Faridkot**, the catchments that drain to the **Chand Bhan** drain and the other WRD drains of the south-west, and the depressions with no gravity outfall, with the capacity of the receiving drain as the boundary condition, the October water table as a design condition, and pumped outfalls with storage in the 1D network.

Other Tier A bodies, among them Moga, Barnala and Batala, shall define their basins in the first BSMP that covers them. Where WRD, BBMB or a court has a design flood level, limits notified under s.38 of the Punjab Canal and Drainage Act 2023 or s.55 of the 1873 Act, a fixed width or a line around a choe, or an operating rule for a dam, headworks, regulator or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

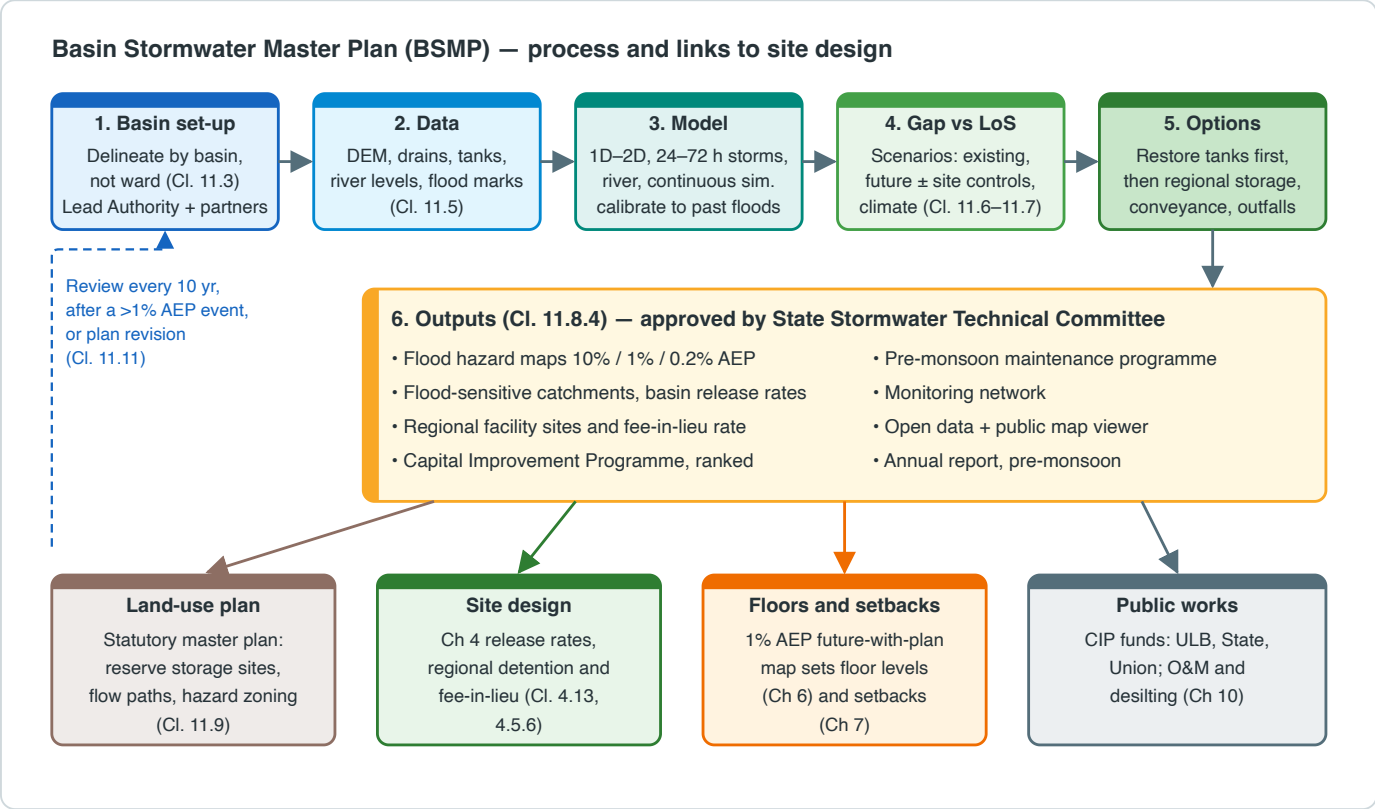


Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

> **Commentary.** Water does not follow ward boundaries. A ward-by-ward drain plan can pass the problem to the next ward, and to the next local body. In Punjab a single drain can pass through several hands on its way to a river. The street drains and sewers of a town are the municipal body's, under the Punjab Municipal Corporation Act 1976 or the Punjab Municipal Act 1911, whose drain-vesting sections were not read [TBC], and PWSSB builds them in many towns; the sector drains of an urban estate or scheme are PUDA's or the development authority's until they are handed over (as this Manual reads the record); the rivers, the choes and the drains that WRD maintains are "canal" under the Punjab Canal and Drainage Act 2023, which includes "all drains, works, embankments and structures, connected with drains, maintained or controlled by the State Government" (s.2(1)(g)), while its "drainage work" excludes the "removal of sewage from towns, villages or any other habitat" (s.2(7)); WRD's Drainage Administration counts 869 drains, choes and rivers, of which it had notified 393 under s.55 of the 1873 Act (WRD; a press report of November 2024 gives 514 of 935); and the village chhappars are the common

land of the Gram Panchayats. The Buddha Nallah shows the split: its length of 47.55 km is taken from the records of the Drainage department at Ludhiana (PMIDC, 2020), its 14 km city reach runs through MC Ludhiana, whose road along it is said to have narrowed it (OA 327/2025), and it receives the treated effluent of the city's STPs and of three dyeing CETPs. Other drains cross the State's boundaries: the N-Choe, the Sukhna Choe and the Patiala ki Rao cross between Chandigarh and SAS Nagar on their way to the Ghaggar, the Ghaggar runs on into Haryana, and the Hudiara drain into Pakistan. No rule divides WRD's drains from the drains of the municipal bodies and the development authorities (as this Manual reads the record). This clause makes the basin the planning unit, so that one model carries each drain from its head to the river 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 Ludhiana, **MC Ludhiana**; in SAS Nagar, the **Municipal Corporation SAS Nagar**), jointly with the **development authority** of the area (in Ludhiana, **GLADA**; in SAS Nagar, **GMADA**; elsewhere the development authorities of Amritsar, Jalandhar, Patiala and Bathinda [TBC]), which plans and builds the drains of its urban estates and schemes; either may prepare the plan as the State directs, and HUD carries it into the master plan, with DLG for the municipal area (Clause 11.9). Where a basin extends beyond the Corporation, as from SAS Nagar to Zirakpur, Kharar and New Chandigarh, 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 WRD's drains from the drains of the municipal bodies and the development authorities was found; until one is made, this Manual assigns the reaches within each BSMP as follows, each body being Lead Authority for the reaches and works it owns or runs and for the parts of the CIP on them: **WRD** (Drainage-cum-Mining & Geology) for the rivers, the choes, the notified drains (among them the Buddha Nallah, the Tung Dhab, the City Outfall and Hudiara drains and the Chand Bhan drain), the dhussi bandhs, the regulators on them and the limits notified under s.38 of the Punjab Canal and Drainage Act 2023; **WRD** (canals) for the canals, distributaries and minors and the siphons and culverts that carry drains under them; the **Gram Panchayat**, with the Department of Rural Development and Panchayats, for the chhappars on its common land; the **Punjab State Wetlands Authority** for wetlands notified under the Wetlands Rules 2017; the **Municipal Corporation**, **Municipal Council** or **Nagar Panchayat** for its street drains and sewers; **PUDA**, **GMADA**, **GLADA** and the other development authorities for the drains of their estates and schemes until they are handed over; the **Department of Soil and Water Conservation** and WRD's Kandi Area Development wing for the check dams and low dams of the Kandi; and PWD (B&R) and NHAI for the drains of their roads.
- In Tier B bodies: the Lead Authority is named by DLG, with HUD where the basin includes a scheme of PUDA or a development authority. Basins draining to a common river reach or WRD drain may be grouped into one district-level plan.

PSDMA and the district administration shall be consulted on every BSMP; BBMB on every BSMP whose outfall levels its releases from Bhakra and Pong set; PPCB on every BSMP that proposes works on a drain that carries sewage or industrial effluent, such as the Buddha Nallah and the Kala Sanghian drain; the Punjab State Wetlands Authority on every BSMP whose basin drains to a Ramsar site (Harike, Kanjli, Ropar, Keshopur-Miani, the Beas Conservation Reserve or Nangal); and, for a basin shared with the Union Territory of Chandigarh, the Chandigarh Administration and the Municipal Corporation Chandigarh as Supplement S01 sets out, and, for the Ghaggar downstream of the State, Haryana's Irrigation and Water Resources Department, through WRD.

WRD, through its Drainage-cum-Mining & Geology wing for rivers, choes, notified drains and dhussi bandhs and its canal wing for canals, 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, chhappar, 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, WRD drains, choes and canal crossings	The datum of every level named, with the gauge zero of every WRD and BBMB gauge [TBC] and levels published in feet converted at 0.3048 m per foot; outfall invert levels against the levels of the receiving river at the nearest WRD headworks or BBMB gauge and its recorded peaks, never a CWC danger level, since CWC has no flood site in Punjab (as reported): for the Sutlej, the discharges and levels at the Ropar, Harike and Hussainiwala headworks, with Harike's "High Flood" band above 3,00,000 cusecs and 3,35,030 cusecs at 686.50 ft upstream on 3 September 2025 (as reported); for the Beas, the releases from Pong, whose full reservoir level is 1,390 ft (higher limits also quoted); for the Ravi, the releases from Ranjit Sagar (full reservoir level 527.91 m) and Shahpur Kandi and the record of the Madhopur headworks, whose gates failed in August 2025; for the Ghaggar, the WRD gauges at Bhankharpur, Sarala Kalan, Khanauri and Sardulgarh with their danger marks (at Khanauri 748 ft, with 752 and 753 ft also reported, against 754.2 ft on 15 July 2023, as reported) or surveyed marks of the July 2023 flood; for outfalls to WRD drains, the design discharge and design water level of the drain at the outfall from WRD; for choes, raos and nallahs, surveyed flood marks and bed levels and the 1% AEP level with its sand bulking; the limits notified under s.38 of the Punjab Canal and Drainage Act 2023 (or s.55 of the 1873 Act) and the widths fixed under court orders, such as the 200 ft pillared width of the Patiala ki Rao; and the regulators, sluices, flap gates, dhussi bandhs, siphons and culverts under canals and pumping stations on the outfalls, with their capacities and operating rules

Data	Minimum requirement
Rainfall and levels	All available rain gauges (IMD, including its observatories and stations at Ludhiana, Patiala, Amritsar, Ferozepore, Kapurthala, Bhatinda, Halwara and Adampur, its station at Chandigarh for SAS Nagar, and the automatic weather stations and rain gauges reported by the Meteorological Centre Chandigarh; the self-recording gauges at Madhopur, Patiala and Hoshiarpur used for the CWC Flood Estimation Report for zone 7; the observatories of Punjab Agricultural University at Ludhiana, Ballowal Saunkhri and Bathinda; the district and tehsil rain gauges of the State; the river, headworks and drain gauges of WRD and the rain and reservoir records of BBMB at Bhakra and Pong; and any gauges kept by the Municipal Corporations, GMADA, GLADA and the Smart City companies) and water-level records, including those for the 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala, IMD), 11 July 1993 (356.5 mm at Patiala, IMD), 5 September 1995 (286.8 mm at Ludhiana, IMD), August 2019 (the Sutlej breaches at Shahkot, Gidderpindi and Mandala, as reported), 8–10 July 2023 (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD, and the Ghaggar at 754.2 ft at Khanauri, as reported) and August–September 2025 (Harike at 3,35,030 cusecs on 3 September and the town floods of 1–3 September in SAS Nagar, Ludhiana, Jalandhar and Amritsar, as reported) events
Flood evidence	Surveyed flood marks and mapped flood extents from past events, including public reports
Land use	Existing land use and imperviousness; future land use from the statutory master plan
Soils and groundwater	HSG map (Annex 3A); seasonal high groundwater; aquifer and recharge zones
Sewer interaction	Known sewage cross-connections, dry-weather flow in drains, and solid-waste hotspots

Commentary. The 0.15 m accuracy has no direct precedent; this Manual sets it because on the bet lands of the Sutlej, the Beas, the Ravi and the Ghaggar between and behind the dhussi bandhs, across the flat canal-commanded plains, where river slopes seldom exceed 0.38 m per km (CWC Flood Estimation Report, subzone 1(e)) and canal banks, roads and paddy bunds hold water back, in the waterlogged depressions of the south-west, on the Kandi fans, where a road or a wall can turn a choe from one side of its fan to the other, and around the margins of the chhappars, 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 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala, IMD), 11 July 1993 (356.5 mm at Patiala, IMD), 5 September 1995 (286.8 mm at Ludhiana, IMD), August 2019 (the Sutlej breaches at Shahkot, Gidderpindi and Mandala, as reported), 8–10 July 2023 (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD, and the Ghaggar at 754.2 ft at Khanauri, as reported) and August–September 2025 (Harike at 3,35,030 cusecs on 3 September and the town floods of 1–3 September in SAS Nagar, Ludhiana, Jalandhar and Amritsar, as reported) events are the best calibration data Punjab 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

Element	Minimum level of service
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 chhappar 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. Punjab has no pond statute and no pond authority (as this Manual reads the record): its village chhappars are common (shamlat) land under the Punjab Village Common Lands (Regulation) Act 1961, the Supreme Court has held such commons protected against encroachment (*Jagpal Singh v. State of Punjab*, 2011, as reported), and the High Court ordered encroachments on ponds removed within six months (2020, as reported); the Punjab Canal and Drainage Act 2023 gives water-user bodies the "use of village ponds and drains for irrigation purposes" (s.51). The counts do not agree: the first water-bodies census found 16,012 water bodies, 1,578 of them encroached, and the State's cleaning programme covers about 15,000 ponds in about 13,500 villages (both as reported). The chhappars are combined sullage and storm basins: they are restored on the Seechewal and Thapar models, which treat village sullage before it enters the pond (as reported), and CAG found a choked screening chamber at the pond treatment works of Punnawal and Bhalwan (Dhuri block) discharging untreated wastewater into the drain (Report No. 1 of 2026). The larger waters are protected as wetlands, though only in part: Harike, Kanjli, Ropar, Keshopur-Miani, the Beas Conservation Reserve and Nangal are Ramsar sites, but no wetland notified under rule 7 of the Wetlands Rules 2017 was found, and the Punjab State Wetlands Authority recommended 72 water bodies for notification in September 2025 (as reported). No survey of the storage of any chhappar 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

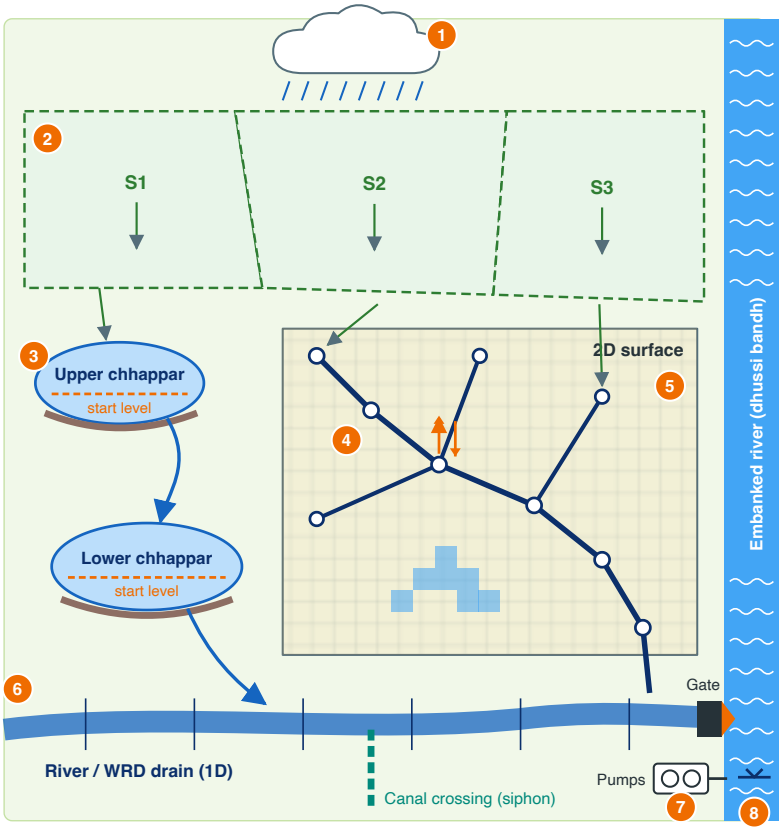
closed outfall. The two-step approach of Clause 3.13.5 may be used: a simplified storage model is run for the whole record, and the coupled 1D–2D model of Clause 11.7.1 is run only for the design storms, starting from the tank levels the continuous run gives. A continuous run of the full 1D–2D model 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 Punjab with a design factor was found; the State Action Plan on Climate Change 2.0 projects annual rainfall rising by 5.4–12.8% under RCP4.5 and RCP8.5, most in Gurdaspur and Hoshiarpur, but gives no projection of heavy rainfall, and its count of days above 100 mm per decade at its stations peaked in the 1980s and 1990s (8.3 and 8.0) and fell to 3.8 and 4.3 in the 2000s and 2010s; but the 24-hour records set after the CWC plates were drawn, 338.0 mm at Ludhiana PAU (1988), 356.5 mm at Patiala (1993) and 35 cm at Ropar (2023) (IMD), and the record inflow to Pong in August 2023 (as reported), are a reason to keep the factors, not to reduce them; in the central plains the 24-hour record check of Clause 2.3.6 is the larger correction.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala, IMD), 11 July 1993 (356.5 mm at Patiala, IMD), 5 September 1995 (286.8 mm at Ludhiana, IMD), August 2019 (the Sutlej breaches at Shahkot, Gidderpindi and Mandala, as reported), 8–10 July 2023 (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD, and the Ghaggar at 754.2 ft at Khanauri, as reported) and August–September 2025 (Harike at 3,35,030 cusecs on 3 September and the town floods of 1–3 September in SAS Nagar, Ludhiana, Jalandhar and Amritsar, as reported) events where data exist.

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



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

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

3 **Chhappars and ponds**
Surveyed FTL, MWL, stage–storage, outlets, sullage inflow (Cl. 11.5.1); start level from continuous run (Cl. 3.13.5, 11.7.3)

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

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

6 **Rivers, drains and canals (1D)**
Sections ≤ 200 m apart and at every structure; siphons under canals as controls; diversions mapped (Cl. 11.3.2)

7 **Outfall**
Flap gates and sluices in the dhussi bandh, pumps; joint and outfall-closed cases, Ch. 5

8 **River stage boundary**
Embanked river: WRD or BBMB gauge (ft → m, gauge zero stated); gated outfall, Ch. 5

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

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and chhappars 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:** chhappars, tanks, marshes and floodplains, including desilting to the original bed and recovering encroached area (Chapter 7);
2. **Regional retention and detention**, sited by modelling so that releases do not coincide with the main-stem peak (Clause 4.13);
3. **Conveyance** upgrades to drains, canals and culverts;
4. **Outfall works:** flap gates and sluices on the outfalls through the dhussi bandhs to the Sutlej, the Beas, the Ravi and the Ghaggar, with storage or pumping behind them where a river in flood can close an outfall, as on the Sutlej from Rupnagar and Ludhiana to Ferozepur and on the Ghaggar from SAS Nagar to Sardulgarh; storage and pumped outfalls for the depressions of the waterlogged south-west; the desilting, widening and protection of the WRD drains that receive the towns, among them the Buddha Nallah, the Tung Dhab and the Chitti Bein, and of the siphons and culverts that carry them under canals; sediment traps and choe crossings designed for sand where the Kandi choes enter the towns; interception works that keep sewage and industrial effluent out of the Buddha Nallah, the Kala Sanghian drain and the other storm channels without taking their storm capacity; the dhussi bandhs themselves; and the release and gate-operating rules of Bhakra, Pong, Ranjit Sagar and the Ropar, Harike, Hussainiwala and Madhopur headworks that set the receiving levels, agreed with WRD and BBMB;
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, notice of releases from Bhakra and Pong by BBMB and from Ranjit Sagar and Shahpur Kandi to the towns downstream, the discharges and levels reported by WRD at the Ropar, Harike, Hussainiwala and Madhopur headworks and at its gauges on the Ghaggar, since CWC has no flood sites in Punjab, 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 Ludhiana, Jalandhar, Patiala, Sangrur, Moga and most of the central plains (115 of the State's 153 assessment units over-exploited, stage of extraction 156.87%; CGWB and WRD, 2024) and in the Kandi recharge belt of sub-area PB-A, waterlogging where the October water table is within 3 m, as in parts of Sri Muktsar Sahib, Fazilka, Faridkot and Bathinda, in the Sirowal and on the bet lands, and the quality of the groundwater, which is saline in much of the south-west and exceeds the limits for uranium, nitrate, fluoride or arsenic in parts of the State, and of the drains, beins, choes and chhappars that the runoff reaches (Chapter 8);
- effect on downstream basins and the receiving river, WRD drain or choe; and
- who benefits.

11.8.3 **Basin release rates.** Where scenario (c) does not meet the level of service, the BSMP may set a basin-specific **permissible site discharge** (m³/s/ha) stricter than Chapter 4, by AEP and sub-catchment. The rate takes effect under the notification procedure of Clause 4.5.4.

11.8.4 **Outputs.** Each BSMP shall produce:

- (a) flood hazard maps (extent, depth, velocity, hazard class) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan. The **1% AEP future-with-plan map** becomes the reference map for floor levels (Chapter 6) and setbacks (Chapter 7);
- (b) recommended flood-sensitive catchments and any basin release rates (Clauses 4.5.4 and 11.8.3);
- (c) regional facility sites, with storage volumes, land needs and the sites they serve;
- (d) the fee-in-lieu unit rate for the basin (Clause 4.13.3);
- (e) the **Capital Improvement Programme**: works ranked by risk reduction per rupee, with cost, phasing and agency;
- (f) a pre-monsoon **maintenance programme**: desilting, gate and pump testing, and tank operating rules (Chapter 10); and
- (g) monitoring needs: new rain gauges, level sensors and flood-mark survey points.

> Commentary. Restoring storage comes first because many of the outfalls of Punjab's towns are closed or limited in the wettest weeks. The Sutlej stood in the "High Flood" band at Harike, at 3,35,030 cusecs, on 3 September 2025, the Ghaggar stood above its danger mark at Khanauri from 13 to 15 July 2023, and Pong spilled for weeks after its record inflow in August 2023 (all as reported); a town drain through a dhussi bandh cannot discharge against such a river, and in the south-west many depressions have no gravity outfall at all. Within the towns, only about 5% of Jalandhar is covered by a storm-water network, and its rain goes largely to the sewers (Jalandhar master plan report). The State's storage has been lost, too: the first water-bodies census counted 16,012 water bodies in Punjab, 1,578 of them encroached (as reported), the State has sanctioned ₹4,573 crore for cleaning about 15,000 village chhappars (as reported), of which about 1,062 were reported dewatered and about 400 desilted; on the Kandi "About 40% of this rain water gets wasted in floods" (WRD, Kandi Area Development). The storms are large for drains designed for a 2-year storm or none: IMD has recorded 354.3 mm in a day at Ludhiana (4 October 1955), 356.5 mm at Patiala (11 July 1993) and 338.0 mm at Ludhiana PAU (24 September 1988), 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 Sutlej, the Beas, the Ravi or the Ghaggar in flood may close at its dhussi bandh, one limited by the capacity of its gate, its pumping station, the receiving WRD drain or a siphon under a canal, or a depression of the south-west that has no gravity outfall at all. Groundwater in Punjab calls for recharge over most of the State and forbids it in part of it. The State's stage of extraction was 156.87% in 2024, with 115 of its 153 assessment units over-exploited (CGWB and WRD), and the area where the June water table was deeper than 10 m grew from 14.9% of the State in 1989 to 68% in 2019 (CGWB and WRD, 2020); "deep water levels are recorded in Kandi belt". But "Water logging conditions exist in some parts of south-western districts": in June 2019 the water table stood 0.79 m below ground at Abohar, and about 15% of the State had it within 1.5–5 m, mostly in the south-west (CGWB and WRD, 2020); there, recharge adds to waterlogging. Quality limits recharge too: CGWB found uranium above 30 ppb in 32.6% of its samples, fluoride above 1.5 mg/L in 13.77%, nitrate above 45 mg/L in 12.58%, arsenic above 10 ppb in 4.85% and electrical conductivity above 3,000 µS/cm in 6.72% (2024), and says that "Groundwater at Shallow depth is largely contaminated caused by surface water pollution". The building instruments ask for recharge without regard to the depth of the water table (PMBBL 2018, cl. 10.5; PUDBR 2021, r.40; as this Manual reads them), PUDBR bars the injection of contaminated water in industrial areas (r.40), and PWRDA credits approved rainwater harvesting (Directions 2023, cl. 2.7). 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 master plans of the local planning areas notified under the Punjab Regional and Town Planning and Development Act 1995 (s.70(5)), among them the Master Plan Ludhiana (2007–2031) and the master plans of Amritsar, Jalandhar, Patiala, Bathinda and the SAS Nagar local planning area (the notification of each to be confirmed [TBC]), with the Unified Zoning Regulations of the master plans (as amended on 24 September 2021), and the layouts of the urban estates and schemes of PUDA, GMADA, GLADA and the other development authorities; and, for a plan that covers a river, choe or notified drain, with the limits notified under s.38 of the Punjab Canal and Drainage Act 2023 shown on it. 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. Punjab draws its water lines by notification in a few places and by court order elsewhere. Neither PMBBL 2018 nor PUDBR 2021 sets a setback from a river, nallah, choe, pond or canal. Section 38 of the Punjab Canal and Drainage Act 2023, which carries over s.55 of the 1873 Act, lets the State prohibit obstructions within notified limits along a river, stream or drainage channel; WRD's method is to notify the waterway of the 100-year flood, computed by Gumbel's method with Lacey's width, in which "no construction is to be allowed" (Chief Engineer Drainage to CWC, 2 May 2024), but its first zone, on the Sutlej in Ferozepur and Tarn Taran (4 March 2024), was drawn as the land between the embankments, and the National Green Tribunal found no material showing the zone demarcated (OA 303/2023); on the Patiala ki Rao a s.55 notification of 2013 is directed against any construction in or covering of the nadi, and pillars at a width of 200 ft are being fixed under the High Court's orders (CWP 5901/2017), a width for that case only. The Jalandhar master plan report proposes a 30 m buffer and a 200 m no-construction zone along the Chitti Bein and a 30 m plantation strip along the Kala Sanghian drain, plan proposals and not statutory buffers. A no-objection of WRD's drainage wing for projects within 150 m of a water body was announced in 2023 (as reported), but no order was found, and the Punjab Land Preservation (Chos) Act 1900 regulates clearing and quarrying in notified Kandi areas (s.4) without drawing a line along the choes. Punjab has no floodplain zoning Act (as reported), and no wetland has been notified under the Wetlands Rules 2017. These are river 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.38 limits or a court line bind and are wider, they apply. A BSMP gives the master 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 PMBBL 2018 already asks that public open spaces of more than 500 m² provide for the "complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (cl. 10.4), that the projects of its Chapter 15 keep the inlet and outlet points of the natural drainage with a channel of adequate size and leave at least 20% of the recreational open space unpaved (Table 15.1), and, with PUDBR 2021 (r.40), that the open parking of group housing be of permeable materials, but neither instrument sets a detention or peak-runoff 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 Punjab 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 areas of GMADA, GLADA and the other development authorities

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

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

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

Item	Tier A authority	Clause
(a)	Municipal Corporation Ludhiana (MC Ludhiana), with GLADA and every other approving authority within GLADA's area	1.6.1(a)
(b)	Municipal Corporation SAS Nagar (Mohali), with GMADA and every other approving authority within GMADA's area, among them the local bodies of Zirakpur and Kharar and the authority for New Chandigarh	1.6.1(b)
(c)	Every other Municipal Corporation constituted under the Punjab Municipal Corporation Act, 1976 (among them Amritsar, Jalandhar and Patiala; 13 at March 2023, with Barnala reported as the fourteenth [TBC]), with every other approving authority within its limits	1.6.1(c)
(c)	PUDA and the development authorities in their urban estates and schemes, 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 development authority in the State, and of every approving authority within their areas, with the urban estates and schemes of PUDA and the authorities, 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 current list and limits of the Municipal Corporations, Municipal Councils and Nagar Panchayats (DLG): the CAG counted 13 Municipal Corporations, 101 Municipal Councils and 52 town councils (166 urban local bodies) at March 2023 (Report No. 1 of 2026), Barnala is reported to have become the fourteenth Municipal Corporation in October 2025, and the working list of this Manual, Amritsar, Jalandhar, Ludhiana, Patiala, Phagwara, SAS Nagar (Mohali), Bathinda, Abohar, Barnala, Kapurthala, Moga, Batala, Pathankot and Hoshiarpur, is to be confirmed against a notification of DLG [TBC]; the notified areas of GMADA and GLADA and of the other development authorities, whose constituting notifications were not read [TBC], with the local planning areas of SAS Nagar and New Chandigarh; the urban estates and other schemes of PUDA and the authorities (HUD); and the district and tehsil boundaries (Department of Revenue, Rehabilitation and Disaster Management, Survey of India). Until it is published, the tier is decided by the classes in Clause 1.6.1 and recorded on Form 1-1, and the Authority confirms it at the pre-application stage (Clause 1.5.9).

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

No.	Authority	Class (Municipal Corporation / Municipal Council / Nagar Panchayat / 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 development authority 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)	Ludhiana on the Buddha Nallah	The catchment of the Buddha Nallah and its city reach through Ludhiana, from the Kum Link and Neelon drains to its outfall to the Sutlej at Walipur Kalan; the channel, 47.55 km long, was designed for a 2-year return period (PMIDC, 2020), carries about 700 MLD of treated and untreated effluent (PPCB, reply to the NGT, 2025), and is alleged to have been narrowed "from 58 feet to 35 feet" by a road (NGT, O.A. 327/2025)
(b)	SAS Nagar–Zirakpur–Kharar–Dera Bassi–New Chandigarh on the Shivalik choes	The land that drains to the N-Choe, the Patiali-ki-Rao, the Sukhna Choe, the Jayanti Devi ki Rao and the Lakhnaur choe, which come down from the Shivaliks and through Chandigarh, and to the Ghaggar at Bhankharpur; the Patiala ki Rao is notified under s.55 of the Act of 1873 (2013) and was found "heavily encroached" on the Punjab side in 2024 (CWP 5901/2017), and Phase 11 of Mohali floods when the Lakhnaur choe is not cleared (as reported)

Item	Catchment	Extent as described in Chapter 4
(c)	Patiala–Rajpura–Samana on the Nadis and the Ghaggar	The land of Patiala, Rajpura and Samana that drains to the Badi and Chhoti Nadi, the Ghaggar and the canal crossings; the SYL canal and the Narwana branch breached and flooded Rajpura in 2023, and the Hansi–Butana siphon on the Ghaggar is blamed for ponding at Samana (as reported)
(d)	The Ghaggar towns of Sangrur and Mansa	Moonak, Khanauri, Makraud Sahib and Sardulgarh and the land that drains to the Ghaggar there; the river stood at 754.2 ft at Khanauri on 15 July 2023, against a danger mark reported as 748 ft, and breached in 1993, 2010 and 2023 (as reported)
(e)	Jalandhar–Kapurthala–Phagwara on the Beins and the Sutlej	The land that drains to the Kali Bein, the Chitti Bein and the Kala Sanghian drain, and to the Sutlej at Phillaur and Shahkot, where the dhussi bandh breached on 19–20 August 2019 (as reported); only about 5% of Jalandhar's area was served by storm drains (Master Plan Jalandhar report)
(f)	Amritsar on the Tung Dhab–Hudiara outfall	The walled city, whose road-side drains join the sewers to make "the sewerage system as combined system" (Amritsar Smart City bid, 2018), and the land that drains by the Tung Dhab and City Outfall drains to the Hudiara drain, which enters Pakistan near Lalo
(g)	Pathankot–Gurdaspur–Dera Baba Nanak on the Ravi	The land that drains to the Ravi, the Chakki Khad and the dhussi bandh, below Ranjit Sagar, Shahpur Kandi and the Madhopur headworks, whose gates failed on 27–28 August 2025 (as reported)
(h)	The Kandi towns of Hoshiarpur, Garhshankar, Mukerian and Talwara	The land that drains to the choes, "more than 100" in Hoshiarpur district (Hoshiarpur District Environment Plan), and to the Beas below Pong
(i)	Rupnagar–Nangal–Anandpur Sahib on the Sutlej and the Swan	The land that drains to the Sutlej below Bhakra and to the Swan; the Ropar gauge recorded 35 cm in the 24 hours to 08:30 on 10 July 2023 (IMD) and the Ropar headworks passed 2.4 lakh cusecs in 1988 and 1.79 lakh in July 2023 (as reported)
(j)	Ferozepur and the Harike–Hussainiwala reach	The land of Ferozepur and the towns of the reach that drains to the Sutlej at Harike and Hussainiwala, which passed 3,35,030 and 3,02,508 cusecs on 3 September 2025 (as reported), including the floodplain zone of the Sutlej notified in Ferozepur and Tarn Taran (4 March 2024)
(k)	The waterlogged south-west	Bathinda, Sri Muktsar Sahib, Fazilka, Abohar and Faridkot and the land that drains from them, where the water table lies within 3 m of the surface over large areas and outfalls are pumped (CGWB; WRD)
(l)	Notified catchments	Any catchment notified under Clause 4.5.4

To be prepared. This annex will contain a map of each catchment in Table 1B.1 at a scale fit for deciding whether a plot lies inside it, and the same boundaries as a GIS layer. It needs catchment boundaries drawn from a digital elevation model and the drain network (the Municipal Corporations of Ludhiana, SAS Nagar, Patiala, Jalandhar, Kapurthala, Phagwara, Amritsar, Pathankot, Hoshiarpur, Bathinda and Abohar, the Municipal Councils and Nagar Panchayats of the other towns listed, GMADA, GLADA and the other development authorities, Survey of India); the WRD drains, choes and rivers with their notifications under s.38 of the Punjab Canal and Drainage Act, 2023 or s.55 of the Act of 1873, their outfalls and levels on a stated gauge and datum, among them the Buddha Nallah, the Tung Dhab, City Outfall and Hudiara drains, the Kali and Chitti Bein, the Kala Sanghian drain and the Patiala ki Rao (WRD); the levels and gauge zeros of the headworks at Ropar, Harike, Hussainiwala and Madhopur and of the Ghaggar at Bhankharpur, Sarala Kalan, Khanauri and Sardulgarh (WRD), and the release records of Bhakra and Pong (BBMB) and Ranjit Sagar; the floodplain zone of the Sutlej in Ferozepur and Tarn Taran with its khasra list; the depth to water in the south-west and the Sirowal belt, in October (CGWB, WRD); and the land flooded in 1988, 1993, 2019, 2023 and 2025, with the waterlogging points listed by the district administrations (the Deputy Commissioners, PSDMA, the local bodies). Khanna, Batala, Moga, Barnala, Malerkotla, Sultanpur Lodhi and Tarn Taran are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented. The river floodplains between the dhussi bandhs, the Ramsar sites and the village chhappars 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 (k), or the notification under Clause 4.5.4	text
notification_ref	Gazette notification number, where notified	text
notified_on	Date of notification	date
applies_from	Date from which the rule applies to applications (Clause 4.5.4.2, step 5)	date
boundary_source	Source and date of the boundary	text
area_km2	Catchment area	km²

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

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

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

Part 1 — General provisions

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

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

P1.3 **Adoption.**

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

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

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

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

Part 2 — The alternatives

S-1 — Design-aid route for storage

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

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

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

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

S-2 — Permissible site discharge (PSD)

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

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

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

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

S-3 — Fixed-width waterbody setback

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

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

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

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

S-4 — Downstream screening checklist

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

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

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

S-4.4 *Conditions:* the checklist is signed by the registered professional who signs the drainage report (Clause 10.6); flood-prone locations are those recorded by the local body, the Deputy Commissioner and the District Disaster Management Authority, PSDMA, WRD, or GMADA, GLADA or another development authority in its area (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 chhappar or tank storage identified in the basin plan (Clause 4.13.1).

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

S-5.4 *Conditions:*

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

Part 3 — Model council resolution

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

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

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

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

- (i) the Punjab 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 PMBBL/PUDBR 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 at which the new rule and the conditions would be inserted, and the enabling sections of the Punjab Regional and Town Planning and Development Act, 1995 (for PUDBR) and of the Punjab Municipal Corporation Act, 1976 and the Punjab Municipal Act, 1911 (for PMBBL) 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021

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

- (1) These rules may be called the Punjab Municipal Building (Stormwater Management) Bye-Laws and Punjab Urban Planning and Development Building (Stormwater Management) Rules, _____.
- (2) They shall come into force on the date six months after their publication in the Punjab Government Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building bye-laws made by the Department of Local Government on 22 November 2018 for the municipal areas of the State, and the building rules made by the Department of Housing and Urban Development on 31 August 2021 for the rest of the State and for the schemes of the development authorities, the following rule shall be inserted:

> **Rule [_____]. Stormwater management.**
>
> (1) *Definitions.* In this rule, "the Manual" means the Punjab 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 Punjab 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 — Punjab 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 — 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 (PMBBL 2018, cl. 10.1 (municipal areas): plot of 100 m² or more, and group housing, public, commercial and industrial buildings of any size; PUDBR 2021, r.40 (elsewhere): residential or public plot of more than 250 m², commercial, mixed-use or industrial plot of more than 100 m², group housing of any size) — 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 — Punjab 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 rain gauges whose readings the district administrations and the Department of Revenue, Rehabilitation and Disaster Management report, the gauges of WRD and BBMB, the agrometeorological observatories of PAU at Ludhiana, Ballowal Saunkhri and Bathinda, and any automatic gauges of the Municipal Corporations and the Smart City command centres [TBC]), and district and basin boundaries (Survey of India, WRD). Until it is published, design depths are taken from NIH-DHAARA under Clause 2.3.1, the cross-checks of Clause 2.3.3 are reported on Form 2-1, and the zone of a site is the one agreed with the Authority and recorded on Form 2-1.

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

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

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

Table 2A.2 — Rainfall zones (layout)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
PB-Z1 Shivalik–Kandi	The Shivalik hills and the Kandi piedmont below them, from Pathankot and Dhar Kalan through Talwara, Mukerian–Dasuya, Hoshiarpur and Garhshankar to Nangal, Anandpur Sahib, Rupnagar and the Kharar–Mullanpur hills: CWC zone 7 in the hills and on the Shivalik fringe beyond the line, subzone 1(e) on the piedmont, and both at Rupnagar, on the line (Clause 2.3.6(b)); catchments that cross a report or zone line take the higher value	Pathankot Aero (no IMD station with 30 years found [TBC]); the zone-7 recording gauges at Madhopur and Hoshiarpur; Chandigarh 42105 (1954–2009) for the Kharar hills	District annual normals 801.4 mm in Rupnagar, 818.8 mm in Hoshiarpur and 1,106.1 mm in Gurdaspur, the highest in the State (IMD, 1901–1980). Zone-7 Plate 9 about 320 mm at Pathankot and 280 mm at Nangal and Anandpur Sahib; 1(e) spot of 263 mm at Hoshiarpur and about 240–260 mm at Rupnagar (50-yr); 1-h ratio 0.425 (zone 7) or 0.34 (1(e)). NIH-DHAARA 50-yr 24-h high here (Pathankot 443, Nangal 307, Rupnagar 302, Hoshiarpur 300 mm)
PB-Z1 Shivalik–Kandi: PB-A Shivalik foothills and Kandi (Pathankot–Talwara–Hoshiarpur–Garhshankar–Nangal–Anandpur Sahib–Rupnagar–Mullanpur)	Also Dhar Kalan, Sujanpur, the Mukerian–Dasuya hills, Balachaur, Kurali, New Chandigarh, the Siswan and the Kharar hills; boundaries [TBC]	Pathankot Aero, Madhopur, Hoshiarpur, Garhshankar, Rupnagar (rain gauges of *Climate of Punjab*)	The Kandi belt, 10–15 km wide below the hills, of deposits grading "from boulders to clays", explored to 450 m, with a slope of about 16 m/km decreasing westwards, and the Sirowal seepage belt at its toe (CGWB); "more than 100 choes" in Hoshiarpur district leaving "thick deposits of sand and silt" (Hoshiarpur District Environment Plan); deep water tables on the fans (stage of extraction 53% in Pathankot, 100% in Ropar, 102% in Hoshiarpur district, 2020). Records: Garhshankar 470.0 mm (31 Jul 1976), Pathankot Aero 355.0 mm (14 Jul 1980), Madhopur 351.0 mm (5 Oct 1955), Rupnagar 310.4 mm (30 Jul 1951) (IMD); Ropar 35 cm in the 24 hours to 08:30 on 10 Jul 2023 and Nangal 28 cm to 9 Jul 2023 (IMD press releases); recording-gauge maxima Madhopur 100 mm in 1 h (16 Sep 1975) and 329 mm in 24 h (23–24 Jul 1974), Hoshiarpur 81 mm in 1 h (5 Aug 1982) (CWC, zone 7). Receiving waters: the Chakki Khad at Pathankot (657.86 km², a zone-7 unit-hydrograph catchment); the Ravi at Madhopur and Shahpur Kandi; the Beas below Pong at Talwara; the Sutlej at Nangal and Ropar below Bhakra (Ropar 2.4 lakh cusecs in 1988 and 1.79 lakh in Jul 2023, as reported); the Swan to the Sutlej near Anandpur Sahib; the Kandi choes, with 12 low dams and WRD's 410 check dams on rivers and nallahs
PB-Z2 Northern and central plains	The wetter plains of Majha and Doaba north of the "240 arm" of the plates, and the central belt from the Sutlej at Ludhiana to the Ghaggar at Patiala and SAS Nagar, in CWC subzone 1(e); catchments that cross a zone line take the higher zone value	Ludhiana(A) 42099 (1901–2012), Patiala 42101 (1901–2012), Kapurthala 42074 (1972–2012), Ludhiana PAU 06203 (1966–2011), Chandigarh 42105 (1954–2009) for SAS Nagar	District annual normals 648.1 mm in Patiala, 660.3 mm in Ludhiana, 703.0 mm in Jullundur, 778.9 mm in Kapurthala (IMD, 1901–1980). FER 1(e) 50-yr 24-h about 240–262 mm and 100-yr about 240–292 mm; 1-h ratio 0.34. The storm of 4–5 October 1955 put more than 330 mm in a day on several gauges at once. NIH-DHAARA 50-yr 24-h 211–341 mm

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
PB-Z2 Northern and central plains: PB-B Majha–Doaba north (Gurdaspur–Batala–Jalandhar–Kapurthala–Phagwara–Nawanshahr)	Also Dera Baba Nanak, Dinanagar and the Mukerian plains; boundaries [TBC]	Kapurthala 42074; Gurdaspur, Batala and Tibri (rain gauges of *Climate of Punjab*)	Recent alluvium of the Ravi, Beas and Sutlej; stage of extraction 257% in Jalandhar and 220% in Kapurthala district (2020), with water levels falling more than 0.5 m a year in Jalandhar; 1.5–5 m pockets in Gurdaspur. FER 1(e) 50-yr 24-h about 240–260 mm at Gurdaspur, Batala and Kapurthala, and about 200 mm at Jalandhar, inside a closed loop (Clause 2.3.6(c); low confidence). Records: Aliwal 495.3 mm, Batala 474.5 mm and Gurdaspur 370.3 mm (5 Oct 1955), Tibri 385.6 mm (4 Sep 1950), Kapurthala 284.2 mm (24 Sep 1988) (IMD). Receiving waters: the Ravi and its dhussi bandh (breaches in the Ajnala–Ramdass area in 2025, as reported); the Beas from Mukerian to Harike; the Kali Bein, the Chitti Bein and the Kala Sanghian drain; the Sakki/Kiran nallah; the Sutlej at Phillaur and Shahkot (breaches of 19–20 Aug 2019, as reported)
PB-Z2 Northern and central plains: PB-C Central Sutlej–Ghaggar belt (Ludhiana–Khanna–SAS Nagar–Zirakpur–Rajpura–Patiala–Fatehgarh Sahib)	Also Samrala, Jagraon, Kharar, Dera Bassi, Nabha and Sirhind; boundaries [TBC]	Ludhiana(A) 42099, Ludhiana PAU 06203, Patiala 42101, Chandigarh 42105; Jagraon (rain gauge of *Climate of Punjab*); the Patiala recording gauge of the zone-7 report	Older alluvium, sandy loam to loam; stage of extraction 211% in Ludhiana, 226% in Patiala and 202% in Fatehgarh Sahib district (2020), with a fall of 36.15 m at Rajpura in 1984–2019 (CGWB). FER 1(e) 50-yr 24-h about 240–262 mm in a central cell bounded by the 240 mm line, with spots of 262 and 289 mm at Chandigarh; the short-storm floors of Clause 2.3.6(g)(ii) apply. Records: Jagraon 433.6 mm (18 Sep 1950), Patiala 356.5 mm (11 Jul 1993), Ludhiana 354.3 mm (4 Oct 1955), Ludhiana PAU 338.0 mm (24 Sep 1988), Chandigarh 302.2 mm (9 Jul 2023), Rajpura 26 cm (to 08:30 on 10 Jul 2023) (IMD); Patiala recording gauge 93 mm in 1 h and 153 mm in 3 h (21 Jul 1982) (CWC, zone 7). Receiving waters: the Buddha Nallah to the Sutlej at Walipur Kalan (2-yr channel design; PMIDC); the Sutlej at Ludhiana; the Ghaggar at Bhankharpur and Sarala Kalan, with the Patiali-ki-Rao, the Jayanti Devi ki Rao, the N-Choe and the Sukhna Choe from the Shivaliks and Chandigarh; the Badi and Chhoti Nadi at Patiala; the Sirhind choe under the Bhakra Main Line by siphon; the SYL and Narwana branch crossings at Rajpura
PB-Z3 Western and Malwa plains	The plains of Majha west of the "240 arm" to the border and of central Malwa, in CWC subzone 1(e); catchments that cross a zone line take the higher zone value	Amritsar(A) 42071 (1948–2011), Ferozepore 42096 (1950–2012); no IMD station with 30 years found for Sangrur, Moga or Mansa [TBC]	District annual normals 388.6 mm in Ferozpur, 557.6 mm in Sangrur and 598.7 mm in Amritsar (IMD, 1901–1980). FER 1(e) 50-yr 24-h about 200–240 mm and 100-yr about 200–240 mm; 1-h ratio 0.34. NIH-DHAARA 50-yr 24-h 146–215 mm, below the plates at Firozpur and Moga
PB-Z3 Western and Malwa plains: PB-D Majha west and the border (Amritsar–Tarn Taran–Patti–Ferozepur–Zira)	Also Ajnala and Khemkaran; boundaries [TBC]	Amritsar(A) 42071, Ferozepore 42096; Khara, Raya, Zira and Ferozpur Sadar (rain gauges of *Climate of Punjab*)	Stage of extraction 167% in Amritsar, 193% in Tarn Taran and 133% in Ferozpur district (2020). FER 1(e) 50-yr 24-h about 220 mm (200–240 mm) at Amritsar, Tarn Taran and Ferozepur. Records: Khara 457.2 mm and Raya 367.0 mm (5 Oct 1955), Amritsar 308.4 mm (22 Sep 1962), Zira 301.7 mm (17 Sep 1950), Ferozpur Sadar 282.7 mm (18 Aug 1964), Ferozepore 240.0 mm (1 Aug 1976) (IMD). Receiving waters: the Tung Dhab and City Outfall drains of Amritsar to the Hudiara drain, which enters Pakistan near Lalo; the Kasur and Patti nallahs; the Ravi at Ajnala; the Sutlej at Harike (3,35,030 cusecs on 3 Sep 2025, above the 3-lakh "High Flood" band) and Hussainiwala (3,02,508 cusecs), as reported, with the Sutlej floodplain zone of Ferozepur and Tarn Taran notified on 4 Mar 2024

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
PB-Z3 Western and Malwa plains: PB-E Malwa centre (Sangrur–Barnala–Malerkotla–Moga–Mansa)	Also Sunam, Dhuri, the north of Mansa district and the east of Bathinda district; boundaries [TBC]	Patiala 42101 and Ludhiana(A) 42099 (nearest with 30 years); Moga, Bandhar and Bharala (rain gauges of *Climate of Punjab*)	Old alluvium with kankar and sodic patches; the most over-drawn districts, stage of extraction 301% in Sangrur (342% in Dirba block), 250% in Moga and 211% in Barnala (2020), with water tables deeper than 30 m. FER 1(e) 50-yr 24-h about 220–240 mm at Sangrur and Sunam and 200–240 mm at Moga (low confidence). Records: Moga 335.0 mm (5 Oct 1955), Bharala 275.6 mm and Bandhar 266.7 mm (26 Sep 1945) (IMD); Jawahrke 377.2 mm and Mansa 332.7 mm (4 Oct 1955) from gauges of fewer than 20 years, excluded by Clause 2.3.6(h). Receiving waters: the Ghaggar at Khanauri (753–754.2 ft on 13–15 Jul 2023 against a danger mark reported as 748 ft), Moonak and Makraud Sahib, with breaches in 1993, 2010 and 2023 (as reported); the Sunam choe
PB-Z4 South-west	The dry south-west, with dune sands, waterlogged depressions and saline groundwater, in CWC subzone 1(e) near its line with subzone 1(a); catchments that cross a zone line take the higher zone value	Bhatinda 42097 (1959–1982) as a check only; no IMD station with 30 years found [TBC]	District annual normals 388.6 mm in Ferozpur, 429.8 mm in Bhatinda and 433.0 mm in Faridkot (IMD, 1901–1980), the lowest in the State. FER 1(e) 50-yr 24-h 160 mm at Bathinda and Abohar (a closed cell, Clause 2.3.6(c)) to about 180 mm; 1-h ratio 0.34. NIH-DHAARA 50-yr 24-h low here (Abohar 104, Fazilka 116, Sri Muktsar Sahib 116, Mansa 123, Bathinda 126 mm)
PB-Z4 South-west: PB-F South-west sands, waterlogging and salinity (Bathinda–Sri Muktsar Sahib–Malout–Fazilka–Abohar–Faridkot)	Also Gidderbaha, Kotkapura and Sardulgarh in the south of Mansa district; boundaries [TBC]	Bhatinda 42097 (check only); Bhatinda, Fazilka and Abohar (rain gauges of *Climate of Punjab*)	Dune sands to sandy loam, with final infiltration rates of 0.05–0.26 cm/min measured on dry cultivated soils (PAU, 1995); the water table within 3 m over the waterlogged parts of Sri Muktsar Sahib, Fazilka and Faridkot (0.53 m at Kot Bhai in October 2019) and saline groundwater, with an EC of up to 8,320 µS/cm at Abohar (CGWB). FER 1(e) 50-yr 24-h about 160–180 mm. Records: Bhatinda rain gauge 256.1 mm (18 Aug 1964), Fazilka 182.9 mm (31 Aug 1908), Faridkot 182.0 mm (18 Aug 1964), Abohar 175.8 mm (2 Sep 1958) (IMD). Receiving waters: seasonal drains with little fall to the Sutlej at Hussainiwala; the Rajasthan and Sirhind feeders, which block cross-drainage and whose seepage feeds the waterlogging (as reported); pumped drainage and RCC pipelines from low villages (WRD); the Ghaggar at Sardulgarh

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Annex 2B — Sub-daily ratios P(t)/P(24h) by zone: NIH-DHAARA (hourly-based) vs the one-third rule

Supports Clauses 2.6.1 to 2.6.4 of Chapter 2.

To be prepared. This annex will tabulate, for each zone of Annex 2A, the ratios of the t-hour to the 24-hour design depth from NIH-DHAARA, which are derived from hourly records, against the ratios implied by IMD Das et al. (2022) and by the one-third rule. It needs NIH-DHAARA depths for each duration at representative points in each zone (NIH), IMD recording-gauge data and the IDF values of Das et al. (2022) (IMD). Until it is published, sub-daily depths are read directly from NIH-DHAARA or an approved station IDF (Clause 2.6.1). Where only daily depths are available, the ratios used are those agreed with the Authority, which in Punjab are those of Clause 2.3.6: the CWC Flood Estimation Report ratios in Table 2B.1 for the report that covers the site (subzone 1(e) in the plains and the Kandi piedmont; zone 7 in the zone-7 part of sub-area PB-A; both at Rupnagar, the higher governing), raised at 1 and 3 hours to the floors of Clause 2.3.6(g) for the 10-yr and rarer storms, and applied to the 24-hour depth before the record check of Clause 2.3.6(h) (Clause 2.6.2), and are recorded on Form 2-1. The one-third rule is not used (Clause 2.6.4).

2B.1 The first row of Table 2B.1 gives the ratios of the one-third rule P(t) = P(24)·(t/24)^(1/3), for comparison only. The 1, 3, 6 and 12 h values are those stated in the commentary to Clause 2.6; the 2 h value is computed from the same formula. The rule shall not be used for design unless this annex confirms it for the zone concerned (Clause 2.6.4).

Table 2B.1 — Ratios P(t)/P(24h) by zone (layout)

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
All (reference only, not for design)	One-third rule	0.35	0.44	0.50	0.63	0.79	1.00
PB-Z1 (the 1(e) part of PB-A, the Kandi piedmont), PB-Z2, PB-Z3 and PB-Z4 (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
PB-Z1 (the zone-7 part of PB-A: Pathankot, Dhar Kalan, Sujanpur, Talwara, Nangal, Anandpur Sahib and the Shivalik hills)	CWC FER zone 7, 10-yr partial-duration basis (interim design ratios, Clause 2.3.6(f); 2-h value interpolated on logarithmic axes; at Rupnagar both sets, the higher depth governing)	0.425		0.600	0.725	0.845	1.00
All sub-areas, 10–100 yr	Ratio floor of Clause 2.3.6(g)(i)	0.35		0.57			1.00
PB-Z1 (zone-7 part of PB-A), every AEP	1-hour floor where a station IDF governs, Clause 2.3.6(f), set by this Manual	0.34					
PB-Z2 (PB-C)	Floors of Clause 2.3.6(g)(ii) at 50-yr, 93 mm and 153 mm, as ratios to the 240–262 mm of the plates in PB-C (comparison only; the floors are depths)	0.35–0.39		0.58–0.64			1.00
PB-Z2 (PB-C): Patiala	CWC FER zone 7, Annex 4.4: recording-gauge maxima as ratios to the 24-h maximum of the same record (separate storms: 1 and 6 h on 21 Jul 1982, 24 h on 21–22 Jul 1979; date of the 3-h maximum not read [TBC]; comparison only)	0.44		0.73	0.86	1.00	1.00
PB-Z1 (PB-A): Madhopur	CWC FER zone 7, Annex 4.4: recording-gauge maxima (separate storms: 1 h on 16 Sep 1975, 3 to 24 h on 23–24 Jul 1974; comparison only)	0.30		0.66	0.87	1.00	1.00
PB-Z1 (PB-A): Hoshiarpur	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 4–5 Aug 1982, one compact storm (comparison only)	0.59		0.96	1.00	1.00	1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
PB-Z2 (PB-C): Ludhiana	NIH-DHAARA, 50-yr, Ludhiana cell (comparison only; 3- and 6-hour values not queried)	0.33	0.48			0.83	1.00
PB-Z2 (PB-C): Mohali	NIH-DHAARA, 50-yr, Mohali cell (comparison only; 3- and 6-hour values not queried)	0.25	0.38			0.83	1.00
PB-Z1 (PB-A): Pathankot	NIH-DHAARA, 50-yr, Pathankot cell (comparison only; 3- and 6-hour values not queried)	0.24	0.38			0.83	1.00
PB-Z4 (PB-F): Bathinda	NIH-DHAARA, 50-yr, Bathinda cell (comparison only; 2-, 3- and 6-hour values not queried)	0.35				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, WRD, PAU 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 Punjab the reanalysis cells err in both directions, more widely than in any other State of the series. In the south-west they err low: the IMDAA cell of NIH-DHAARA (about 12 km) at Bathinda gives a 50-year 24-hour depth of about 126 mm and a 100-year depth of about 141 mm, against a CWC plate value of 160 mm and the 256.1 mm recorded by the Bhatinda rain gauge on 18 August 1964; at Mansa about 123 mm; at Firozpur about 146 mm, against about 220 mm on the plate and the 301.7 mm recorded at Zira on 17 September 1950; and at Abohar, Fazilka and Sri Muktsar Sahib about 104–116 mm, against plate values of about 160–180 mm. In the centre the cell at Ludhiana gives about 211 mm, against the 354.3 mm of the Ludhiana observatory (4 October 1955). On the Shivalik front they err high: about 443 mm at Pathankot, against about 320 mm on the zone-7 plate, 341 mm at Gurdaspur and 300–307 mm at Hoshiarpur, Rupnagar and Nangal, against about 240–263 mm on the 1(e) plates. The cells' 50-year 1-hour depths, about 39–105 mm, are 0.24–0.39 of their 24-hour depths (NIH-DHAARA, queried 13 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 Punjab 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 — Punjab 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 Punjab 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, among them Balachaur, Ropar KVK, Fatehgarh Sahib and Adampur, under the Meteorological Centre Chandigarh; the recording gauges of PAU; and any recording gauges of WRD, BBMB and the city command centres [TBC]), separated into independent storms by a stated rule, and the storms of 4–5 October 1955 across Majha, Doaba and central Malwa, 24 September 1988 at Ludhiana and Kapurthala, 11 July 1993 at Patiala, 5 September 1995 at Ludhiana and 8–10 July 2023 at Ropar, Nangal, Balachaur, Rajpura and Chandigarh, and the falls of August–September 2025 over the Ravi, Beas and Ghaggar catchments and in Mohali, Ludhiana, Jalandhar and Amritsar 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, WRD, PAU 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
PB-Z1 Shivalik–Kandi					
PB-Z2 Northern and central plains					
PB-Z3 Western and Malwa plains					
PB-Z4 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 — Punjab Stormwater Design Manual, Draft v1.0. One sheet for each hydrologic submittal. The steps follow Figure 2.3 of Chapter 2.

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

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

No.	Item (clause)	Entry
E2	CWC subzone 1(e) or zone 7 24-hour point value, catchments of 25–5,000 km²: subzone used	_____
E3	CWC floor governs for any AEP: No / Yes — AEPs	_____
	F. Retention depth (Clause 2.10)	
F1	P_R (mm) and source: Annex 2E zone value / computed under Annex 2E, 2E.1 — station and period	_____
F2	No climate factor applied to P_R (Clause 2.8.3): confirmed	_____
	G. Design storms (Clauses 2.9, 2.11, 2.12; items 5 and 6)	
G1	Storms up to 24 h: alternating block, peak at 50%; time step (≤ Tc/3 and ≤ 15 min)	_____
G2	48 and 72 h storms: built under Clause 2.9.2 (Table 2F.3)	_____
G3	Other pattern used: none / Annex 2D / CWC FER with sensitivity run (Clauses 2.9.3, 2.9.4)	_____
G4	Hyetographs attached as a table and a plot for each design storm: reference	_____
G5	AMC: III for every design storm of 15 June–30 September under paddy or other ponded fields in PB-B to PB-F and on the bet lands of the Sutlej, Beas, Ravi and Ghaggar, and of 1 July–31 October in PB-F and the Sirowal belt where the October water table is within 3 m, 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 — Punjab 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 Punjab 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 Punjab Remote Sensing Centre (PRSC) or Punjab Agricultural University (PAU) [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 Water Resources Department, supplemented by piezometers in the waterlogged south-west (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda and Ferozepur), the land along the Rajasthan and Sirhind feeders, the Sirowal belt below the Kandi, the bet lands of the Sutlej, Beas, Ravi and Ghaggar, and the beds and margins of chhappars. 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 — Punjab CN calibration and supplementary land covers (choe beds and Kandi scrub, paddy fields, saline-sodic fields, dune sand, chhappar 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 Punjab 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 Kandi choes, and the scrub, grass and plantation on the Kandi fans and on the sandstone and clay of the Shivalik slopes of Pathankot, Hoshiarpur, Nawanshahr, Rupnagar and SAS Nagar; paddy fields, puddled and bunded from transplanting in early June, which stand under water at the start of a monsoon storm and spill over their bunds; the saline-sodic and waterlogged fields of the south-west, in Sri Muktsar Sahib, Fazilka, Faridkot and parts of Bathinda and Ferozepur, and the sodic patches of the old alluvium of Patiala, Sangrur and Mansa, which either stand under water at the start of a storm or shed it from a sealed, crusted surface; the dune sands and loamy sands of Bathinda, Fazilka, Abohar and Sri Muktsar Sahib, bare or under sparse crops; and the beds of chhappars, tobas and dhabs that are dry, silted or cultivated at the start of a storm. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from WRD gauging sites, agricultural research stations and tank gauges, analysed by event and by antecedent moisture. Until it is published: the pre-development reference stays open space in good condition for every site (Clause 3.3.2), so these covers do not enter the pre-development run; for off-site existing conditions, use the nearest Table 3.5 or TR-55 cover row, including the cultivated rows (Clause 3.8.3(c)), and state the row chosen and the reason on Form 3-1; land under standing water at the start of the design storm is modelled as water surface with no losses (Table 3.5; Clause 3.10.4(b)). Any departure from these defaults requires calibration under Clause 3.15 (Clause 3.15.1(d)).

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

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Boulder, gravel and sand bed of a Kandi choe, dry at the start of the storm						
Scrub, grass or plantation on a Kandi fan or on the sandstone and clay of the Shivalik slopes						
Paddy field, puddled and bunded, under standing water at the start of the storm (15 June–30 September)						
Paddy field after harvest or before puddling, bunds intact						
Waterlogged or saline-sodic field, south-west, above standing water or a water table within 1.5 m at the start of the storm						
Sodic patch with a crusted surface, old alluvium of Patiala, Sangrur and Mansa						
Dune or sandy plain, bare or under sparse crops, south-west						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Chhappar, toba or dhab bed, dry, silted 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**

Step	Calculation	Result
(a) Composite CN (Clause 3.9.4)	61 + 0.50 × (98 − 61)	79.5
(a) Runoff with composite CN	S = 65.50 mm, Ia = 13.10 mm; Q = 11.90² / (11.90 + 65.50)	**1.83 mm**
(b) Interval check (Clause 3.11.3(a))	0.133 × 1.0 = 0.133 h ≥ Δt = 0.1 h	satisfied
(b) Lag and time to peak (Clause 3.11.2)	tL = 0.6 × 1.0 = 0.60 h; tp = 0.1 / 2 + 0.60	tp = 0.65 h
(b) Unit hydrograph peak, Q = 1 mm	0.208 × 2.5 × 1 / 0.65	**qp = 0.800 m³/s per mm**

Part (a) reproduces the comparison in the commentary to Clause 3.9 (about 9.9 mm vs 1.8 mm).

Problem 3C-5 — Level-pool (modified Puls) storage routing (Clause 3.12.1)

Inputs. A detention basin with vertical sides and plan area 500 m², with the stage–storage–discharge relationship of Table 3C.5. Triangular inflow hydrograph: 0 at t = 0, rising linearly to 0.50 m³/s at t = 30 min, falling linearly to 0 at t = 90 min. Basin empty at t = 0. Routing interval Δt = 10 min (600 s). No tailwater.

Table 3C.5 — Problem 3C-5 stage–storage–discharge relationship

Stage (m)	Storage S (m³)	Outflow O (m³/s)
0.0	0	0.00
0.5	250	0.05
1.0	500	0.10
1.5	750	0.15
2.0	1,000	0.20
2.5	1,250	0.25

Method. The storage-indication equation is (I1 + I2) + (2S1/Δt − O1) = (2S2/Δt + O2). The table gives O = S / 5,000 (S in m³, O in m³/s), so 2S/Δt + O = 17.667 O and 2S/Δt − O = 15.667 O, and each step is O2 = [(I1 + I2) + 15.667 O1] / 17.667. Software interpolating linearly in Table 3C.5 shall give the same result.

Table 3C.6 — Problem 3C-5 routed outflow

Time (min)	Inflow I (m³/s)	Outflow O (m³/s)	Storage (m³)	Stage (m)
0	0.0000	0.0000	0.0	0.000
10	0.1667	0.0094	47.2	0.094
20	0.3333	0.0367	183.3	0.367
30	0.5000	0.0797	398.4	0.797
40	0.4167	0.1226	612.8	1.226
50	0.3333	0.1511	755.7	1.511
60	0.2500	0.1670	835.2	1.670
70	0.1667	**0.1717**	**858.6**	**1.717**
80	0.0833	0.1664	832.1	1.664
90	0.0000	0.1523	761.5	1.523

Time (min)	Inflow I (m³/s)	Outflow O (m³/s)	Storage (m³)	Stage (m)
120	0.0000	0.1062	531.1	1.062
180	0.0000	0.0517	258.3	0.517

Results. Peak outflow 0.172 m³/s at 70 min; peak storage 859 m³; peak stage 1.72 m. The inflow peak of 0.50 m³/s is reduced to 34% of its value.

Table 3C.7 — Benchmark results to be reported by the applicant

Problem	Result	Benchmark	Software result	Difference (%)	Within ±5%?
3C-1	Q, main case (m³/s)	0.500			
3C-1	Q, part (b) (m³/s)	0.208			
3C-2	Tc (min)	26.27			
3C-3	Q, case (a), P = 100 mm (mm)	39.38			
3C-3	Q, case (b), P = 100 mm (mm)	64.93			
3C-3	Q, case (c), P = 100 mm (mm)	36.49			
3C-3	Q, case (c), P = 25 mm (mm)	1.97			
3C-4	Runoff, separate sub-areas (mm)	9.85			
3C-4	Runoff, composite CN (mm)	1.83			
3C-4	qp (m³/s per mm)	0.800			
3C-5	Peak outflow (m³/s)	0.172			
3C-5	Peak storage (m³)	859			

Annex 3D — Peak rate factor study for flat coastal land

Supports Clauses 3.11.5 and 3.15 of Chapter 3.

> **Not required in Punjab.** Punjab 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 waterlogged south-west, the bet lands of the rivers, the paddy plains and the land held behind canal banks and raised roads are flat but are not coastal plain; their slow response is represented by storage and backwater (Clauses 3.10.4 and 3.12, and rule (b) of the Commentary to Clause 3.7), 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) and zone 7, with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzone 1(e) (Upper Indo-Ganga Plains) and zone 7 (Western Himalayas), the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs the two CWC Flood Estimation Reports that cover Punjab, split at the Shivalik front: the Upper Indo-Ganga Plains subzone 1(e) report, approved at the 40th meeting of the Planning and Co-ordination Committee on 23–24 July 1984, whose design-office report number is not on the scanned copy read for this Manual [TBC], which "covers almost entire Haryana and Punjab" and here covers the plains and the Kandi piedmont, with Rupnagar on its boundary; and the Western Himalayas zone 7 report (No. WH/22/1994, November 1994), which names "parts of Punjab" and here covers Pathankot, Dhar Kalan, Sujanpur, Talwara, Nangal, Anandpur Sahib and the Shivalik hills of Hoshiarpur, Nawanshahr, Rupnagar and SAS Nagar (see the References of Chapter 3); with the 1(e) areal reduction rows for areas above 50 km² and its 24-hour time-distribution fractions, the zone 7 areal reduction factors for areas above 300 km² and for 24 hours, a cleaner copy of the zone 7 Plates 9 and 10 at Pathankot, whose Plate 10 is misregistered on the copy read, the loss rate of the zone 7 worked example, printed as 0.20 cm/h against the 0.5 cm/h the report recommends, and the boundary between the two reports at Dera Baba Nanak, Gurdaspur, Mukerian, Hoshiarpur, Anandpur Sahib and Rupnagar, read by eye from Plate 9 of the 1(e) report and still to be confirmed on the index maps of both reports [TBC], transcribed and checked against the published reports, and a catchment with physiographic parameters measured from survey or a DEM. Until it is published, take all SUH inputs directly from the applicable Flood Estimation Report (Clause 3.11.4(a)), apply the 24-hour design rainfall of Clauses 2.3.3(b) and 2.7.3 with the climate factor of Clause 2.8 (Clause 3.11.4(b)), report the SUH result alongside the HEC-HMS or SWMM result for the existing natural condition (Clause 3.11.4(c)), and, where the hydrograph model gives a lower 1% AEP peak, either justify it by calibration under Clause 3.15 or adopt the SUH peak (Clause 3.11.4(d)).

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

Parameter	Symbol	Unit	Subzone 1(e) (Upper Indo-Ganga Plains) relationship	Zone 7 (Western Himalayas) relationship
Peak discharge per unit area	qp	m³/s per km²	qp = 2.030 (L/√S)^−0.649	qp = 1.048 tp^−0.178
Time from centre of unit rainfall to peak	tp	h	tp = 1.858 qp^−1.038	tp = 2.498 (L·Lc/S)^0.156 (printed with S, not √S; see the note)
Width of UH at 50% of peak	W50	h	W50 = 2.217 qp^−0.990	W50 = 1.954 (L·Lc/S)^0.099
Width of UH at 75% of peak	W75	h	W75 = 1.477 qp^−0.876	W75 = 0.972 (L·Lc/S)^0.124
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.812 qp^−0.907	WR50 = 0.189 W50^1.769
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.606 qp^−0.791	WR75 = 0.419 W75^1.246

Parameter	Symbol	Unit	Subzone 1(e) (Upper Indo-Ganga Plains) relationship	Zone 7 (Western Himalayas) relationship
Base width of UH	TB	h	TB = 7.744 tp^0.779	TB = 7.845 tp^0.453
Unit duration	tr	h	2	1
Design storm duration	TD	h	TD = 1.1 tp, limited to 24 h	TD = 1.1 tp (it gave the highest peak on all the gauged catchments)
Design loss rate	—	mm/h	3.0 (printed "3.0 mm per hour" and, in the worked example, 0.3 cm/h)	5 (printed "0.5 cm/hr"; "Designers can modify this value as per local conditions"); the worked example uses 0.20 cm/h "as recommended in para 3.5", which conflicts with para 3.5 [TBC]
Design base flow	—	m^3/s per km^2	0.05 (the average of 126 flood events in the range 0.01–0.09)	0.05 (27 of 45 events in the range 0.00–0.10)
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	10-yr, partial duration: 1 h 0.425; 3 h 0.600; 6 h 0.725; 9 h 0.790; 12 h 0.845; 15 h 0.895; 18 h 0.935; 24 h 1.000
Time distribution of 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]	3-h storm 0.73, 0.92, 1.00; 6-h storm 0.52, 0.69, 0.82, 0.91, 0.97, 1.00; 12-h storm 0.34, 0.49, 0.60, 0.67, 0.74, 0.81, 0.86, 0.90, 0.94, 0.96, 0.98, 1.00; 24-h storm 0.17, 0.27, 0.36, 0.43, 0.48, 0.53, 0.58, 0.63, 0.67, 0.70, 0.73, 0.76, 0.79, 0.82, 0.84, 0.86, 0.88, 0.90, 0.92, 0.94, 0.96, 0.98, 0.99, 1.00
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	1.15
Areal reduction factor	ARF	—	Table 6 of the report; at 50 km^2, 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]; the worked example uses 0.765 for 12 hours at 1,126 km^2	Annex 4.2: 50 km^2, 0.940 at 1 h, 0.964 at 3 h, 0.977 at 6 h, 0.9825 at 12 h; 100 km^2, 0.890, 0.929, 0.954, 0.965; 200 km^2, 0.8075, 0.862, 0.898, 0.935; 300 km^2, 0.7425, 0.800, 0.862, 0.905; the 24-hour column and the rows above 300 km^2 not read [TBC]

Parameter	Symbol	Unit	Subzone 1(e) (Upper Indo-Ganga Plains) relationship	Zone 7 (Western Himalayas) relationship
50-yr 24-hour point rainfall at Punjab towns (100-yr in brackets)	—	mm	Plate 9 (Plate 10), read by eye within about one contour (interval 40 mm): SAS Nagar, Kharar and Zirakpur about 255–262 (280–289), beside the Chandigarh spot values of 262 (289); Hoshiarpur about 263, a spot value (280–292); Rupnagar, on the line, 240–260 (about 280); Ludhiana 240–255 (240–280), in a central cell of 240; Patiala and Rajpura about 240 (about 260); Gurdaspur, Batala and Kapurthala 240–260 (240–292); Amritsar and Tarn Taran about 220, between 200 and 240 (about 240); Sangrur and Sunam 220–240 (about 240); Ferozepur about 220 (about 240); Moga 200–240, of low confidence; Jalandhar about 200, inside a closed low loop of 180–220 (220–240, of low confidence); Fazilka and Sri Muktsar Sahib 160–180 (180–200); Bathinda and Abohar 150–160, inside a closed 160 cell with a spot value of 148 (about 180); Mansa 160–200 (180–200, of low confidence). Inside a closed low the value is the enclosing contour, never lower (Clause 2.3.6(c)). Bridge numbers printed beside crosses on the plates are not rainfall values	Plate 9 (Plate 10), read by eye: Pathankot and Dhar Kalan about 320, on a poorly registered plate (320 or more on Plate 10, which is offset by about 0.1–0.2° on the copy read and is not used) [TBC]; Nangal and Anandpur Sahib about 280; the zone 7 plate gives about 280–320 at Hoshiarpur, which lies in 1(e) and uses it only as a sensitivity check (Clause 2.3.6(b))
Gauged catchments in Punjab	—	—	Table 1 of the report, considered for the regression: the White Bein at bridge 20 on the Amritsar–Ludhiana line (2,426 km²; 1962, 1966, 1976–78); the Sunam Choe at bridge 181 on the Dhuri–Jakhal line (912 km²; 1963–66); the Patti Nalla at bridge 99(I) on the Jullundur–Amritsar line (297 km²; 1968–71); the Siswan at bridge 93(II) (141 km²; 1967–71) and the Sughrao at bridge 104(II) (105 km²; 1962–65), both on the Sirhind–Nangal Dam line and both Shivalik-foothill choes; and the Ghaggar at road bridge No. 2 on the border reach (1,126 km²; 1981–83), the worked example. Other Punjab bridge catchments in the table, among them the Kasur Nalla (743 km²), the Sareta drain, the Dhanaula drain, the Rahi–Beas, the Jassowal drain, the Nasrala and Kingerwala choes, the Dagru drain, the Kail Nala, the Budki Nadi and the Mudki drain, are listed but were not used, with remarks such as "floods unsuitable for U.G. analysis", "no floods" and "inadequate data"	2 of the 6 used: the Chakki Khad at bridge 232 on the Jalandhar–Pathankot line (657.86 km²; L 51.49 km, Lc 24.13 km, S 9.90 m/km; 1963–67), whose bridge is at Pathankot and whose catchment lies mainly in Kangra and Chamba in Himachal Pradesh; and a tributary printed as "Jhalum (Tri.)" at bridge 154 on the Sirhind–Nangal Dam line (43.82 km²; L 13.10 km, Lc 7.50 km, S 13.85 m/km; 1962–67)
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	25–1,000; not in snow-fed catchments
Report reference	—	—	§3.9 (p. 42), §§3.11–3.12 (p. 57), text table (p. 61), Fig. 12, Table 1, Table 6, §§6.1–6.3, Plates 9 and 10	§§3.3–3.6, Annexes 3.1 and 3.2, §4.4.2, Annexes 4.1 to 4.4, worked example, Plates 9 and 10

Note: relationships as printed in the two CWC reports that cover Punjab (References of Chapter 3), read from scanned copies and checked against the page images except where marked. L is the length of the main stream in km, Lc the length to the point nearest the catchment centroid in km, S the equivalent slope in m/km and A the catchment area in km². Subzone 1(e) relates the peak to L/√S and derives tp from qp; zone 7 relates tp to L·Lc/S, printed without the square root that most subzone reports use, and the printed equations reproduce the report's own unit hydrograph only in that form. Each column shall be used only in its own area. **Where each report applies.** Subzone 1(e) "covers almost entire Haryana and Punjab" and notes that "The plains in the Punjab State are flat with the exception of Hoshiarpur tract where the general elevation varies between 300 m to 400 m"; the zone 7 report names "parts of Punjab" among the States it covers, drew on rain-gauge data from five Punjab districts and self-recording gauges in three, and marks

Gurdaspur, Hoshiarpur and Rupar as "partly outside" the zone and Jullundar and Patiala as "fully outside". On Plate 9 of the 1(e) report, by NEER's reading within about 5–10 km, the boundary of zone 7 leaves the international border at Dera Baba Nanak, passes about 15 km north of Gurdaspur and north of Mukerian and Dasuya, about 0.25° north-east of Hoshiarpur and along the Shivalik front past Garhshankar and Balachaur, which are on the 1(e) side, then between Anandpur Sahib and Nangal, on the zone 7 side, and Rupnagar, which is on the line, and north-east of Chandigarh, keeping SAS Nagar, Kharar and Zirakpur in 1(e); Fazilka and Abohar are just inside 1(e), at most a sliver of the far south-west could fall in subzone 1(a), and subzone 1(f) does not reach the State [TBC]. Rupnagar reads both reports and takes the higher result, and a Kandi choe of 25 km² or more that rises in the Shivaliks is run with zone 7 as a sensitivity check (Clause 2.3.6(b)). **Subzone 1(e).** The report was derived from 23 gauged catchments (137 bridge-years), none urban. Its own worked example is the Ghaggar at road bridge No. 2 (30°24' N, 76°44' E), on the river's border reach near Ambala, below its course past Panchkula, SAS Nagar and Dera Bassi (by NEER's reading of the printed coordinates), 1,126 km² of "moderate steep slope", 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, the yardstick for the Ghaggar as it enters Patiala and Sangrur districts. The five Punjab catchments of the regression were gauged for only 4–8 years each, and the two Shivalik-foothill choes among them, the Siswan and the Sughrao, for 4–5 years, so the relationships rest lightly on the Kandi. In Punjab they apply to the rural streams of 25–2,500 km² that enter the towns: the Ghaggar above Patiala and Sangrur; the White, Kali and Chitti Beins; the Sunam choe; the Patti, Kasur and Hudiara nallahs; and the Kandi choes that enter Hoshiarpur, Garhshankar, Kharar and SAS Nagar, with the "suitable increase" for foothill catchments, which the designer shall state and justify. The Sutlej, Beas and Ravi, whose catchments in the report run to 25,540, 5,859 and 4,667 km² (the Ravi to the Sakki Nala), are regulated by dams and headworks and are outside the relationships; the river levels they set are tailwater under Chapter 5. **Zone 7.** The report rests on six catchments of 44–658 km², with 2–5 years of record each in 1962–67 and 45 flood events, all near the southern edge of the zone: about 1% of it. Two of the six are Punjab bridges, the Chakki Khad at Pathankot and the tributary at bridge 154. For these the printed relationships give L·Lc/S = 125.5, tp ≈ 5.3 h, qp ≈ 0.78 m³/s per km², TB ≈ 17 h and TD ≈ 5.8 h for the Chakki Khad, and L·Lc/S = 7.09, tp ≈ 3.4 h, qp ≈ 0.84 m³/s per km², TB ≈ 14 h and TD ≈ 3.7 h for the tributary at bridge 154 (NEER's computation; yardsticks, not design values). The report itself warns that a design flood computed from these relations is not to be used "without verifying the results on the basis of alternate methods". Its worked example, the Banu Khad at bridge 629 in Himachal Pradesh, prints tp = 2.5 h where its equations give about 3.05 h, and applies a loss of 0.20 cm/h where para 3.5 recommends 0.5 cm/h; this Manual uses 0.5 cm/h and reads tp from the equations [TBC]. In Punjab the zone 7 relationships apply to the Chakki Khad and the other khads that enter Pathankot, and to the Swan and the Sutlej tributaries of 25–1,000 km² at Nangal and Anandpur Sahib. **Both.** Where a city catchment lies within the range, the SUH is computed only as the benchmark of its natural condition (Clause 3.11.4), and the city itself is designed by the methods of Clause 3.4. The design loss rates of 3.0 and 5 mm/h are φ-indices fitted to the monsoon floods of whole rural catchments; they are 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 ratios are not to be used to derive intensities for durations shorter than the TD of the SUH without the short-storm floors of Clause 2.3.6(g): the 1(e) 1-hour ratio of 0.34 gives a 50-yr 1-hour depth of only about 82 mm at Patiala, where the recording gauge measured 93 mm in one hour on 21 July 1982, and the largest single-event ratios of the zone 7 report's Punjab recording gauges are 0.30 at Madhopur, 0.44 at Patiala and 0.59 at Hoshiarpur (NEER's arithmetic from Annex 4.4; at Madhopur and Patiala the largest hour and the largest day are different storms, so these are not event ratios in the strict sense).

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)

Step	Content	Clause
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 — Punjab 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 Punjab 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 — Punjab 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 — Punjab 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 waterlogged south-west of sub-area PB-F of Annex 2A (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda and Ferozepur), the land along the Rajasthan and Sirhind feeders, the Sirowal belt below the Kandi in sub-area PB-A, the bet (floodplain) lands of the Sutlej, Beas, Ravi and Ghaggar, and the beds and margins of chhappars, 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 (WRD, NRSC, Survey of India), the drains, dhussi bandhs, regulators and canals of WRD, its list of the drains, choes and rivers notified under section 38 of the Punjab Canal and Drainage Act 2023 or section 55 of the Northern India Canal and Drainage Act 1873 (393 of 869 by the WRD website, 514 of 935 as reported in November 2024 [TBC]), the floodplain zone of the Sutlej in Ferozepur and Tarn Taran districts notified on 4 March 2024, the Patiala ki Rao notification of 4 March 2013, the ponds of the pond-cleaning programme of the Department of Rural Development and Panchayats and the first census of water bodies, the boundaries of the six Ramsar sites, the areas notified under the Punjab Land Preservation (Chos) Act 1900, the land recorded as chhappar, toba, dhab, choe, rao, bein, nala or bet in the revenue records, town boundaries (DLG, HUD and its DTCP, PUDA, GMADA, GLADA and the other development authorities, and the Municipal Corporations, Municipal Councils and Nagar Panchayats), flood maps held by PSDMA, observation-well records of the CGWB and the WRD (or PWRDA), and the extent of the Kandi boulder–gravel fans and choe beds, the Shivalik slopes, the Sirowal belt, the bet lands of the rivers, the waterlogged and saline-sodic soils of the south-west, the sodic patches of the old alluvium of Patiala, Sangrur and Mansa, and the dune sands of the south-west from soil survey maps (NBSS&LUP, the Punjab Remote Sensing Centre (PRSC) or Punjab Agricultural University (PAU) [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, choe, bein, drain, canal or chhappar (Clause 4.12.1(b)). For the flotation check in the waterlogged south-west (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda), the Sirowal belt below the Kandi, and the bet (floodplain) lands of the Sutlej, Beas, Ravi and Ghaggar 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	South-west waterlogged belt (PB-F); land along the Rajasthan or Sirhind feeder; Sirowal belt (PB-A); bet land of the Sutlej, Beas, Ravi or Ghaggar; chhappar bed and margin; other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, SW monsoon season	m
shgw_basis	Wells or piezometers used, and period of record	text
tidal_influence	Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b))	yes / no
source	Source agency and date of the data	text
geometry	Zone boundary	polygon

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

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

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

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

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

4B.2 PSD and SSR (Table 4.3)

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
PB-Z1 Shivalik–Kandi: PB-A Shivalik foothills and Kandi (Pathankot–Talwara–Hoshiarpur–Garhshankar–Nangal–Anandpur Sahib–Rupnagar–Mullanpur)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
PB-Z2 Northern and central plains: PB-B Majha–Doaba north (Gurdaspur–Batala–Jalandhar–Kapurthala–Phagwara–Nawanshahr)	B / C / D	50% / 70% / 90%	—	—	—	—	—
PB-Z2 Northern and central plains: PB-C Central Sutlej–Ghaggar belt (Ludhiana–Khanna–SAS Nagar–Zirakpur–Rajpura–Patiala–Fatehgarh Sahib)	B / C / D	50% / 70% / 90%	—	—	—	—	—
PB-Z3 Western and Malwa plains: PB-D Majha west and the border (Amritsar–Tarn Taran–Patti–Ferozepur–Zira)	B / C / D	50% / 70% / 90%	—	—	—	—	—

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
PB-Z3 Western and Malwa plains: PB-E Malwa centre (Sangrur–Barnala–Malerkotla–Moga–Mansa)	B / C / D	50% / 70% / 90%	—	—	—	—	—
PB-Z4 South-west: PB-F South-west sands, waterlogging and salinity (Bathinda–Sri Muktsar Sahib–Malout–Fazilka–Abohar–Faridkot)	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
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 a choe in SAS Nagar (Mohali); they are not NIH-DHAARA values and must not be used for design. Part 1 sets out the inputs, hydrographs and routing step by step, for a trial outlet. Part 2 finds that the

trial outlet fails the drawdown check with the blockage of Clause 4.8.3, and revises it to the outlet reported in Table 4.2. Part 3 completes the spillway, outlet, safety and retention checks. The outfall-closed check of Chapter 5 for the same facility on an outfall to a choe draining to the Ghaggar in SAS Nagar (Mohali) is in Annex 5C.

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

4C.1 **Inputs.**

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

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

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

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

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

Duration (h)	1	2	3	6	12	24	48	72
50% AEP (2-yr)	30.9	40.7	47.9	63.2	83.4	110.0	137.5	154.0

Duration (h)	1	2	3	6	12	24	48	72
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 $\bar{O}$ is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: $\Delta S = 2{,}853.0 - 2{,}613.3 = 239.7$ m³, and $(1.0891 - (0.2655 + 0.3069)/2) \times 300 = 240.9$ m³.

Table 4C.7 — Routing of the 100-yr 72-hour storm through the trial outlet, around the peak (Illustrative — not design values)

Time (h:min)	Rainfall in step (mm)	Inflow I (L/s)	Outflow O (L/s)	Storage S (m³)	Stage h (m)
60:00	8.44	286.3	169.5	2,164.0	0.866
60:05	36.33	354.2	184.1	2,216.9	0.887
60:10	11.61	703.3	218.0	2,367.1	0.947
60:15	6.88	1,066.0	265.5	2,613.3	1.045
60:20	5.23	1,089.1	306.9	2,853.0	1.141
60:25	4.34	897.5	334.8	3,025.0	1.210
60:30	3.77	653.2	349.9	3,117.6	1.247
60:35	3.36	403.6	353.8	**3,132.9**	**1.253**
60:40	3.05	301.5	352.3	3,117.3	1.247
60:45	2.81	254.8	348.6	3,088.7	1.235
60:50	2.61	224.9	343.7	3,052.4	1.221
60:55	2.45	203.3	337.9	3,011.3	1.205

Storage is greatest at the end of the step ending at 60:35. In the next step the mean inflow (302 L/s) is below the outflow (about 352 L/s), so storage falls.

Table 4C.8 — Routing of the 100-yr 72-hour storm through the trial outlet, hourly (Illustrative — not design values)

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
12	35.0	14	8	0.130	325
24	70.0	15	12	0.215	536
36	105.0	16	14	0.264	660
48	140.0	16	15	0.294	736
54	181.7	47	19	0.469	1,172
57	213.5	69	23	0.623	1,559
59	248.5	120	91	0.789	1,971
60	293.3	286	170	0.866	2,164
61	378.0	187	332	1.187	2,967
62	399.3	106	237	0.968	2,421
63	414.5	80	142	0.829	2,072
66	446.9	51	52	0.771	1,927
72	489.5	33	33	0.768	1,920
84	489.5	0	18	0.405	1,012

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
96	489.5	0	10	0.167	418
108	489.5	0	4	0.058	146

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

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

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

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

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

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

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

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

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

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

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

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

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
0.085	213	8.8	0.0	8.8
0.17	425	17.6	0.0	17.6
0.30	750	28.0	0.0	28.0
0.40	1,000	33.9	0.0	33.9
0.50	1,250	38.9	0.0	38.9
0.60	1,500	43.3	0.0	43.3
0.70	1,750	47.3	0.0	47.3
0.76	1,900	49.6	0.0	49.6
0.80	2,000	51.0	88.3	139.3
0.90	2,250	54.5	165.3	219.7
1.00	2,500	57.7	216.4	274.1
1.10	2,750	60.8	257.5	318.3
1.17	2,925	62.8	282.8	345.6
1.20	3,000	63.7	293.0	356.7
1.30	3,250	66.5	324.6	391.1

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

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

Findings:

- **100-yr cap:** largest detained peak 343 L/s ≤ 356 L/s. Met.
- **2-yr cap:** largest detained peak 34 L/s ≤ 180 L/s. Met.
- **Drawdown:** longest blocked drawdown 45.3 h ≤ 48 h (Clause 4.7.1). Met.

- **Governing storage: 2,913 m³** (100-yr, 48 h), at a maximum stage of **1.17 m**. The larger low-flow orifice releases more water early in the long storms, so the revised outlet needs about 220 m³ less storage than the trial outlet. Table 4.2 in Clause 4.6.7 reports this revised design.
- **Governing storms (Clause 4.6.2, step 12):** storage, the 100-yr 48-hour storm; Stage 1, the 10-yr 24-hour storm (drawdown); Stage 2, the 100-yr 48-hour storm (cap).

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

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

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

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

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

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

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

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

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

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

Item	Requirement	Value	Result
Minimum orifice	≥ 50 mm (Clause 4.8.2)	170 mm	Met

Item	Requirement	Value	Result
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 a choe draining to the Ghaggar in SAS Nagar (Mohali) (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 — Punjab 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 Punjab 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 — Punjab 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 — Punjab Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for Tier B sites using Clause 4.14.2. It can be used only after Table 4.3 is published in Annex 4B; until then, Tier B sites use Clause 4.6 or, for sites of 1 ha or less, the fixed-coefficient route (Clauses 4.14.1 and 4.14.3).

A. Eligibility (Clause 4.14.1)

Table 4F.12 — Form 4-2: eligibility

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

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

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

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

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

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

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

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

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

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

E. Statement

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

Table 4F.16 — Form 4-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Punjab 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 — Punjab 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 — Punjab 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 Punjab. Punjab has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Punjab 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(g)).

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

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Annex 5B — Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map

Supports Clauses 5.2, 5.3, 5.8 and 5.13 of Chapter 5.

5B.1 Table 5B.1 lists the water bodies that Chapter 5 already names. It is not complete: the annex will add the extents of each reach, the other rivers, canals and mouths of the State, and a map.

Table 5B.1 — Water bodies named in Chapter 5

Water body	Region	Listed as	Clause
Sutlej from the Bhakra dam to the Ropar headworks	Nangal, Anandpur Sahib, Rupnagar	Riverine outfall reach below a dam; no CWC gauge; Bhakra releases included (permissible level 1,680 ft, technical limit 1,690 ft, as reported); flow of about 2.4 lakh cusecs at Ropar (1988) and 1.79 lakh cusecs (July 2023), as reported; gauge zero [TBC]; flood marks of 2019, 2023 and 2025 + 0.5 m; lock of at least 7 days	5.8.1, 5.8.3, 5.8.5
Sutlej from the Ropar headworks to Harike	Ludhiana, Phillaur, Shahkot	Riverine outfall reach behind dhussi bandhs; no CWC gauge; 10% AEP level not below the level for 3,00,000 cusecs at Harike, or the 1988 Ropar flow above Harike, routed; flood marks + 0.5 m; breaches of August 2019 (Janian Chahal, Gidderpindi, Mandala); lock of at least 7 days	5.8.1, 5.8.5
Sutlej from Harike to Hussainiwala and the border	Tarn Taran, Ferozepur	Riverine outfall reach; floodplain zone notified 4 March 2024 between the embankments; 100-year discharge 5,34,441 cusecs (WRD); Harike 3,35,030 cusecs, 686.50 ft u/s, and Hussainiwala 3,02,508 cusecs, 646.50 ft u/s, on 3 September 2025 (as reported); "High Flood" above 3,00,000 cusecs at Harike; gauge zeros [TBC]; lock of at least 7 days	5.8.1, 5.8.5
Beas from the Pong dam to Harike	Talwara, Mukerian, Kapurthala district	Riverine outfall reach below a dam; Pong releases included (largest about 1.49 lakh cusecs, 2023, as reported; FRL 1,390 ft, permissible 1,394 ft and technical limit 1,410 ft reported); lock of at least 7 days	5.8.1, 5.8.3, 5.8.5
Ravi below Ranjit Sagar, Shahpur Kandi and Madhopur	Pathankot, Gurdaspur, Dera Baba Nanak	Riverine outfall reach below dams; Ranjit Sagar FRL 527.91 m (also reported as 1,731 ft), Shahpur Kandi maximum 405 m; Ranjit Sagar releases of August 2025 conflict (about 1 lakh and 2.21 lakh cusecs reported), the higher applying; Madhopur gate failure of 27–28 August 2025 as a stress case; dhussi bandh breaches of 2025; border reach; lock of at least 7 days	5.8.1, 5.8.3, 5.8.5
Chakki Khad; Swan	Pathankot; Anandpur Sahib	Shivalik rivers; no gauge level found; bulked 1% AEP study; lock of at least 72 hours	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Ghaggar at Mubarakpur, Bhankharpur and Dera Bassi	SAS Nagar district (Dera Bassi, Zirakpur)	Riverine outfall reach; no CWC gauge; 1.22 lakh cusecs reported at Bhankharpur against a stated capacity of 70,000 cusecs; model inflow not below 2.40 $m^3/s/km^2$; Haryana's Panchkula floodplain zone upstream; lock of at least 72 hours	5.8.1, 5.8.5
Ghaggar below the Patiala district boundary	Patiala, Samana, Moonak, Khanauri, Makraud Sahib, Sardulgarh	Riverine outfall reach; no CWC gauge; Khanauri 753 ft (13 July 2023) and 754.2 ft (15 July 2023), danger mark reported as 748, 752 and 753 ft (conflict); Sarala Kalan danger about 16 ft; Sardulgarh danger 20 ft (all as reported); gauge zeros [TBC]; breaches of 1993, 2010 and 2023; Haryana reach downstream; lock of at least 7 days	5.8.1, 5.8.5
N-Choe, Sukhna Choe, Patiali-ki-Rao, Jayanti Devi ki Rao, Lakhnaur choe	SAS Nagar, Zirakpur, Kharar, New Chandigarh; Chandigarh (Supplement S01)	Choes to the Ghaggar; ungauged; bulked 1% AEP study and flood marks + 0.5 m; invert 0.5 m above the highest surveyed bed; Patiala ki Rao notified under section 55 (4 March 2013) with 200 ft pillars ordered (court-monitored); lock of at least 72 hours	5.8.1, 5.8.5
Badi Nadi and Chhoti Nadi	Patiala	Nadis to the Ghaggar; capacities not found [TBC]; lock of at least 72 hours, or that of the Ghaggar where it backs them up	5.8.5
Choes of the Kandi, among them those of Hoshiarpur, Garhshankar and Balachaur, and the Sirhind choe	Sub-area PB-A; Fatehgarh Sahib	Choes; "more than 100" in Hoshiarpur district; sand and silt; Sirhind choe passes under the Bhakra Main Line by a siphon; Clause 6.3.6 applies; lock of at least 72 hours	5.8.5
Buddha Nallah	Ludhiana	Major drain of WRD, 47.55 km, to the Sutlej at Walipur Kalan; 2-year rejuvenation design (PMIDC, 2020), not a bound; about 700 MLD of wastewater; width alleged reduced from 58 ft to 35 ft (OA 327/2025); level computed with the Sutlej at Walipur Kalan; drain lock, or the Sutlej lock where the river backs it up	5.2, 5.8.5
Tung Dhab and City Outfall drains; Hudiara drain	Amritsar	Major drains of WRD; the Hudiara drain enters Pakistan near village Lalo; level beyond the border outside Indian control; junction level from the Indian side; lock of at least 7 days	5.2, 5.8.5
Kala Sanghian drain, Chitti Bein, Kali Bein	Jalandhar, Kapurthala	Major drains and beins to the Sutlej and the Beas; flow-augmentation figures only, no flood capacity found [TBC]; Chitti Bein high flood level reported as "generally 12'" at the Chaheru railway bridge (Master Plan Jalandhar report)	5.2, 5.8.5
Sakki/Kiran, Patti and Kasur nallahs; Chand Bhan drain and diversion drain; other WRD and notified drains	Majha; the south-west	Major drains of WRD; design discharges not found [TBC]; drain lock of at least 72 hours	5.2, 5.8.5
Depressions, chhappars and pumped drains of the south-west	Sub-area PB-F (Bathinda, Sri Muktsar Sahib, Fazilka, Abohar, Faridkot)	No outfall or pumped outfall; 72-hour design volume; permanent pumps less the largest; pumping credited only under WRD's consent while the receiving drain is full; no infiltration credit where the October water table is within 3 m	5.8.5

Water body	Region	Listed as	Clause
Sirhind canal, Bhakra Main Line, Sirhind and Rajasthan feeders, SYL canal, Narwana branch, and the other canals, distributaries, minors and kassis of WRD	Punjab	Not drainage outfalls; WRD's written consent required; siphons and canal banks modelled as controls; SYL and Narwana branch breaches at Rajpura (2023); Hansi–Butana siphon at Samana	5.8.5
Drains of WRD, PUDA, GMADA, GLADA and the other development authorities, Municipal Corporations, Municipal Councils and Nagar Panchayats 1.0 m wide or more	Punjab	Major drains; owner's consent, design water level and flap gate	5.2, 5.8.5
Bhakra and Pong dams (BBMB); Ranjit Sagar and Shahpur Kandi dams; Ropar, Harike, Hussainiwala and Madhopur headworks; Kandi low dams	Himachal Pradesh (Bhakra, Pong); Pathankot district (Ranjit Sagar, Shahpur Kandi, Madhopur); Rupnagar, Tarn Taran and Ferozepur districts (Ropar, Harike, Hussainiwala); sub-area PB-A (low dams)	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 Punjab	Not applicable (Clause 5.1.4)	5.13.1

To be prepared. This annex will list and map (a) the major drains of each basin plan, (b) the riverine outfall reaches where backwater shall be modelled, with their upstream and downstream limits and the source of their design flood levels, and (c) the river mouths and creek inlets subject to seasonal sand-bar closure, with the most recent pre-monsoon bar crest levels and any WRD mouth-maintenance programme. It needs WRD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (WRD), the drain inventories of MC Ludhiana and other local bodies, basin stormwater master plans (Chapter 11), and base mapping from the Survey of India and NRSC. Until it is published: every river, WRD canal, the Buddha Nallah, the Tung Dhab and City Outfall drains and the Hudiara drain, the Kala Sanghian drain and the Chitti and Kali Beins, the Sakki/Kiran, Patti and Kasur nallahs, the Chand Bhan drain and its diversion drain, every choe, rao and nadi, every drain notified under section 38 of the Punjab Canal and Drainage Act 2023 or section 55 of the Northern India Canal and Drainage Act 1873, any drain of WRD, and any drain maintained by PUDA, GMADA, GLADA or another development authority, a Municipal Corporation, a Municipal Council or a Nagar Panchayat with an internal width of 1.0 m or more and every tidal creek is a major drain (Clause 5.2); the water bodies of Table 5B.1 are riverine outfall reaches (Clause 5.8.1); and the mouths of the coastal States' rivers (there is none in Punjab) are assumed closed at the start of the SW monsoon unless 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

Field	Content	Unit or format
reach_limits	Upstream and downstream limits of the reach	text
design_flood_level_source	WRD design or highest recorded flood level, or hydraulic model (Clause 5.8.2)	text
reservoir_release	Upstream reservoir or tank and its operating rule, where any (Clause 5.8.3)	text
bar_crest_level	Most recent pre-monsoon bar crest level, for mouths	m (Survey of India datum)
mouth_programme	WRD mouth-maintenance programme and certification (Clause 5.13.2)	text
source	Source agency and date	text
geometry	Line (drains and reaches) or point (mouths)	line / point

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Annex 5C — Worked example: outfall-closed check for a site on a choe draining to the Ghaggar in SAS Nagar (Mohali)

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 choe in SAS Nagar (Mohali), which runs on to the Ghaggar; the choe's level rises when it runs full of sand-laden water from the Shivaliks and when the Ghaggar 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 Punjab an outfall to a choe has a lock of at least 72 hours under Clause 5.8.5(e), an outfall to the Ghaggar below the Patiala district boundary or to the Sutlej, the Beas or the Ravi below the dams a single lock of at least 7 days under Clause 5.8.5(a) to (c), an outfall to a WRD drain that is full a drain lock of at least 72 hours under Clause 5.8.5(i), and a site with no defined outfall must hold the 72-hour design volume of Clause 5.8.5(g), 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 outfall invert is also set at least 0.5 m above the highest surveyed bed of the choe within 50 m downstream (Clause 5.8.5(e)). 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

Item	Value	Basis
Receiving drain during each lock window	Backs up above the site outlet invert, so the site cannot discharge	Illustrative input; Clause 5.10.3(b)
Flap gate on the site outlet	Set 0.15 m below the orifice inverts in the outlet chamber, so that outside the lock windows its opening head and head loss do not affect the orifice control	Illustrative input; to be confirmed from the certified curve (Clause 5.11.2)
Lock windows	Two of 6 h each, starts 12.4 h apart (semi-diurnal tide)	Clause 5.10.3(a)
Pumps	None	—

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

Lock windows (Clause 5.10.3)

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

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

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

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

Results

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

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

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

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

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

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

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

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

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
24	20	Open	18	0.18	445
28	39	Open	24	0.25	621
32	59	Open	32	0.36	906
34	85	Open	37	0.47	1,166
36	286	Closed	0	0.78	1,944
38	106	Closed	0	1.73	4,321
40	66	Closed	0	1.96	4,904
42	51	Open	529	1.79	4,472
44	42	Open	204	0.87	2,181
46	37	Open	49	0.74	1,854
48	33	Open	47	0.70	1,756
50	0	Closed	0	0.71	1,784
54	0	Closed	0	0.71	1,784
56	0	Open	43	0.58	1,459
60	0	Open	32	0.37	921
66	0	Open	16	0.16	397
72	0	Open	7	0.06	162

Assessment

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

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

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

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

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

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

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 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 waterlogged south-west (Sri Muktsar Sahib, Fazilka, Faridkot and the waterlogged parts of Bathinda), the Sirowal belt below the Kandi, and the bet (floodplain) lands of the Sutlej, Beas, Ravi and Ghaggar 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 — Punjab 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 chhappar, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or chhappar: 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. Rivers, the Hudiara drain, choes, canals, south-west depressions and WRD drains (Clause 5.8.5): for every level, the gauge, its unit (ft or m), its gauge zero and the levelled tie to the project datum and a Survey of India benchmark, with WRD's or BBMB's confirmation (no CWC level exists in Punjab); for a river outfall through a dhussi bandh, operator of each gate and pumping station identified, gate sills, bandh crest, installed capacity, operating levels and gate-closing level obtained; 1% AEP river level from a Gumbel 100-year flood and a model (not less than 5,34,441 cusecs on the Ferozepur–Tarn Taran reach of the Sutlej), and not below the surveyed 2019, 2023 and 2025 flood marks + 0.5 m; 10% AEP level not below the level for 3,00,000 cusecs at Harike (or the 1988 Ropar flow above Harike); on the Ghaggar, model inflow not below 2.40 $m^3/s/km^2$, level not below 754.2 ft at Khanauri + 0.5 m, 10% AEP level not below the highest reported danger mark (753 ft at Khanauri), and whether the level was coordinated through WRD with Haryana; drain behind the bandh routed with its whole catchment and present storage, permanent pumps only, not more than installed capacity less the largest pump, operable at the design river level; river lock of not less than 7 days (Sutlej, Beas and Ravi below the dams; Ghaggar below the Patiala district boundary; Hudiara drain) or 72 hours (upper Ghaggar, choes, Chakki Khad, Swan), covering the whole storm, and its source; gate-failure and breach checks; the design storm with the largest recorded release of the dam or headworks above (the higher of conflicting reports), placed before, during and after the storm; for a reservoir or pond outfall, the level used (Ranjit Sagar 527.91 m, Shahpur Kandi 405 m, Pong 1,410 ft, each + 0.5 m); the Madhopur 2025 stress case and its result; for the Buddha Nallah, its level with all inflows and dry-weather flow and the Sutlej at Walipur Kalan; for Amritsar, the junction level of the Tung Dhab and Hudiara drains; for a choe, the bulked 1% AEP study, crossings blocked, flood marks + 0.5 m, invert at least 0.5 m above the highest bed surveyed within 50 m downstream; for a canal, WRD's written consent (or none: no discharge), full supply level, permitted rate and flap gate, and every siphon, culvert and canal bank modelled as a control with the breach check; 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 depression or chhappar with and without the project and its starting level, and the overflow path traced to public land; for a pumped outfall, the pumping credited under WRD's consent while its drain is full, and no infiltration credit where the October water table is within 3 m; for a WRD or other drain, the owner's consent and permitted rate, design water level or computed level with all its inflows, present condition and narrowest section, the lowest reported capacity or width, proposed works not counted, and the drain lock of not less than 72 hours; WRD's consent, whether the outfall lies within limits notified under section 38 (or section 55), and the court and plan lines checked (Clause 5.8.5)	

G. Joint cases (Clause 5.9; Clause 5.14, item 6)

Table 5F.8 — Form 5-1: joint-case results

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
J1				
J2				
J3				
J4				
R1				
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 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 Punjab 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 — Punjab Stormwater Design Manual, Draft v1.0.

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — Punjab 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, MC Ludhiana, PSDMA, 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 — Punjab 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 Punjab 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 Punjab streets (kerb-opening, grate and combination inlets, including the road-level wall opening into a covered drain) and, for each type, capacity curves on grade and in a sag. It needs a fixed set of standard inlet geometries agreed with the road-owning agencies, and rating tests of those geometries (laboratory or full-scale), or HEC-22 calculations for each geometry checked against tests (data and likely sources: Public Works Department (Buildings and Roads) (PWD B&R), NHAI and Municipal Corporation Ludhiana standard details, the Water Resources Laboratory of the Department of Civil Engineering, Thapar Institute of Engineering and Technology, Patiala or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

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

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

Item	Requirement	Clause
Grate pattern	Openings parallel to the direction of travel not wider than 25 mm	9.11.3(a)
Load class	D400 in carriageways and medians; C250 within 0.5 m of the kerb; B125 in footpaths and cycle tracks (or the equivalent IS class)	9.11.2
Connection pipe	At least 300 mm diameter; gradient giving at least 0.9 m/s at the inlet's design flow	6.6.6
Silt sump	At least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7, 9.11.6

The intended layout of the annex is given in Tables 6A.2 to 6A.4.

Table 6A.2 — Register of standard inlet types (layout)

Type code	Description	Grate size or kerb opening (mm)	Gutter depression (mm)	Load class	Standard drawing
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6A.3 — Capacity on grade (layout; one table per inlet type)

Cross slope Sx (m/m)	Longitudinal slope SL (m/m)	Gutter flow Q (L/s)	Spread T (m)	Clean intercepted flow (L/s)	Design intercepted flow after clogging (L/s)	Bypass flow (L/s)
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Table 6A.4 — Capacity in a sag (layout; one table per inlet type)

Ponded depth at the inlet (mm)	Clean capacity (L/s)	Clogging factor (Table 6.5)	Design capacity (L/s)	Flow regime (weir, orifice or transition)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Annex 6B — Sediment yield for silt-trap sizing and calibration of the sediment allowance

Supports Clauses 6.7.4, 6.7.8, 6.13.3 and 6.13.10 of Chapter 6.

To be prepared. This annex will contain sediment yields for urban drains in Punjab, 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 Ludhiana and other urban local bodies, WRD records for channels, land cover from NRSC, soils from the Punjab 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.

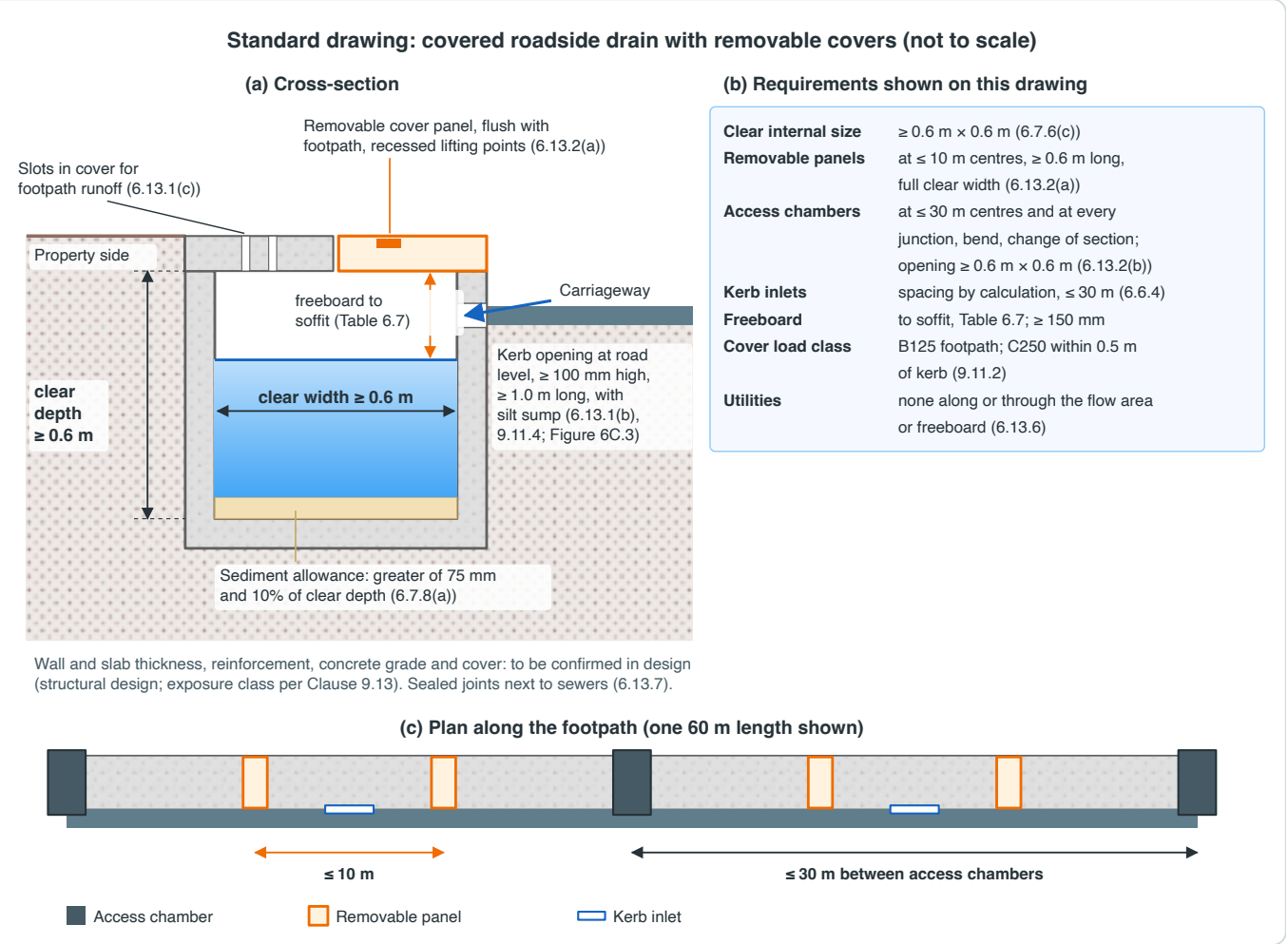

Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

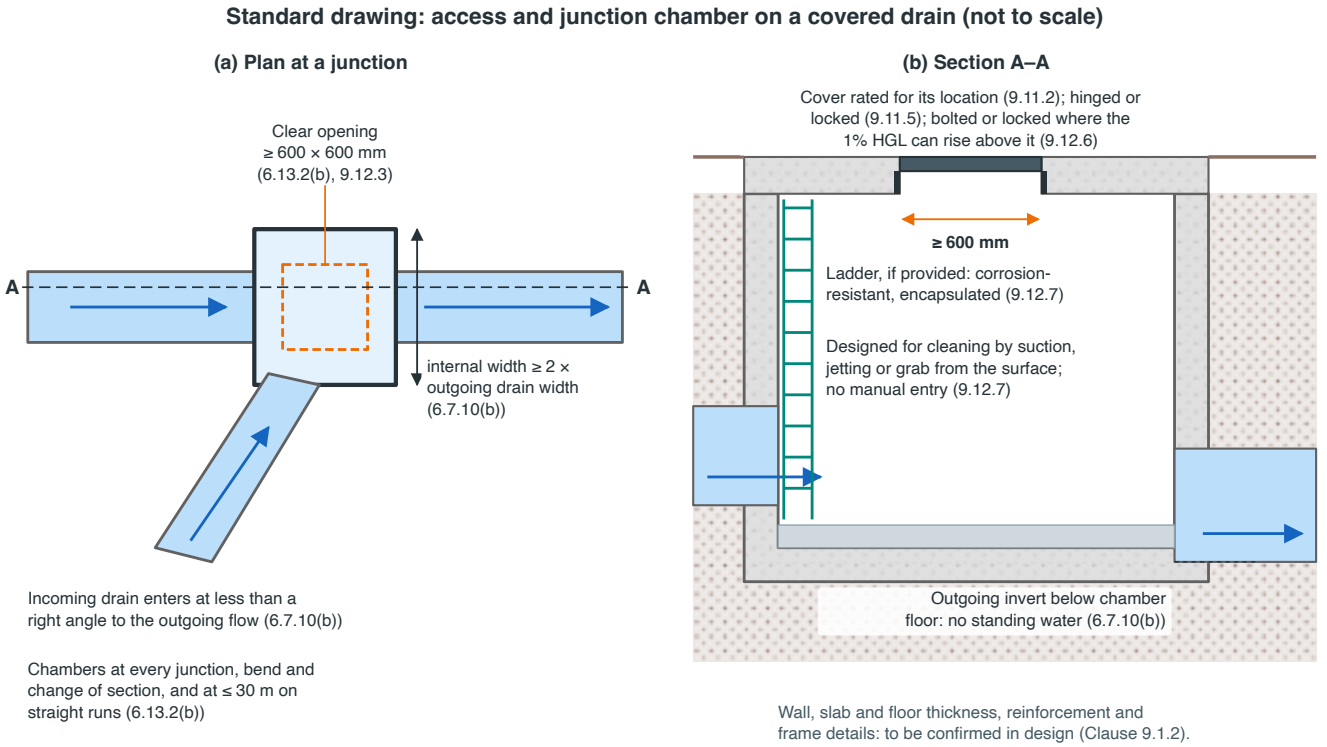

Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

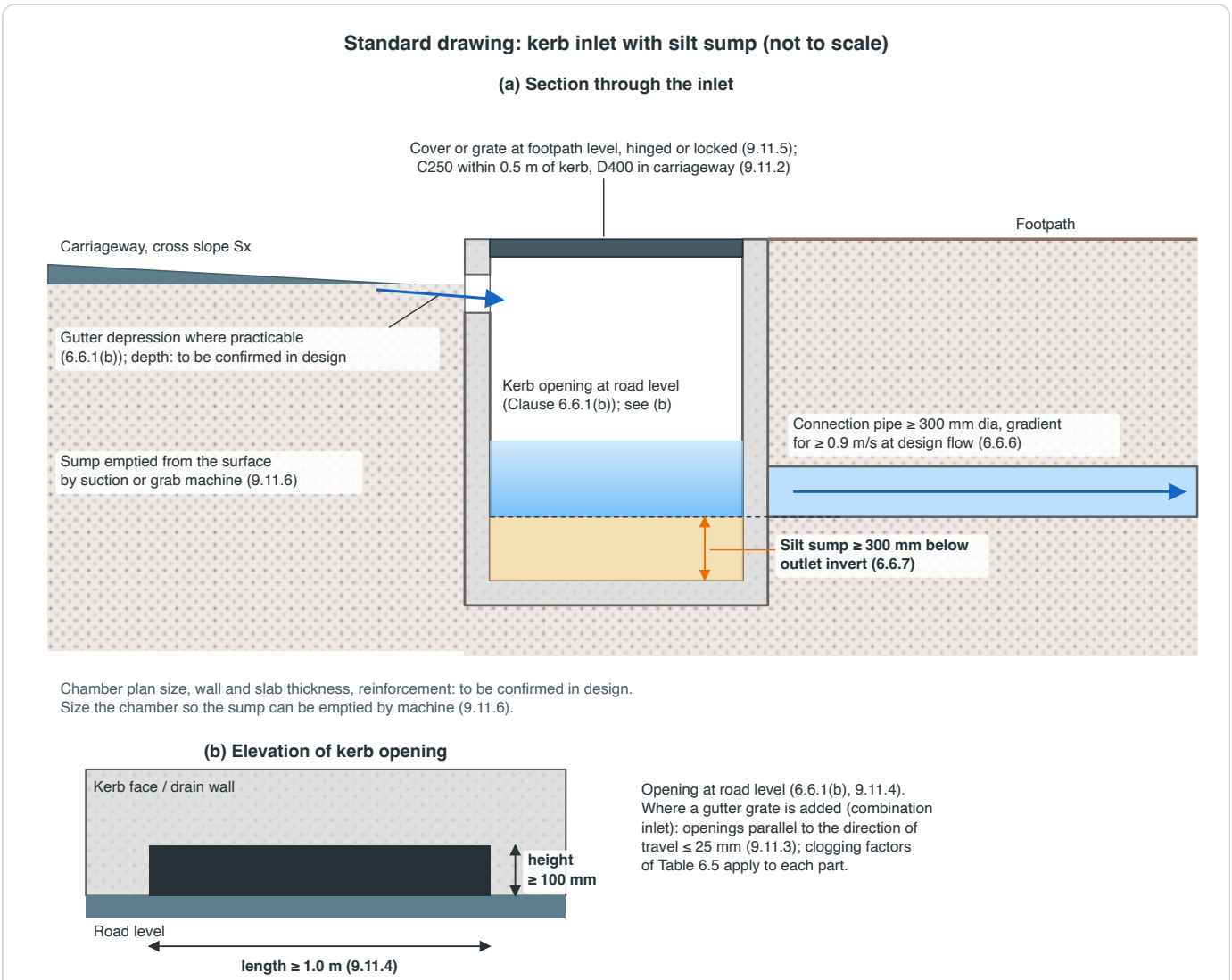

Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th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

ANNEXES TO CHAPTER 7

Waterbodies, Chhappars (Village 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 Punjabi 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 WRD and the Department of Revenue, Rehabilitation and Disaster Management. It needs the Revenue records and khasra maps of the Department of Revenue, Rehabilitation and Disaster Management, in which village ponds stand on shamlat land (the common land of the village under the Punjab Village Common Lands (Regulation) Act, 1961) and ponds, choes, nalas and bet parcels are entered under their local names (the entries used for chhappars, tobas and dhabs were not checked for this Manual [TBC]); the pond lists of the Department of Rural Development and Panchayats for its programme for some 15,000 chhappars, and the first census of water bodies, which counted 16,012 in Punjab, 1,578 of them encroached (both as reported); WRD's list of drains notified under section 55 of the Northern India Canal and Drainage Act, 1873 or section 38 of the Punjab Canal and Drainage Act, 2023 (393 of 869 drains, choes and rivers on WRD's page; 514 of 935 as reported in November 2024; the counts differ and no list was found [TBC]) and its notifications, such as those for the Patiala ki Rao (4 March 2013) and the Sutlej floodplain in Ferozepur and Tarn Taran (4 March 2024); the alignments of WRD's dhussi bandhs, canals and minors; the drains, green belts and waterbodies shown in master plans and plan reports, such as the Ludhiana Master Plan (2007–2031) and the Master Plan Jalandhar report (Vision 2031), and in the layouts of PUDA and the development authorities; the boundaries of the six Ramsar sites and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was confirmed for this Manual), with the 72 water bodies recommended for notification in September 2025; the areas of the Kandi notified under the Punjab Land Preservation Act, 1900; and the wetlands of the national atlas; the 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 WRD records, with local name	7.3.1(a)
WB_NAME_PA	Text	Punjabi script	Yes	Name in Punjabi	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	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)

Field	Type	Unit / domain	Required	Content	Clause
CATCH_AREA	Number	ha	Channels	Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1)	7.4.1
DATUM	Text	—	Yes	Datum of all levels; conversion from any older WRD datum	7.3.5
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, rao); bein; natural drain or nala; WRD drain (notified or not); canal, distributary, minor or kassi; pond (chhappar, toba); dhab or natural depression or lake; marsh or wetland; bet land; Kandi low-dam or check-dam pondage; abandoned borrow or mining pit; supply channel (feeder inlet, khal); surplus course	7.2
CUSTODIAN	WRD Drainage (division; s. 38 or s. 55 reach; dhussi bandh); WRD canals; WRD Kandi Area Development (low dam); Municipal Corporation, Municipal Council or Nagar Panchayat; PUDA, GMADA, GLADA or other development authority (scheme); Gram Panchayat (chhappar, shamlat); Department of Soil and Water Conservation (check dam); Forests and Wildlife or Punjab State Wetlands Authority (Ramsar site, reserve, notified wetland); BBMB; 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

Field	Type	Unit	Content	Clause
CONDITION	Code	Serviceable / defective	Result of the latest pre-monsoon inspection, with date	7.7.1(d), 7.14.4

Annex 7B — Fixed-width setback table (alternative S-3, with Annex 1C)

Supports Clauses 7.3.4, 7.4.3, 7.4.6 and 7.4.7 of Chapter 7, and alternative S-3 of the Policy Supplement (Annex 1C).

7B.1 When the table may be used

The fixed-width setback may be used only where all of the following apply:

- (a) the Authority has not adopted a 1% AEP flood extent map for the waterbody (Clause 7.3.4);
- (b) Clause 7.3.4 does not require the Applicant to determine the 1% AEP extent by a hydraulic study: the site is not in a flood-sensitive catchment, is not a site of 1 ha or more adjoining a waterbody, and the Authority has not asked for a study; and
- (c) the waterbody is one to which setbacks apply (Clause 7.4.1): any recorded or found waterbody, and any natural channel draining 8 ha or more at the site.

Where an Authority adopts alternative S-3 under Clause 1.7, the table below is the S-3 table. Clause 1.7.3(e) provides for the S-3 table to be issued by the State Stormwater Technical Committee. Until it is issued, the values are those of Clause 7.4.6, repeated here without change.

Table 7B.1 — Fixed-width setback by waterbody class (alternative S-3)

Waterbody class	Drainage area at the site	Total setback (Zone 1 + Zone 2)	Of which Zone 1	Measured from
Channel, small	8 ha to 65 ha	25 m	15 m	Top of bank (Clause 7.4.3)
Channel, medium	65 ha to 20 km²	40 m	15 m	Top of bank
Channel, large, and rivers	More than 20 km²	50 m	20 m	Top of bank
Tank, lake or pond	Any	MWL contour + 25 m	To the MWL contour, and not less than 15 m from FTL	FTL contour (Zone 1); MWL contour (total)
Marsh, estuary or backwater	Any	As notified by the Authority, and not less than 50 m	15 m	The waterbody boundary of Clause 7.13.1

Values from Clause 7.4.6 (Table 7.1). Zone 2 is the total setback less Zone 1.

7B.2 Rules of application

- (a) **Measurement.** Measure horizontally on plan, outward from the boundary of Clause 7.13.1: the larger of the Revenue record boundary and the surveyed FTL (or top of bank). Where FTL and top of bank both apply, use whichever gives the wider zone (Clause 7.4.3).
- (b) **Drainage area.** For a channel, use the drainage area at the downstream end of the reach that adjoins the site. Where a reach crosses a class limit within the site, apply the wider setback to the whole reach within the site.
- (c) **Both banks.** The setback applies on each bank of a channel and all round a tank, lake, pond or marsh.
- (d) **Minimum set by this Manual.** Zone 1 is never less than 15 m (Clause 7.4.7). A wider statutory or approval setback governs for the uses it restricts (Clause 7.4.5).

- (e) **Stricter of the two.** Where a hydraulic study is made voluntarily, the setback is the wider of Table 7B.1 and Clauses 7.4.3 and 7.4.4.
- (f) **Record.** The basis of the setback (fixed width) shall be stated on the Waterbody Sheet (Form 7-1) and in the approval (Clause 7.4, Disclosure).
- (g) **Review.** The table shall be reviewed within 2 years of the Authority adopting 1% AEP flood maps (Clause 7.16.1).

7B.3 Source of the channel widths

The channel widths were set by this Manual with reference to the 2006 Kansas City APWA default stream buffers, rounded up and floored at the 15 m minimum (Clause 7.4.6, commentary). The source values, as cited in the chapter, are:

Table 7B.2 — Source buffers cited in Clause 7.4.6 (KC APWA 5600, 2006, §5605.3)

Drainage area (source, acres)	Approximate SI equivalent	Source buffer
Less than 40 ac	Less than 16 ha	40 ft (12 m)
40–160 ac	16–65 ha	60 ft (18 m)
160–5,000 ac	65 ha – 20 km²	100 ft (30 m)
More than 5,000 ac	More than 20 km²	120 ft (37 m)

The 65 ha and 20 km² class limits in Table 7B.1 are the SI equivalents of 160 ac and 5,000 ac. The 8 ha lower limit is the 20-acre trigger of APWA 2025.01 (Clause 7.4.1(b)).

Annex 7C — Template tank operating rule, with flood cushion

Supports Clauses 7.7.1(c), 7.7.3, 7.8 and 7.14.4 of Chapter 7.

Model text for consideration by a competent authority. Not in force. For tanks under WRD control, the operating rule is WRD's rule (Clause 7.8.4); this template sets out the content that Clause 7.8 asks for, so that the custodian's rule can be checked against it. Text in square brackets is to be completed for each tank.

7C.1 Identification

1. Tank: [name, WB_ID of Annex 7A, village, tehsil, district].
2. Custodian: [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
[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 PSDMA red alert	IMD, PSDMA	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 15 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the SW monsoon, records shall be kept [weekly].
23. Records shall be kept with the O&M plan (Chapter 10) and given to the Authority on request.
24. The tank shall be inspected before the SW monsoon (by 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 Punjab Pollution Control Board (PPCB) 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 Punjab Pollution Control Board (PPCB) 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 Punjabi waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Punjabi words for waterbodies, streams, drains and riverine land as used in Punjab, given in Gurmukhi, the script of Punjabi, and in Roman letters. Many of them appear in place, stream and drain names (the Kali Bein, the Patiala ki Rao, the N-Choe, the Buddha Nallah, Sidhwan Bet). The name used in the Revenue, panchayat, 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 Bhai Maya Singh, *The Panjabi Dictionary* (1895), or in J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884), both as served by the Digital South Asia Library, or in a statute or official document, are listed in Tables 7E.1 to 7E.3; the meanings are the dictionaries' English glosses, with the page shown by the Digital South Asia Library, and modern usage may be narrower or wider. Maya Singh prints his headwords in the Gurmukhi spelling of 1895, which often differs from the modern spelling; the modern spelling is given first, and the 1895 spelling only where it was recorded. **Bhai Kahn Singh Nabha's *Mahan Kosh* and the Punjabi University's Punjabi–English Dictionary were not consulted for this Manual**, so the administrative terms dhussi bandh and kandi, the hydrogeological term Sirowal, and the Revenue entries for ponds 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, panchayat, WRD and municipal usage and with those dictionaries.

The Manual's term for a tank or pond in Punjab is **chhappar (ਛੱਪੜ)**, with **toba (ਟੋਭਾ)** as its synonym, and on first use in each chapter it is written "chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond)": chhappar is the everyday word for the village pond across the State and the word of the State's own pond programme (some 15,000 "chappars", as reported); Maya Singh glosses it "A pond; a puddle", which fits the shallow, often sullage-fed village ponds that this Manual designs for and restores; and toba, equally well sourced, is common in Malwa, so that naming both avoids a regional bias. Two cautions apply. In Roman letters chhappar is spelt like ਛੱਪਰ (1895: ਛਪੱਰ), "A thatched roof", and Platts, a dictionary of Urdu and Hindi, has only the thatch sense, so the Gurmukhi is always printed at first use; and toba (ਟੋਭਾ) is not ਤੋਬਾ, *tobá*, "repentance". Dhab, choe, rao, bein, nala, khal, kassi and bet keep their own meanings. The word *sua*, used colloquially for a small canal, is omitted: Maya Singh gives ਸੂਆ only as "A large needle", with no canal sense.

Table 7E.1 — Waterbodies

Term	Meaning	Source of the term	Manual term (Clause 7.2)
ਛੱਪੜ (chhappar; 1895: ਛਪੱੜ *chhappaṛ*)	"A pond; a puddle". Distinct from ਛੱਪਰ (1895: ਛਪੱਰ), "A thatched roof" (same page). Platts gives ਛਪ੍ਪੜ *ćhappaṛ* only as an incorrect form of *ćhappar*, thatch, with no pond sense (p. 458)	Maya Singh, p. 218; the State's pond programme (as reported)	Chhappar (tank or pond), see the definitions after Clause 7.2
ਟੋਭਾ (toba; *ṭobhā*)	"An unwalled tank, a pond, a pool; a diver". Not ਤੋਬਾ *tobá*, "repentance" (same page)	Maya Singh, p. 1144	Chhappar (tank or pond); the synonym, common in Malwa
ਢਾਬ (dhab; *ḍhāb*)	"An unwalled tank or pond, a natural pool, a lake, a deep depression in the earth"	Maya Singh, p. 288	Lake or natural depression; a wetland under Clause 7.12 where listed there; a recorded chhappar where recorded

Table 7E.2 — Streams, channels and riverine land

Term	Meaning	Source of the term	Manual term (Clause 7.2)
ਚੋ (cho; choe)	"A creek, a rivulet …;—(K.) A water-fall in low hills, the bed of a torrent"	Maya Singh, p. 240	River or seasonal stream; the seasonal torrents of the Kandi and the Shivalik foothills, such as the choes of Hoshiarpur district, the N-Choe and the Lakhnaur choe (definitions after Clause 7.2)
ਰੌ (rau; rao)	"A small stream from the mountains, the dry bed of such a stream;— The course or flowing of a river"	Maya Singh, p. 961	River or seasonal stream, such as the Patiala ki Rao
ਬੇਈਂ (bein)	"An irregular stream with a clay bottom, having the appearance of a canal"	Maya Singh, p. 111	River or seasonal stream, such as the Kali (Holy) Bein, the Chitti (East) Bein and the Black Bein (Kala Sanghian drain)
ਨਾਲਾ (nala; nallah, nullah)	"A brook, a rivulet"; ਨਲਾ *nalá*, "A stream, a brook" (same page)	Maya Singh, p. 797	Natural drain or nala. In Punjab the word covers both natural streams and large engineered or sewage-laden drains (the Buddha Nallah, the Sakki/Kiran nallah); the definition, not the word, decides which this chapter applies to
ਖਾਲ (khal)	"A drain, an acqueduct, a gutter, an inlet, a hollow or cutting big or little made by water; a groove"	Maya Singh, p. 579	Field channel or watercourse; a supply channel or flow path of a chhappar where it feeds one
ਕੱਸੀ (kassi)	"(M.) A small distributary channel from a canal"	Maya Singh, p. 565	Canal distributary; **not a storm drain** and not a receiving water (Chapter 5)
ਬੇਟ (bet; *beṭ*)	"Low, alluvial lands, or islands in the bed of rivers"	Maya Singh, p. 114	Floodplain land; within the 1% AEP extent until a study shows otherwise (definitions after Clause 7.2)

Table 7E.3 — Statutory and official terms

Term	Meaning
drainage work (Canal and Drainage Act)	Excludes the "removal of sewage from towns, villages or any other habitat by whatever name it is known" (Punjab Canal and Drainage Act, 2023, s. 2(7)); a river, stream or drainage channel within limits notified under s. 38 "shall be held to be a drainage-work as defined in section 2" (s. 38; s. 55 of the Northern India Canal and Drainage Act, 1873, before it)
canal (Canal and Drainage Act)	Includes "all parts of a river, stream, lake or natural collection of water or natural drainage channel, to which the State Government has applied the provisions of Part II", "all field drains", and "all drains, works, embankments and structures, connected with drains, maintained or controlled by the State Government" (s. 2(1)(d), (e) and (g)). The statutory word is wider than the Manual's "canal", which means only a channel that carries irrigation water

Term	Meaning
floodplain zone (WRD)	The area of waterway corresponding to the 100-year flood, found by Gumbel's method and Lacey's formula and notified under the drainage law, "in which no construction is to be allowed" (Chief Engineer, Drainage-cum-Mining & Geology, to the CWC, 2 May 2024); declared on the Sutlej in Ferozepur and Tarn Taran districts on 4 March 2024 as the land between the embankments
shamlat	The common land of a village, on which village ponds stand, regulated by the Punjab Village Common Lands (Regulation) Act, 1961 (not read for this Manual); protected as commons in *Jagpal Singh v. State of Punjab* (Supreme Court, 2011, as reported)
notified area (Land Preservation Act)	An area notified under s. 3 of the Punjab Land Preservation Act, 1900, in which the State may regulate, restrict or prohibit clearing, quarrying, cultivation and the cutting of trees (s. 4) (as cited; the Punjab text was not read)
wetland (Wetlands Rules)	A wetland notified under rule 7 of the Wetlands (Conservation and Management) Rules, 2017; none in Punjab was found notified, and 72 water bodies were recommended for notification in September 2025 (as reported)

Table 7E.4 — Terms not yet verified

The following terms are in use for Punjab's waterbodies and land, but their meaning or regional use was not confirmed in Maya Singh, Platts or a statute 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
dhussi bandh (dhussi bundh)	WRD's flood embankment along a river (about 1,365 km by one count, as reported)	Administrative term with **no dictionary match**: Maya Singh has ਧੁੱਸ *dhuss*, "Rushing head foremost" (p. 317), and ਬਨ੍ਹਾ *banná*, "earth thrown up into a ridge to form a boundary" (p. 94); Platts has *dhussā*, "coarse woollen stuff" (p. 544). No Gurmukhi spelling is printed. Used in this Manual with its gloss, as a flood embankment (Clause 7.14)
kandi	The foothill belt of boulder-gravel fans below the Shivalik hills (WRD's Kandi Area Development; CGWB)	Administrative term with **no hydrological match**: Maya Singh has ਕਾਂਦੀ *káṇdí*, "Side, part, margin, shore" (p. 546), and ਕੰਡੀ *kaṇḍí*, "small scales … basket" (p. 547). No Gurmukhi spelling is printed. Used with its gloss (definitions after Clause 7.2)
Sirowal	The belt below the Kandi where the fans give way to the alluvial plain, with a shallow water table and seepage (CGWB)	A hydrogeological term of the CGWB, not checked in a dictionary. Used with its gloss
Revenue entries for ponds	The names under which chhappars, tobas and dhabs are entered in the khasra and other Revenue records	Not checked for this Manual [TBC]; land so recorded is shown on the Waterbody Sheet (Form 7-1) and treated as a waterbody under Clause 7.3
Modern and regional forms	The modern and regional forms of the terms of Tables 7E.1 and 7E.2, and the local words for a chhappar's rim, spill point and feeder inlets	Not checked in the *Mahan Kosh* or a modern dictionary

Form 7-1 — Waterbody Sheet

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

Draft form — Punjab 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 Punjabi) 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 (shamlat; chhappar, toba, dhab; choe, nala, bet), Rural Development and Panchayats pond lists, water-bodies census, WRD notified-drain list and s. 38 / s. 55 notifications, dhussi bandh and canal alignments, master plans and authority layouts, Ramsar and wetland boundaries, PLPA areas □; 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 WRD datum	_____	7.3.5

Table 7F.2 — Form 7-1, Section B: Levels and features

No.	Field	Entry	Clause
B1	FTL (tanks, lakes, ponds) or top of bank (channels), m	_____	7.2
B2	MWL (tanks), m, and basis (WRD record or 1% AEP computed)	_____	7.2
B3	TBL, lowest point (tanks), m	_____	7.3.1(d)
B4	1% AEP flood level, m, and source (adopted map / hydraulic study / not available)	_____	7.3.4
B5	Drainage area at the site (channels), ha	_____	7.4.1(b)
B6	Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no)	_____	7.3.2
B7	Known encroachments, with date recorded	_____	7.3.1(g)

Table 7F.3 — Form 7-1, Section C: Setback

No.	Field	Entry	Clause
C1	Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B)	_____	7.15(1)
C2	Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)?	_____	7.3.4
C3	Floodway outer edge, m from FTL or top of bank, and how delineated	_____	7.6.1
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3

No.	Field	Entry	Clause
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider statutory, court, plan or approval line: limits notified under s. 38 of the Punjab Canal and Drainage Act, 2023 (or s. 55 of the 1873 Act), such as the Patiala ki Rao (2013) or the Sutlej floodplain in Ferozepur and Tarn Taran (2024); a court-fixed width, such as the 200 ft of the Patiala ki Rao; a master-plan buffer in force; 50 m from the mean high flood level of a notified wetland; a Ramsar site boundary; a WRD drain, dhussi bandh 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 — Punjab 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; 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 — Punjab 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 Punjab 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 Punjab 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 — Punjab 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 Punjab, 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

No Punjab source on planting for stormwater BMPs was found during research for this Manual, and none of the sources read names the native species to be used in bioretention, swales, filter strips or constructed wetlands in the State. This annex therefore lists **no species** for Punjab, and gives no Punjabi plant names, rather than carry over lists drawn up for other States or invent local names. Until the State Stormwater Technical Committee issues lists, the species for each BMP shall be chosen, and recorded on the BMP design sheet, by a horticulturist or the Forests department for the site's sub-area of Annex 2A, its soil, its salinity and its water table, under the following rules (set by this Manual):

- (a) **Native or long naturalised species only**, as the Forests department or a horticulturist confirms for the site; no species named in Table 8D.15 or otherwise known to be invasive in the State.
- (b) **Dry and wet ground.** In the dry south-west (sub-area PB-F) and on the dune sands, species that survive long droughts on sand with no irrigation once established; on the saline and sodic ground of the south-west and of the old alluvium between Patiala, Sangrur and Mansa, and in the Sirowal and on the bet lands where the water table is within 3 m, species tolerant of salt and of standing water; on the Kandi fans (PB-A), species tolerant of dry, stony ground, chosen first on the banks of choes and on cut slopes to bind the soil.
- (c) **Not in the waterway.** No planting in the bed or on the banks of a river, choe, rao, bein or WRD drain, on a dhussi bandh or on a canal bank, without WRD's consent, and none that would obstruct the flow of a channel, a siphon or the outlet of a chhappar.
- (d) **Not in the waterbodies.** No planting under this annex in a chhappar (ਛੱਪੜ; toba ਟੋਭਾ; pond), dhab, Kandi low-dam pondage or wetland, whose vegetation is managed by its custodian under Chapter 7, nor in a Ramsar site or notified wetland without the Punjab State Wetlands Authority's permission where its rules require it.

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

Use	Botanical name	Local name	Notes
All BMPs of Clause 8.7	None listed for Punjab in this draft	—	Chosen under rules (a) to (d) above and recorded on the BMP design sheet (Annex 8D)

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

Zone	Botanical name	Local name	Notes
All zones	None listed for Punjab in this draft	—	Chosen under rules (a) to (d) above; constructed wetlands are built outside the waterspread of any natural waterbody (Clause 8.7.9(e)), and are rarely practical in the dry south-west (Clause 8.7.8)

Table 8D.15 — Species not to be planted

Botanical name	Local name	Reason
Any species the Forests department lists as invasive in Punjab	—	No list of invasive species for Punjab was read for this Manual [TBC]

Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

Table 8E.1 — Selection of measures (Clause 8.12.3)

Situation	Measure	Detail
Sheet flow leaving a disturbed area, along its downslope edge	Silt fence	Figure 8E.1
Concentrated flow from a disturbed area of up to 2 ha	Sediment trap	Figure 8E.2
Disturbed area of more than 2 ha	Sediment basin with surface dewatering outlet	Figure 8E.2
Existing drain inlet receiving site runoff	Inlet protection	Figure 8E.4
Vehicle exit to a public road	Stabilised construction exit, with wheel washing	Figure 8E.3
Stockpiles	Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the 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

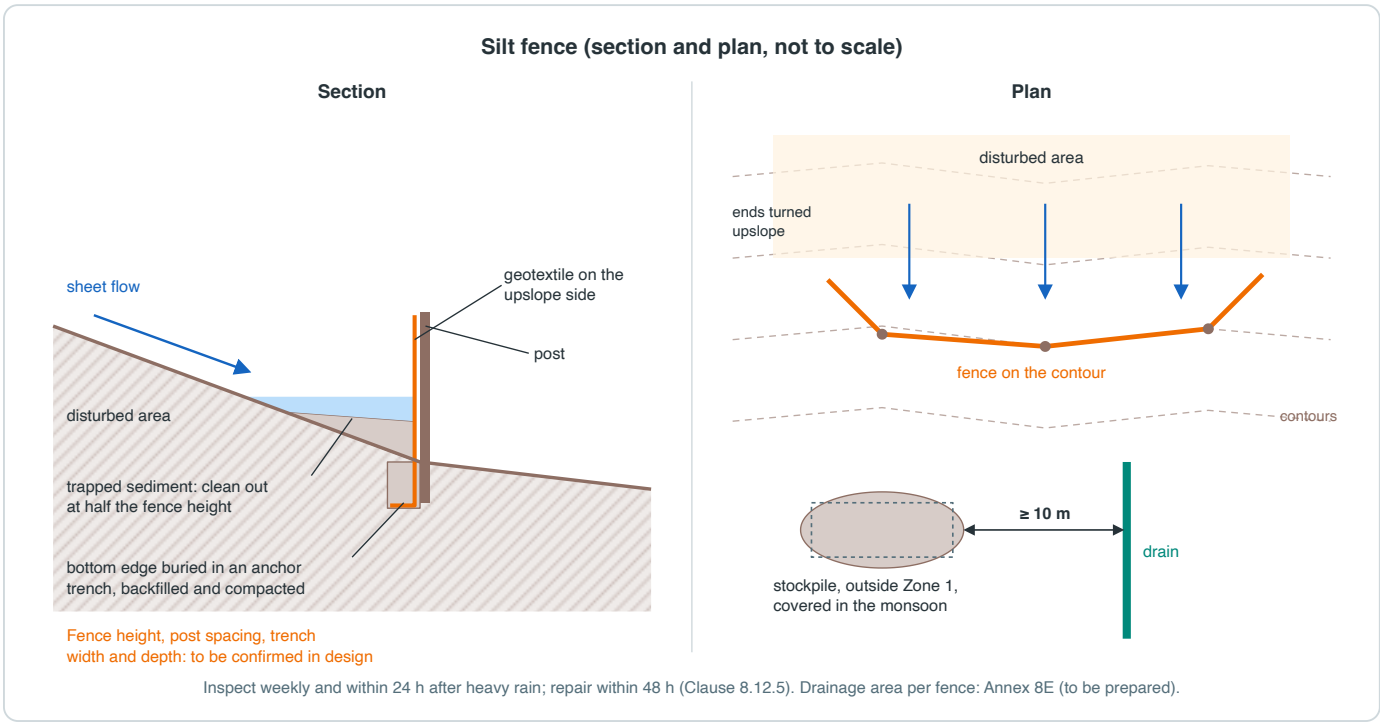

Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted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

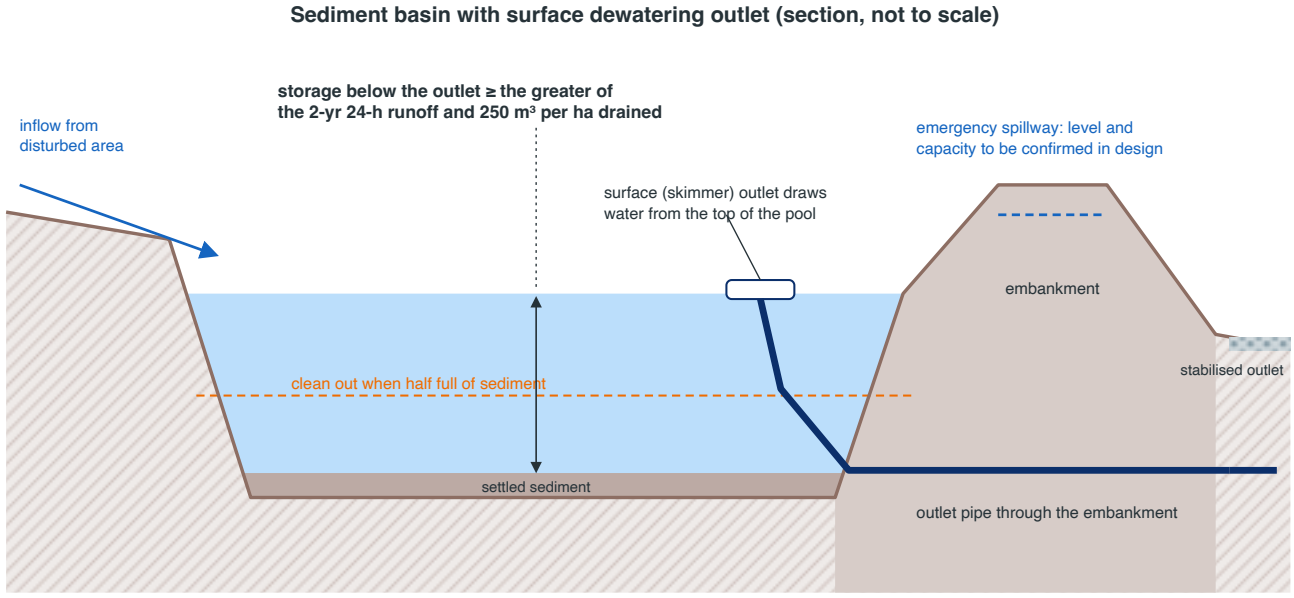

Figure 8E.2 — Sediment trap or basin in section: inflow, storage volume below the outlet, surface dewatering outlet (skimmer) drawing water from the top of the pool, emergency spillway, and sediment cleanout level at half the storage. Original drawing for this Manual, adapted from US EPA, NPDES Construction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

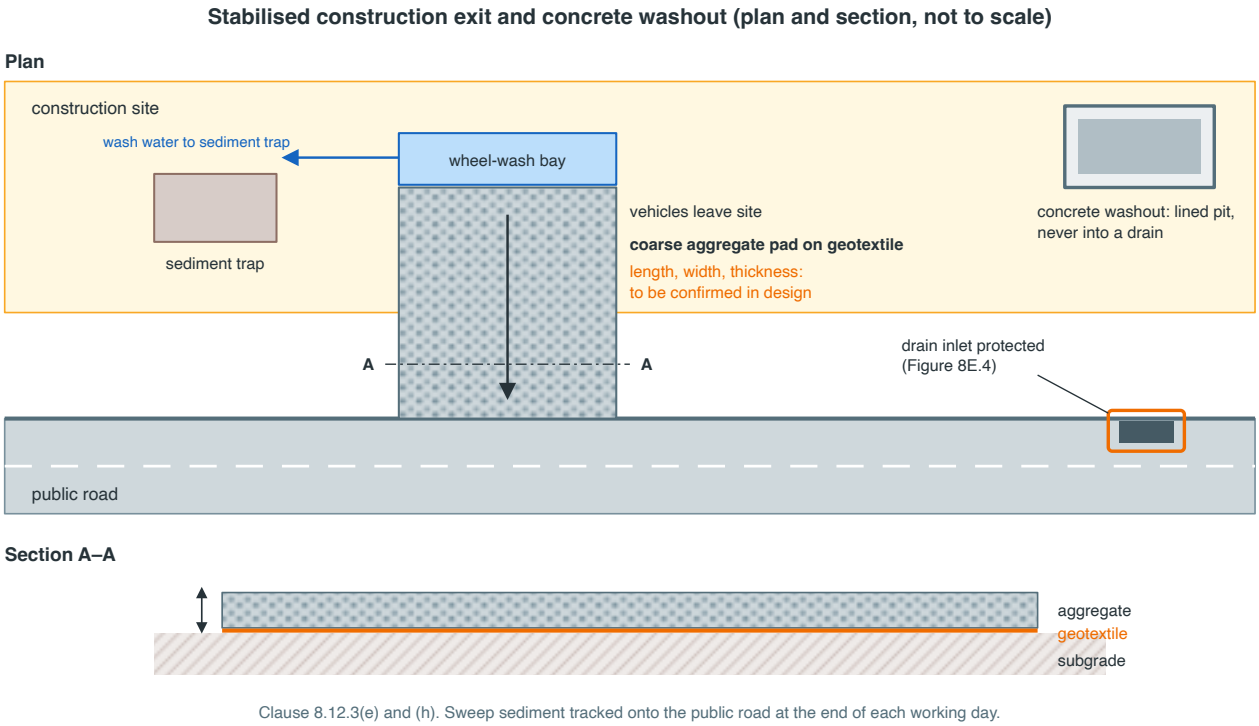

Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing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

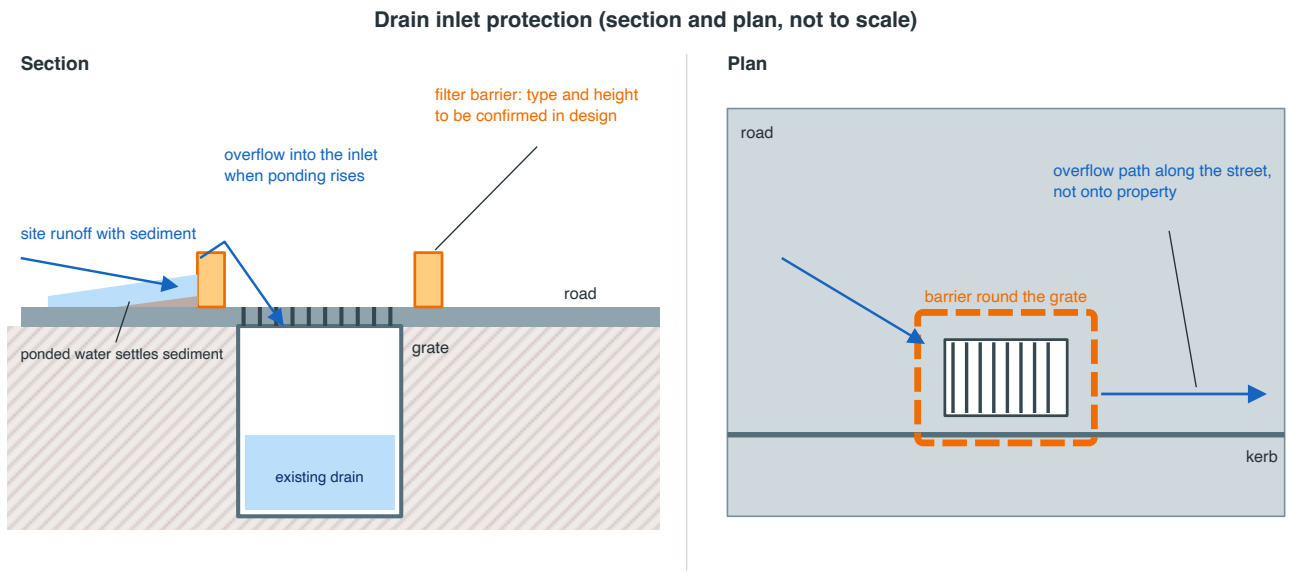

Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (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 15 October	Sediment controls in place before clearing
Area exposed in the SW monsoon	As small as practicable
Inspection	Weekly, and within 24 h after every heavy-rainfall event (Chapter 10)
Repair	Within 48 h
Cleaning	When half full of sediment
Removal	Only after the area draining to the measure is stabilised

Form 8-1 — Water Quality Sheet

Supports Clauses 8.4, 8.6 and 8.14 of Chapter 8.

Draft form — Punjab 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 — Punjab 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.

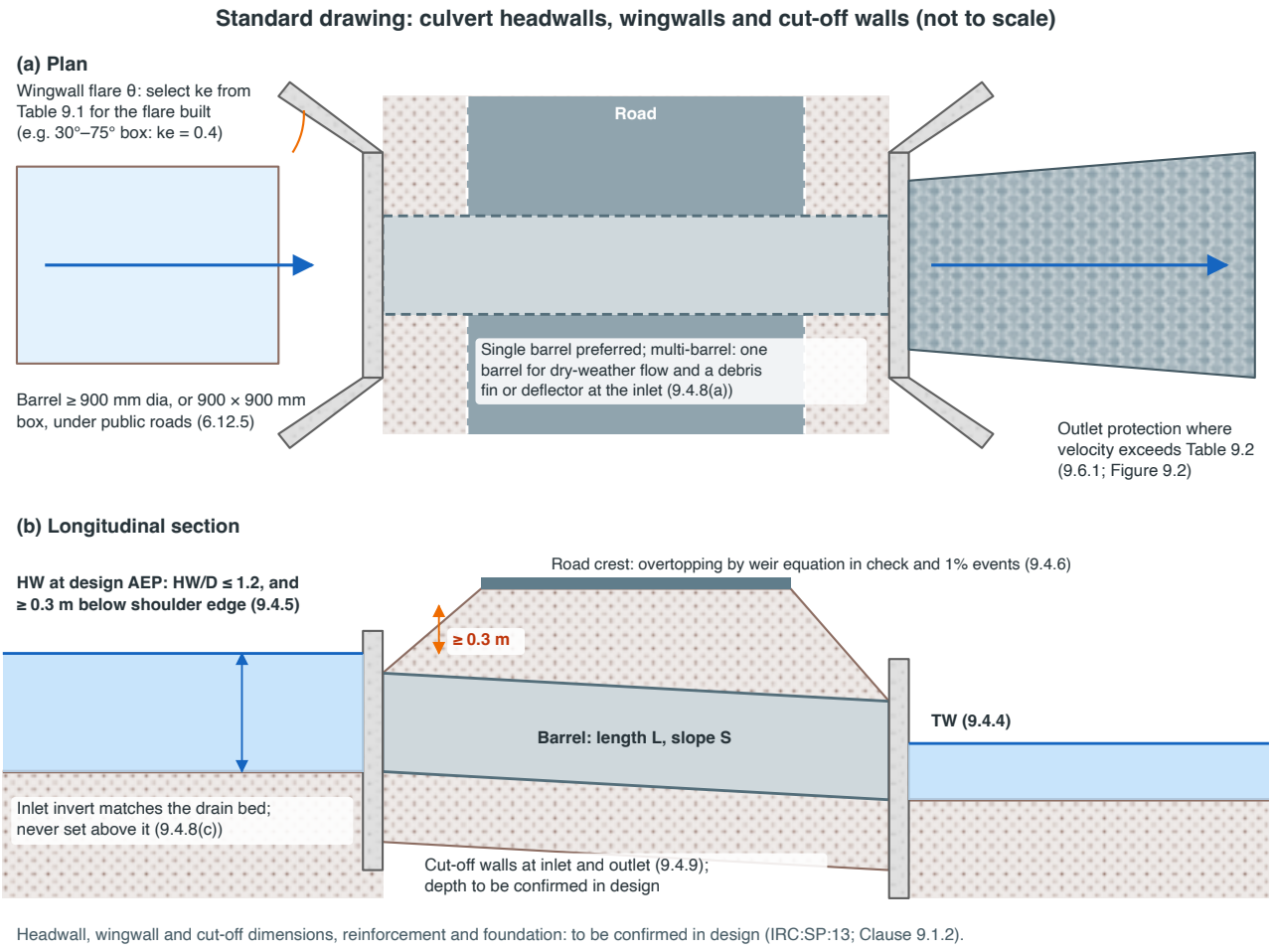

Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

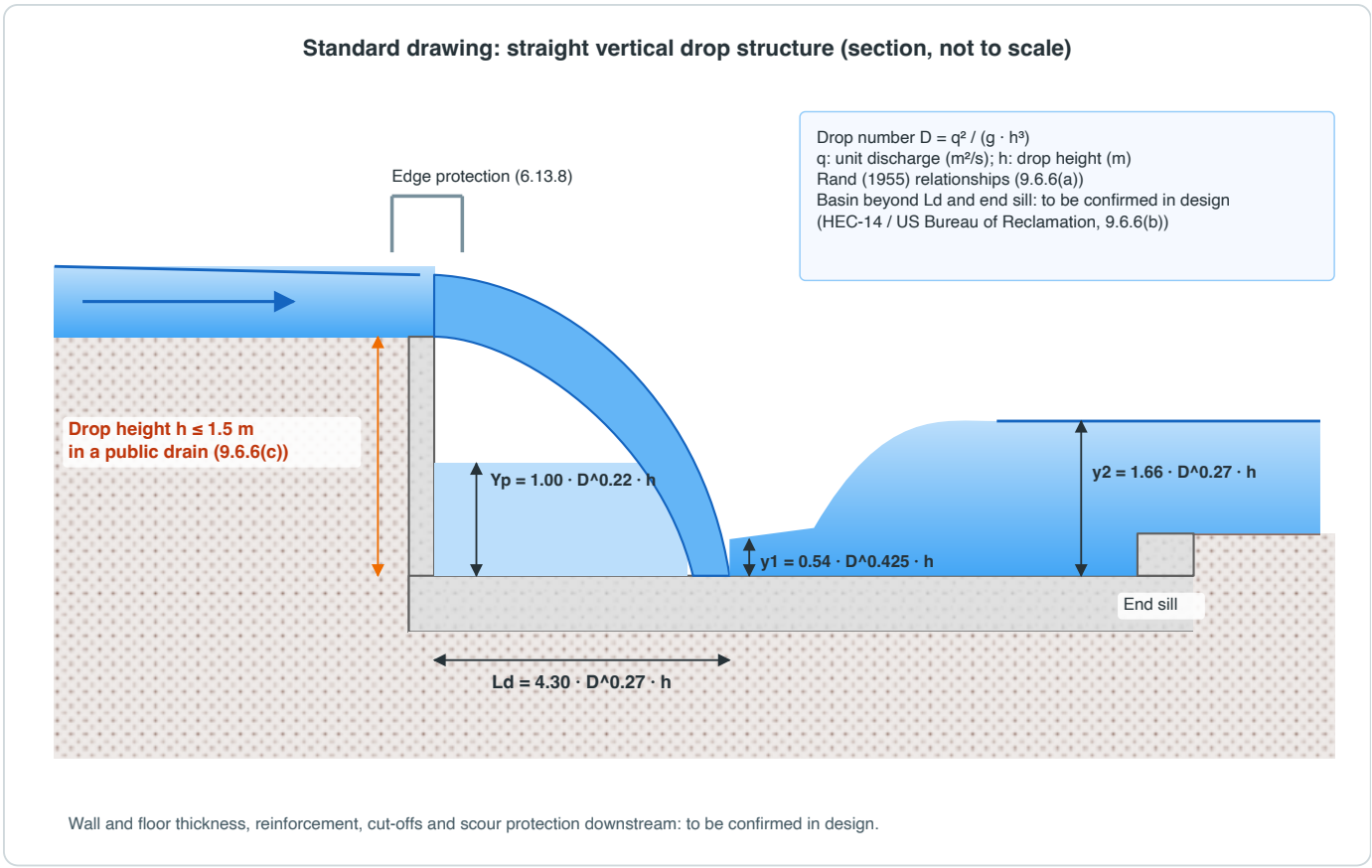

Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

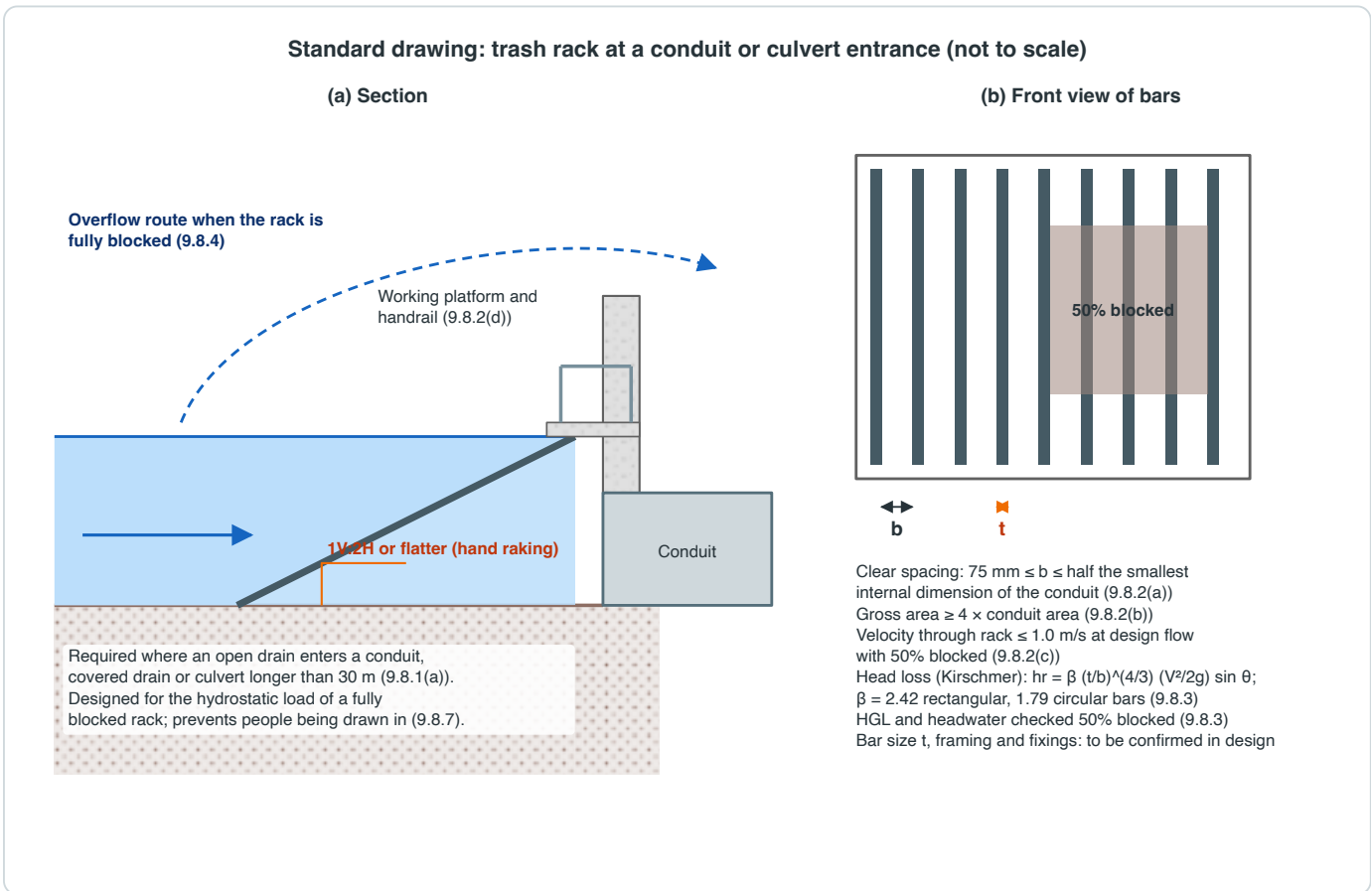

Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

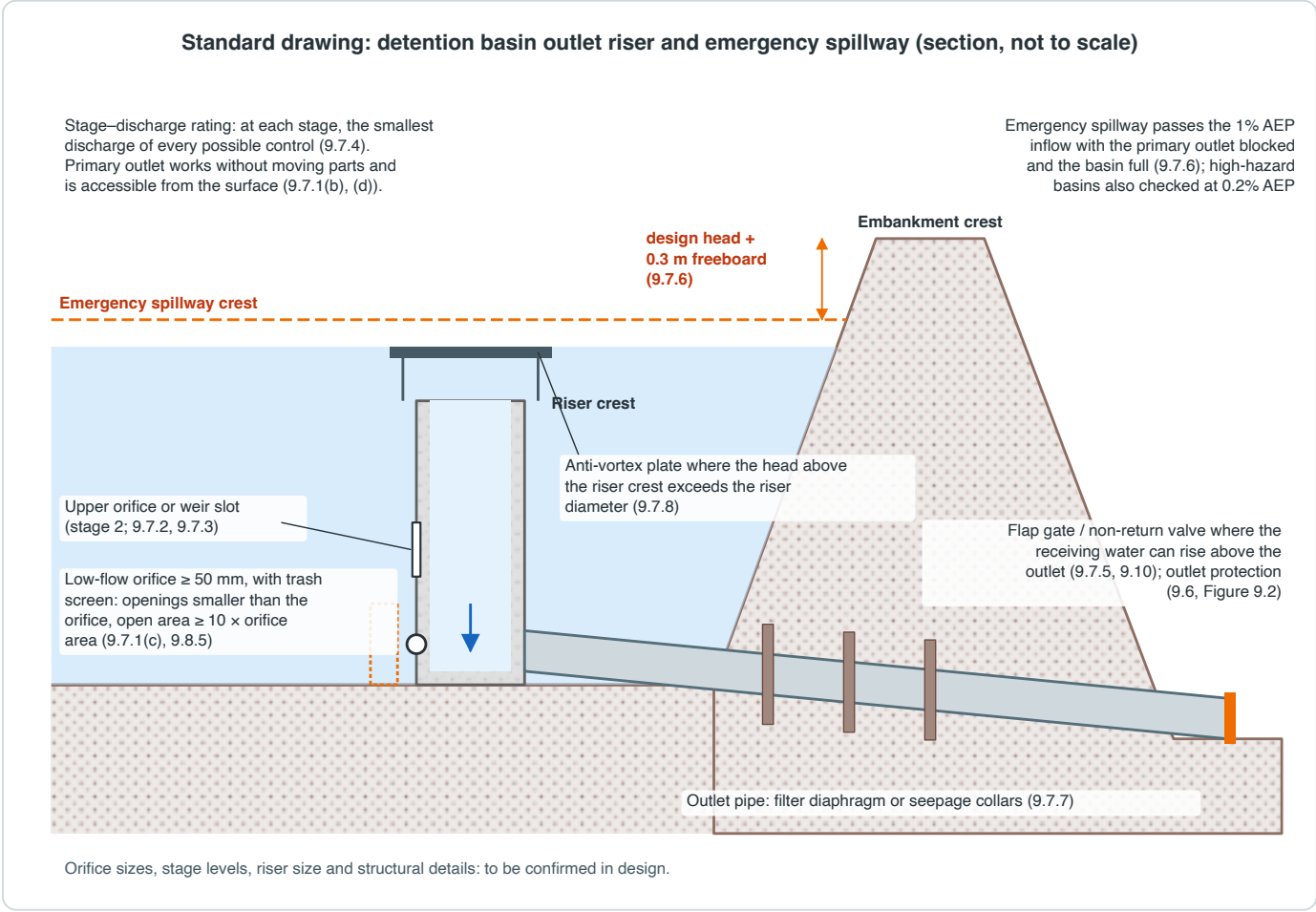

Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — Punjab 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 — Punjab Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

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

Annex 10A — Compliance calculator and user guide

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

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

10A.1 General requirements

The calculator shall:

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

10A.2 Inputs

Table 10A.1 — Calculator inputs

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

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

10A.3 Calculations, by clause

Table 10A.2 — Calculations the calculator shall perform

Step	Calculation	Clause
C1	**Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies in a municipal area to buildings on plots of 100 m² or more (PMBBL 2018, cl. 10.1), and elsewhere to residential plots and public and institutional buildings of more than 250 m², commercial, mixed-use and industrial buildings of more than 100 m² and all group housing (PUDBR 2021, r.40); recharge is credited, with first-flush diversion and pre-treatment and with no direct injection of road, parking, yard or industrial runoff, where the October water table is deeper than 10 m, after a site water-table check where it is 3–10 m deep, and not at all where it is within 3 m, as in the waterlogged south-west, the Sirowal and the bet lands, where rainwater harvesting is storage and reuse and detention and drainage govern; on the Shivalik slopes of sub-area PB-A no water is deliberately infiltrated on a natural slope steeper than 10° (Clause 4.11).	1.5.2–1.5.8
C2	**Process flags.** Stage 0 mandatory (≥ 2 ha, flood-sensitive, variance or regional route, tidal outfall or waterbody); Stages 1 and 2 may be combined (< 1 ha, not flood-sensitive); empanelled signatory required; independent check required.	10.3.2, 10.3.3, 10.6.1, 10.6.4
C3	**Route eligibility.** Tier B simplified method: ≤ 2 ha, or ≤ 0.5 ha in a flood-sensitive catchment, and only once Table 4.3 is published. Fixed-coefficient route: ≤ 1 ha and none of the exclusions of Clause 4.14.3. Constrained redevelopment: existing ≥ 60% impervious and ≤ 1 ha. Regional detention or fee-in-lieu: only in a basin with an approved BSMP.	4.5.6.1, 4.13.1, 4.14.1, 4.14.3, 11.12.1(b)
C4	**Retention volume.** RRV = 10 × Q_R × A, with Q_R the SCS-CN runoff from P_R for each sub-area at AMC II, summed over sub-areas. The larger of the Ia = 0.2S and Ia = 0.05S results governs. The Rv form (RRV = 10 × P_R × Rv × A, Rv = 0.05 + 0.009 × I) is offered only for sites < 0.5 ha and the Tier B method. No climate factor.	4.4.2, 3.8.5(c), 2.8.3
C5	**Preservation credit.** Preserved areas are modelled at their pre-development CN in the post-development condition.	4.4.7
C6	**Retention checks.** Design infiltration rate ≤ half the measured rate; groundwater ≥ 1.0 m below the base; drawdown of the retained volume within 72 h at the design rate (or by the stated reuse demand). A practice that fails any check gets no credit; any shortfall is reported and treated as WQv.	4.4.3–4.4.5, 4.4.6.4
C7	**Water quality volume.** P_wq = max(P_ret, P_3m); WQv = 10 × Q_wq × A by SCS-CN, or (P_wq / 1000) × Rv × A (A in m²) for sites < 0.5 ha and the Tier B method. The retained volume counts toward the WQv in full. No climate factor.	8.4.1–8.4.4, 3.8.5(c)
C8	**Retention credit.** Tier A: the credit found by routing is entered (I16); the calculator does not compute it. Tier B: V_credit = C_R × RRV provided, with C_R = 0 until Annex 4B is published.	4.4.6
C9	**Design-aid route (S-1).** V = SSR × A − V_credit; Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages, from Table 4.3. Shown as "not available" until Table 4.3 is published.	1.7.2, 4.14.2
C10	**Permissible site discharge (S-2).** Q = PSD (m³/s/ha) × A for each AEP, from the S-2 tables. Shown as "not available" until they are issued.	1.7.2, 1.7.3(e)
C11	**Fixed-coefficient route.** Q_cap,10 = 2.78 × C_10 × i_10 × A and Q_cap,2 = 2.78 × C_2 × i_2 × A (L/s); V_100 and V_2 = max over d of [10 × C_v × P(d) × A − 1.8 × Q_cap × d] for d = 1 to 72 h, with pervious C ≥ 0.50 for d ≥ 12 h; V = max(V_100, V_2); retention added without credit. Coefficients from Table 4.3A (provisional).	4.14.4–4.14.7
C12	**Release-rate screen (full method).** For each AEP and duration: Q_post ≤ 0.9 × Q_pre (standard), or the two mixed-frequency caps (flood-sensitive). Report the governing duration and margin.	4.5.2, 4.5.3
C13	**Constrained redevelopment.** Q_post ≤ 0.5 × Q_existing for 2-, 10- and 100-yr at each duration; shortfall volume = greenfield storage − storage provided; fee = shortfall × unit rate.	4.5.6.2, 4.5.6.3
C14	**Minimum orifice.** Flag any orifice < 50 mm. Where a cap is below the discharge of a 50 mm orifice at the corresponding stage, report "50 mm orifice deemed to comply".	4.5.5.1, 4.8.2
C15	**Drawdown.** Report the detention drawdown (90% of the 10-yr stored volume within 48 h), the WQv release time (24–48 h) and the retention emptying time (≤ 72 h).	4.7
C16	**Fee-in-lieu.** Fee = detention volume required on site × notified unit rate.	4.13.3
C17	**Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide.	10.5.2(c)

Step	Calculation	Clause
C18	**As-built re-run.** At Stage 4, repeat C4 to C17 with the as-built values and report each change from Stage 2.	10.9.1(b), 10.9.2

10A.4 Outputs

The calculator produces:

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

10A.5 Testing before release

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

10A.6 Outline of the user guide

The user guide shall contain at least:

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

Annex 10B — GIS data specification and attribute schema

Supports Clauses 10.4.4, 10.14.1(d), 10.14.3 and 10.17 of Chapter 10.

10B.1 Format and reference systems

- (a) **Format.** One OGC GeoPackage (.gpkg) per submittal is preferred. Shapefiles are accepted, one per layer, zipped with all component files. Field names shall be as in Tables 10B.2 to 10B.6; shapefile names are limited to 10 characters, and the names below meet that limit.
- (b) **Horizontal reference.** WGS 84 geographic (EPSG:4326), or WGS 84 / UTM zone 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 WRD's headworks and drain gauges and of BBMB's reservoir levels for Bhakra and Pong (published in feet, on gauge zeros to be

confirmed [TBC], and converted at 0.3048 m per foot), of the Ranjit Sagar and Shahpur Kandi levels published in metres, and of the flood marks surveyed on ungauged choes, raos and drains 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 `ULB–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

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

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

Field	Type	Unit	Req.	Content	Source
OUT_ID	T	—	Yes	Outfall identifier	10B.1(f)
RECEIVER	T	—	Yes	Receiving drain, channel, waterbody or sea, by name	Clause 4.5.1.3
RECV_TYPE	T	—	Yes	PUBLIC_DRAIN / CANAL / RIVER / TANK / SEA / OTHER	Chapter 5
INV_LEVEL	R	m	Yes	Outfall invert level	Clause 10.9.1(a)
SIZE_MM	R	mm	Yes	Diameter, or width × height written in the drawing	Chapter 6
TIDAL	T	—	Yes	Y / N	Chapter 5
GATE_TYPE	T	—		NONE / FLAP / TIDE / DUCKBILL / PENSTOCK / NRV	Clauses 5.11, 9.10
GATE_REQ	T	—	Yes	Y / N: invert below the 1% AEP still-water level	Clause 5.11.1
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1
Q_100	R	L/s		Design 1% AEP discharge	Chapter 5

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

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

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

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

Table 10B.6 — Metadata (SW_META)

Field	Content
FILE_NO	Authority file number
STAGE	1, 2, 4 or HANDOVER
H_CRS	EPSG code of the horizontal reference system
V_DATUM	Name of the vertical datum
TIDE_REL	Relationship of the vertical datum to the Chapter 5 river datums of WRD's headworks and drain gauges and of BBMB's reservoir levels for Bhakra and Pong (published in feet, on gauge zeros to be confirmed [TBC], and converted at 0.3048 m per foot), of the Ranjit Sagar and Shahpur Kandi levels published in metres, and of the flood marks surveyed on ungauged choes, raos and drains (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"

Field	Content
DATE	Date the file was prepared

10B.4 Code lists

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

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

Table 10B.8 — Status codes (STATUS)

Code	Meaning
PROPOSED	In a Stage 1 or Stage 2 submittal
APPROVED	Stage 2 approved; not yet built
ASBUILT	As-built certificate accepted (Clause 10.9)
HANDEDOVER	Accepted by the ULB (Clause 10.14)
ALTERED	Changed with the Authority's approval (Clause 10.3.5)
REMOVED	Removed with the Authority's approval

Table 10B.9 — Inspection result codes (INSP_RES)

Code	Meaning
OK	Working as designed; no defect
MINOR	Defect found and corrected; date in the inspection record
MAJOR	Defect affecting storage, outlet or safety; notice issued (Clause 10.15.2, step 1)
NOACCESS	Inspection could not be made
NOTFOUND	Facility missing, filled, covered or changed in use (Clause 10.15.1(c))

10B.5 Facility register extract

The public facility register of Clause 10.17.1(a) is an extract of SW_FAC: FAC_ID, FAC_TYPE, location (centroid), V_DET (and V_RET, V_WQ), Q_100 (and Q_2, Q_10), OWNER_NM, ASB_DATE, LAST_INSP and INSP_RES. It is published as CSV and GeoPackage under the licence of Clause 10.17.4. Personal data are not published (Clause 10.17.3).

Annex 10C — Maintenance access dimensions

Supports Clause 10.13 of Chapter 10.

Clause 10.13 sets access by function. This annex collects the access dimensions that the Manual already sets in other chapters, and lists the dimensions that it does not set. Where a dimension is not set by the Manual, the designer shall state it on the drawings, show that it suits the plant and equipment named in the O&M plan (Clause 10.11.1(h)), and mark it "to be confirmed in design".

Table 10C.1 — Access dimensions set by the Manual

Element	Requirement	Clause
Open drains with a top width of 2 m or more	Maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m	6.9.4
Drainage reserves	Width not less than Table 6.9, based on the required drain size; where the access strip of Clause 6.9.4 is wider, the wider governs	6.9.7
Covered drains, minimum section	0.6 m × 0.6 m clear	6.7.6
Covered drains, removable covers	Panels at not more than 10 m centres, each at least 0.6 m long and spanning the full clear width, liftable by two workers or a hand-operated device	6.13.2(a)
Covered drains, access chambers	Clear opening at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than 30 m centres on straight runs	6.13.2(b)
Manholes and access chambers on public drains	Clear access opening at least 600 mm	9.12.3
Inlet chambers on public roads	Silt sump at least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7
Underground tanks and vaults	Access openings over the outlet chamber and over every inlet; in tanks over 500 m², not more than 30 m apart; floor falling at least 1% to a sump at the outlet	4.10.2(b), (c)
Detention outlets serving more than 1 ha	A means of isolating the outlet (stop-log slot or penstock)	4.8.6

Element	Requirement	Clause
Outfall gates	Stop-log slot or penstock upstream on outfalls larger than 600 mm (Chapter 5) and on outfalls of 900 mm or more or serving a pumped or storage system (Chapter 9); the gate chamber accessible at all tides, with its access above HAT + surge + sea-level allowance	5.11.3(d), (e); 9.10.3
Pump stations	Maintenance vehicle access usable in the 1% AEP event; hard standing and a quick-coupling connection for mobile pumps; clear space between adjacent pumps or motors of 0.6 m (small and medium units) or 1.0 m (large units)	9.9.6, 9.9.10, 9.9.12
Pretreatment devices	Cleanable without entering or disturbing the main BMP	8.5.4
Screens at outfalls, culvert inlets and pump sumps	Cleanable from a safe platform, with vehicle access	8.10.3(d)
Infiltration trenches	Observation well to the base of each trench	8.7.6(c)
Publicly accessible storage	Side slopes no steeper than 4H:1V, with at least a quarter of the perimeter at 6H:1V or flatter	4.15.1(c)
Wet basins	Safety bench at least 3 m wide, no more than 0.3 m below normal water level	4.15.2
Fencing	At least 1.2 m high, non-climbable, with a lockable gate, where Clause 4.15.3 requires it	4.15.3

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

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

> **Commentary.** APWA 5600 (2006, §5608) required a maintenance access strip of 15 ft (about 4.5 m) for detention facilities. The Manual did not adopt a fixed width for private sites, because plot sizes in Punjab 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)
Safety features	Every 6 months	Signs in Punjabi 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)

Task	Frequency	Standard or trigger	Clause
Warning actions	On an IMD heavy-rainfall or cyclone warning	Actions written in the plan: _____ (for example staff on site, fuel topped up, mobile pump connection checked)	10.11.1(e), 9.9.12

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

Task	Frequency	Standard or trigger	Clause
Inspect and operate	Every 3 months; after each heavy-rainfall day	Opens at a small head; no debris, sand or growth holding it	Table 10.3, 9.10.4
Seal test	Before 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 DLG. 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 Punjab Municipal Building Bye-Laws 2018 and the Punjab Urban Planning and Development Building Rules 2021 (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 — Punjab 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 WRD's headworks and drain gauges and of BBMB's reservoir levels for Bhakra and Pong (published in feet, on gauge zeros to be confirmed [TBC], and converted at 0.3048 m per foot), of the Ranjit Sagar and Shahpur Kandi levels published in metres, and of the flood marks surveyed on ungauged choes, raos and drains	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 — Punjab 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 — Punjab 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, PMBBL/PUDBR 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 Punjab 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 — Punjab 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 — Punjab 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 — Punjab 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 — Punjab 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 — Punjab 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 15 October, after handover)	_____	10.14.2
C2	Developer responsible during the period for defects and routine maintenance	_____	10.14.2
C3	Security deposit held by the ULB, ₹, and release date	_____	10.14.2
C4	Entered in the ULB GIS drainage asset register and the facility register: date	_____	10.14.3

Table 10F.33 — Form 10-8, Section D: Signatures

Party	Name and designation	Signature	Date
Developer	_____	_____	_____
Certifying professional	_____	_____	_____
ULB	_____	_____	_____

ANNEXES TO CHAPTER 11

Basin and City Stormwater Master Plans

These annexes support Chapter 11. They give a terms of reference template for a Basin Stormwater Master Plan (BSMP), the layout of the basin list and boundary layer, the layout and method for depth–damage curves, the standard for publishing BSMP data and models, and the annual implementation report form. Annexes 11B and 11C need data that are not yet available; they say so and give the rule to use in the meantime. The template and the form are a model and a draft form for consideration by a competent authority, and are not in force.

Annex 11A — BSMP terms of reference template

Supports Clauses 11.1 to 11.12 of Chapter 11.

> *Model text for consideration by a competent authority. Not in force.* The Lead Authority adapts this template for each basin. Items in "[ ]" are for the Lead Authority to complete. Clause references are to this Manual, which the consultant shall follow in full.

11A.1 Background and purpose

1. The [Lead Authority] intends to prepare a Basin Stormwater Master Plan for the [name] basin under Chapter 11 of the Punjab 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, chhappar and tank restoration and major flow paths;
    - (e) set the basin inputs for site design: regional facilities, the fee-in-lieu unit rate, and any basin release rate stricter than Chapter 4; and
    - (f) recommend catchments for notification as flood-sensitive.
3. The BSMP may make the site criteria of Chapters 4 to 8 stricter for the basin. It shall not relax them, except through the regional detention and fee-in-lieu routes of Clauses 4.13 and 4.5.6 (Clause 11.1.3).

11A.2 Client, partners and study area

1. **Client:** [Lead Authority] (Clause 11.4.1).
2. **Partners:** WRD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, a development authority or DLG, PSDMA] (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, WRD drain or choe 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, chhappar, 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, WRD drains, choes and canal crossings: outfall invert levels, on a named datum and with the gauge zero stated, against the levels of the receiving river at the nearest WRD headworks or BBMB gauge (Ropar, Harike, Hussainiwala and Madhopur; Bhakra, Pong, Ranjit Sagar and Shahpur Kandi; the WRD gauges on the Ghaggar) and its recorded peaks, with levels published in feet converted at 0.3048 m per foot, any conflict between published values stated, and no CWC danger level; for outfalls to WRD drains, the drain's design discharge and design water level at the outfall; for ungauged choes, raos and nallahs, surveyed flood marks and bed levels and the 1% AEP level with its sand bulking; the limits notified under s.38 of the Punjab Canal and Drainage Act 2023 (or s.55 of the 1873 Act) and the lines fixed under court orders where they bind; and regulators, sluices, flap gates, dhussi bandhs, siphons and culverts under canals and pumping stations on the outfalls, with their capacities and operating rules;
- (f) rainfall and water levels: all available records (IMD, including its observatories and stations at Ludhiana, Patiala, Amritsar, Ferozepore, Kapurthala, Bhatinda, Halwara and Adampur, its station at Chandigarh for SAS Nagar, and the automatic weather stations and rain gauges reported by the Meteorological Centre Chandigarh; the self-recording gauges at Madhopur, Patiala and Hoshiarpur used for the CWC Flood Estimation Report for zone 7; the observatories of Punjab Agricultural University at Ludhiana, Ballowal Saunkhri and Bathinda; the district and tehsil rain gauges of the State; the river, headworks and drain gauges of WRD and the rain and reservoir records of BBMB at Bhakra and Pong; and any gauges kept by the Municipal Corporations, GMADA, GLADA and the Smart City companies), including the 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala, IMD), 11 July 1993 (356.5 mm at Patiala, IMD), 5 September 1995 (286.8 mm at Ludhiana, IMD), August 2019 (the Sutlej breaches at Shahkot, Gidderpindi and Mandala, as reported), 8–10 July 2023 (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD, and the Ghaggar at 754.2 ft at Khanauri, as reported) and August–September 2025 (Harike at 3,35,030 cusecs on 3 September and the town floods of 1–3 September in SAS Nagar, Ludhiana, Jalandhar and Amritsar, as reported) events;
- (g) flood evidence: surveyed flood marks and mapped extents of past events, including public reports, photographs and residents' records;

- (h) land use: existing land use and imperviousness; future land use from the statutory master plan;
- (i) soils and groundwater: HSG map (Annex 3A or Clause 3.7.2), seasonal high groundwater, aquifer and recharge zones; and
- (j) sewer interaction: known cross-connections, dry-weather flow in drains, solid-waste hotspots.

Confirm the basin boundary and the inter-basin diversions (Clause 11.3.2). Deliver the data report and the data in the formats of Annex 11D.

Task 3 — Model build. Build a coupled 1D–2D hydraulic model of the minor system, the major (overland) system, rivers, canals and tanks, and the outfalls (Clause 11.7.1; Figure 11.2). Use the methods of Chapter 3 and the tidal and river boundaries of Chapter 5. Run the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs, with areal reduction under Clause 2.7.3 (Clause 11.7.2). Where the basin has tank cascades, run continuous simulation under Clause 3.13 with the full IMD gridded daily record where available, and at least 30 years, disaggregated by the temporal patterns of Annex 2D. The two-step approach of Clause 3.13.5 may be used: starting tank levels and antecedent conditions from the continuous run are passed to the design-storm runs (Clause 11.7.3).

Task 4 — Calibration and validation. Calibrate and validate the model under Clause 3.15, using at least two of the 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala, IMD), 11 July 1993 (356.5 mm at Patiala, IMD), 5 September 1995 (286.8 mm at Ludhiana, IMD), August 2019 (the Sutlej breaches at Shahkot, Gidderpindi and Mandala, as reported), 8–10 July 2023 (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD, and the Ghaggar at 754.2 ft at Khanauri, as reported) and August–September 2025 (Harike at 3,35,030 cusecs on 3 September and the town floods of 1–3 September in SAS Nagar, Ludhiana, Jalandhar and Amritsar, as reported) events where data exist (Clause 11.7.5). Report the performance measures of Clause 3.15.4 and the reasonableness check of Clause 3.15.6.

Task 5 — Scenarios and hazard maps. Model the scenarios of Clause 11.7.4: (a) existing; (b) future, uncontrolled; (c) future, controlled; (d) future, with plan; and (e) climate, applied to (a) and (d). Produce flood hazard maps of extent, depth, velocity and hazard class (H1–H6, Chapter 6) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan (Clause 11.8.4(a)).

Task 6 — Level-of-service assessment. Compare scenarios (a), (c) and (d) with the levels of service of Table 11.2 and any stricter levels the client adopts (Clause 11.6.1). Map every shortfall.

Task 7 — Options. Develop options in the order of Clause 11.8.1: protect and restore storage; regional retention and detention, sited by modelling; conveyance; outfall works; property-level protection; non-structural measures. Assess each option for the criteria of Clause 11.8.2: reduction in flood risk (buildings and people flooded, and expected annual damage using Annex 11C); capital and 30-year maintenance cost; land required; effect on groundwater recharge where the water table is deep and over-exploited, as under Ludhiana, Jalandhar, Patiala, Sangrur, Moga and most of the central plains (115 of the State's 153 assessment units over-exploited, stage of extraction 156.87%; CGWB and WRD, 2024) and in the Kandi recharge belt of sub-area PB-A, waterlogging where the October water table is within 3 m, as in parts of Sri Muktsar Sahib, Fazilka, Faridkot and Bathinda, in the Sirowal and on the bet lands, and the quality of the groundwater, which is saline in much of the south-west and exceeds the limits for uranium, nitrate, fluoride or arsenic in parts of the State, and of the drains, beins, choes and chhappars that the runoff reaches; effect on downstream basins and the receiving river, WRD drain or choe; and who benefits.

Task 8 — Basin inputs for site design. Where scenario (c) does not meet the level of service, propose basin release rates ($m^3/s/ha$) by AEP and sub-catchment (Clause 11.8.3). Recommend catchments for notification as flood-sensitive, with the evidence of Clause 4.5.4.1. Identify regional facility sites, with storage volumes, land needs and the sites they serve, and compute the fee-in-lieu unit rate, including land, construction and 10 years of maintenance (Clauses 4.13.3, 11.8.4(c), (d)).

Task 9 — Capital Improvement Programme. Rank the works by risk reduction per rupee, with cost, phasing and responsible agency (Clause 11.8.4(e)).

Task 10 — Maintenance and monitoring. Prepare the pre-monsoon maintenance programme: desilting, gate and pump testing, and tank operating rules (Clause 11.8.4(f); Chapters 7 and 10). Specify monitoring needs: new rain gauges, level sensors and flood-mark survey points (Clause 11.8.4(g); Clause 10.16.1).

Task 11 — Land-use integration. Prepare the material for the statutory land-use plan required by Clause 11.9.1: sites to be reserved; the 1% AEP hazard map with the Chapter 7 setbacks; land in hazard classes H5–H6 in the 1% AEP event; and open space locations that can form part of flow paths or regional storage.

Task 12 — Consultation. Publish the draft BSMP for public comment for at least 60 days, with public meetings in each affected local body (Clause 11.10.1). Keep a log of comments and responses.

Task 13 — Final BSMP and publication. Revise the BSMP after consultation. Prepare the package for approval by the State Stormwater Technical Committee, including the model for review (Clause 11.11.1). Publish the data, models, maps and CIP under Annex 11D (Clause 11.10.2).

11A.5 Deliverables

Table 11A.1 — Deliverables

No.	Deliverable	Task	Due (months from start)
D1	Inception report, data inventory and survey plan	1	[ ]
D2	Data report and data sets (Annex 11D)	2	[ ]
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, Municipal Councils and Nagar Panchayats, the sector drains of PUDA, GMADA, GLADA and the other development authorities, and the sewage interceptions on the drains), WRD's rivers, choes and notified drains with their design discharges and design water levels and the list and limits of the drains notified under s.38 of the Punjab Canal and Drainage Act 2023 or s.55 of the 1873 Act, the dhussi bandhs, regulators, sluices, flap gates and pumping stations on the outfalls and the siphons and culverts under the canals, with their operating rules, the gauge zeros and danger marks of WRD's headworks and drain gauges and BBMB's release records for Bhakra and Pong, the village chhappars (ਛੱਪੜ; toba ਟੋਭਾ; ponds) from the revenue records and the water-bodies census, with their levels, the lines fixed under court orders, such as the pillared width of the Patiala ki Rao, the Kandi low dams and check dams, and the catchment of the Buddha Nallah used in PMIDC's feasibility report (2020) (other likely sources: Survey of India, CGWB and the Punjab State Wetlands Authority). No basin map of any Punjab city was found. Until the annex is published, the basins of Ludhiana, SAS Nagar and its neighbours, Patiala, the Ghaggar towns, Jalandhar–Kapurthala–Phagwara, Amritsar, Pathankot, Hoshiarpur and the Kandi towns, and the south-west 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
Ludhiana (MC Ludhiana, GLADA)	The Buddha Nallah, from the Kum Link and Neelon drains near Ghumait through the city reach to the Sutlej at Walipur Kalan	STP and CETP discharges and sewage interceptions mapped (Clause 8.9.5); disputed width surveyed; Sutlej level behind the dhussi bandh as boundary
SAS Nagar, Zirakpur, Kharar, Dera Bassi and New Chandigarh (Municipal Corporation SAS Nagar, GMADA)	The N-Choe, Patiala ki Rao, Sukhna Choe, Jayanti Devi ki Rao and Lakhnaur choe, to the Ghaggar	Shared with Chandigarh (Supplement S01); Sukhna Lake releases as inflow; Patiala ki Rao limits and width shown; sand bulking at choe crossings; Ghaggar level as boundary
Patiala (Municipal Corporation, development authority [TBC])	The Badi Nadi, Chhoti Nadi and Patiala Nadi, to the Ghaggar	Canal siphons and culverts as controls; outfall-closed case a design case
Ghaggar towns of Patiala, Sangrur and Mansa districts (Samana, Moonak, Khanauri, Makraud Sahib, Sardulgarh)	Catchments draining to the Ghaggar	Channel narrowing below Makraud Sahib; Hansi–Butana siphon as a control; WRD gauges at Khanauri and Sardulgarh as boundary; Haryana reach agreed through WRD
Jalandhar, Kapurthala and Phagwara (Municipal Corporations)	The Kali Bein, Chitti Bein and Kala Sanghian drain	Chitti Bein level at the Chaheru railway bridge; CETP and sewage interceptions mapped; Sutlej at Phillaur–Shahkot as boundary
Amritsar (Municipal Corporation)	The walled city and the town, through the Tung Dhab and City Outfall drains to the Hudiara drain	Joint level at the Tung Dhab–Hudiara junction as boundary; transboundary reach an uncertain boundary
Pathankot (Municipal Corporation)	The Chakki Khad and the Ravi	Ranjit Sagar and Shahpur Kandi releases and the Madhopur headworks level as boundary; 2025 gate failure a stress case
Hoshiarpur and the Kandi towns (Garhshankar, Mukerian, Talwara)	The Hoshiarpur choes and the other Kandi choes	Split at the break of slope; low dams and check dams as storage; channel losses on the fans; Beas below Pong as boundary

Tier A body or area	Basin	Note from Chapter 11
Bathinda, Abohar, Sri Muktsar Sahib, Fazilka and Faridkot	The Chand Bhan and other WRD drains of the south-west, and the depressions with no gravity outfall	Drain capacity as boundary; October water table as a design condition; pumped outfalls with storage
Other Tier A bodies, including Moga, Barnala and Batala	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_PA	Text	Basin name in English and Punjabi
TIER_A	Text	Tier A body or bodies in the basin
OUTFALL	Text	Outfall to the sea, river or major waterbody (Clause 11.2)
AREA_KM2	Real	Basin area, km²
LEAD_AUTH	Text	Lead Authority (Clause 11.4.1)
PARTNERS	Text	Partners, including WRD where it applies
LINKS	Text	Diversions to and from other basins (Clause 11.3.2)
BSMP_STAT	Text	None / in preparation / draft published / approved
BSMP_DATE	Date	Date of approval of the current BSMP
REVIEW_DUE	Date	Date of the next review (Clause 11.11.2)

Annex 11C — Depth–damage curves for Punjab 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 Punjab 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 4–5 October 1955 (354.3 mm at Ludhiana on 4 October, IMD), 24 September 1988 (338.0 mm at Ludhiana PAU and 284.2 mm at Kapurthala, IMD), 11 July 1993 (356.5 mm at Patiala, IMD), 5 September 1995 (286.8 mm at Ludhiana, IMD), August 2019 (the Sutlej breaches at Shahkot, Gidderpindi and Mandala, as reported), 8–10 July 2023 (35 cm at Ropar in the 24 hours to 08:30 on 10 July, IMD, and the Ghaggar at 754.2 ft at Khanauri, as reported) and August–September 2025 (Harike at 3,35,030 cusecs on 3 September and the town floods of 1–3 September in SAS Nagar, Ludhiana, Jalandhar and Amritsar, as reported) floods (Department of Revenue, Rehabilitation and Disaster Management and PSDMA 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
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, choe beds 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 WRD's headworks and drain gauges and of BBMB's reservoir levels for Bhakra and Pong (published in feet, on gauge zeros to be confirmed [TBC], and converted at 0.3048 m per foot), of the Ranjit Sagar and Shahpur Kandi levels published in metres, and of the flood marks surveyed on ungauged choes, raos and drains 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 `buddha_nallah_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 — Punjab 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 chhappar desilting and restoration (tanks, number; storage restored, m³)	_____	_____	_____
D3	Gate tests (number of gates)	_____	_____	_____
D4	Pump station duty tests (number of stations)	_____	_____	_____
D5	Tank operating rules reviewed with the custodian (number)	_____	_____	_____
D6	Monitoring added: rain gauges, level sensors, flood-mark points (Clause 11.8.4(g))	_____	_____	_____

Table 11F.5 — Form 11-1, Section E: Flooding against the levels of service

Event (dates)	Rainfall compared with the design depths (Clause 10.16.2(a))	Level-of-service element (Table 11.2)	Location	Met (yes / no)	Event report reference (Clause 10.16.2)
_____	_____	_____	_____	_____	_____

Table 11F.6 — Form 11-1, Section F: Review triggers and sign-off

No.	Field	Entry
F1	Event exceeding the 1% AEP design depth in the basin this year (yes / no). If yes, review due within 2 years (Clause 11.11.2)	_____
F2	Statutory land-use plan revised this year (yes / no) (Clause 11.11.2)	_____
F3	Next 10-year review due (date)	_____
F4	Officer of the Lead Authority: name, designation, signature, date	_____

SUPPLEMENT

Union Territory of Chandigarh

Status. This Supplement is part of Draft v1.0 of the Manual. Neer prepared it as a proposal for applying the Manual in the Union Territory of Chandigarh, which adjoins Punjab and Haryana and is the capital of both. The Union Territory is administered by an Administrator appointed by the President under Article 239 of the Constitution; the office has been held by the Governor of Punjab since 1 June 1984, as reported. The authority that could adopt this Supplement is therefore the Administrator, acting through the Chandigarh Administration. The Union Territory lies outside the State's jurisdiction: the Manual's statewide rules are written for Punjab, and this Supplement states how they would be read in a territory the State does not govern.

Not adopted. This Supplement has not been adopted, notified or endorsed by the Administrator (the Governor of Punjab), the Chandigarh Administration or its Chief Secretary, the Department of Urban Planning (the Chief Architect), the Estate Office, the Engineering Department, the Municipal Corporation Chandigarh (MCC), the Chandigarh Housing Board (CHB), Chandigarh Smart City Ltd, the Chandigarh Pollution Control Committee (CPCC), the Department of Forests and Wildlife, the Union Territory of Chandigarh Wetlands Authority, the Chandigarh Disaster Management Authority, the Deputy Commissioner, or any other department or agency of the Administration, nor by the Government of Punjab, the Government of Haryana or the Government of Himachal Pradesh, or by any of their departments and bodies, including GMADA, the Municipal Corporation SAS Nagar, the local bodies of Zirakpur and Nayagaon and the Water Resources Department of Punjab. Where it names a body, it describes the role that body would have if the Manual and this Supplement were adopted. It does not say the body has agreed to that role. Until the Administrator adopts it, the Chandigarh Building Rules (Urban) 2017, the zoning plans and architectural controls, and the approval conditions in force in the Union Territory continue to apply.

S1.1 Scope

S1.1.1 This Supplement applies to the whole of the Union Territory of Chandigarh (about 114 km²), including:

- (a) the area of the Municipal Corporation Chandigarh, which was 79.34 km² at the Corporation's formation in 1994 by one passage of the City Development Plan (CDP) and 79.74 km² by another; it has since been enlarged by the addition of villages, but its present extent was not confirmed **[TBC]**; and
- (b) the rest of the Union Territory, including Sukhna Lake, the Sukhna Wildlife Sanctuary, the part of the Sukhna Lake catchment in the Union Territory, and the sectors, villages and roads developed or maintained by the Engineering Department of the Administration.

S1.1.2 **How this Supplement works.** In the Union Territory, the chapters and annexes of the Manual apply as written, except as modified by Table S1.1 and Clauses S1.3 to S1.8. Where the Manual names a Punjab body, statute or rule, the Union Territory equivalent in Table S1.1 is read in its place. The following do not apply inside the Union Territory:

- (a) PMBBL and PUDBR, and every clause of the Manual that cites them, which is read with the instrument of Table S1.1;
- (b) the Punjab Water Resources (Management and Regulation) Act, 2020, the PWRDA Groundwater Extraction and Conservation Directions, 2023 and their water-conservation credits;
- (c) the Punjab Canal and Drainage Act, 2023, and section 55 of the Northern India Canal and Drainage Act, 1873, unless either is shown to apply to the choes inside the Union Territory **[TBC]**; and

- (d) the rainfall zones PB-Z1 to PB-Z4 and the sub-areas PB-A to PB-F of Annex 2A, except where this Supplement applies the rule of a named sub-area.

Punjab bodies remain named for the reaches of the choes downstream in Punjab (Clause S1.4). Clause, table, annex and form numbers do not change.

S1.1.3 Values marked **[TBC]** are to be confirmed from the primary source before adoption. Until they are confirmed, the clause concerned states the rule that applies in the meantime.

> **Commentary.** This is the series' first Supplement for a capital city, and the first whose every outfall leaves its territory. Chandigarh is laid out in sectors on the plain between two seasonal streams, the Sukhna Choe on the east and Patiali-ki-Rao on the west, with the N-Choe through its centre (CDP). Its rainfall, soils and streams are those of the Shivalik piedmont of sub-area PB-C and the foothills of PB-A, so the engineering of the Manual applies to it unchanged. Its law is its own: development control runs under the Capital of Punjab (Development and Regulation) Act, 1952 as in force in the Union Territory, through the Chandigarh Building Rules (Urban) 2017 and the zoning plans; municipal law is the Punjab Municipal Corporation Act, 1976 as extended to Chandigarh in 1994, read in its Chandigarh text. The Punjab building instruments, the Punjab groundwater regulator and the Punjab drainage statute do not reach it. All of its storm water leaves through three choes into SAS Nagar (Mohali) and on to the Ghaggar, so its drains are designed against levels set outside the Union Territory, and its works change levels in Punjab.

S1.2 How the Manual applies: clause-by-clause modifications

S1.2.1 The clauses of the Manual listed in Table S1.1 apply in the Union Territory with the changes shown. Clauses not listed apply unchanged.

Table S1.1 — Modifications to the Manual for the Union Territory of Chandigarh

Manual clause	What changes in the Union Territory	Status of the basis
Status and Not adopted	The authority that could adopt the Manual and this Supplement is the Administrator, acting through the Chandigarh Administration, in place of the Government of Punjab.	Article 239; the Governor of Punjab as Administrator since 1984, as reported
1.3.1 Notification	Statutory effect would be given by: (a) an amendment to the Chandigarh Building Rules (Urban) 2017 (CBR), made by the Administrator under the Capital of Punjab (Development and Regulation) Act, 1952 as in force in the Union Territory (the section under which the CBR are framed is **[TBC]**); (b) for site-specific conditions, zoning plans and architectural controls, which are "Directions issued by the Chief Administrator in exercise of powers conferred upon him under Section 4(1)" of that Act; and (c) bye-laws or standing orders of the MCC under the Punjab Municipal Corporation Act, 1976 as extended to the Union Territory (section **[TBC]**). PMBBL and PUDBR do not apply.	Zoning plan, Sector 23-D (read); CBR enabling section and MCC section not found

Manual clause	What changes in the Union Territory	Status of the basis
Building rules ("PMBBL/PUDBR" throughout)	Read as the CBR, notified on 25-07-2017 (as quoted on the Sector 23-D zoning plan; a copy dated 02-05-2017 conflicts and the date is **[TBC]**), as amended in 2018 (an amendment notification of the Administration, listed but not read) and, as reported, in 2019 and 2020. The CBR rule numbers are **[TBC]**: their text was not obtained, so this Supplement cites the zoning-plan wording. Where the CBR are silent, the National Building Code and the Model Building Bye-Laws 2016, and the Chandigarh Master Plan 2031, prevail, as quoted in a summary of the CBR **[TBC]**. Older zoning plans cite the Capital of Punjab (Development and Regulation) Building Rules 1952 and apply the National Building Code where those rules are silent. "PMBBL/PUDBR registration number" on the Forms is read as the registration under the CBR **[TBC]**.	Zoning plan (read); CBR text not obtained
1.3.2 State Stormwater Technical Committee	The committee would be constituted by the Administrator. CPHEEO (2019) allows a committee "constituted by State/UT Government".	CPHEEO (2019)
1.4.1 Approving Authority	The authority that sanctions building plans under the CBR is **[TBC]**. Until it is confirmed, the Approving Authority is the authority that sanctions the plan in each case; the Chief Architect (Department of Urban Planning) issues zoning plans and architectural controls; the Estate Officer (the Deputy Commissioner) enforces building and rainwater-harvesting violations under the Chandigarh Estate Rules, 2007, as reported; the MCC approves connections to its drains and sewers; and a department of the Administration, or the CHB, is the Authority for its own works and estates.	Zoning plan (read); Estate Rules not read
1.5.3 RWH	The rainwater-harvesting requirement in force in the Union Territory applies in place of the PMBBL and PUDBR thresholds: "All building on a plot of one kanal and above shall have rain water harvesting system to recharge ground water installed as per specification of Chandigarh Administration" (Sector 23-D zoning plan). A Rajya Sabha answer of 8 July 2019 applies the same rule to existing and new buildings, as quoted in a search copy **[TBC]**, and an Estate Office notice of 28 June 2024 applied it to group housing, hotels, malls, hospitals, schools, hostels, religious sites and commercial, institutional and industrial plots of one kanal and above, as reported. One kanal is taken as 500 square yards (about 418 m²), set by this Supplement until the CBR definition is confirmed **[TBC]**. The 100-litre and 200-litre figures on the same zoning plan are solar water-heater capacities, not rainwater-harvesting volumes. Recharge is modified by Clause S1.6.	Zoning plan (read); notice and answer as stated
1.6 Tiers	The MCC is a **Tier A** authority (set by this Supplement). The Engineering Department and the CHB apply the Tier A methods to their own works and estates (set by this Supplement).	Set by this Supplement
1.8, 1.9 Other instruments and roles	PMBBL, PUDBR, the Punjab Municipal Act, 1911, the PRTPD Act, 1995, the Punjab Water Resources (Management and Regulation) Act, 2020 and the PWRDA Directions do not apply. The Punjab Municipal Corporation Act, 1976 applies as extended, with the modifications in its Schedule, by the Punjab Municipal Corporation Law (Extension to Chandigarh) Act, 1994 (Act 45 of 1994, in force from 24 May 1994); its Chandigarh text, not Punjab's, is cited, and the Schedule was not read **[TBC]**. Also in force: the Chandigarh Estate Rules, 2007 (not read **[TBC]**); the Chandigarh Master Plan 2031, notified in April 2015 as reported, under section 4(1)(f) of the 1952 Act as quoted in a summary of a Supreme Court judgment **[TBC]**, whose drainage, choe and disaster chapters were not read **[TBC]**; the Wetlands (Conservation and Management) Rules, 2017; the eco-sensitive zone notification of the Sukhna Wildlife Sanctuary; and the High Court judgment of Clause S1.5. Whether the Punjab New Capital (Periphery) Control Act, 1952 (Punjab Act 1 of 1953) has any present application inside the Union Territory is **[TBC]**. Roles are as in Table S1.2.	As stated
2.3 to 2.12 Design rainfall	Chapter 2 applies, with Clause S1.3. Clause 2.3.6 of this Manual applies as written, with the sub-area references read as in Clause S1.3.	—
2.11.4 Antecedent moisture	The rule of Clause 2.11.4 for a site outside the paddy and waterlogged areas applies throughout the Union Territory: AMC III for a design storm that follows or contains a 5-day total of more than 53 mm, and AMC II otherwise. The paddy rule applies only to the parts of a choe catchment in Punjab that lie under paddy or other ponded fields.	Rule of this Manual

Manual clause	What changes in the Union Territory	Status of the basis
4.4, 4.11, 8.8, 8.11 Retention, infiltration and recharge	Modified by Clause S1.6.	—
5.3, 5.8, 5.9, 5.10 Downstream analysis, river backwater and outfall closure	The three choes are the governing receiving channels, and the downstream analysis continues across the boundary into Punjab to the Ghaggar, as in Clause S1.4. Clause 5.8.5(b) (the Ghaggar) and (e) (choes and nallahs) of this Manual apply to the reaches in Punjab and, for (e), to the choes in the Union Territory.	—
5.8.3 Reservoir releases	Releases from Sukhna Lake are as in Clause S1.5.	—
6.3.6 Choe crossings and Kandi drains	Clause 6.3.6 applies to every road crossing, causeway, culvert, bridge and tail end (Clause S1.8) on the Sukhna Choe, the N-Choe, Patiali-ki-Rao and the other choes of the Union Territory, as if they were in sub-area PB-A (set by this Supplement).	Set by this Supplement
6.11 Floor levels	The kanal-plot zoning plan sets the plinth at "minimum 0.30m (1'-0") and maximum upto 1.20m (4'-0")" for buildings intended for human habitation; basements, where built, are for "parking, storage and services etc."; and "Adequate arrangement shall be made so that surface drainage does not enter into the basement" (zoning plan, Sector 23-D; site plan, Rajiv Gandhi Chandigarh Technology Park). Habitable use of basements was withdrawn by the CBR in 2017, as reported. Clauses 6.11.1 to 6.11.4 also apply, with the choe levels of Clause S1.4.2, and the higher level governs: the 0.30 m minimum is below both the default of Clause 6.11.3 and the 450 mm of PMBBL in Punjab. Where the level required by Clause 6.11 is above the 1.20 m maximum, the conflict shall be put to the Chief Architect before approval; this Supplement does not override the zoning plan (set by this Supplement).	Zoning and site plans (read)
7.4 Setbacks	No CBR or zoning-plan setback from a choe was found. Clauses 7.4.3 to 7.4.7 apply, with the Zone 1 minimum of Clause 7.4.7 as the Manual's minimum. The pillar line on Patiali-ki-Rao (Clause S1.4.5), the catchment construction restraint of Clause S1.5.6 and the eco-sensitive zone of Clause S1.5.7 bind under Clause 7.4.5 for the uses they restrict, each with its status; the 50 m of the draft wetland notification is not applied until a final notification is confirmed (Clause S1.5.7). Section 38 of the Punjab Canal and Drainage Act, 2023 does not apply in the Union Territory unless shown to apply **[TBC]**.	As stated
Chapter 7 custodian and NOC	The MCC builds and maintains the storm drains in its area (CDP). The legal custodian of the choes, and the division of trunk drains and road drains between the MCC and the Engineering Department after the transfer of the V3 roads in 2025–26 (as reported), are **[TBC]**. Until they are confirmed, where the Manual names WRD as custodian of a channel or requires its NOC, the Authority shall consult the Engineering Department for every work in or on a choe, and the MCC for every connection to a drain in its area, and record their responses; the Department of Forests and Wildlife is consulted for the Sukhna catchment and sanctuary, and the Union Territory of Chandigarh Wetlands Authority for the lake.	CDP (read); transfer as reported
7.8 Operating rules	Sukhna Lake is as in Clause S1.5.	—
7.12 Wetlands	The wetland authority is the Union Territory of Chandigarh Wetlands Authority, constituted by the Administrator on 6 December 2017 (as recorded in the High Court judgment). Sukhna Lake is as in Clause S1.5.7.	Judgment (read)
8.9 Sewage and dry-weather flow	Modified by Clause S1.7.	—
10.10 Works calendar	The calendar of this Manual applies: desilting complete by 15 June, gates, pumps, inlets and choe crossings certified ready by 25 June, standby to 15 October. The post-monsoon clearance of sand and debris that this Manual sets for sub-area PB-A, by 31 October, applies to the choe crossings, causeways and tail ends of the Union Territory (set by this Supplement).	Dates set by this Manual

Manual clause	What changes in the Union Territory	Status of the basis
10.16 Post-event review	Led by the Chandigarh Disaster Management Authority or the Deputy Commissioner, in place of PSDMA **[TBC]**, with the MCC and the Engineering Department.	Body to be confirmed
Chapter 11 Basin plans	The planning unit is the Ghaggar basin, with Punjab, Haryana and Himachal Pradesh. The Sukhna Lake catchment is a joint unit of the Union Territory, Punjab and Haryana, and the N-Choe and Patiali-ki-Rao are joint units of the Union Territory and Punjab. A basin plan would be prepared with the bodies of Clause S1.4.4.	—
Heritage controls	The controls on the Capitol Complex (a World Heritage property) and its buffer zone, and the Edict of Chandigarh, were not researched for this draft **[TBC]**. Any approval within their scope follows those controls.	Not researched

Table S1.2 — Roles in the Union Territory

Body	Role under this Manual (if adopted)	Status of the basis
Administrator; Chief Secretary (the post renamed from "Adviser to the Administrator" in January 2025, as reported)	Would amend the CBR and constitute the committee of Clause 1.3.2.	As reported
Department of Urban Planning (Chief Architect; Senior Town Planner)	Would issue the zoning plans and architectural controls that carry site conditions under section 4(1) of the 1952 Act; keeper of the Master Plan 2031.	Zoning plan (read)
Estate Office (the Deputy Commissioner as Estate Officer)	Would enforce rainwater harvesting and building conditions under the Estate Rules 2007; its role in plan sanction is **[TBC]**.	As reported
Engineering Department (Chief Engineer; Public Health Circle)	Would design and build storm drainage outside the MCC area and in new sectors, and on the V3 roads; operate the Sukhna Lake regulator and gates and publish its operating rule and releases (Clause S1.5); desilt the choes; approve rainwater-harvesting specifications; consulted on every work in or on a choe (Table S1.1).	Department page (summary); press
Municipal Corporation Chandigarh (Public Health and Roads wings)	Tier A Approving Authority for connections to its drains; owner and maintainer of the storm drains in its area (713 km, or "About 720 k.m", of main and branch lines in the CDP — older figures, current length **[TBC]**); receives handed-over assets (Clause 10.14); monsoon control rooms; owner of the Diggian sewage treatment plant, which lies in SAS Nagar according to the annexures of an NGT appeal seen only in a copy **[TBC]**.	CDP (read)
Chandigarh Housing Board	Would be the Authority for the drainage of its own housing estates **[TBC]**.	Role not confirmed
Chandigarh Smart City Ltd	Would apply the Manual to its own works; it upgraded five sewage treatment plants and built a 2 MLD plant at Kishangarh (State of Environment report, 2018), and proposed an underground storm drain of about 1 km in Sector 43, as reported.	SoE 2018 (read); press
Department of Forests and Wildlife	Would keep the check dams and silt-retention dams of the Sukhna catchment, the Sukhna Wildlife Sanctuary and its eco-sensitive zone, and comment on any work there.	Judgment (read)
Union Territory of Chandigarh Wetlands Authority	Would administer the Sukhna Wetland under the Wetlands Rules 2017 and the Ramsar listing (Clause S1.5.7).	Judgment (read); press

Body	Role under this Manual (if adopted)	Status of the basis
Chandigarh Pollution Control Committee (CPCC)	Water Act consents for sewage treatment plants and outfalls into the choes (Clause S1.7).	SoE 2018 (read)
Chandigarh Disaster Management Authority; Deputy Commissioner	Warnings, including Sukhna release alerts; flood records; post-event review **[TBC]**.	Body to be confirmed
Punjab: Water Resources Department (Drainage), including the Executive Engineer, Water Management Investigation Division, Rupnagar, for Patiala Ki Rao; Deputy Commissioner SAS Nagar; GMADA; Municipal Corporation SAS Nagar; the Municipal Council Zirakpur; the Nayagaon body (called a Municipal Council in the body of a reply to the NGT and a Nagar Panchayat in its index **[TBC]**); PPCB	Owners of the receiving reaches of the N-Choe, Patiali-ki-Rao and the Sukhna Choe in Punjab; would comment on drainage reports and works under Clause S1.4.4; the Punjab part of the Sukhna catchment (Kansal, Nayagaon).	NGT reply, OA 180/2026 (read); press
Haryana: Irrigation and Water Resources Department; the Town and Country Planning Department (periphery control); the Panchkula Metropolitan Development Authority; Deputy Commissioner, Panchkula	The Haryana part of the Sukhna catchment (Saketri and the Mata Mansa Devi complex); the Ghaggar and its notified floodplain zone at Panchkula (Clause S1.4.3).	Judgment (read); Haryana research
Himachal Pradesh	The upper Ghaggar catchment; no direct outfall from the Union Territory was found.	NEER reading
CWC; IMD (Meteorological Centre, Chandigarh); CGWB (North Western Region)	The Flood Estimation Reports; rainfall records (Chandigarh, 42105); groundwater assessment.	—

> **Commentary.** The CBR were drafted by the Department of Urban Planning on the model of the Model Building Bye-Laws 2016, as reported, and their text was not obtained for this draft; the zoning plans, which were read, carry the rules that matter for drainage — rainwater harvesting on plots of one kanal and above, the plinth band and the basement condition. No CBR or zoning-plan rule on paving, detention or setbacks from a choe was found, which is the gap the Manual fills. The MCC is set at Tier A because it is the only urban local body, it serves almost the whole city, and its drains discharge into choes shared with Punjab, where errors are exported to another jurisdiction. The Punjab Municipal Corporation Act, 1976 is the one Punjab statute this Supplement carries into the Union Territory, and only in the text extended to Chandigarh.

S1.3 Design rainfall and season

S1.3.1 **Report.** The whole Union Territory lies in CWC subzone 1(e), whose report names Chandigarh among its towns and Union Territories. Under Clause 2.3.6(c) the 24-hour depths are read from Plates 9 and 10 at the coordinates of the site; at Chandigarh the 50-year plate prints a spot value of **262 mm** and the 100-year plate about **289 mm**, inside a closed 280 mm contour.

S1.3.2 **Shivalik catchments.** On the 1(e) plates the boundary with zone 7 runs just north-east of the city (NEER reading by eye, to be confirmed on the report's index maps **[TBC]**). For the Sukhna Lake catchment, for Patiali-ki-Rao above Kansal and Nayagaon, and for any other choe catchment of 25 km² or more that rises in the Shivalik hills, Clause 2.3.6(b) and (i) apply as they do in sub-area PB-A: the design depth is the larger of the 1(e) plate and a station fit that includes the 2023 storm; the zone 7 report is run as a sensitivity check and the higher result is reported; the 1(e) "suitable increase" for foothill catchments is applied; and choe crossings carry the sediment allowance of Clause 6.3.6.

S1.3.3 **Station.** For Clause 2.3.6(a) and (d), the station is IMD Chandigarh, 42105 (daily record 1954–2009 in IMD's *Extremes*). Its recording-gauge annual maxima and the airport (Aero) record after 2009 are part of the first data request of Clause 2.3.6(a) **[TBC]**.

S1.3.4 **24-hour record check.** Clause 2.3.6(h) applies. IMD recorded **302.2 mm** at Chandigarh on 9 July 2023 (IMD *Monthly Climate Summary*, July 2023, "based on real time available data"; the previous July record was 262 mm on 18 July 2000). This exceeds the 100-year plate value of about 289 mm, so in the whole Union Territory, all of which lies within 25 km of the gauge, the **1% AEP (100-yr) 24-hour depth is 302.2 mm** and the **2% AEP (50-yr) 24-hour depth is not less than 262.2 mm**, about equal to the plate. This follows from the Manual's rule; it is not a new value. IMD's final (non-real-time) value is **[TBC]**; if IMD revises the figure, the revised value is used. The press figures of 322.2 mm and 290.9 mm for the same day conflict with IMD's and are not used. Earlier records at the station are 234.9 mm at the observatory (26 September 1955) and 212.0 mm at the aerodrome (19 August 1978) (IMD *Extremes*), both below the plates.

S1.3.5 **Short storms.** The statewide floors of Clause 2.3.6(g)(i) apply. The floors that Clause 2.3.6(g)(ii) sets for sub-area PB-C — a 2% AEP one-hour depth of not less than 93 mm and a three-hour depth of not less than 153 mm, with other AEPs scaled as that clause provides — apply in the whole Union Territory as they do in PB-C (set by this Supplement: the city lies in the same plate cell as SAS Nagar and Zirakpur, and its drains discharge into the same choes). The record check of S1.3.4 raises the 24-hour and longer depths, not the depths of one to 18 hours.

S1.3.6 **Legacy design basis.** The City Development Plan and the State of Environment report of 2018 state that the drainage system "was designed for the rainfall of 12 mm/hour", and, in another passage of the same documents, that the northern sectors "have been designed at 15mm rainfall intensity per hour" and the southern sectors at 20 mm, with "dire need to augment the whole S.W.D. system of the city at 25mm rainfall intensity/hr"; a press account gives "half an inch of rainfall per hour". The 12 mm/h and the 15 and 20 mm/h figures conflict within the same documents, and neither is confirmed by design records. These figures carry no stated AEP, so under Clause 2.3.4(d) they are evidence of the capacity of the existing network only and are never design values under this Manual:

- (a) new and replacement drains follow Chapter 2 and the depths of this Clause; and
- (b) where a development connects to an existing drain, the capacity check of Chapter 5 shall take that drain at the legacy basis (12 mm/h, the lower figure) unless the MCC or the Engineering Department gives its as-built capacity (set by this Supplement).

S1.3.7 **Season.** The season, the works calendar and the antecedent moisture rule of this Manual apply as stated in Table S1.1. The monsoon's new normal dates at Chandigarh are onset on 28 June and withdrawal on 23 September (IMD, Pai et al., 2020).

> Commentary. IMD's normal annual rainfall for Chandigarh is 1,073.6 mm over 48.7 rainy days (1901–80); CGWB uses 1,078 mm and the CDP 1,150 mm. NIH-DHAARA gives about 313 mm for the 50-year 24-hour depth at the city's cell, above the plate; under Clause 2.3.6(l) it is used only for the ratio of projected to present-day depths, never as a value, check or floor. The Sukhna catchment is steep, with slopes "ranging from 30 degree to 75 degree", and its soil is "sandy, embedded with pockets of clay, which is highly susceptible to erosion" (High Court judgment, 2020), which is why the foothill rules of Clause 2.3.6(i) and Clause 6.3.6 are applied to the choes. The 12 mm/h figure is about the average intensity of the 302.2 mm day of 9 July 2023 spread evenly over 24 hours (about 12.6 mm/h, NEER reading), so that storm exceeded every legacy figure for most of its duration, and the 25 mm/h augmentation proposed in the CDP would still be an evidence figure, not a design basis. No IMD hourly or 15-minute maximum for Chandigarh was found **[TBC]**.

S1.4 The three choes and the boundary with Punjab

S1.4.1 **Governing receiving channels.** Every outfall of the Union Territory discharges, directly or through the city drains, to one of three choes, each of which leaves the Union Territory into Punjab and reaches the Ghaggar:

- (a) the **N-Choe**, which rises near Sector 2, passes through Leisure Valley and Sectors 16, 23, 36 and 42, leaves the Union Territory at Sector 53 (30.721836 N, 76.731728 E), flows through Sectors 62, 63, Phase 9, 67 and 81 of SAS Nagar to Chilla Manauli, and, as the **Pachisdhara drain**, joins the Ghaggar at Sarala Khurd (Rajpura, Patiala district), about 70 km from its source (CPCB inspection report, 2024);
- (b) the **Sukhna Choe**, which carries the releases of Sukhna Lake from the regulator past the causeways at Kishangarh, Bapu Dham and Industrial Area Phase I, through Baltana (Zirakpur, SAS Nagar), to the Ghaggar near Bhankharpur, as reported; and
- (c) **Patiali-ki-Rao** (also Patiala Ki Rao), which enters the Union Territory from Nayagaon and Kansal in Punjab, passes Dhanas and Dadumajra, and leaves for SAS Nagar.

Other choes named in the press (Attawa, Baltana and Faida) and the nala that the CDP says starts at Sector 29 are receiving channels where an outfall reaches them.

S1.4.2 **Choe levels.** No design flood level for any reach of the three choes was found **[TBC]**. Until the custodian (Table S1.1) publishes one, the high flood level used for Clause 5.8.2, for Clause 6.11.2(b) and for Clause S1.5 shall be the higher of:

- (a) the highest recorded flood level at the site, from the records of the MCC, the Engineering Department or the Deputy Commissioner, or a surveyed flood mark, with the record stated on Form 5-1; and
- (b) the level from a hydraulic model of the reach under Clause 5.8.2(b), with the choe in its present condition (silt, debris and encroachment included), the bed taken at its highest surveyed level, and, on the Sukhna Choe, the release of Clause S1.5.2.

Where neither (a) nor (b) is available for a plot below the Chapter 1 thresholds, Clause 6.11.3 applies.

S1.4.3 **Downstream analysis across the boundary.** Where the downstream analysis of Chapter 5 reaches a choe or drain in Punjab, it shall continue to the point required by Clause 5.3, whatever the boundary, and where Clause 5.3 requires it, to the Ghaggar, with the Ghaggar tailwater of Clause 5.8.5(b) of this Manual. For the Ghaggar downstream of the Sukhna Choe the notified floodplain zone of Haryana at Panchkula (section 45 of the Haryana Canal and Drainage Act, 1974, 27 October 2023, on a 100-year flood of 2,933.45 m³/s, as recorded in the research for the Haryana edition) is a check on the river level.

S1.4.4 **Cross-boundary consultation.** Before approval under this Manual:

- (a) the drainage report of a development whose downstream analysis reaches SAS Nagar, Zirakpur or Nayagaon should be sent for comment to the local body concerned, and to GMADA where it reaches a GMADA scheme;
- (b) a work in or on Patiali-ki-Rao on or near the boundary should be referred to the Water Resources Department of Punjab (the Executive Engineer, Water Management Investigation Division, Rupnagar, who is authorised under the notification of 4 March 2013 under section 55 of the Northern India Canal and Drainage Act, 1873 on the Punjab side);
- (c) a work on the N-Choe at or near its exit at Sector 53 should be referred to the Water Resources Department of Punjab, GMADA and the Municipal Corporation SAS Nagar; and
- (d) a work on the Sukhna Choe below the regulator should be referred to the Municipal Council Zirakpur and the Water Resources Department of Punjab.

Each comment shall be recorded. These bodies have not agreed to this role; it is the role they would have if the Manual and this Supplement were adopted (set by this Supplement).

S1.4.5 **No narrowing of a choe.** No work shall narrow, cover, fill or realign the bed of a choe, or reduce its section below the section needed to carry its 1% AEP flow with the freeboard of Chapter 6, and Clause 6.3.6 applies to every crossing. Court and plan lines are taken as in Clause 5.8.5(h). On Patiali-ki-Rao, boundary pillars have been fixed in the Union Territory on both sides of a width of 200 ft, under the High Court's directions in CWP 5901 of 2017 (Local Commissioner's report of 8 January 2024); the fixing of pillars on the Punjab side was still pending. That width is court-monitored and specific to this case. It is not a rule of this Supplement, but Zones 1 and 2 of Clause 7.4 shall be measured outward from the pillar line wherever it lies outside the top of bank (set by this Supplement).

S1.4.6 **Outfall closure.** Where the choe level of Clause S1.4.2 is above the invert of an outfall or tail end, the outfall shall be treated as closed for the whole design storm (Clause 5.9.4) and the outfall-closed check of Clause 5.10 applies, with the lock duration that Clause 5.8.5 of this Manual sets for the choes (at least 72 hours, and covering the whole of the 48- and 72-hour storms); storage and pumping shall handle the storm volume, and pumps shall meet Clause 5.12. On the Sukhna Choe the check is made with the release of Clause S1.5.2 coinciding with the local storm.

> Commentary. The N-Choe is, in the CPCB's words, an "interstate drain which carry sewage, storm water / over flow of fresh water of Chandigarh and Mohali (SAS Nagar)". The CDP lists its "disappearance" through urbanisation, filling, dumping and the laying of service lines along and across natural courses among the causes of flooding, and the NGT, in OA 736 of 2022, recorded that debris was "shrinking size of drain causing serious apprehension of flood in Chandigarh" (as quoted in the CPCB report). The CDP also records that the railway from Morinda to Ludhiana, built on fill, formed a barrier around the eastern and southern part of the city. On Patiali-ki-Rao, the Local Commissioner found the Punjab side "heavily encroached" and the Union Territory side cleared of debris (report of 8 January 2024, annexed to the reply in NGT OA 180 of 2026); a public-interest petition (CWP-PIL 79 of 2025) seeks an embankment against "season flooding" at Khuda Lahora, Nada, Nayagaon and Karoran, and an application in it (notice of 7 May 2026) reports construction in the Rao "significantly increasing the risk of flooding". The rao overflowed at Dadumajra and Dhanas on 6 September 2025, and in July 2025 water from Patiala Ki Rao and Jayanti ki Rao entered houses at Rurka in SAS Nagar, as reported. The Administration has asked SAS Nagar to clean the Sukhna Choe in its area, as reported. Works on a shared choe change levels on both sides of the boundary, which is why S1.4.3 carries the analysis across it and S1.4.4 makes the downstream bodies' comment a step in approval. The Sukhna Choe of this Supplement is not the stream of the same name in Himachal Pradesh that CPCB lists among polluted river stretches.

S1.5 Sukhna Lake: gates, catchment and the courts

S1.5.1 **The lake as a reservoir.** Sukhna Lake was built in 1958 across the Sukhna Choe. Its releases to the Sukhna Choe are reservoir releases under Clause 5.8.3. The Engineering Department operates the regulator and its floodgates (three, as reported); the danger mark is **1,163 ft** and the gates are usually opened above 1,162 ft, as reported. No operating rule, spillway or gate capacity, rating, release record, or datum for the 1,163 ft mark was found **[TBC]**. Every lake level used under this Clause shall be stated with its gauge and datum.

S1.5.2 **Downstream design case.** Until the Engineering Department publishes an operating rule and a rating for the regulator, the release used on the Sukhna Choe shall be the discharge of all gates fully open with the lake at the danger mark, from a rating computed for the design and agreed with the Engineering Department **[TBC]**, and, once a release record exists, the higher of that discharge and the largest recorded release (set by this Supplement). The coincidence of the release with the local storm is as in Clause 5.8.4.

S1.5.3 **No credit for unrecorded coordination.** No reduction in the release of Clause S1.5.2, and no credit for the timing of releases relative to local rain, shall be taken on the basis of coordination between the operator of the regulator and the bodies downstream unless that coordination is set out in a published operating rule or a written agreement that the Authority has seen and recorded (set by this Supplement).

S1.5.4 **No flood cushion.** No flood cushion in Sukhna Lake shall be counted as storage under Clause 7.7 until the conditions of Clause 7.8.2 are met; until then Clause 7.8.3 applies.

S1.5.5 **Upstream of the lake.** No new urban drain shall be connected to the lake or to a stream that feeds it, and no work in the catchment shall divert or reduce the inflow to the lake (set by this Supplement, following directions L and M of the judgment of S1.5.6). Every work in the catchment shall carry the construction-stage erosion and sediment controls of Clause 8.12.

S1.5.6 **Court restrictions in the catchment.** In *Court on its own motion v. Chandigarh Administration* (CWP 18253 of 2009 and connected cases, judgment of 2 March 2020), the Punjab and Haryana High Court, among other directions:

- (a) declared Sukhna Lake a "legal entity/legal person/juristic person" (direction B);
- (b) declared illegal, and ordered the demolition of, structures in the catchment "as delineated in the map prepared by the Survey of India on 21.9.2004" in Punjab, Haryana and the Union Territory (directions C and D), and directed Punjab and Haryana to pay ₹100 crore each for its restoration (direction A);
- (c) directed that "New construction is completely banned in the catchment areas as delineated in the Survey of India map dated 21.9.2004 falling in the States of Punjab, Haryana and UT Chandigarh as well as in the Sukhna Wetland, Sukhna Wildlife Sanctuary" (direction J);
- (d) directed dredging to raise the lake's capacity, lowering of the storage of the check dams "to ensure regular flow of water into Sukhna Lake", and a "permanent discharge measurement site about half a km upstream in the channel" (direction L); and
- (e) directed that "no waste water/sewage flows into the river from the villages i.e Kansal, Kaimbwala and Saketri" (direction M).

The demolition direction was stayed by a coordinate Bench of the High Court on 18 December 2020 pending review applications; the restraint on construction in the catchment was not disturbed, as reported. The review applications were still pending, and physical demarcation of the catchment was ordered, in CWP-PIL 9 of 2023 (interim order of 2 August 2024, as quoted in a report of the order **[TBC]**). The only Supreme Court stay found in research for this draft is of 2012, of an earlier High Court direction to demolish constructions in the catchment, as reported; no Supreme Court stay of the 2020 judgment was found. The construction restraint is a court restriction, not a rule of this Supplement: before any approval in or near the catchment, the Authority shall confirm the current status of the judgment and of the demarcation, and record it **[TBC]**.

S1.5.7 **Wetland, eco-sensitive zone and Ramsar listing.** The lake was declared a "common wetland" on 6 July 1988, and a draft notification under the Wetlands (Conservation and Management) Rules, 2017 was issued on 21 October 2019 (High Court judgment); the draft proposed no "permanent construction within 50 metres of the mean high flood level", as reported. Whether a final notification has been issued, and its buffer, are **[TBC]**; until it is confirmed, the 50 m is not applied as a statutory setback, and Clause 7.4 applies to the lake as a waterbody. The Ministry of Environment, Forest and Climate Change notified 1,050 ha "to an extent varying 2.0 to 2.75 kilometres from the boundary of Sukhna Wildlife Sanctuary" as its eco-sensitive zone on 18 January 2017 (as recorded in the judgment); Punjab's position before the Court was an eco-sensitive zone of 100 metres, and the Court directed at least 1.0 km in Punjab and Haryana (direction H). The Union Minister announced Sukhna Wetland as a Ramsar site on 15 October 2026, as reported; its site number, area and designation date are from a single secondary source and are **[TBC]** against the Ramsar Sites Information Service.

> Commentary. The judgment records that the lake's capacity fell from 1,074.4 ha·m in 1958 to 513.28 ha·m in 2005 and its water spread from 228.64 ha to 148.28 ha, and that 192 silt-retention dams and 200 check dams had been built in the catchment, 110 of them silted or partly silted. The Sukhna Wildlife Sanctuary covers 25.9849 km². The catchment is about 10,395 acres, of which about 2,525 acres are in Haryana and 684 in Punjab, as reported in 2019; the rest, about 29 km², is in the Union Territory (NEER reading by difference). The judgment's narrative also dates the Survey of India map 14.9.2004 and records it taken on record on 24.09.2004; this Supplement uses 21.9.2004, the date in the directions. The gates were opened eleven times in the 2025 monsoon, a record, four times in 2023, six in 2022 and five in 2021; in August 2020 the opening of two gates flooded low-lying Zirakpur

along the Sukhna Choe; and the opening of 24 September 2018 was the first in ten years (all as reported). During one release all three causeways on the choe overflowed, and traffic on the Baltana bridge and on the Ghaggar causeway at Mubarikpur has been suspended at high flows, as reported. The releases are therefore a recurring design load on the Sukhna Choe in Punjab, set by a gate whose rule is not published; S1.5.2 and S1.5.3 apply the Manual's reservoir rule to it. The Engineering Department runs a control room at the regulator end in the monsoon, coordinating with the Deputy Commissioners of Chandigarh and SAS Nagar, as reported.

S1.6 Groundwater, infiltration and rainwater harvesting

S1.6.1 **Recharge permitted.** In the Union Territory, recharge and infiltration under Clauses 4.4, 8.8 and 8.11 are permitted, subject to S1.6.2 to S1.6.4. Punjab's three infiltration rules for the Kandi, the over-exploited central plains and the waterlogged south-west, and the PWRDA water-conservation credits, do not apply (set by this Supplement).

S1.6.2 **Southern sectors and shallow water.** In the southern sectors, and wherever the pre-monsoon water table is within about 3 m of the ground, infiltration shall be credited only at a rate measured on site under Chapter 8, after a water-table check at the site, and the separation of Clause 8.8.1 shall be shown from the seasonal-high water table (set by this Supplement). The extent of the southern sectors to which this applies (roughly south of Sector 30) is **[TBC]**; until a depth-to-water map is published, the check is made at every site south of Sector 30.

S1.6.3 **Shivalik slopes.** On the natural slopes of the Shivalik hills in the Union Territory (the Sukhna catchment and the sanctuary), the hill rule of Clause 4.11 applies as in sub-area PB-A: no deliberate infiltration on a natural slope steeper than 10°, or within twice the wall height upslope of a cut, without a geotechnical certificate.

S1.6.4 **Quality.** Road, parking, yard and industrial runoff shall not be led into an injection well or recharge shaft; only roof water may be (set by this Supplement, as in Punjab). Recharge structures shall be kept away from sewers, septic tanks and soak pits as Chapter 8 requires.

S1.6.5 **Rainwater harvesting.** The one-kanal rule of Table S1.1 applies, with the specification of the Administration. Its structures count toward retention only as Clauses 8.11.4 and 8.11.5 allow.

Commentary. CGWB's assessment for 2024 rates the Union Territory "Safe", with a stage of extraction of 66.13%, down from 89% in 2017, 80.6% in 2020, 80.99% in 2022 and 75.41% in 2023; it describes "Fair to good aquifer horizons" of medium to coarse sand to 180 m below ground, with "Coarser sediments … along the Sukhna Choe and Patialiki Rao", groundwater "under confined as well as semi-confined conditions", no quality exceedance in its eight samples, and recommends "Roof Top Rainwater Harvesting in feasible areas of Chandigarh for recharging the Ground water Reservoirs". The brochure prints the recharge-worthy area as "11.4 Thousand Sq. Km", an error for the 114 km² it gives elsewhere; a secondary summary placing the Union Territory in the 70–90% band conflicts with CGWB's own figure, which governs. The ground is therefore unlike most of Punjab, where 115 of 153 assessment units are over-exploited, and the Punjab rules are not imported. A shallow aquifer between about 1.22 and 45 m and a deep one between 15 and 70 m are reported, with shallow levels in the southern sectors where "flooding there occurs even after light rain", as reported; S1.6.2 screens those areas. The groundwater-extraction guidelines of the Ministry of Jal Shakti (24 September 2020, amended March 2023) apply in the Union Territory, as the CGWB brochure notes.

S1.7 Sewage in the choes

S1.7.1 **Mixed-flow channels.** The choes carry sewage, treated effluent and fresh-water leakage as well as storm water. Clause 8.9 applies in full; in addition, before approval of an outfall to a choe:

- (a) the outfall invert, or the invert of the tail end it discharges through, shall be above the dry-weather flow level of the choe at that point, from a survey in the dry season, as well as meeting the bed rule of Clause 6.3.6; and
- (b) where the outfall has been intercepted ("tapped") to take dry-weather flow to a sewer, the design shall check that the interceptor, when surcharged in a storm, does not back sewage into the storm drain or flood its catchment (set by this Supplement).

S1.7.2 **Interception ahead of the choes.** Every new or reconstructed outfall to a choe shall have dry-weather-flow interception and screening ahead of it, under Clause 8.9 (set by this Supplement).

> Commentary. In January 2024 CPCB measured a BOD of 28 mg/l in the N-Choe at Sector 36 and 22 mg/l at its exit at Sector 53; 31 mg/l where it enters SAS Nagar (Sector 83, behind the industrial area) and 50 mg/l 1 km before its confluence with the Ghaggar at Sarala Khurd; the outlet of the 45 MLD sewage treatment plant at Chilla (Sector 83, SAS Nagar) had a BOD of 68 mg/l. CPCB found the outfalls at Sector 36 and Sector 42 intercepted, four tail ends in Bougainvillea Garden and three in Leisure Valley "tapped", and untreated domestic sewage entering the choe at several points in SAS Nagar (CPCB inspection report, 2024). The Indian Express had reported "a wide drain pipe which is only for the storm and rain water" at Sector 36 "emitting continuous sewage water" (15 December 2023, as quoted in the NGT's order). The CDP records that "22 mgd sewage is being dispose off dumping into 'N' choe" and that the MCC was treating 30 mgd of the 60 mgd it received — figures of about 2006 (NEER reading of the CDP's date), not current. Interception structures that back up in storms, and base flow from treated effluent, raise the water at the outfalls; S1.7.1 sets the outfall above it.

S1.8 Local terms and event evidence

S1.8.1 **Terms.** In this Supplement:

- (a) **choe** is a seasonal stream of the Shivalik foothills and the plain below them (the Sukhna Choe, the N-Choe);
- (b) **rao** is the local name of a larger seasonal stream, used for Patiali-ki-Rao, which documents also call Patiala-Ki-Rao, Patiala Ki Rao and Patialiki Rao, a "Nadi/Choe", and "Chao"; this Supplement writes Patiali-ki-Rao;
- (c) **nallah** is an open drain or minor stream ("open Nallahs/N-choe", CDP);
- (d) **tail end** is the outfall structure by which a storm drain discharges into a choe, built "to avoid scouring of the embankments & its bed" (CDP);
- (e) **causeway** is a road crossing laid on the bed of a choe; and
- (f) **regulator end** is the outlet end of Sukhna Lake, with its spillway and gates.

> Commentary. The CDP lists the low-lying areas of the city as Sectors 11 and 24, parts of Sectors 15 and 35, Mauli Jagran and the Gobindpura area of Manimajra. On 9 July 2023 IMD recorded 302.2 mm (Clause S1.3.4); underpasses were submerged and the road at the Kaimbwala turn closed, and 531.6 mm was reported over 8–10 July for Chandigarh, SAS Nagar and Panchkula together, as reported. In 2025 the city received 1,071.2 mm by 24 September, 27.9% above normal, as reported; the lake gates opened eleven times (Clause S1.5) and Patiali-ki-Rao overflowed on 6 September. The trunk main laid between Sectors 17/18, 21/22, 34/35 and 43/44 to the N-Choe at Sector 51, at a cost of about ₹2 crore, and about 500 vertical road gullies (State of Environment report, 2018), and

the MCC's storm-water master plan study, which recommended "deepening and widening of the nallahs for the sections affected by encroachments" (CDP), are the augmentation works found; the study's date, consultant and design storm were not found. These records are evidence only and are not design values (Clause 2.3.4(c)).

To be confirmed

The following are needed before this Supplement could be adopted; the interim rule stated in each clause applies until then:

1. the text of the Chandigarh Building Rules (Urban) 2017, with their rule numbers for rainwater harvesting, plinth, basements and paving, the section of the 1952 Act under which they are framed, their notification date (25-07-2017 or 02-05-2017) and the amendments of 2018 to date (Table S1.1);
2. the plan-sanctioning authority under the CBR, the Estate Rules 2007, the CBR definition of a kanal, and the Engineering Department's current rainwater-harvesting specification (Table S1.1);
3. the Chandigarh text of the Schedule to Act 45 of 1994, and the sections under which the MCC could adopt bye-laws (Table S1.1);
4. the drainage, choe and disaster chapters of the Chandigarh Master Plan 2031 and its 2026 amendments, and the section under which it is notified (Table S1.1);
5. the present area of the MCC, the length of its storm drains, the MCC storm-water master plan study, and the division of drains and choes between the MCC and the Engineering Department after the transfer of the V3 roads, including the legal custodian of the choes (Clauses S1.1 and S1.4; Table S1.1);
6. whether the Northern India Canal and Drainage Act, 1873, the Punjab Canal and Drainage Act, 2023 or any other statute applies to the choes inside the Union Territory, and whether the Punjab New Capital (Periphery) Control Act, 1952 applies there (Clause S1.1.2);
7. the name and status of the Nayagaon local body, and the role of the Chandigarh Housing Board (Table S1.2);
8. the Sukhna Lake regulator: its gates, spillway capacity, rating, operating rule, release record and the datum of the 1,163 ft mark (Clause S1.5);
9. the current status of the 2020 Sukhna judgment (the review applications, the demarcation in CWP-PIL 9 of 2023 and the payments of direction A), the final wetland notification and its buffer, and the Ramsar entry (Clauses S1.5.6 and S1.5.7);
10. IMD's final value for 9 July 2023, Chandigarh's recording-gauge maxima and any hourly data, and the airport record after 2009 (Clause S1.3);
11. the zone-7 line near the city on the index maps of the two CWC reports (Clause S1.3.2);
12. design flood levels and surveyed flood marks for the three choes (Clause S1.4.2), and a depth-to-water map for the southern sectors (Clause S1.6.2);
13. the Chandigarh Disaster Management Authority and its plan (Table S1.1, Clause 10.16);
14. any CAG audit of storm drainage in the Union Territory (none was found); and
15. the controls of the Capitol Complex and its buffer zone and of the Edict of Chandigarh (Table S1.1).

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