MIZORAM

Stormwater Design Manual

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

Preserve | Retain | Detain | Convey | Maintain

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Prepared by

Neer.

About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Mizoram, by its Governor, its Council of Ministers or its Legislative Assembly, or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Urban Development and Poverty Alleviation Department (UD&PA), the Aizawl Municipal Corporation, its Board of Councillors, its Local Councils or its Ward Committees, the Lunglei Municipal Council (LMC), the erstwhile Aizawl Development Authority (ADA), the Landslide Policy Committee for Aizawl City or Aizawl Smart City Ltd. Nor has it been adopted, notified or endorsed by the Lai, Mara or Chakma Autonomous District Councils, by any Village Council, by the Mizoram State Water Resources Council (MISWARC), the Water Resources Development and Management Authority (WARDMA) or any District, Village or Local Water Resources Committee, by the River Rejuvenation Committee, or by the Mizoram River Protection Authority, which has not been found to have been constituted. Where it names a body, such as the Public Works Department (PWD), the Public Health Engineering Department (PHED), the Irrigation and Water Resources Department (IWRD), the State Investment Programme Management and Implementation Unit (SIPMIU), the Disaster Management and Rehabilitation Department (DM&R), the Mizoram State Disaster Management Authority (MSDMA) or a District Disaster Management Authority, the Mizoram Pollution Control Board (MPCB), the Environment, Forest and Climate Change Department (EF&CC), the Land Revenue and Settlement Department, the Directorate of Geology and Mineral Resources, the Mizoram Remote Sensing Application Centre (MIRSAC), the Directorate of Science and Technology (DST), the Young Mizo Association (YMA), a Deputy Commissioner, the Gauhati High Court (Aizawl Bench), the National Green Tribunal (NGT) or the Supreme Court, or a body of the Union or another public body, such as the Central Water Commission (CWC), the India Meteorological Department (IMD), the Central Ground Water Board (CGWB), the Central Pollution Control Board (CPCB), the Comptroller and Auditor General of India (CAG), the National Institute of Hydrology (NIH), NEEPCO, the National Highways and Infrastructure Development Corporation Ltd (NHIDCL), the National Disaster Management Authority (NDMA) or the Ministry of Environment, Forest and Climate Change (MoEF&CC), or a research body, lender or adviser, such as Mizoram University (MZU), the Asian Development Bank (ADB) or GeoHazards International (GHI), it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role. Citing a body's document does not make this Manual that body's document.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. Until then, the Aizawl Municipal Corporation Building Regulations, 2012 as amended (AMCBR); the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 (SD&SM); the Mizoram Municipalities Act, 2007 and the rules made under it; the Mizoram (Village Councils) Act, 2025; the Mizoram Water Resources (Management and Regulation) Act, 2024; the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, if and as enacted, their enactment not having been confirmed; the Master Plan for Aizawl: Vision 2030; the Corporation's landslide hazard maps; orders of courts and tribunals; and approval conditions in force continue to apply.

Mizoram, its Village Councils and the Sixth Schedule. The State has three legal geographies, and this Manual reaches them differently. The Mizoram Municipalities Act, 2007 "shall extend to the whole of the State of Mizoram except the area which has been or may hereafter be declared as, or included in, a Panchayat or a Village Council … but shall not extend to the Mizoram Tribal Areas, as referred to in PART III of the paragraph 20 of the Sixth Schedule" (section 1(2)); in practice it reaches two bodies, the Aizawl Municipal Corporation and the Lunglei Municipal Council. The Mizoram (Village Councils) Act, 2025 "shall extend to the whole of Mizoram except the areas under the jurisdiction of the Municipalities and the Lai, Mara and Chakma Autonomous District Councils" (section 1(2)); it reaches the villages and the notified towns that have no urban local body, 13 of them

with 5,950 to 32,734 people, as the CAG found. The three Autonomous District Councils in the south, the Lai (Lawngtlai), the Mara (Siaha) and the Chakma (Kamalanagar/Chawngte), as reported, lie outside both Acts, and outside the Water Resources Act, 2024 ("except the Autonomous District Councils") and the Rivers Bill, 2023; the provisions of the 74th Amendment "are not applicable in the Sixth Schedule areas", as the CAG found. Only the Corporation has building and site-development regulations: AMCBR and SD&SM apply to "all the areas covered by the Aizawl Municipal Council" (AMCBR reg. 1(2)), no statewide building regulation was found, and no regulation of the LMC was found [TBC]. In a Village Council area the 2025 Act lets the Council "adopt and enforce the model building bye-laws as may be framed by the State Government" and, with the approval of the District Disaster Management Authority, "declare certain area … as unsafe site for house construction for mitigation of landslide" (section 13(6)); no model bye-laws were found. In the District Council areas no building or drainage regulation was found: notices of the Chakma District Council that require a permission and no-objection certificate of the Kamalanagar Town Planning Committee (2018) and prior approval for roadside buildings (20 November 2020), a provision of 2002 for the Chakma District Council's Village Councils that bars house construction "without the written permission from the Village Council", and the Lai District Council's Land Holding and Settlement Act, 2002 are known only from titles and search snippets [TBC], and nothing was found for the Mara District Council. Outside the Corporation's area, then, this Manual can reach the public works that the State's departments and agencies execute (roads, culverts, drains, water supply and river works, Clause 1.5.1(b)) and any body that adopts it; in a Village Council area it could also reach new buildings through the model building bye-laws once the State frames them; in a District Council area it reaches nothing unless the District Council adopts it. For a household outside the Corporation's area the Manual is guidance. UD&PA could carry it into amendments of AMCBR and SD&SM, which the Corporation's Board of Councillors makes under section 371 of the Municipalities Act "after previous publication" and UD&PA notifies, and into the model building bye-laws of the Village Councils Act as a drainage annex; the LMC could adopt the same through regulations of its own; WARDMA could direct rainwater harvesting under section 16(2)(ix) of the Water Resources Act, 2024, and the Village and Local Water Resources Committees could protect the catchments of tuikhur; MSDMA and the District Disaster Management Authorities could use it in landslide mitigation and in approving the Village Councils' unsafe-site declarations; and a District Council could adopt it for its area by an instrument of its own. None has done so. Land records and land use are with the Land Revenue and Settlement Department, even inside the Corporation's area, as the CAG found; Village Councils allot house sites under the 2025 Act; and in the District Council areas land is under the District Councils [TBC]. This Manual reserves drainage corridors and easements in a master plan or secures them by agreement; it does not assume that land can be taken. The paragraphs of the Sixth Schedule were not read for this Manual and are not quoted; the division is described by its effect, from the extent clauses of the State's Acts and the CAG's audit.

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

- the **Aizawl Municipal Council** became the **Aizawl Municipal Corporation** on 15 October 2015, by the fourth amendment of the Municipalities Act. The Act's preface gives the Council's establishment as 1 July 2008, and the CAG as 2010; the sources conflict. The building regulations kept "Council" in their title until the amendment of 2023 renamed them. The sources write the Corporation as "AMC"; **this Manual writes it in full**, "the Aizawl Municipal Corporation", and then "the Corporation", because **AMC in this Manual means only the antecedent moisture condition** of Chapters 2, 3 and 5. "AMC" appears as the Corporation's name only inside a quotation;
- **AMCBR** is this Manual's short form for the Aizawl Municipal Corporation Building Regulations, 2012 as amended, and a provision is cited as "AMCBR reg. 33". **SD&SM** is the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017, the short form that the amendment of 2025 itself uses, and a provision is cited as "SD&SM reg. 27". The shared chapters cite the two as a pair, **AMCBR/SD&SM**, because the drainage rules that bind a site are in the second. **"MBBL 2016"**, in Chapters 1 and 10, is the national Model Building Bye-Laws of 2016, not a Mizoram rule;
- the **Master Plan for Aizawl: Vision 2030** was prepared for the erstwhile Aizawl Development Authority, which is "now absorbed in AMC", as the CAG records. An "Aizawl Master Plan 2030" is this plan, not a separate document. No notification approving it was found; one source says the Government approved it

in March 2013, which is unverified; and the amendment of AMCBR of 2023 makes the online permit system return any proposal that is not as per the regulations "and the Master Plan for Aizawl, Vision-2030". This Manual cites it as the plan in use, without a date of approval;

- the **Tlawng** is the Dhaleswari of CWC's tables; the **Tuirial** is the Sonai, and CWC prints its site as "Turial"; the **Khawthlangtuipui** is the Karnaphuli, which flows to Bangladesh; and the **Chhimtuipui** is the Kaladan (Kolodyne in CWC's tables), which flows to Myanmar. The **Tuipui** of Champhai district is a different river from the Chhimtuipui. The subzone list of CWC's flood estimation report for subzone 2(b) names the Barak and the "Kalden" among the rivers of subzone 2(c); "Kalden" is the Kaladan, as this Manual reads it;
- **Siaha** is also spelt Saiha, and **Lawngtlai** appears as "Lwangtlai" in IMD's list of gauges;
- **Hlimen** and **Melthum** lie on Aizawl's southern edge. The stone-quarry collapse at **South Hlimen** on 9 August 1992 and the collapse of a disused quarry between Melthum and Hlimen in Cyclone Remal on 28 May 2024 are different events. The rockslide of 2013 was at **Laipuitlang**, not in 1992;
- **IMD's Meteorological Centre Aizawl** keeps the State's IMD gauges; IMD's city pages list Aizawl (42726) and Aizawl-Lengpui (42727), the airport. IMD runs automatic weather stations (AWS) at most district towns, and most automatic rain gauges (ARGs) in its list are run by an operator printed as **"Mz-SWIC"**, a name the source does not expand [TBC];
- the **Directorate of Geology and Mineral Resources** (DG&MR) is the "Directorate of Geology and Mining" of press reports, the same body as this Manual reads it;
- **NH-6** through Aizawl is the old NH-54, and the press uses both numbers;
- CWC's flood estimation reports place the whole State in **subzone 2(c), "Barak and others"**, for which CWC never published a report. These subzones are not the four rainfall zones (MZ-Z1 to MZ-Z4) and seven hydrologic sub-areas (MZ-A, MZ-A1, MZ-B, MZ-C, MZ-C1, MZ-D and MZ-D1) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7, nor the landslide hazard zones of the Corporation's maps, nor a River Conservation Zone under the Rivers Ordinance and Bill, 2023, of which none has been notified; and
- in this Manual **"the monsoon" and "the monsoon season" mean the wet season of 1 April to 31 October**. That is not IMD's usage: IMD counts April and May as pre-monsoon months, and the south-west monsoon comes later: in 2026 it reached Mizoram about 6 June, as reported, and IMD's normal dates of onset and withdrawal at Aizawl were not obtained [TBC]. The Manual's season begins on 1 April because the deadliest dated rain events of recent years, the Laipuitlang rockslide of 2013 and the slides of Cyclone Remal in 2024, both fell in May, before the onset, as did the 598 landslides of late May and early June 2025 (Chapter 2).

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

- **AMCBR** was published by UD&PA Notification No. B.13017/8/2012-UD&PA of 20 December 2012 (Mizoram Gazette Extraordinary Vol. XLII, Issue No. 4, 10 January 2013) and amended by the Amendment Regulations of 2019 (No. B.13017/8(2)/2018-UD&PA; only the draft published for objections was read, and the final gazette is to be checked [TBC]), of 2023 (No. B.13017/8/2021-UD&PA/Pt of 14 August 2023, in force on 28 August 2023) and of 2025 (No. B.13017/8/2021-UD&PA/Loose of 21 November 2025). **SD&SM** was published by No. B.13017/75/2016-UD&PA of 4 April 2017 (Gazette Extraordinary Vol. XLVI, Issue No. 161, 11 April 2017); whether it has been amended is not known [TBC]. The Corporation's Board of Councillors makes both under section 371 of the Municipalities Act, and UD&PA notifies them. SD&SM requires a site development permit "in addition to a building permit", ties its permit tracks to the Corporation's **Landslide Hazard Maps** "created in 2014 or later to the standards adopted by the Landslide Policy Committee for Aizawl City", and makes civil-engineer licensees competent for "Design of drainage structures, including hydrology and hydraulic calculations" (Schedule I). Building permits are applied for through the Corporation's online permit system (**OBPAS**), in use since June 2018;
- the **Aizawl Municipal Corporation** has 15 of the 18 functions of the Twelfth Schedule; "Roads & Bridges, Water supply … and Fire Services were not devolved", and land use is still administered by the Land Revenue and Settlement Department, as the CAG found. Its **Local Councils**, one for each locality, give no-

objection certificates and see that the regulations "are strictly observed" (AMCBR reg. 15). All public drains and all drains "in, alongside, or under any public street" vest in it (section 289(1) of the Municipalities Act). The **LMC** was established in November 2021 and first elected on 29 March 2023, as the CAG records;

- **UD&PA** notifies the Corporation's regulations and holds the master plans of urban areas and town development plans under the Allocation of Business Rules of 2019, as the CAG quotes them. The Mizoram Urban and Regional Development Act, 1990 is known to this Manual by its title only [TBC];
- **PWD** keeps the State's roads, which were never devolved to the Corporation, and so keeps their roadside drains in practice, although those drains vest in the Corporation by statute; this Manual states the overlap and does not resolve it. **SIPMIU** built the State's one sewage treatment plant, at Chite, and **PHED** holds sewerage and the bio-digesters; **IWRD** is the member secretary of WARDMA and is named in this Manual as the State groundwater agency, although no State network of observation wells was found, the only one found being CGWB's, in its North Eastern Region; **EF&CC** holds the riverine reserves and the wetlands;
- the **Water Resources Act, 2024** (Act No. 1 of 2024) sets up MISWARC, WARDMA, the District Water Resources Committees (DWRC) under the Deputy Commissioners and the Village and Local Water Resources Committees (VWRC and LWRC) under the Village Council Presidents and Local Council Chairmen, and counts springs, ponds, lakes and "traditional water harvesting structures" among "community water resources". The notifications constituting MISWARC and WARDMA were not found [TBC];
- **MSDMA** is the State's disaster management authority; its notification was not found [TBC]. The counts of landslides and deaths quoted in this Manual are those of **DM&R**, as reported, or of the CAG. The District Disaster Management Authorities are written in full;
- the **Gauhati High Court (Aizawl Bench)** and the **NGT** have taken up the State's slopes and waters: in July 2024 the High Court stopped new construction on either side of the Bawngkawn–Durtlang road, as reported (case number not found [TBC]); on 27 January 2021 it quashed the notification of 1965 on which the riverine reserved forests rested, as reported; and the State's reports to the NGT in OA 593 of 2017, OA 673 of 2018 and OA 606 of 2018 record the sewage in the State's drains. This Manual cites court and tribunal orders with their status; and
- where a shared clause names a revenue subdivision, this Manual uses the **sub-division**. A district is headed by a **Deputy Commissioner**.

Where a shared clause calls for the local language on a sign, a form field or a basin name, this Manual writes "Mizo". The Mizoram Official Language Act, 1974 (Act No. 3 of 1975) made Mizo the official language of the State, with effect from 1 August 1977, as fixed by a notification of 6 May 1996 (No. H.12017/14/90-LJD, the number read from a poor scan); that English may also be used for official purposes is known only as quoted, the section not having been read [TBC]; a direction of June 2021 to issue notifications in both English and Mizo is as reported; and the Corporation's Local Council Rules of 2010 are printed in both languages. **English is the language of this Manual.** So, as set by this Manual, **signs and flood-depth markers are in Mizo and English; in the Lai, Mara and Chakma Autonomous District Council areas, also in the language in local use where the District Council or the competent authority so directs.** The languages of those areas were not researched for this Manual [TBC], and a sign must be readable by the people it warns. Mizo is written in the Roman script, so where a shared clause says "Mizo script" it means Mizo in its standard Roman spelling. In Annexes 7A and 11 the GIS fields NAME_LUS and WB_NAME_LUS hold a name in Mizo; LUS is the code of this Manual for Mizo, after its ISO 639 code, lus. A Mizo edition of this Manual will follow.

Some Mizo words are used in the text, and are explained again where they first appear. The glosses follow Lorrain and Savidge's *A Grammar and Dictionary of the Lushai Language* (1898, abbreviated L&S below) and Pachuau's *English–Mizo Dictionary* (1997), and their spellings; modern Mizo writes most compounds closed, as in tuikhur and tuihawr.

- a **dil** (Mizo: a lake or pond; *dil té*, a small pond or tank; plural dils) is this Manual's word for a lake, a pond or a tank, natural or dug: L&S gives *dil* "a lake" and *dil té* "a pond, a tank" (pp. 81–85), and Pachuau gives "lake: dil" and "pond: dil, tui tling reng". The State's best-known lakes carry the word, as in Palak Dil and

Tam Dil. Mizo marks the plural with *-te*, which would be confused with *té*, "small", so the English plural "dils" is a convention of this Manual, to be confirmed by a Mizo editor before print. This Manual calls engineered storage a **detention pond**, never a dil or a tuikhur, and a natural lake keeps its own name;

- a **tuikhur** (Mizo: a spring or water point) is a spring or a spring-fed water point: L&S gives "a well, a waterhole" (pp. 213–215), Pachuau "fountain: tuikhur", and the Village Councils Act, 2025 defines it as "any place wherein water supply is obtained" (section 2(29)). This Manual uses the word only for springs and spring-fed water points, protects them from stormwater, and never uses one as storage. A spring, as the source of a stream, is also **hna** (L&S, pp. 99–103) or **tuihna** (Pachuau);
- a **lui** is a stream or river (L&S, pp. 137–139; Pachuau gives "stream: lui te"), as in the Chite lui and the Ser lui that drain Aizawl, and a **lui-pui** a river (L&S, pp. 137–139). This Manual writes "lui" for the hill streams and "river" for the larger rivers;
- **tui luankawr** (Pachuau: "drain: tui luankawr") and **tui-hawr** (L&S: "a gutter, a ditch", pp. 213–215) are a drain or ditch. The text keeps the English "drain";
- **tui lian** is a flood (Pachuau); L&S gives the older *tui lét* (pp. 215–217);
- **lei min** is a landslide or landslip (L&S, English–Lushai part, pp. 289–291); and
- a **kor** is a ravine (L&S, English–Lushai part, pp. 313–315).

The page numbers of L&S were inferred from the running heads of a scanned text, and Pachuau's pages were not recorded; both are to be checked [TBC]. Lorrain's *Dictionary of the Lushai Language* (1940) was not read. Some words given for Mizoram elsewhere, such as *minpui*, *tuikawng* and *kawr* (for a gully), were not found in either dictionary and are not used. A Mizo editor is to confirm these glosses before print.

Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2, 3 and 5; this Manual does not use it for the Aizawl Municipal Corporation, which it writes in full;
- AMCBR and SD&SM are the Corporation's two regulations, cited as a pair in the shared chapters, and "MBBL 2016" is the national Model Building Bye-Laws 2016. None is the building rule of any other State;
- ADC is an Autonomous District Council: the LADC, the MADC or the CADC. LMC is the Lunglei Municipal Council and VC a Village Council;
- HFL is the highest flood level recorded at a gauge, as CWC uses it. It is not a design level. The only HFL printed for a CWC site in the State is that of the Tuirial at "Turial", 149.0 m (17 June 1995), found only in a transcription, on no stated datum; no CWC site in the State has a warning or danger level; and
- FRL (full reservoir level), MDDL (minimum draw-down level) and MWL (maximum water level) are used for the Tuirial and Serlui B reservoirs.

The sense is clear from the context.

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

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

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

Preface

Mizoram's towns fail in storms for three reasons. Aizawl showed the first on 28 May 2024, when the rains of Cyclone Remal brought down a disused stone quarry between Melthum and Hlimen and set off slides across the city, as reported; the whole State shows the second, because no gauge record, CWC report or IDF relationship covers any part of it, while Aizawl had 148 mm in a day, probably in June 2018, and Serchhip district 677 mm in the first 13 days of June 2018, as reported; and Aizawl shows the third every day, because its storm drains carry its sewage: the State told the NGT that it produces 51.81 MLD of sewage, against 10 MLD of treatment capacity "only for Aizawl city".

1. **Towns on ridges, where water put into the slopes moves them.** Practically every town in the State sits on a ridge or a slope, and Aizawl, the capital, is a ridge-top city with no valley floor of its own: its master plan gives its slopes as 30° to 45° (printed "300 to 450" in the copy read, the degree signs lost) and its soil as "young and in a loose state". MIRSAC's zonation of Serchhip town puts about 89% of the town on slopes steeper than 30°, by this Manual's sum of its slope classes. "More than 71 per cent of the total area is in Very High to Moderate Hazard Zone", the CAG found, and landslides from 2017-18 to 2021-22 affected 661 villages and killed 41 people. What starts them is often water: DG&MR found, after inspecting 55 locations in 2022-23, that "two-thirds of large-scale landslides … were due to improper drainage", as reported, and SD&SM opens by naming "increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner" among the human activities that "can greatly increase slope instability". The record is long: the South Hlimen quarry collapse of 9 August 1992, which "claimed the lives of almost 100 people", as a MIRSAC paper of 2013 records from earlier work; the Laipuitlang rockslide in Aizawl, which destroyed 15 houses and killed 17 people, with 8 rescued, by one paper's count and 8 people by another review's, on 11 May 2013 by the press and on 15 May by one paper; the collapse of three of the 20 blocks of the Durtlang housing complex on 2 July 2019, with 3 dead and 11 injured, as the CAG records; and Cyclone Remal on 28 May 2024, whose toll in Aizawl district was reported as 29 dead with 7 missing on 29 May, as 15 at the quarry and 5 at Hlimen in another report, and as 34 in seven areas of Aizawl in a later one, the sources conflicting. From 24 May to 3 June 2025 the State recorded 598 landslides and five deaths, DM&R's figures as reported.
2. **Rainfall that no record, report or curve covers.** No Mizoram station appears in IMD's tables of extremes, so no official 24-hour record exists for any town. The whole State is in CWC's subzone 2(c), for which no flood estimation report was ever published, so there is no CWC plate, ratio or synthetic unit hydrograph for any part of it. IMD's national set of rainfall intensity curves (Das et al., 2022) has no panel for any Mizoram station, and no IDF relationship for any Mizoram gauge was found; the only peer-reviewed frequency study of the State's rainfall (Lallawmzuali and Muniyan, 2024) fits monthly and annual totals only. The reanalysis grids of NIH-DHAARA are the only spatial source: they give a 50-year day of 220 mm at Aizawl, 295 mm at Lunglei and Tlabung, 315 to 338 mm at Bairabi and Vairengte in the north, and 157 to 181 mm on the eastern uplands round Champhai, and no gauge record has tested them. The largest days found are press values: Aizawl's 148 mm, reported as "the highest in India" that day, probably on 12 June 2018 as this Manual reads the report; 104.6 mm at Serchhip and 97.4 mm at Aizawl on one day of the storm of late May and early June 2025; and 130 mm at Chawngte in October 2025, all as reported. No hourly maximum for any Mizoram gauge was found.
3. **Storm drains that are the sewers.** Outside one sewered catchment in Aizawl, every building sends septic-tank effluent to a soak pit and its sullage to the nearest drain: "the sullage (i.e. kitchen and bathroom waste) is discharged into drains which ultimately pollutes the fresh water sources", the master plan records, and septic effluent finds "its way through drains and cross drains to the rivers, which are the sources of water supply". The State's 10 MLD plant at Chite, on trial run from 6 February 2021, serves one catchment of the capital, and the State reported in 2025 that "Due to peculiar topography of the hilly regions, treatment of Grey Water remains a huge challenge". CPCB lists the Chite stream, below the plant, and the Tuikual stream in Priority II, with a biochemical oxygen demand (BOD) of 29 and 29.1 mg/L, and the Lawibual stream in Priority III. In 67% of the Aizawl Urban Area the drains are kutcha, 18% has no drains at all, and only 15% has pucca drains, as the master plan found, and drains "silted up frequently due to insufficiency in the hydraulic design".

Over all three lie four more. **A slope regulation with drainage geometry but no design storm**: SD&SM reg. 27 sets terraces at least 2 m wide at not more than 10 m vertical intervals on every cut and fill slope, terrace swales of reinforced concrete at a gradient of at least 1 in 20, a limit of 400 m² on the area that one run of swale may drain before it discharges to a down-drain, paved interceptor drains along the top of every cut slope whose uphill drainage path exceeds 10 m, building pads graded at 1 in 50 to approved drainage, and a duty on every site developed downhill to carry the drainage of the site above it "in a safe manner to the nearest practicable drainage way"; it gives no design storm, return period or runoff coefficient, and leaves "hydrology and hydraulic calculations" to licensed civil engineers. **A building regulation with an unsized duty**: AMCBR reg. 33 says that "A suitable rain water harvesting facility shall also be provided in all buildings", and the same regulation requires "a septic tank of appropriate capacity with soak pit" for every latrine, while the Landslide Policy Committee's *Roadmap to Stability* (2014) would "eliminate all septic tanks, leach fields and soak pits within Aizawl City" because they wet the slopes. **Three legal geographies**, of which only one has a building rule: the Corporation's area, the Village Council areas, where the model building bye-laws that the 2025 Act provides for have not been found, and the three Autonomous District Council areas, outside the State's municipal, village-council, water-resources and rivers laws alike. And **valley-floor towns that flood from rivers in a State officially said to have no flood plain**: "Mizoram being a hilly state, there is no flood plain zone in the catchment area", MPCB told the NGT, yet the Khawthlangtuipui flooded Tlabung in June 2017, when about 350 houses were reported submerged in the sub-division, or 9 fully and more than 60 partly by the count of disaster officials, again in July 2019, when about 400 houses were reported flooded, and again in August 2023, as reported; families were stranded at Sairang on the Tlawng in June 2018, when houses at Tiperabagh and Serhuan were flooded, as reported; and Champhai was among the places worst hit by the landslides and floods of June 2025, as reported. No flood plain zoning law was found, and the "flood hazard areas as designated and defined by Aizawl Municipal Corporation" that SD&SM reg. 6 asks a site plan to show have not been found to be designated.

Behind all of this lie the springs, the rain tanks, the dils and two reservoirs. "Mizoram is an abode of springs", CGWB notes, and the ridges are a "run off zone" of shale, siltstone and sandstone with "very low permeability and infiltration"; the State draws 3.95% of its extractable groundwater, as quoted from the assessment of 2024, and no area is notified for regulation. Water comes from the tuikhur and from roofs: 27.16% of households in the Aizawl Urban Area use rain water and 1.01% spring water, as the master plan records, while the city's piped supply is pumped up from the Tlawng. The Village Councils Act, 2025 makes the tuikhur a statutory word, and the Water Resources Act, 2024 counts springs among the community water resources that its Village and Local Water Resources Committees are to keep from pollution. Among the dils, the Pala Wetland (Palak Dil), in the Mara District Council's area, is Ramsar site no. 2484, designated on 31 August 2021 according to its information sheet and announced on 26 July 2022, as reported; Tam Dil, near Saitual, was rebuilt as a fishery reservoir, as reported. On the Tuirial, NEEPCO's dam holds a reservoir with a full reservoir level of 90.5 m and a minimum draw-down level of 68.0 m, and a study routed a dam-break flood of 3,035.34 m³/s near the confluence below it, as reported; the levels of the Serlui B reservoir were not found.

Design for Mizoram therefore has to cover a wet season that begins with the storms of April and May, before the south-west monsoon arrives (about 6 June in 2026, as reported), and runs to its end in October; it is this Manual's monsoon season, 1 April to 31 October. Storms on 27–28 April 2026 shut schools in five to nine districts, with 70.5 mm at Serchhip, as reported, and the Laipuitlang rockslide of 2013, the slides of Cyclone Remal in 2024 and the landslides of late May 2025 all came in May. Storms come outside the season too: "the cyclones of the Post Monsoon season (October to December) are more intense than those of Pre-Monsoon season (April & May)", as a State document of 2016 records, so design statistics use the annual maxima of every month. The sources give the State's mean annual rainfall as anything from about 2,057 mm to 2,794 mm; annual totals do not set the size of a drain, and this Manual picks none of them. There is no snow. Underground, the hill rock will not take water, and rainwater put into a slope can move it: rainwater is worth storing for use, not putting into the ground.

National guidance sizes public drains but does not control the runoff that new building adds. This Manual makes stormwater a **condition of development approval**. Every development above a modest size must:

- hold frequent rainfall on site, in tanks for use in the dry season, and never in the ground of a slope;
- release the large storms no faster than the undeveloped land did, or slower where catchments already flood, and carry them to a stable outfall without wetting the slope below; and

- show that its outfall still works when a drain is choked with slide debris, silt or garbage, when the receiving lui is in spate, and, on the valley floors, when the river is high and its flap gate shut or a dam upstream is releasing.

The Manual also sets how public drains, roads and their drains, hill roads, terraces, swales, interceptor drains and down-drains, lui and rivers, outfalls on the valley floors, dils, springs and basin-wide master plans are designed, and how drains are protected against debris and silt, 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 Mizoram's wet season of April to October, with its pre-monsoon storms; to steep ridges of Surma-group shale, siltstone and sandstone where the water that drains into a slope can move it; to towns on ridges whose drains fall to steep lui, such as the Chite lui and the Ser lui of Aizawl; to the narrow valley floors and river terraces of the Tlawng, the Tuirial, the Khawthlangtuipui and the Tiau, at Sairang, Bairabi, Vairengte, Tlabung and the Champhai flats; to the reservoirs on the Tuirial and the Serlui; to springs that supply the villages and rain tanks that supply a quarter of the capital's households; and to storm drains that carry sewage.

1. **National base.** The CPHEEO *Manual on Storm Water Drainage Systems* (2019). This Manual builds on it and sets higher standards where it allows a State to do so. IRC road-drainage codes, including IRC:SP:42-2014 on hill roads, and the NDMA urban flood guidelines are also used.
2. **Overall structure.** Kansas City Metro APWA Section 5600 (Version 2025.01), the most recent comprehensive regional standard. It supplies the preserve, retain, detain, convey and maintain sequence and the required retention volume.
3. **Design rainfall.** No station record, CWC report or published IDF covers any part of the State, so every design rainfall value in Mizoram is set by this Manual, in four rainfall zones and seven hydrologic sub-areas. In every sub-area the design day is the higher of NIH-DHAARA's value for the site and a statewide floor taken from NIH-DHAARA's cell for Aizawl (85 mm at 2 years to 250 mm at 100 years), so that a local dip in the grid never sets a depth below the capital's; on the eastern uplands, where NIH-DHAARA's cells are the lowest in the State and no gauge confirms them, the floor governs. In the northern hills and valley floors, which drain to the Barak plain, the design day is also not less than 320 mm at 2% AEP and 360 mm at 1% AEP, the values of the adjoining Barak-headwater edition of this series, which carry the floors of the adjoining Barak-valley rule, so that one storm reads alike on both sides of the State's border. Shorter durations use interim ratios that are never lower than those of the CWC report for subzone 2(a) and never give a depth below NIH-DHAARA's own for that duration at the site; the 72-hour depth is 1.70 times the 24-hour depth until a 3-day series is analysed. The design day is checked against the largest reliable days recorded within 25 km and within the same zone, but no record in or near the State yet qualifies, and obtaining the IMD and State daily series is the first data request of Chapter 2.
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.** AMCBR and its amendments of 2019, 2023 and 2025; SD&SM; the Mizoram Municipalities Act, 2007, with the Ward Committee and Local Council Rules, 2010; the Mizoram (Village Councils) Act, 2025; the Mizoram Water Resources (Management and Regulation) Act, 2024; the Mizoram (Protection of Rivers) Ordinance and Bill, 2023, whose enactment was not confirmed; the Master Plan for Aizawl: Vision 2030 and the draft zonal regulations of 2015; the *Roadmap to Stability* (2014); the Mizoram Official Language Act, 1974; the CAG's Report No. 1 of 2025; and the State's reports to the NGT. This Manual follows them or, where disclosed, makes them stricter. The final gazette of the amendment of 2019, any regulation of the LMC, the model building bye-laws of the Village Councils Act, any building or drainage instrument of the three District Councils, the notifications constituting MSDMA, MISWARC and WARDMA, the April 2021 notification on the river belts, the Mizoram Urban and Regional Development Act, 1990, the Mizoram Ground Water (Control and Regulation) Bill, 2023 beyond its title page, the State Action Plan on Climate Change and the paragraphs of the Sixth Schedule were not read. Every rule cited must be checked against the current text.

Why this Manual is needed

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

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

- **Return periods.** CPHEEO recommends 5 years for drains in Class I cities and 2 years elsewhere, and lets a State committee adopt higher values. A 2023 CPHEEO presentation shows a different table. IRC:SP:50-2013 suggests 1–2 years for urban road drains; IRC:SP:42-2014 suggests 5–25 years for road drains and 10–50 years for culverts, by class of road and size of culvert. An engineer designing a drain in Mizoram can cite 1, 2, 5, 10 or 25 years, depending on the code chosen.
- **Detention.** CPHEEO describes limiting peak outflow to pre-development rates as general practice. It uses no "shall" and names no storm frequencies.
- **Climate.** The NDMA Urban Flooding Guidelines (2010) call for detention and retention facilities and for rainfall curves adjusted for climate change, but give no sizing rule or return period. The State Action Plan on Climate Change (SAPCC) was not read. A State document of 2016 for the National Adaptation Fund for Climate Change (NAFCC), citing a State remote sensing report, expects "nearly 25% increase in rainfall" in some districts and the number of extreme rainfall events to rise by "about 26%"; these are statements about totals and counts, not factors for intensity, and this Manual uses neither as a design value.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. Mizoram lies wholly in a CWC subzone for which no report was ever published; IMD's 2022 national set of rainfall intensity curves has no panel for any Mizoram station; and the reanalysis grids of NIH-DHAARA, the only source that covers the State, have not been tested against any Mizoram gauge.

Mizoram has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of UD&PA, the Aizawl Municipal Corporation, the LMC, PWD, PHED or IWRD that fixes a return period, a runoff coefficient or a design rainfall for town storm drains, and no IDF relationship for any station in the State. The master plan's chapter on drainage describes the drains and proposes eight check dams, but sets no design storm; no storm-drain project of Aizawl Smart City was found, and the documents found for the State's tranche of the ADB-assisted North Eastern Region Capital Cities Development Investment Program (NERCCDIP) deal with water supply, solid waste and sewerage, not storm drains. AMCBR and SD&SM regulate the site, the slope and the outfall, but neither says what storm a drain is sized for. This Manual is offered as a technical companion to AMCBR, SD&SM and the Municipalities Act, to the model building bye-laws that the Village Councils Act provides for, to the Water Resources Act, 2024, to the Rivers Ordinance and Bill, 2023 if enacted, and to the master plan: it supplies the design storm, detention, tailwater, setback and spring-protection values that they leave open. It has not been adopted by UD&PA, the Corporation, the LMC, any District Council, any Village Council or any other body. In particular:

- **The slope regulation fixes the geometry of the drains but not the water they carry.** SD&SM reg. 27 sizes terraces, swales, interceptor drains and pads by their dimensions and limits each run of swale to 400 m², and its engineered track asks for "A map showing the drainage area and the estimated runoff of the area served by any drains"; but it names no design storm, return period, runoff coefficient or freeboard, and puts the "hydrology and hydraulic calculations" on the licensed civil engineer, with no method to follow;
- **The building regulation requires rainwater harvesting, but sizes nothing.** AMCBR reg. 33 requires "A suitable rain water harvesting facility" in all buildings and reg. 5(6)(ix) asks plans to show it; the amendment of 2025 makes rainwater harvesting and the "Reduction of Hardscape" incentives for plots above 100 m²; and reg. 37(ii) asks for a drain or conduit "of adequate capacity to the nearest public drain". None gives a storage volume, a release rate or a design storm;

- **The rules put septic effluent into slopes.** AMCBR reg. 33 requires a soak pit with every septic tank, and keeps it 15 m from a water source; on a landslide-prone slope that is the practice the *Roadmap to Stability* would end. This Manual states the conflict, puts no stormwater into a soak pit and no infiltration on a slope, and does not override the regulation;
- **The stream lines are recommendations, or have lost their basis.** The master plan recommends "a 15 meters wide green buffer on both sides" of the major drainage channels and keeps an 800 m green belt on either side of the Tlawng under the Mizo District (Forest) Act, 1955; the notification of 1965 on which the riverine reserved forests rested was quashed by the High Court on 27 January 2021, as reported, and a notification of April 2021 that is reported to set an 800 m restricted zone was not read, so this Manual does not treat the 800 m belt as a statutory line. SD&SM reg. 28 says that "the riverine reserve shall be maintained" without defining it, and no River Conservation Zone has been notified. Neither regulation has a metric setback from a stream or a spring;
- **No flood line has been drawn.** No flood plain zoning law, no designated flood hazard area and no published flood level for any Mizoram town was found, and the State's own statement is that it has no flood plain zone. This Manual offers a method for drawing a design flood line on the valley floors (Chapter 7) as an input to any future designation; it does not replace a line that is notified, that a plan draws or that a court orders, and where such a line binds and is wider, it governs; and
- **No document sets the river or reservoir level for which an outfall is designed.** CWC has seven level-monitoring sites in the State, five of them inactive, no flood-forecasting site and no warning or danger level, as transcribed by SANDRP (2018); the only highest flood level printed is the Tuirial's at "Turial", 149.0 m (17 June 1995), on no stated datum, and how it relates to the reservoir's full level of 90.5 m is not stated. No inventory of flap gates on the valley floors, and no rule for releases from the Tuirial or Serlui B dams that a town could design for, was found.

So each agency and each local body interprets the central manual its own way. The Corporation and its Local Councils, the LMC, UD&PA, PWD and the national-highway agencies, PHED and SIPMIU, IWRD, EF&CC, the Land Revenue and Settlement Department, the Village Councils and the three District Councils, Aizawl Smart City Ltd, their consultants and funding agencies fill the gaps differently. No notification divides the drains among them. A drain in Aizawl may be the Corporation's street drain by statute and a PWD roadside drain in practice, carry the sullage of the houses above it, cross a cut slope that a private owner must keep drained under SD&SM, and fall to a lui in a riverine reserve that EF&CC holds and that runs to a CPCB-listed stretch. Outside the Corporation's area no building rule applies at all. And a reviewer has no common basis against which to check a design.

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

- one source and method for design rainfall across the State, in four rainfall zones and seven hydrologic sub-areas: NIH-DHAARA with a statewide floor everywhere, the Barak-valley values in the northern hills and valley floors, interim ratios for short storms, 72-hour depths for the multi-day storms that start landslides, and a check of the design day against the largest reliable days recorded nearby that never crosses a zone line or a main ridge (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites, with the rainwater stores of AMCBR reg. 33 sized and credited (Chapter 4);
- a required check of every outfall: on the hills, a free outfall to a lui with energy dissipation and a check of the lui's capacity and stability to the next confluence; on the valley floors and terraces, a check against a design river level, with the outfall treated as closed for the whole of the 72-hour design storm, and longer at Tlabung where flood marks show the river held up for longer; and below the Tuirial and Serlui B dams, a check against a release (Chapter 5);
- a design flood line on the valley floors, and corridors and setbacks along every lui and river and round every dil and tuikhur, proposed by this Manual for use where nothing wider binds: a corridor at least 15 m from the top of bank on each side of every natural channel draining 8 ha or more, measured on an incised lui whose bank is a slope steeper than 10° from the crest of that slope, or to the 1% AEP flood extent plus 10 m on the valley floors, whichever is wider; no storm outfall, soakaway or drain discharge within 15 m of a tuikhur; and the master plan's buffers and any notified River Conservation Zone wherever those are wider (Chapters 7 and 8);

- no deliberate infiltration on slopes steeper than 10°, on Surma-group shale, siltstone or mudstone at any slope, on colluvium, fill or slide debris, in a mapped Moderate, High or Very High landslide hazard zone or close above a cut or retaining wall, without a geotechnical certificate, and none at all in High and Very High hazard zones; recharge only on tested valley alluvium and river terraces above the 1% AEP flood level; roof runoff to storage, with its overflow to lined drains; and the interception and screening of dry-weather flow before every outfall to a CPCB-listed lui, a dil or a tuikhur's catchment, where drains carry sewage (Chapters 4 and 8);
- the hydrology that SD&SM leaves to the engineer, for its terraces, swales, interceptor drains and down-drains; debris racks, allowances for sediment, bulking and blockage, and lined, stepped and baffled drains for steep streets and hill roads (Chapters 6 and 9), with drains, swales, interceptor drains, weep holes, racks and gates cleared, inspected and certified ready by 31 March, before the April storms, cleared again by 30 April, before the May storms that brought the Laipuitlang and Remal slides, and by 15 November after the season, with a survey of cut slopes and retaining walls, and standby kept from 1 April to 31 October (Chapter 10); and
- basin-wide master plans, so that the agencies that share a lui's catchment, from the ridge-top town to the river below, plan together (Chapter 11).

It uses the route the CPHEEO manual itself provides: a State may adopt standards higher than the national values (CPHEEO 2019, Table 4.1, Note 2). The Corporation in its regulations, UD&PA in the model building bye-laws for the Village Councils, the LMC in its own regulations, or a District Council by an instrument of its own can still adopt a stricter standard (Chapter 1).

Sources: CPHEEO (2019) Part A §4.4–4.5 and Table 4.1; CPHEEO presentation to CSE (August 2023); IRC:SP:50-2013 §6; IRC:SP:42-2014 cl. 7.1.4 and 8.5.1; NDMA (2010) Urban Flooding Guidelines, para 6.6.2; MoHUA Model Building Bye-Laws (2016); Aizawl Municipal Council (now Corporation) Building Regulations, 2012, UD&PA Notification No. B.13017/8/2012-UD&PA of 20 December 2012 (Mizoram Gazette Extraordinary Vol. XLII, Issue No. 4, 10 January 2013), regs. 1, 5, 15, 21, 26, 33 and 37, with the Amendment Regulations of 2019 (public notification No. B.13017/8(2)/2018-UD&PA of 10 April 2019, draft), 2023 (No. B.13017/8/2021-UD&PA/Pt of 14 August 2023; Gazette Extraordinary Vol. LII, Issue No. 459, 28 August 2023) and 2025 (No. B.13017/8/2021-UD&PA/Loose of 21 November 2025); Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017, No. B.13017/75/2016-UD&PA of 4 April 2017 (Gazette Extraordinary Vol. XLVI, Issue No. 161, 11 April 2017), regs. 1, 4–6, 14 and 24–29 and Schedule I; Mizoram Municipalities Act, 2007 (Act No. 6 of 2007), ss. 1, 80, 288–300 and 371, and the Mizoram Municipalities (Ward Committee and Local Council) Rules, 2010; Mizoram (Village Councils) Act, 2025 (Act No. 7 of 2025; Gazette Extraordinary Vol. LIV, Issue No. 178, 20 March 2025), ss. 1, 2, 13–15; Mizoram Water Resources (Management and Regulation) Act, 2024 (Act No. 1 of 2024), ss. 1–6, 9–12, 14, 16 and 24; Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023; Mizoram Official Language Act, 1974 (Act No. 3 of 1975) and notification No. H.12017/14/90-LJD of 6 May 1996; Master Plan for Aizawl: Vision 2030 (Aizawl Development Authority; Chief Minister's message of 11 September 2012; approval notification not found), chapters 4, 8 and 12; Draft AMC (Master Plan and Strategic Zonal/Ward Development Plan) Regulations, 2015; Landslide Policy Committee for Aizawl City, Roadmap to Stability: Actions to Reduce the Landslide Risk in Aizawl (February 2014); CAG, Report No. 1 of 2025 (Government of Mizoram), Chapters I and V and Appendix 5.3; NGT, OA 593/2017 and OA 673/2018, report of the Mizoram Pollution Control Board (February 2021), and OA 606/2018, Government of Mizoram, six-monthly report (January–June 2025); CPCB, Polluted River Stretches for Restoration of Water Quality (2025); CGWB, Ground Water Scenario of Mizoram (State profile) and Ground Water Information Booklets, Lunglei and Serchhip districts; MIRSAC, micro-level landslide hazard zonation of Serchhip town, Science Vision 13(1) (2013); Lallawmzuali and Muniyan (2024), MAUSAM 75(3); Mizoram Agriculture Department, DPR for the NAFCC (February 2016); CERC, Petition 125/MP/2021 (NEEPCO, Tuirial HEP); CWC, Flood Estimation Report for South Brahmaputra subzone 2(b) (Revised), Annexure 1.1, and Flood Estimation Report for North Brahmaputra subzone 2(a) (NB/18/1991); IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012), and the Meteorological Centre Aizawl's list of rain gauges (14 November 2026); Das et al. (2022), MAUSAM 73(4); NIH-DHAARA (queried 14 November 2026); J. H. Lorrain and F. W. Savidge, A Grammar and Dictionary of the Lushai Language (1898); L. Pachuau, English–Mizo Dictionary (1997); CWC levels as transcribed by SANDRP (2018); reports of the landslides of 1992, 2013, 2019, 2024 and 2025, of the floods at Tlabung, Sairang and Champhai, of the storms of 2018, 2025 and 2026, of the High Court's orders and of the Pala Wetland (press and secondary sources).

How to use this Manual

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

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

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

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

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

Where to start.

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

Contents

Ch	Title	Annexes and forms
1	Policy, Applicability and Adoption	Annexes 1
2	Design Rainfall and Design Storms	Annexes 2
3	Hydrologic Methods	Annexes 3
4	Site Runoff Control: Retention and Detention	Annexes 4
5	Downstream and Tailwater Analysis	Annexes 5
6	Minor and Major Drainage Systems	Annexes 6
7	Waterbodies, Dils (Lakes and Ponds) and Setbacks	Annexes 7
8	Water Quality and Recharge	Annexes 8
9	Hydraulic Design of Structures	Annexes 9
10	Submittals, Review, Operation & Maintenance and Enforcement	Annexes 10

Ch	Title	Annexes and forms
11	Basin and City Stormwater Master Plans	Annexes 11

List of tables

Table	Title
1.1	Differences between Tier A and Tier B authorities
1.2	Policy supplement: adoptable alternatives S-1 to S-5
1.3	Relationship with other instruments
1.4	Roles and responsibilities under this Manual
1.5	Working assignment of drainage elements under this Manual
2.1	Design return periods (summary)
2.2	Interim climate factors
2.3	Illustrative scale of the mixed-frequency rule (not design values)
3.1	Permitted hydrologic methods
3.2	Runoff coefficient C (for AEP of 10% or more frequent)
3.3	Frequency factor Cf
3.4	Manning's n for sheet flow (USDA SCS TR-55, 1986, Table 3-1)
3.5	Runoff curve numbers, AMC II, Ia = 0.2S (USDA SCS TR-55, 1986, Tables 2-2a and 2-2c)
4.1	Design storms to be routed for detention sizing
4.2	Illustrative example: peak discharges and storage used, by duration (Illustrative — not design values)
4.3	Tier B permissible site discharge and site storage requirement (template)
4.3A	Fixed release coefficients (provisional)
5.1	Design tailwater levels for tidal outfalls
5.2	Joint-probability cases for tidal and riverine outfalls
6.1	Design AEPs for conveyance (matches Clause 2.4)
6.2	Street flow limits
6.3	Flow hazard limits for streets and overland flow paths
6.4	Combined flood hazard vulnerability classes (reproduced for reference)
6.5	Inlet clogging factors (share of clean capacity assumed lost)
6.6	Manning's n for design (from CPHEEO 2019)
6.7	Minimum freeboard in open and covered drains
6.8	Maximum spacing of manholes on straight pipe runs
6.9	Minimum drainage reserve width (adopted from PUB Singapore)
7.1	Fixed-width setback where no 1% AEP extent is available

Table	Title
8.1	Pollutants of concern, sources and primary controls
8.2	Required Level of Service for sites that are not redevelopment
8.3	BMP Value Ratings and suitability in Mizoram
9.1	Entrance loss coefficients ke (outlet control, full or partly full)
9.2	Maximum permissible mean velocities in channels
9.3	Riprap classes and apron dimensions (HEC-14)
9.4	Minimum internal size of manholes
9.5	Minimum IS 456 exposure classes for Mizoram locations
10.1	Submittal stages and linked approvals
10.2	Forms used in submittals
10.3	Minimum owner inspection frequencies
10.4	Graduated enforcement response
11.1	Minimum data and surveys for a BSMP
11.2	Minimum levels of service
1A.1	Tier A authorities as defined in Clause 1.6.1
1A.2	Register of Tier A authorities (layout)
1B.1	Flood-sensitive catchments listed in Clause 4.5.3.2
1B.2	Attributes of the flood-sensitive catchment layer (layout)
1C.1	Alternatives adopted by this resolution
1D.1	Schedule: alternatives adopted (layout)
2A.1	Benchmark comparison of design depths (layout)
2A.2	Rainfall zones (layout)
2B.1	Ratios P(t)/P(24h) by zone (layout)
2B.2	Fixed-interval adjustment factors (Clause 2.6.3)
2C.1	Grid-to-point factors (layout)
2D.1	Cumulative fraction of storm depth against cumulative fraction of storm time (layout, one table per zone, duration class and quartile)
2E.1	Retention depth P_R by zone (layout)
3A.1	Soil series to HSG lookup (layout)
3A.2	Seasonal high water table, by mapping unit (layout)
3B.1	Supplementary land covers, AMC II (layout)
3B.2	CN calibration catchments (layout)
3C.1	Problem 3C-1 solution
3C.2	Problem 3C-2 solution
3C.3	Problem 3C-3 solution

Table	Title
3C.4	Problem 3C-4 solution
3C.5	Problem 3C-5 stage–storage–discharge relationship
3C.6	Problem 3C-5 routed outflow
3C.7	Benchmark results to be reported by the applicant
3D.1	Calibrated peak rate factors (layout)
3E.1	SUH relationships by subzone (layout)
3E.2	Worked example outline (layout)
4A.1	Attributes of the shallow-groundwater zone layer (layout)
4B.1	Contents of Annex 4B and their status
4B.2	Tier B PSD and SSR (layout of Table 4.3)
4B.3	Retention credit factor C_R (layout)
4B.4	Largest orifice diameter (mm) for a permissible discharge at a given head (Cd = 0.60, free discharge)
4B.5	Fixed release coefficients C_10 and C_2 (provisional, Table 4.3A)
4C.1	Inputs (Illustrative — not design values)
4C.2	Design rainfall depths, mm (Illustrative — not design values)
4C.3	Curve numbers and abstractions (Illustrative — not design values)
4C.4	Storm runoff depth Q, mm (Illustrative — not design values)
4C.5	Unit hydrograph parameters (Illustrative — not design values)
4C.6	Stage–storage–discharge, trial outlet (Illustrative — not design values)
4C.7	Routing of the 100-yr 72-hour storm through the trial outlet, around the peak (Illustrative — not design values)
4C.8	Routing of the 100-yr 72-hour storm through the trial outlet, hourly (Illustrative — not design values)
4C.9	Results for the trial outlet (120 mm and 470 mm orifices) (Illustrative — not design values)
4C.10	Stage–storage–discharge, revised outlet (Illustrative — not design values)
4C.11	Results for the revised outlet (170 mm and 460 mm orifices) (Illustrative — not design values)
4C.12	Retention credit by routing, revised outlet (Illustrative — not design values)
4C.13	Outlet checks, revised outlet (Illustrative — not design values)
4C.14	Summary of the revised design (Illustrative — not design values)
5A.1	Use of the Annex 5A values in the design tailwater (Table 5.1)
5A.2	Tidal datums, surge and still-water levels by coastal segment (layout)
5B.1	Water bodies named in Chapter 5
5B.2	Attributes of the Annex 5B layers (layout)
5C.1	Inputs (Illustrative — not design values)
5C.2	Outfall-closed check results (Illustrative — not design values)
5C.3	Volume balance, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Table	Title
5C.4	Stage hydrograph, 1% AEP 48-hour storm, Run B (Illustrative — not design values)
5C.5	Summary (Illustrative — not design values)
6A.1	Interim requirements for inlets until Annex 6A is published (from Chapters 6 and 9)
6A.2	Register of standard inlet types (layout)
6A.3	Capacity on grade (layout; one table per inlet type)
6A.4	Capacity in a sag (layout; one table per inlet type)
6B.1	Sediment allowances already set by Chapter 6 (provisional, to be calibrated)
6B.2	Sediment yield by land use and drain type (layout)
6B.3	Calibration of the sediment allowance (layout)
6C.1	Dimensions on the standard drawings and their source clauses
7A.1	Attribute fields of the waterbody inventory (WB_POLY)
7A.2	Code lists
7A.3	Attribute fields of structures (WB_STRUCT)
7B.1	Fixed-width setback by waterbody class (alternative S-3)
7B.2	Source buffers cited in Clause 7.4.6 (KC APWA 5600, 2006, §5605.3)
7C.1	Rule levels by period (to be completed for each tank)
7C.2	Outlet settings by level (to be completed for each tank)
7C.3	Triggers and actions (to be completed for each tank)
7D.1	Hold points for desilting and restoration works
7E.1	Waterbodies and springs
7E.2	Streams, drains and floods
7E.3	Land and works
7E.4	Terms and forms not yet verified
8A.1	Water quality rainfall depths by zone (layout)
8A.2	3-month ARI intensity by duration (layout)
8B.1	Required LoS for redevelopment (layout)
8B.2	Worked example: composite VR (illustrative)
8B.3	Composite VR of treatment trains (layout)
8C.1	Monitoring site register (layout)
8C.2	Event record (layout; parameters of Clause 8.13.2)
8C.3	Performance summary and proposed VR (layout)
8D.1	Pretreatment (all BMPs)
8D.2	Bioretention and rain gardens (Figure 8.2)
8D.3	Vegetated swales

Table	Title
8D.4	Vegetated filter strips
8D.5	Permeable pavement
8D.6	Infiltration trenches and basins (Figure 8.3)
8D.7	Wet ponds (extended wet detention)
8D.8	Constructed wetlands
8D.9	Gross pollutant traps and outfall screens
8D.10	Oil-grit separators
8D.11	Infiltration and recharge criteria (all infiltrating BMPs)
8D.12	Bioretention filter media and layers
8D.13	Indicative plants for bioretention, swales and filter strips
8D.14	Indicative plants for constructed wetlands and wet ponds
8D.15	Species not to be planted
8E.1	Selection of measures (Clause 8.12.3)
8E.2	ESC timing and inspection (Clauses 8.12.2 and 8.12.5)
9A.1	HDS-5 inlet-control coefficients for common inlets
9A.2	Inputs for the worked example
9A.3	Critical depth and specific head (D = 1.2 m)
9A.4	Inlet-control headwater
9A.5	Outlet-control headwater
9A.6	Governing headwater and checks
9A.7	Riprap apron sizing
9A.8	Summary of the worked example (Illustrative — not design values)
9B.1	Dimensions and rules on the standard drawings and their source clauses
9C.1	Pump station design checklist
9C.2	Control levels (values to be set in design)
10A.1	Calculator inputs
10A.2	Calculations the calculator shall perform
10B.1	Layers
10B.2	Attributes of SW_FAC (facilities)
10B.3	Attributes of SW_OUTF (outfalls)
10B.4	Attributes of SW_CATCH (catchments)
10B.5	Attributes of SW_FLOW and SW_CONV (flow paths and conveyance)
10B.6	Metadata (SW_META)
10B.7	Facility type codes (FAC_TYPE)

Table	Title
10B.8	Status codes (STATUS)
10B.9	Inspection result codes (INSP_RES)
10C.1	Access dimensions set by the Manual
10C.2	Access dimensions not set by the Manual (to be confirmed in design)
10D.1	Contents of an O&M plan
10D.2	Retention and infiltration (soakaways, trenches, bioretention, permeable paving)
10D.3	Surface detention basin or multi-use open space area
10D.4	Underground or podium detention tank, gravity outlet
10D.5	Pumped detention, pumps and controls
10D.6	Flap or tide gate, non-return valve
10D.7	Gross pollutant trap or first-flush device
10D.8	Private drains and inlets
11A.1	Deliverables
11B.1	Basins named in Clause 11.3.3 (provisional)
11B.2	Attributes of the basin boundary layer (layout)
11C.1	Depth–damage curve (layout, one table per building type)
11D.1	Items to be published

List of figures

Figure	Title
1.1	Stormwater management hierarchy
1.2	Applicability decision flowchart
2.1	Design rainfall source hierarchy and adjustments
2.2	Design hyetographs
2.3	From design rainfall source to design storm
3.1	Selection of hydrologic method
3.2	Time of concentration: flow segments along the longest flow path (schematic)
3.3	SCS-CN runoff depth versus rainfall depth
3.4	Two-step continuous simulation: starting tank level (schematic)
3.5	Pre- and post-development hydrographs
4.1	Pre-development 10-yr, post-development 100-yr uncontrolled, and detained hydrographs (illustrative)
4.2	Detention storage stack and multi-stage outlet (schematic)
4.3	Fixed-coefficient route: release caps, storage by the mass-curve method and two-stage outlet (schematic)

Figure	Title
5.1	Extent of downstream analysis
5.2	Tidal outfall section with flap gate and design tailwater levels
5.3	Tide-locked outfall timeline (illustrative)
6.1	Minor and major drainage in a kerbed street
6.2	Gutter spread, inlet interception and clogging
6.3	Drain sections: freeboard, sediment allowance and access
6.4	Drainage reserve: cross-section (schematic)
6.5	Coastal band: floor level stack and extent of the band (schematic)
7.1	Waterbody setback zones
7.2	Compensatory storage by elevation band (schematic)
7.3	A ridge town: its terraces, swales, spring and stream. A section across a ridge town with a lined road drain, roof water to storage tanks, a cut slope with an interceptor drain, terraces with lined swales to a stepped down-drain and an energy dissipator at the stream, a downhill plot carrying the uphill plot's drainage in a closed conduit, and a landslide-hazard band with no infiltration; and a plan of the slope below with a spring (tuikhur), its protected catchment and its 15 m no-discharge circle, the stream with the Manual's 15 m corridor from the crest of its bank slope, a dry-weather-flow interceptor on the outfall, a disused quarry face with a cut-off drain, and the stream running down to a valley-floor river with a terrace settlement behind a flap-gated outfall
8.1	Treatment train
8.2	Bioretention cell
8.3	Infiltration trench
9.1	Culvert hydraulics: inlet control and outlet control
9.2	Riprap apron at a pipe or culvert outlet (schematic)
9.3	Stormwater pump station: wet well, screens, levels and outfall
10.1	Submittal, review and approval workflow
10.2	Construction hold points from approval to handover
10.3	Maintenance cycle and responsibility
11.1	Basin master plan process
11.2	BSMP model schematic
6C.1	Covered roadside drain with removable covers
6C.2	Access and junction chamber on a covered drain
6C.3	Kerb inlet with silt sump
8E.1	Silt fence: section and plan (schematic)
8E.2	Sediment basin with surface dewatering outlet: section (schematic)
8E.3	Stabilised construction exit: plan and section (schematic)
8E.4	Drain inlet protection (schematic)
9B.1	Culvert headwalls, wingwalls and cut-off walls
9B.2	Straight vertical drop structure

Figure	Title
9B.3	Trash rack at a conduit entrance
9B.4	Detention outlet riser and emergency spillway

Abbreviations

Abbreviation	Meaning
ABC Waters	Active, Beautiful, Clean Waters (PUB Singapore's design guidelines)
ADA	Aizawl Development Authority (erstwhile; "now absorbed in AMC", as the CAG records)
ADB	Asian Development Bank
ADC	Autonomous District Council (the LADC, MADC or CADC, under the Sixth Schedule)
AEP	Annual exceedance probability
AIDR	Australian Institute for Disaster Resilience
AMC	Antecedent moisture condition only (this Manual writes the Aizawl Municipal Corporation in full)
AMCBR	Aizawl Municipal Corporation Building Regulations, 2012, as amended
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
ARF	Areal reduction factor
ARG	Automatic rain gauge
ASABE	American Society of Agricultural and Biological Engineers
ASTM	ASTM International (standards)
AWS	Automatic weather station
BOD	Biochemical oxygen demand
BRE	Building Research Establishment (UK)
BSMP	Basin Stormwater Master Plan
BSUP	Basic Services to the Urban Poor (as in the Durtlang BSUP complex)
CADC	Chakma Autonomous District Council
CAG	Comptroller and Auditor General of India
CGP	Construction General Permit (US EPA)
CGWB	Central Ground Water Board
CN	Curve number (SCS/NRCS method)
COD	Chemical oxygen demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation

Abbreviation	Meaning
CSE	Centre for Science and Environment
CWC	Central Water Commission
DG&MR	Directorate of Geology and Mineral Resources (the "Directorate of Geology and Mining" of press reports)
DM&R	Disaster Management and Rehabilitation Department
DPR	Detailed project report
DST	Directorate of Science and Technology (its State Meteorological Centre keeps a rainfall series)
DWF	Dry-weather flow
DWRC	District Water Resources Committee (Water Resources Act, 2024)
EF&CC	Environment, Forest and Climate Change Department
EN	European Standard (Norme Européenne)
EPD	Environmental Protection Division (Georgia, United States)
ESC	Erosion and sediment control
EV1	Extreme value type I (Gumbel) distribution
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FRL / MWL / MDDL	Full reservoir level / maximum water level / minimum draw-down level
FRP	Fibre-reinforced plastic
GHI	GeoHazards International
GWRA	Ground water resource assessment (CGWB)
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Mizoram)
HEP	Hydro-electric project
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HSG	Hydrologic soil group
HY-8	FHWA's culvert hydraulic analysis program
IDF	Intensity–duration–frequency
IIT	Indian Institute of Technology
IMD	India Meteorological Department
IMDAA	Indian Monsoon Data Assimilation and Analysis (a regional reanalysis)
IRC	Indian Roads Congress
ISO	International Organization for Standardization
IST	Indian Standard Time
IWRD	Irrigation and Water Resources Department
KC	Kansas City (Kansas City Metro APWA Section 5600)

Abbreviation	Meaning
LADC	Lai Autonomous District Council
LiDAR	Light detection and ranging (laser survey)
LMC	Lunglei Municipal Council
LWRC	Local Water Resources Committee (Water Resources Act, 2024; in a locality with a Local Council)
MADC	Mara Autonomous District Council
MBBL 2016	Model Building Bye-Laws 2016 (MoHUA; not the State's rule)
MIRSAC	Mizoram Remote Sensing Application Centre
MISWARC	Mizoram State Water Resources Council (Water Resources Act, 2024)
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MPCB	Mizoram Pollution Control Board
MSDMA	Mizoram State Disaster Management Authority
Mz-SWIC	The operator of most automatic rain gauges in IMD's Mizoram list (name not expanded in the source)
MZU	Mizoram University
NAFCC	National Adaptation Fund for Climate Change
NDMA	National Disaster Management Authority
NEEPCO	North Eastern Electric Power Corporation Ltd (operator of the Tuirial HEP)
NERCCDIP	North Eastern Region Capital Cities Development Investment Program (ADB)
NGT	National Green Tribunal
NH	National highway
NHIDCL	National Highways and Infrastructure Development Corporation Ltd
NIH	National Institute of Hydrology, Roorkee
NIT	National Institute of Technology
NOC	No-objection certificate
NPDES	National Pollutant Discharge Elimination System (United States)
NRSC	National Remote Sensing Centre
NWIA	National Wetland Inventory and Assessment (ISRO)
OA	Original Application (NGT)
OBPAS	Online building permission system of the Aizawl Municipal Corporation
OGC	Open Geospatial Consortium
ORG	Ordinary rain gauge
PHED	Public Health Engineering Department
PIL	Public interest litigation

Abbreviation	Meaning
PSD	Permissible site discharge
PWD	Public Works Department, Mizoram
RDSO	Research Designs and Standards Organisation (Railways)
RMSE	Root-mean-square error
RRV	Required retention volume
RWH	Rainwater harvesting
SANDRP	South Asia Network on Dams, Rivers and People
SAPCC	State Action Plan on Climate Change
SBM-U	Swachh Bharat Mission (Urban)
SD&SM	Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017
SH	State highway
SIPMIU	State Investment Programme Management and Implementation Unit
SLA	Sea-level allowance (coastal term; not applicable in Mizoram)
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
TBC	To be confirmed: a fact or value not yet found in a source
TCPO	Town and Country Planning Organisation (MoHUA)
TR-55	Technical Release 55 (USDA SCS/NRCS)
TWL	Tailwater level
UD&PA	Urban Development and Poverty Alleviation Department
UH	Unit hydrograph
ULB	Urban local body (in Mizoram, the Aizawl Municipal Corporation and the LMC)
USACE	US Army Corps of Engineers
UT	Union Territory
UTM	Universal Transverse Mercator
VC	Village Council (Mizoram (Village Councils) Act, 2025; or, in an ADC area, under the District Council)
VR	Value rating (of a BMP treating the WQv)
VWRC	Village Water Resources Committee (Water Resources Act, 2024)
WARDMA	Water Resources Development and Management Authority (Water Resources Act, 2024)
WQv	Water quality volume
WSUD	Water-sensitive urban design
YMA	Young Mizo Association

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 Mizoram. It applies to private development and to public works, as set out in Clause 1.5.

1.1.2 The Manual has the following objectives:

- (a) to make stormwater management a **condition of development approval**, so that new development and redevelopment do not increase flood peaks or runoff volumes downstream;
- (b) to retain frequent rainfall on site, so that groundwater recharge is sustained and pollutant loads are reduced;
- (c) to size storage for the long-duration storms of the monsoon season, which in Mizoram fall for days on slopes of shale and loose soil (677 mm in Serchhip district in 1–13 June 2018, SANDRP, as reported; 598 landslides across the State in the storms of 24 May–3 June 2025, DM&R figures, as reported), and which, from the pre-monsoon storms of April and May, among them Cyclone Remal on 28 May 2024, to the post-monsoon cyclones of October to December, saturate the ground, set off landslides and keep the streams and valley rivers high, as well as for short-duration intensities;
- (d) to design outfalls for the steep hill streams (lui) into which almost every town drains, among them the Chite lui, which takes "more than two-third of eastern portion" of Aizawl to the Tuirial, and the Ser lui and its streamlets, which take the west of the city to the Tlawng (Master Plan for Aizawl: Vision 2030), and which rise within the hour, run "turbulent with high velocities of currents during the monsoon season" and carry slide debris and garbage, so that most outfalls fall freely and must dissipate their energy; the rivers that stand high beside the valley floors and terraces, the Tlawng at Sairang, Bairabi and Vairengte, the rivers of the Champhai flats and the Kau and the Tuichawng at Chawngte; the Khawthlangtuipui (Karnaphuli) at Tlabung, a river-flood town whose houses were flooded in 2017, 2018, 2019 and 2023 (as reported); the reservoir of the Tuirial dam and the reaches below it and below the Serlui B dam, into which floods are released; and the rivers that leave the State for Bangladesh and Myanmar, the Karnaphuli, the Kaladan (Chhimtuipui) and the Tiau, on which no downstream level is available, including the case where the outfall is closed;
- (e) to protect tanks (dils), 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 and site-development regulations that the Board of Councillors of the Aizawl Municipal Corporation makes under section 371 of the Mizoram Municipalities Act, 2007 and the Urban Development and Poverty Alleviation Department notifies (the Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

Commentary. Mizoram's disasters come from three sources, often together. The first, and the deadliest, is the landslide that rain and drainage set off on the slopes of the ridge towns. On 9 August 1992 a stone quarry at South Hlimen, on Aizawl's southern edge, collapsed in "unprecedented landslides" (Senhri Journal) that "claimed the lives of almost 100 people" (MIRSAC, 2013, citing earlier work); a chronology reports 30 bodies recovered and 68 feared buried in an unnamed Mizoram village in August 1992, which may be the same event (as reported; unverified). Landslides killed at least 25 people in 1995 (as reported), and the Bawngkawn and Vaivakawn slides of 1994 were studied geotechnically (MIRSAC, 2013). At about 3 a.m. on 11 May 2013 by the press and the AGU Landslide Blog, or on 15 May 2013 by one paper (conflict), a rockslide at Laipuitlang–Ramhlun Venglai in Aizawl, after "heavy rainfall, thunderstorm", destroyed 15 houses and brought a vacated PWD building down on nine; 17 bodies were exhumed and 8 people rescued by the paper's account, while another review gives 8 lives (Laldinpuia et al., 2013; as reported; conflict). The paper's volume of "about 8 Mm³" is implausible for a slide of 1,025 m² and is not used [U]. On 2 July 2019 three of the 20 blocks of a housing complex built under BSUP at Durtlang collapsed, killing 3 people and injuring 11, and 140 families were relocated; the rock bolts, wire nets and buttressed toe walls suggested in 2020 were not provided: "none of the suggestions were carried out" (CAG). From 2017-18 to 2021-22 landslides affected 661 villages, killed 41 people, injured 15 and damaged 219 km of road, and floods affected 434 villages and killed 12 (CAG). In 2022-23 a team of the Directorate of Geology and Mineral Resources inspected 55 locations and attributed two-thirds of the large landslides to "improper drainage" (as reported). On 28 May 2024, in Cyclone Remal, after heavy rain from 27 May, the disused quarry between Melthum and Hlimen collapsed at about 6 a.m., other slides struck Aizawl and NH-6 was cut at Hunthar. The tolls rose through the day: 10, then 23, then 29 dead in Aizawl district with 7 missing (29 May); one report gives 15 at the quarry site and 5 at Hlimen, a later report 34 killed in seven Aizawl areas, and the State toll is put at 27 to 29 by various counts (all as reported; conflict). In July 2024 slides on the Bawngkawn–Durtlang road led the High Court to freeze new construction on either side of it (as reported). Over 24 May–3 June 2025, 598 landslides killed five people, damaged 171 houses and blocked roads at 257 places, most of them in Champhai district (209), then Serchhip (116), Khawzawl (75), Lunglei (61) and Aizawl (21) (DM&R figures, as reported). Landslides in August 2026 struck Aizawl, Champhai, Lawngtlai and Hnahthial without casualties, and a landslide at Vairengte killed a boy and injured four people in September 2026 (as reported).

The second source is the river flood of the valley floors and terraces, which the State has described as absent: "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (MPCB, report to the National Green Tribunal in OA 593/2017). Tlabung, on the Khawthlangtuipui, floods from its river. In June 2017 about 350 houses were reported submerged in the sub-division, against 9 fully and more than 60 partly submerged by district officials, with 8 to 10 dead and more than 1,500 families affected (as reported; conflict). In June 2018, when Serchhip district received 677 mm in 1–13 June and Aizawl 148 mm in one day, 100 houses were flooded at Tiperabagh, 70 at Serhuan and 30 at Tlabung, families were stranded at Sairang on the Tlawng, the cuts of NH-54 at Hunthar became unstable and ten people died in landslides on 5 June (SANDRP; as reported). In July 2019 about 400 houses, 150 of them in Tlabung town, were flooded, more than 350 families were evacuated and 3 people were killed across the State, and in August 2023, 40 families were evacuated at Tlabung (as reported). Bairabi on the Tlawng and Champhai on the Tiau flood too (as reported). The State's statement and these floods do not agree, and the statement does not hold beside the valley floors.

The third is the town drain itself. "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all. Only 15% of the area is provided with pucca drains"; the drains are "silted up frequently due to insufficiency in the hydraulic design"; and although "there is no major water logging in Aizawl as it is situated in sloppy ground", a third of Aizawl W-I is waterlogged "for several days or for hours", which the plan blames on solid waste in the roadside drains (Master Plan for Aizawl: Vision 2030). The same drains carry most of the city's sewage (Chapter 8). The final tolls of DM&R for these events were not obtained [TBC], and the tolls above differ in what they count and in the date of the report.

Missing design makes all three worse. No design storm, return period or drain standard was found for the drains of any town in the State, and the slope regulation of the Aizawl Municipal Corporation sets the geometry of terraces and drains but no design storm. Objectives (b) to (e) address the storage, outfall and building-level

failures, which a drain-sizing manual alone cannot fix; the slope source is answered by the siting, screening, infiltration and debris rules of Chapters 2, 4, 6 and 7, because no drain is sized to carry a slide, and the river source by the outfall checks of Chapter 5 and the corridors and floor levels of Chapters 6 and 7.

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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 mandate RWH only. Objective (a) is therefore the main new step this Manual takes.

1.2 Stormwater management hierarchy

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

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

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

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

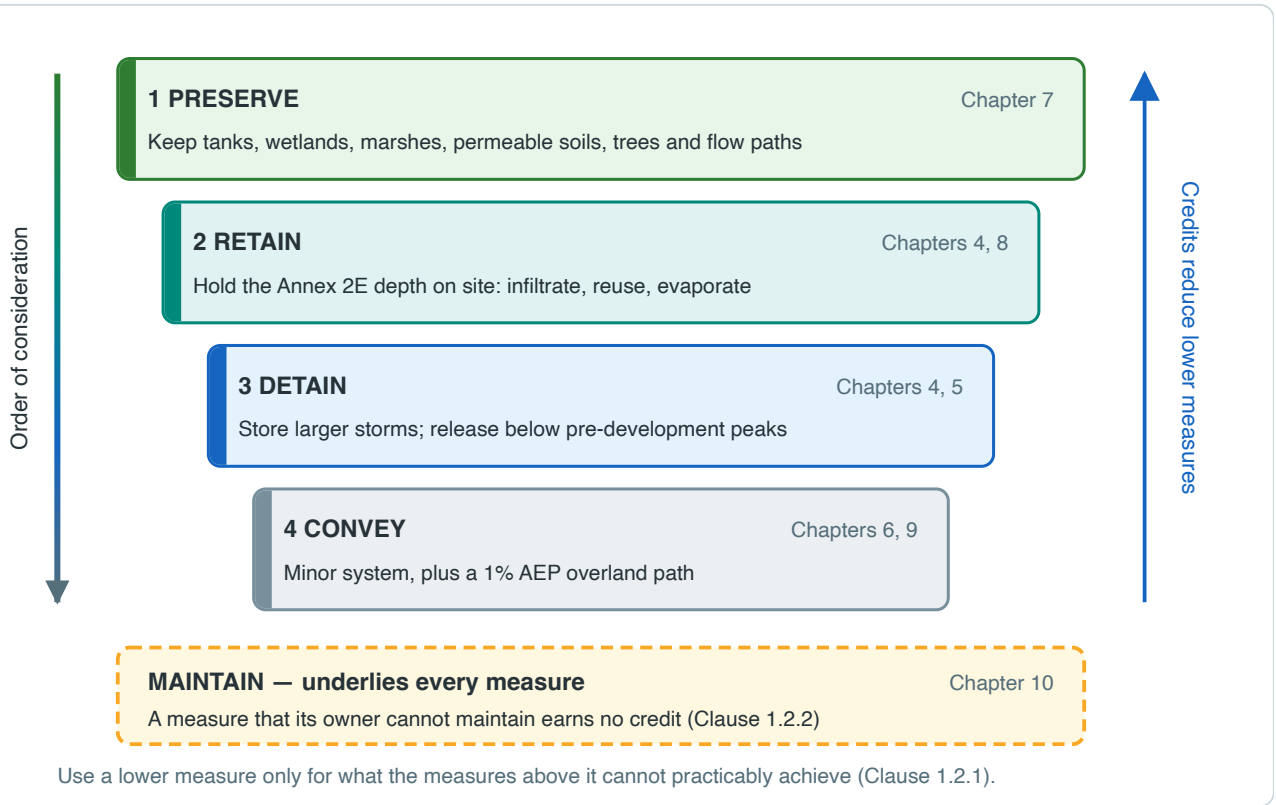

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

> **Commentary.** The order follows the "layers" of Kansas City Metro APWA Section 5600, Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet, 2025). The same logic is behind Georgia's runoff-reduction standard and CSE's "attenuate and infiltrate first" principle (CSE, 2023). For Mizoram, the top two layers have a particular meaning. On the ridges what must be preserved first is the natural drainage of the slope: the lui that carry the towns' water to the rivers, the springs (tuikhur) from which the villages draw their water, the few dils, and the cover of forest and soil on slopes where "The soil in and around the city is young and in a loose state" (Master Plan for Aizawl: Vision 2030). The slope regulation of the Aizawl Municipal Corporation names the danger: "human activities such as slope cutting, filling, increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner can greatly increase slope instability" (SD&SM, reg. 1). The law protects some of this. The master plan keeps "Around 52% of total urban area … under non-urban uses like Agriculture/Forest, Water Bodies, Undevelopable Slopped Lands" and recommends a 15 m green buffer on both sides of major drainage channels; the slope regulation keeps "the riverine reserve" beside natural streams, without defining it (reg. 28), and gives no permit above 60° (reg. 14); and the Mizoram Water Resources (Management and Regulation) Act, 2024 counts springs among the "community water resources" (s.2(1)(i)) that its Village and Local Water Resources Committees are to keep from pollution. Neither regulation sets a metric setback from a stream or a spring, and none of these instruments reaches the areas of the Autonomous District Councils. On hill ground the second layer changes. Retention there is storage and reuse, not infiltration: CGWB finds the shale ridges "characterized by low permeability and infiltration", a "run off zone" (CGWB, Lunglei), and every assessment unit of the State "Safe", with a stage of extraction of 3.52% in 2011 (CGWB, State profile) and 3.95% in 2024 (GWRA 2024, as quoted), so recharge is not a design objective. This Manual therefore bars deliberate infiltration on natural slopes of more than 10°, on the shale, siltstone and mudstone of the Surma group at any slope, on colluvium, fill, cut-spoil or slide debris, in a mapped Moderate, High or Very High landslide hazard zone and within twice the height of a cut or retaining wall upslope of it, unless a geotechnical certificate allows it, and in High and Very High hazard zones not at all (Clause 4.11, hill rule); allows recharge only on tested valley alluvium and river terraces, on flat ground above the 1% AEP flood level and where the water table is at least 2.0 m below ground (Clause 4.11, recharge rule); and keeps stormwater out of every tuikhur, with no storm outfall, soakaway or drain discharge within 15 m of it (the spring rule of Chapter 8) (all set by this Manual). Rainwater harvesting is supply: 27.16% of households in the Aizawl Urban Area use rain water (Master Plan for Aizawl: Vision 2030). On these slopes a drain that puts water into the ground can bring the slope down.

1.3 Legal basis and status

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

- (a) an amendment to the Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 that makes compliance with this Manual a condition of planning permission, building permit, layout approval and completion certificate, for development to which Clause 1.5 applies; and
- (b) bye-laws or standing orders of each urban local body (ULB), adopting the Manual for works executed or approved by that ULB, including the ULB's own drains and roads.

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

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

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

> Commentary. In Mizoram the drainage rule that binds a site is in a slope regulation, not in the building regulation, and this Manual cites the two as a pair, AMCBR/SD&SM. The first is the Aizawl Municipal Corporation Building Regulations, 2012 (UD&PA Notification No. B.13017/8/2012-UD&PA of 20 December 2012; Mizoram Gazette Extraordinary Vol. XLII, Issue No. 4, 10 January 2013), made as the Aizawl Municipal Council Building Regulations, as amended by the Amendment Regulations of 2019 (No. B.13017/8(2)/2018-UD&PA; the draft published for objections on 10 April 2019 was read, the final gazette was not [TBC]), 2023 (No. B.13017/8/2021-UD&PA/Pt of 14 August 2023, in force 28 August 2023, which renamed "Council" to "Corporation") and 2025 (No. B.13017/8/2021-UD&PA/Loose of 21 November 2025). The second is the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 (No. B.13017/75/2016-UD&PA of 4 April 2017; Gazette Extraordinary Vol. XLVI, Issue No. 161, 11 April 2017), drafted with GeoHazards International for the Landslide Policy Committee for Aizawl City (as reported); whether they have been amended is not known [TBC]. Both are made by the Board of Councillors under section 371 of the Mizoram Municipalities Act, 2007, "after previous publication", and notified by UD&PA. Both apply only to "all the areas covered by the Aizawl Municipal Council" (AMCBR reg. 1(2)), and the 2012 Regulations "shall come into force on such date as the Aizawl Municipal Council may notify", a date not found [TBC]. No statewide building regulation was found, and no regulation of the Lunglei Municipal Council (LMC) was found [TBC].
>
> The building regulation requires a site "properly drained or capable of being drained" and "not an active hazard-prone area such as landslide, subsidences, mass movement" (AMCBR reg. 21(ii), (iv)); plans that show "sewerage and surface drains, position and sizes of septic tank and soak pit", a roof plan "indicating drainage and roof slope", "site development and permanent structures like retaining wall, surface drain" and "provision for a suitable rain water harvesting facility" (regs. 5(5)(v), 5(6)(iv), (viii) and (ix)); a plinth that "may preferably be not less than 0.45 metre" so that drainage is assured, and roof water carried by rain gutters and closed conduits and "discharged at ground level by pipe", with "no spout … to drain into the road or public area or within the adjacent compound" (reg. 26(2)); a septic tank "with soak pit" for every water closet, not "within a radius of 15 metres from a water source", and "A suitable rain water harvesting facility … in all buildings" (reg. 33); and a closed conduit through a neighbour's land where "in the interest of public safety" water must cross it, and a drain or closed conduit "of adequate capacity to the nearest public drain" (reg. 37). Since 2023 the online building permission system (OBPAS) returns any proposal "not as per the provisions of the AMC Building Regulations, 2012 and the Master Plan for Aizawl, Vision-2030"; since 2025 rainwater harvesting and "Reduction of Hardscape" are incentives for plots above 100 m² (Chapter VIIIA), and empanelled technical personnel may self-certify ordinary buildings "on plots measuring less than 93 square meters and located within low and moderate geo-hazard zones" (Annexure B-I). The slope regulation requires a site development permit "in addition to a building permit" (SD&SM reg. 5(1)); an engineered track, with a geotechnical report, in the Moderate, High and Very High zones of the Landslide Hazard Maps, on unmapped slopes of 24° or more, for cuts of 3 m or more, for works of more than 200 m³ and for works that support a structure, "Regular site development" being "allowed ONLY in zones of Low landslide hazard"; no permit above 60° (reg. 14); and the drainage of the site (reg. 27): terraces at least 2 m wide at not more than 10 m vertical intervals on cut and fill slopes, with paved swales of at least 1 in 20, no single run of which "shall … collect runoff from a tributary area exceeding 400 square meters (projected horizontally) without discharging into a down drain"; paved interceptor drains along the top of every cut slope whose uphill drainage path exceeds 10 m; building pads graded at least 1 in 50 to approved drainage; "non-erosive downdrains"; and the duty of a site developed downhill to "convey drainage, sewage or seepage from the adjacent site uphill … in a safe manner to the nearest practicable drainage way". Its engineered plans show "the estimated runoff of the area served by any drains" (reg. 6(4)), and its Schedule I makes licensed civil engineers competent for "Design of

drainage structures, including hydrology and hydraulic calculations". Neither regulation sets a design storm, return period, runoff coefficient, release rate or detention volume, a setback from a stream or spring, or a size for rainwater harvesting. The Commentary to Clause 1.1 says that the national Model Building Bye-Laws and the AMCBR/SD&SM "mandate RWH only": that is right for the 2012 Regulations (reg. 33), but the 2017 Regulations mandate no rainwater harvesting and do set the geometry of the site's drainage, though still no detention, peak-flow or design-storm rule (NEER reading). This Manual supplies what the slope regulation leaves to the engineer: the design storm, the intensity, the capacity check, the freeboard and the allowance for debris.

The route of Clause 1.3.1(a) therefore runs through the Board of Councillors and UD&PA. UD&PA could carry this Manual into amendments of AMCBR regs. 5(6), 26, 33 and 37 and SD&SM regs. 6 and 27, which the Board of Councillors would make under section 371 after previous publication and UD&PA would notify (Annex 1D); the Corporation could apply it through OBPAS, the site development permit and its own street drains, which vest in it (Municipalities Act, ss.288–289); the LMC could adopt the same through regulations of its own; and UD&PA could frame the model building bye-laws of section 13(6) of the Mizoram (Village Councils) Act, 2025 with a drainage annex. The Mizoram Urban and Regional Development Act, 1990 (Act 12 of 1990, amended in 2004) is known to this Manual by its title only (as listed) and is not the Act under which either regulation is made; Annex 1D names it only because the core text asks for the State's planning Act. The Master Plan for Aizawl: Vision 2030 was prepared by the erstwhile Aizawl Development Authority, "(now absorbed in AMC)" (CAG); no notification approving it was found, and a report that it was approved in March 2013 is unverified [TBC], yet OBPAS checks every proposal against it.

That route reaches only the Corporation's area. **Mizoram has three legal geographies.** (i) **The municipalities.** The Mizoram Municipalities Act, 2007 (Act No. 6 of 2007) "shall extend to the whole of the State of Mizoram except the area which has been or may hereafter be declared as, or included in, a Panchayat or a Village Council … but shall not extend to the Mizoram Tribal Areas, as referred to in PART III of the paragraph 20 of the Sixth Schedule" (s.1(2)); in practice it reaches the Aizawl Municipal Corporation and the LMC. (ii) **The Village Council areas.** The Mizoram (Village Councils) Act, 2025 (Act No. 7 of 2025; assent 12 March 2025; Gazette Extraordinary Vol. LIV, Issue No. 178, 20 March 2025), which replaced the Lushai Hills District (Village Councils) Act, 1953, "shall extend to the whole of Mizoram except the areas under the jurisdiction of the Municipalities and the Lai, Mara and Chakma Autonomous District Councils" (s.1(2)), and so reaches the villages and the notified towns that have no urban local body, 13 of them with 5,950 to 32,734 people (CAG). Its Village Councils "shall adopt and enforce the model building bye-laws as may be framed by the State Government" and, "subject to the approval of the concerned District Disaster Management Authority", "may declare certain area within their jurisdiction as unsafe site for house construction for mitigation of landslide" (s.13(6)); no model building bye-laws were found (NEER reading). (iii) **The Autonomous District Councils.** The Lai (Lawngtlai), Mara (Siaha) and Chakma (Kamalanagar and Chawngte) Autonomous District Councils of the Sixth Schedule, in the south, are excluded from both Acts, from the Mizoram Water Resources (Management and Regulation) Act, 2024 ("except the Autonomous District Councils") and from the Rivers Bill of 2023, and the provisions of the 74th Amendment "are not applicable in the Sixth Schedule areas" (CAG). No building or drainage regulation of any District Council was found. The Chakma District Council's requirement of a no-objection certificate from the Kamalanagar Town Planning Committee (2018), its notification on prior approval for roadside buildings (20 November 2020) and a provision of 2002 barring house construction "without the written permission from the Village Council" are known only from titles and snippets, the Lai Autonomous District Council (Land Holding and Settlement) Act, 2002 from a snippet, and nothing was found for the Mara District Council (as listed or summarised). This Manual does not quote the Sixth Schedule, which was not read for it; it describes the split by the extent clauses of the Acts and by the CAG.

What the Manual can reach outside the Corporation's area is therefore narrow: public works executed by the State's departments and agencies anywhere in the State, among them roads, culverts, drains, water supply, sewerage and flood works (Clause 1.5.1(b)); any body that adopts it; in the Village Council areas, the model building bye-laws of section 13(6) once the State frames them, and the Village Councils' declarations of unsafe sites with the approval of the District Disaster Management Authority; and in the areas of the Autonomous District Councils, nothing unless a District Council adopts it. A District Council could adopt it for its area by its own instrument, through its Executive Committee, as a District Council of another North-East State has made its own

building regulation; none has. For a household outside the Corporation's area the Manual is guidance (Commentary to Clause 1.5). This Manual is a draft: neither the Government of Mizoram, UD&PA, the Aizawl Municipal Corporation, its Board of Councillors or its Local Councils, the LMC, any Village Council, the Lai, Mara or Chakma Autonomous District Council, nor any other authority has adopted it. MoHUA told Parliament in July 2026 that urban flooding "falls under the purview of the State Governments and the ULBs" and listed the CPHEEO manual among "advisory guidelines" (Lok Sabha AU1847). The State therefore needs no central approval to adopt higher standards. CPHEEO's Note 2 to Table 4.1 (§4.4.1.4) allows "a high powered committee constituted by State/UT Government through a notification" to adopt higher return periods. Clause 1.3.2 uses that route so that higher standards are on record for centrally funded schemes.

1.4 Definitions

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

Term	Meaning in this Manual
Approving Authority (the Authority)	The body that grants planning permission, building permit or layout approval for a development, or that sanctions a public work: the competent authority for the area: in the area of the Aizawl Municipal Corporation, the Corporation, for the building permit, given through its online building permission system (OBPAS) under the Aizawl Municipal Corporation Building Regulations, 2012, for the site development permit that the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 require "in addition to a building permit" (reg. 5(1)), for drain connections (sections 295 and 296 of the Mizoram Municipalities Act, 2007) and for its own drains and works, with its Local Councils for the no-objection certificates they give; in the area of the Lunglei Municipal Council (LMC), the LMC under the Mizoram Municipalities Act, 2007 (no building regulation of the LMC was found [TBC]); in a Village Council area, the Village Council, for building only once the State Government frames the model building bye-laws of section 13(6) of the Mizoram (Village Councils) Act, 2025 (none was found), and for the declaration of an unsafe site for house construction with the approval of the District Disaster Management Authority; the Urban Development and Poverty Alleviation Department (UD&PA) for the master plans of urban areas and notified towns; the Irrigation and Water Resources Department (IWRD) and the Water Resources Development and Management Authority (WARDMA), with the District and the Village or Local Water Resources Committees, for water resources under the Mizoram Water Resources (Management and Regulation) Act, 2024, outside the Autonomous District Councils; the Environment, Forest and Climate Change Department (EF&CC) for riverine reserves and wetlands; the Mizoram River Protection Authority in a River Conservation Zone, only if the Rivers law is in force and a zone has been notified (neither is confirmed); for a public work, the department that executes it (the Public Works Department (PWD), the Public Health Engineering Department (PHED), the IWRD or another works agency); and, in the area of the Lai, Mara or Chakma Autonomous District Council, the District Council (its Executive Committee) and its Village Councils, only if the District Council adopts this Manual (none has), or a department for its own works.
Applicant	The owner, developer or department that seeks approval, and its successors in title.
Development	Any building, layout, sub-division, road, paving or land-use change that requires approval under the Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 or that is executed as a public work.
Redevelopment	Development on a site where impervious cover already exists.
Land disturbance	Clearing, grading, excavation, filling or paving of land, measured in plan area over the whole of a common plan of development (Clause 1.5.5).
Impervious area	Roofs, paving, compacted gravel, decks and other surfaces that prevent infiltration. Permeable paving designed to Chapter 8 is counted as pervious only for the area it treats.
New or replaced impervious area	Impervious area created, or removed and rebuilt down to the subgrade, by the development. Resurfacing that leaves the base in place is not "replaced".
Retention	Permanent removal of runoff from the drainage system on site, by infiltration, reuse or evapotranspiration (Chapter 4).

Term	Meaning in this Manual
Detention	Temporary storage of runoff with a controlled outlet, emptied after the storm (Chapter 4).
Rainwater harvesting (RWH)	Collection of rainfall for supply or recharge under the RWH mandate. RWH storage is not detention unless Chapter 4 allows it.
Minor system	Drains, pipes and inlets designed for the minor-system AEP of Chapter 6.
Major system	The overland and floodway path that carries the 1% AEP (100-yr) flow (Chapter 6).
Pre-development condition	Greenfield: open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted (Chapter 3).
Flood-sensitive catchment	The catchments of Aizawl east, the Chite lui and its tributaries down to the Tuirial; of Aizawl west, the Ser lui with the Khatla, Tuikual, Vaivakawn and Chanmari west lui, down to the Tlawng; of the Hlimen–Melthum quarry belt on Aizawl's southern edge; of Hunthar Veng and the NH-6 corridor at Aizawl; of Durtlang and the Bawngkawn–Durtlang road; of Sairang on the Tlawng; of Bairabi and Vairengte; of Tlabung on the Khawthlangtuipui; of Lunglei town; of Serchhip town; of Champhai town and the Champhai flats; of Siaha and Lawngtlai; and of the release reach below the Tuirial dam, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (dil), 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 to prepare and sign the relevant plans, with any further qualification required by Clause 10.6.
Compliance calculator	The State-issued tool for computing and reporting compliance (Clause 10.5).
Maintenance declaration	The registered undertaking by an owner to maintain a stormwater facility (Clause 10.10).
Variance	Approval to depart from a numeric requirement, with equivalent performance shown (Clause 1.10).
Waiver	Approval that a requirement does not apply to a site, on the grounds in Clause 1.10.
Notified	Published by the Government or the State Stormwater Technical Committee in the Mizoram Gazette.

Term	Meaning in this Manual
Competent authority for the area	The body that grants permission for the site, or consents to the work, under the instrument that applies there: in the area of the Aizawl Municipal Corporation, the Corporation, for the building permit, given through its online building permission system (OBPAS) under the Aizawl Municipal Corporation Building Regulations, 2012, for the site development permit that the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 require "in addition to a building permit" (reg. 5(1)), for drain connections (sections 295 and 296 of the Mizoram Municipalities Act, 2007) and for its own drains and works, with its Local Councils for the no-objection certificates they give; in the area of the Lunglei Municipal Council (LMC), the LMC under the Mizoram Municipalities Act, 2007 (no building regulation of the LMC was found [TBC]); in a Village Council area, the Village Council, for building only once the State Government frames the model building bye-laws of section 13(6) of the Mizoram (Village Councils) Act, 2025 (none was found), and for the declaration of an unsafe site for house construction with the approval of the District Disaster Management Authority; the Urban Development and Poverty Alleviation Department (UD&PA) for the master plans of urban areas and notified towns; the Irrigation and Water Resources Department (IWRD) and the Water Resources Development and Management Authority (WARDMA), with the District and the Village or Local Water Resources Committees, for water resources under the Mizoram Water Resources (Management and Regulation) Act, 2024, outside the Autonomous District Councils; the Environment, Forest and Climate Change Department (EF&CC) for riverine reserves and wetlands; the Mizoram River Protection Authority in a River Conservation Zone, only if the Rivers law is in force and a zone has been notified (neither is confirmed); for a public work, the department that executes it (the Public Works Department (PWD), the Public Health Engineering Department (PHED), the IWRD or another works agency); and, in the area of the Lai, Mara or Chakma Autonomous District Council, the District Council (its Executive Committee) and its Village Councils, only if the District Council adopts this Manual (none has). Where this Manual says "the Authority", the competent authority for the area is meant. This Manual reaches the area of an Autonomous District Council only through that District Council.
Municipal area; Village Council area; Autonomous District Council area	The three legal geographies of the State. A **municipal area** is the area of the Aizawl Municipal Corporation or the Lunglei Municipal Council, to which the Mizoram Municipalities Act, 2007 extends (s.1(2)). A **Village Council area** is any other part of the State outside the three Autonomous District Councils, including the notified towns that have no urban local body, to which the Mizoram (Village Councils) Act, 2025 extends (s.1(2)). An **Autonomous District Council area** is the area of the Lai, Mara or Chakma Autonomous District Council under the Sixth Schedule to the Constitution, in the south of the State, which the municipal, village-council and water-resources Acts and the Rivers Bill of 2023 all exclude; no building or drainage regulation of a District Council was found for this Manual [TBC].
Building regulations; site development permit	The Aizawl Municipal Corporation Building Regulations, 2012, as amended (AMCBR), and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 (SD&SM), made by the Board of Councillors under section 371 of the Mizoram Municipalities Act, 2007 and notified by UD&PA, which apply in the area of the Aizawl Municipal Corporation only. A site development permit under SD&SM is required "in addition to a building permit" (reg. 5(1)), on a regular or an engineered track (Chapter 10).
Landslide Hazard Maps; hazard zone	"The currently adopted version of the Aizawl Municipal Corporation Landslide Hazard Maps, created in 2014 or later to the standards adopted by the Landslide Policy Committee for Aizawl City" (SD&SM, definitions), and their Low, Moderate, High and Very High hazard zones. Outside the Corporation's area, the hazard zonation of MIRSAC for the town concerned, where one exists, is used in the same way (set by this Manual).
Lui	A stream or river (Mizo; *lui te*, a small stream). A lui draining 8 ha or more is a natural channel under Chapter 7, whether or not it carries water all year. Most outfalls in the State discharge to a steep lui (Clause 5.8.5(a)).
Valley-floor land	Land below the 1% AEP flood level of a river, in sub-areas MZ-A1 (Northern valley floors), MZ-C1 (Champhai flats) and MZ-D1 (Tlabung valley floor) of Annex 2A or elsewhere, such as Sairang on the Tlawng and Chawngte on the Kau and the Tuichawng, to which the valley-floor conditions of Chapters 2, 4, 5 and 7 apply (set by this Manual).
Land records; house sites; community land	Land records and land use are with the Land Revenue and Settlement Department, also inside the Corporation's area (CAG); Village Councils allot house sites under the Mizoram (Village Councils) Act, 2025; land in the Autonomous District Council areas is under the District Councils [TBC]. Where this Manual reserves a drainage corridor, an easement or a regional facility site on private land or land held under a pass, it is reserved in the master plan or secured by agreement, not taken (set by this Manual).

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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017;
- (b) all drainage, road, bridge, culvert, waterbody and flood-mitigation works executed by a ULB, a State department, a board, or a State undertaking; and
- (c) works executed by Central agencies or their contractors within Mizoram, to the extent that the Authority's approval or no-objection is required.

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

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

1.5.3 **RWH.** The existing RWH mandate continues to apply under regulation 33 of the Aizawl Municipal Corporation Building Regulations, 2012, "A suitable rain water harvesting facility shall also be provided in all buildings", with plans that "include provision for a suitable rain water harvesting facility" (reg. 5(6)(ix)), in the area of the Aizawl Municipal Corporation, and with rainwater harvesting and "Reduction of Hardscape" offered as incentives, not conditions, for plots above 100 m² under Chapter VIIIA inserted in 2025, but with no storage volume or roof-area rate; the Site Development and Slope Modification Regulations, 2017 contain no rainwater harvesting rule, and no rainwater harvesting rule was found outside the Corporation's area, 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.

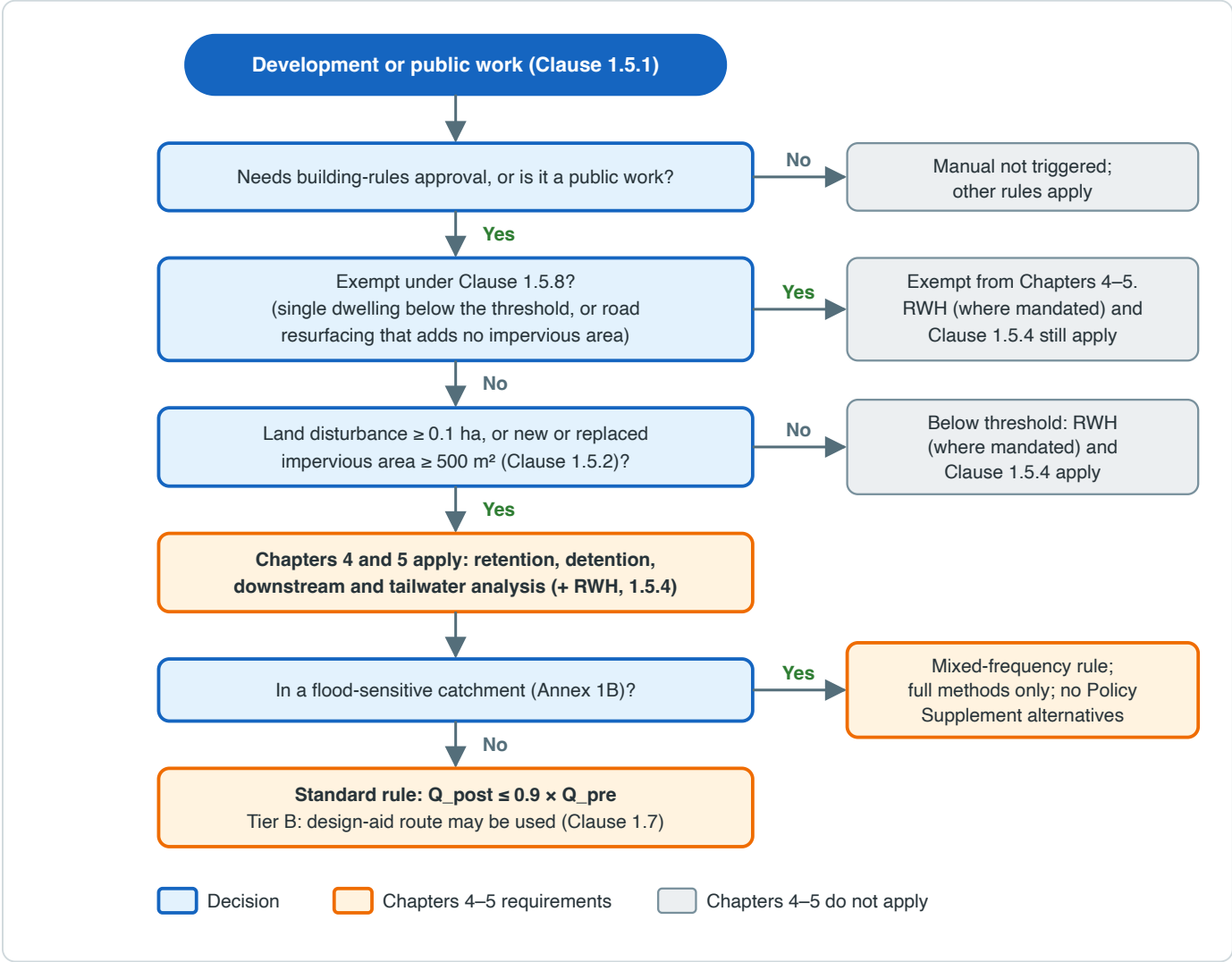

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Mizoram plots are small and the cumulative effect of many small plots is what fills Aizawl's drains. For small buildings in Mizoram, the AMCBR/SD&SM reach every building in the Corporation's area with a duty to provide "a suitable rain water harvesting facility" (AMCBR reg. 33), roof water "discharged at ground level by pipe" and not onto the road or a neighbour's compound (reg. 26(2)(b)), and, where site works are not exempt, the terraces, swales, interceptor

drains and down-drains of SD&SM reg. 27. None of it sets a volume or a design storm, and the tank is full when the season's storm arrives, so none of it limits what leaves the plot. Since 2025 an ordinary building on a plot of less than 93 m² in a low or moderate geo-hazard zone may be self-certified by empanelled technical personnel (Annexure B-I), so the smallest plots are approved without a drainage review; Clause 1.5.4(b) applies to every building whatever its size for this reason. A small building on a hill slope is also where a soak pit does most harm: AMCBR reg. 33 asks for "a septic tank of appropriate capacity with soak pit" for every water closet, which on hazard slopes is the practice the Roadmap to Stability would eliminate; this Manual puts no stormwater into a soak pit and does not override reg. 33 (Table 1.3). Outside the Corporation's area no building rule was found, in a Village Council area or in the area of an Autonomous District Council, and there is no permit to which a small building's drainage could be tied. There the small-site method of Chapter 4 and the hill rule of Clause 4.11, no soak pit or soakaway on a slope of more than 10° or on the shale, roof water to storage and its overflow to a lined drain, never down an unprotected slope, are offered to the household, the village and the agencies that build as guidance, not as a condition of any permit, with the terrace, swale and down-drain geometry of SD&SM reg. 27 as the practical minimum on a slope.

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 Aizawl Municipal Corporation, for its whole area: the only body in the State with building and site-development regulations, an online building permission system and licensed technical personnel (484 at March 2023; 15,162 applications on OBPAS from June 2018 to 1 April 2024; CAG).

1.6.2 **Tier B authorities.** All other Municipal Councils, Village Councils and Autonomous District Councils are Tier B.

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

Table 1.1 — Differences between Tier A and Tier B authorities

Item	Tier A	Tier B
Performance criteria (Chapters 2–9)	Apply in full	Apply in full
Hydrologic method for storage	Hydrograph method (Chapter 3)	Hydrograph method, or the design-aid route of Clause 1.7 where eligible
Compliance calculator (Clause 10.5)	Required as a summary	Required; may be the sole calculation on the design-aid route
Policy supplement alternatives (Clause 1.7)	Only with State Stormwater Technical Committee concurrence	May be adopted by council resolution
Technical review	By the Authority	By the Authority, with UD&PA 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 Aizawl Development Plan Area of the Master Plan for Aizawl: Vision 2030, 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.** Aizawl Municipal Corporation, with an online building permission system (OBPAS) since June 2018, 15,162 applications on it from June 2018 to 1 April 2024 and 484 licensed technical personnel at March 2023 (CAG), but no drain inventory or drainage design standard found for this Manual, in an urban area where "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all" (Master Plan for Aizawl: Vision 2030), and a Village Council in one of the notified towns that have no urban local body, even 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 Aizawl.

1.7 Policy supplement: adoptable alternatives

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

1.7.2 The alternatives are:

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

No.	Main-text requirement	Adoptable alternative	Eligibility
S-1	Storage sized by hydrograph method (Chapter 3)	**Design-aid route:** retention and detention volumes taken from the unit-storage tables (m³ per ha, by rainfall zone, soil group and impervious fraction) in Annex 4 and the compliance calculator	Sites ≤ 2 ha outside flood-sensitive catchments; ≤ 0.5 ha within them (as Clause 4.14.1)
S-2	Release rate Q_post(T) ≤ 0.9 × Q_pre(T), computed for the site	**Permissible site discharge (PSD):** a tabulated unit-area release rate (m³/s/ha) by zone and AEP, derived from the 0.9 × Q_pre rule	Any site outside flood-sensitive catchments
S-3	Waterbody setback extended to the mapped 1% AEP flood extent plus margin (Chapter 7)	**Fixed-width setback table** by waterbody class, where no 1% AEP extent is mapped. Never less than the Zone 1 minimum of Clause 7.4.7 (15 m from top of bank, or from the crest of the bank slope where an incised lui's bank is steeper than 10°)	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
Aizawl Municipal Corporation Building Regulations, 2012 (AMCBR; UD&PA Notification No. B.13017/8/2012-UD&PA of 20 December 2012; Mizoram Gazette Extraordinary Vol. XLII, Issue No. 4, 10 January 2013), as amended by the Amendment Regulations of 2019 (No. B.13017/8(2)/2018-UD&PA; final gazette not read [TBC]), 2023 (No. B.13017/8/2021-UD&PA/Pt of 14 August 2023, in force 28 August 2023) and 2025 (No. B.13017/8/2021-UD&PA/Loose of 21 November 2025)	Continue. They apply only to "all the areas covered by the Aizawl Municipal Council" (reg. 1(2)). They define "Drain" to include "open channel used for conveying surface water" (reg. 3(17)); require a site "properly drained or capable of being drained" and "not an active hazard-prone area" (21), drains and roof drainage on the plans (5(5)(v), 5(6)(iv), (viii)), a plinth of preferably not less than 0.45 m and roof water "discharged at ground level by pipe" (26(2)), a septic tank and soak pit not within 15 m of "a water source" and "A suitable rain water harvesting facility … in all buildings" (33), and a drain "of adequate capacity to the nearest public drain" (37); and list IS 14458 and IS 14496 (Part 2) "For Protection of Landslide Hazard" (Annexure F). The 2023 amendment makes OBPAS return a proposal "not as per the provisions of the AMC Building Regulations, 2012 and the Master Plan for Aizawl, Vision-2030"; the 2025 amendment makes rainwater harvesting and "Reduction of Hardscape" incentives for plots above 100 m², requires excess materials to be removed from public roads before an Occupancy Certificate, and allows self-certification of ordinary buildings on plots of less than 93 m² in low and moderate geo-hazard zones. They set no stream or spring setback, slope limit, detention, rainwater harvesting size or design storm. Reg. 33's soak pit conflicts on hazard slopes with the Roadmap to Stability and with Clause 4.11 (hill rule): this Manual puts no stormwater into a soak pit and does not override reg. 33. The design criteria of Chapters 2–6, the hill and recharge rules of Clause 4.11, the spring rule of Chapter 8 and the corridors of Chapter 7, whose Zone 1 is at least 15 m, are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the regulations, a master plan or a statute are stricter, they govern (Clause 1.3.3).

Instrument	Relationship
Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 (SD&SM; No. B.13017/75/2016-UD&PA of 4 April 2017; Gazette Extraordinary Vol. XLVI, Issue No. 161, 11 April 2017; amendments not known [TBC]); the Corporation's Landslide Hazard Maps	Continue in the Corporation's area. A site development permit is required "in addition to a building permit" (reg. 5(1)); engineered site development, with a geotechnical report, in the Moderate, High and Very High zones of the Landslide Hazard Maps, on unmapped slopes of 24° or more, for cuts of 3 m or more, works of more than 200 m³ and works that support a structure (reg. 4 and the permit tracks); no exemption "within three meters of any slope of 24 degrees or more"; no permit above 60° (reg. 14); plans showing drainage patterns, natural streams, riverine reserves and "flood hazard areas as designated and defined by Aizawl Municipal Corporation" (reg. 6), of which none was found (NEER reading); fill toes drained "with energy dissipaters" (reg. 25); setbacks that "may need to be increased for any required interceptor drains" and the control of "subsurface water, such as springs" (reg. 26); the terraces, swales, interceptor drains, down-drains, pad gradients and downhill conveyance of reg. 27, which this Manual treats as the minimum conveyance layer (Clause 6.3.6); "the riverine reserve shall be maintained" beside natural streams (reg. 28); and excavated material kept off "drainage courses or riverine reserves" (reg. 29). Schedule I makes licensed civil engineers competent for "hydrology and hydraulic calculations". It sets no design storm, return period or runoff coefficient; this Manual supplies them.
Mizoram Municipalities Act, 2007 (Act No. 6 of 2007; Fourth Amendment 2015); the Mizoram Municipalities (Ward Committee and Local Council) Rules, 2010 (No. B.13017/21/2008-UD&PA of 2 November 2010; bilingual)	Continue in the municipal areas, the Aizawl Municipal Corporation and the Lunglei Municipal Council; the Act does not extend to Village Council areas or to "the Mizoram Tribal Areas, as referred to in PART III of the paragraph 20 of the Sixth Schedule" (s.1(2)). It vests "all public tanks, streams, reservoirs, and wells" and the drains, culverts and watercourses along streets in the municipality (s.80(b), (d)); makes it "provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall" (s.288); vests all public drains and drains along public streets in it, "whether made out of Municipal Fund or otherwise" (s.289(1)), with hand-over of sewers to a Government agency (s.289(3)); puts all drains "under the survey and control of the Board of Councillors" (s.290) and requires their cleansing (s.291); allows drainage across private land without notice "in the case of sudden water-logging" (s.294); requires the Chairman's written permission to connect a private drain (s.295) and consent before draining into a municipal drain or "any water-course" (s.296); lets the municipality require foul water to be drained "as distinct from rain-water" (s.298); gives the State control over "imperfect, inefficient or unsuitable" works (s.299); and forbids any structure over a municipal drain, culvert or storm-water channel (s.300). Regulations are made under s.371 "after previous publication". The Corporation's start is given as 1 July 2008 in the Act's preface and as 2010 by the CAG, upgraded on 15 October 2015 [U].
Mizoram (Village Councils) Act, 2025 (Act No. 7 of 2025; Gazette Extraordinary Vol. LIV, Issue No. 178, 20 March 2025), replacing the Lushai Hills District (Village Councils) Act, 1953	Continue in the Village Council areas, including the notified towns without an urban local body; the Act does not extend to the municipalities or the three Autonomous District Councils (s.1(2)). It defines "tuikhur" as "any place wherein water supply is obtained" (s.2(29), numbering inferred from the sequence); lets Village Councils "adopt and enforce the model building bye-laws as may be framed by the State Government" and declare unsafe sites for house construction with the approval of the District Disaster Management Authority (s.13(6)); and lists among their duties "Conserve water resources within the village area" (s.14(6)) and, as assigned, minor irrigation and watershed development, roads and culverts, "Sanitation and drainages" and artificial water bodies (s.15(1)). No model building bye-laws were found (NEER reading); this Manual could be offered as their drainage annex.
The Sixth Schedule areas: the Lai, Mara and Chakma Autonomous District Councils; the Lai Autonomous District Council (Land Holding and Settlement) Act, 2002 (known from a snippet); the Chakma District Council's notices on the Kamalanagar Town Planning Committee (2018), roadside approvals (20 November 2020) and house construction (2002) (known from titles and snippets)	Continue in their areas. The State's municipal, village-council and water-resources Acts and the Rivers Bill of 2023 exclude them, and the 74th Amendment does not apply there (CAG). No building or drainage regulation of a District Council was found [TBC]. This Manual has no force there unless a District Council adopts it (Commentary to Clause 1.3).

Instrument	Relationship
Mizoram Water Resources (Management and Regulation) Act, 2024 (Act No. 1 of 2024; No. H.12018/273/2023-LJD (IWR) of 15 March 2024; Gazette Extraordinary Issue No. 197); the Mizoram State Water Policy 2020 (as named in the Act)	Continue, "except the Autonomous District Councils" (s.1(2)). The Act counts "springs, ponds, lakes, tanks, traditional water harvesting structures, wells" among "community water resources" (s.2(1)(i)); sets up MISWARC and WARDMA (ss.3–6), District Water Resources Committees chaired by the Deputy Commissioner and Village and Local Water Resources Committees chaired by the Village Council President or Local Council Chairman, which are to "Prevent pollution of identified water sources" (ss.9–12); has the IWRD "promote rain water harvesting to augment ground water recharge" (s.14(1)(b)(viii)) and lets WARDMA direct "water conservation and groundwater recharge, including rain water harvesting" (s.16(2)(ix)); requires water-resources mapping within five years (s.17); and sets penalties, with the Deputy Commissioner as penal authority (s.20). On hill ground this Manual reads ss.14 and 16 as storage and reuse, not recharge (Clause 4.11). The constitution notifications of MISWARC and WARDMA were not found [TBC].
Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023; assent 26 May 2023) and Bill, 2023 (Bill No. 70 of 2023 as printed), whose enactment was not confirmed	Not cited as law. As printed, the Bill would extend to the State except the Autonomous District Councils; would provide for Protected Rivers and River Conservation Zones, inside which no construction, "obstruction or diversion of the water course or channel" or land pass would be allowed without the prior approval of a State River Protection Authority, with exemptions that include "bridges and culverts, check dams, waterholes" (s.15(1)); and would let the State regulate catchments "for the prevention of landslips or of the formation of ravines and torrents" and "for the maintenance of water supply in springs, streams and rivers" (s.16). No Protected River or River Conservation Zone is known to have been notified, and no Authority is known to have been constituted. If the law is in force and a zone is notified, its approval is needed in addition to this Manual's.
Mizo District (Forest) Act, 1955 (ss.14 and 21; known by citation); the riverine reserved forests	Not cited as a buffer. A notification of 1965 under the Act declared the forest within half a mile on either side of 16 rivers a reserved forest; the High Court quashed it on 27 January 2021, the State's writ appeal was dismissed as withdrawn on 9 November 2022, a special leave petition was filed (outcome not found), a notification of the General Administration Department of April 2021, not read, is reported to set an 800 m restricted zone from mid-river with development by prior approval, and the Supreme Court issued notice over works in riverine reserved forests in April 2024 (all as reported). The master plan's 800 m green belt along the Tlawng rests on the Act and is not statutory law; this Manual does not use it (Chapter 7).
Master Plan for Aizawl: Vision 2030 (Aizawl Development Authority; IIT Kharagpur; Chief Minister's message of 11 September 2012); the draft Aizawl Municipal Corporation (Master Plan and Strategic Zonal/Ward Development Plan) Regulations, 2015; the Mizoram Urban and Regional Development Act, 1990 (Act 12 of 1990, amended 2004) and the Aizawl Development Authority Act, 2005 (titles as listed)	Continue as the plan against which OBPAS checks every proposal (2023 amendment). No notification approving the plan was found, and a report of approval in March 2013 is unverified [TBC]; the Aizawl Development Authority that prepared it is "now absorbed in AMC" (CAG); and the zonal and ward plan regulations sent to the Government on 17 May 2023 were not approved by September 2023 (CAG). The plan covers the Aizawl Development Plan Area in ten planning zones; recommends a 15 m green buffer on both sides of major drainage channels; marks an "SL" zone of slopes above 36° and "areas adjacent to major drainage lines"; says "development on slope more than 36 degree should be strongly discouraged"; leaves the zoning of natural-hazard areas as "no development zone" to the zonal plans; records that "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all"; proposes eight check dams and "treatment facilities at the outfall points"; and says that "drains need to be cleaned every year before the onset of monsoon". It has no design storm. Master plans would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11).
Roadmap to Stability: Actions to Reduce the Landslide Risk in Aizawl (Landslide Policy Committee for Aizawl City, February 2014); MIRSAC's *Atlas of Micro-level Landslide Hazard Zonation of Aizawl City and Selected Towns*	Inform this Manual. The Roadmap asks PHED to carry rain and waste water "away from exposed hillslopes" to places "that will not saturate potentially unstable slopes", to "eliminate all septic tanks, leach fields and soak pits within Aizawl City" and to set up a drainage office, and gives the Corporation "controlling authority for all developmental activities (Roads, Drainage, quarries etc.)"; its members include PHED, PWD, the Land Revenue and Settlement Department, DM&R, MIRSAC, the Geological Survey of India, Mizoram University, the Corporation and the Directorate of Geology and Mineral Resources. Its drainage actions are the hooks of Clause 4.11 and Chapter 9. The atlas is the only hazard zonation the CAG found (CAG).

Instrument	Relationship
Mizoram Official Language Act, 1974 (Act No. 3 of 1975), in effect from 1 August 1977 by a notification of 6 May 1996 (No. H.12017/14/90-LJD, read from a poor scan)	Continue. Mizo is the official language; that English may also be used is known only as quoted (section not read). Signs and depth markers under this Manual are in Mizo and English (front matter).
Gauhati High Court (Aizawl Bench): the suo motu PIL on the Bawngkawn–Durtlang (Leitan) road (reported 23 July 2024) and the single-bench order of 23 November 2023 in a petition of 2020 (case numbers not found); the riverine reserved forest judgment of 27 January 2021 and Writ Appeal 8 of 2021; the Supreme Court's notice of April 2024 (all as reported)	Apply where they bind; they are directions, not rules of this Manual. The High Court ordered that "no new construction activity shall henceforth be allowed on either side of the Bawngkawn – Durtlang (Leitan) road", kept the Corporation's approvals beyond the first floor "in abeyance", exempted retaining walls for landslide prevention and quoted the master plan's rule against development on slopes of more than 36° (as reported).
National Green Tribunal: OA 593/2017 and OA 673/2018 (MPCB's compliance report, February 2021); OA 606/2018 (the State's report for January–June 2025, liquid-waste table "as on 31st August, 2025")	Apply where they bind. The State reports 51.81 MLD of sewage against treatment of 10 MLD "only for Aizawl city", the Chite treatment plant on trial from 6 February 2021, and the River Rejuvenation Committee and State Level Monitoring Committee; it told the Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area", a statement that does not hold beside the valley floors (Commentary to Clause 1.1). Sewage in storm drains is dealt with in Chapter 8 (Clause 8.9).
Comptroller and Auditor General of India, Report No. 1 of 2025 (tabled 27 August 2025): the performance audits of disaster preparedness and of the 74th Amendment	Inform this Manual. The audits find "more than 71 per cent of the total area is in Very High to Moderate Hazard Zone", no regular inspection of landslide-prone areas, "no Action Plan for checking unplanned urbanisation", the National Building Code for Seismic Zone V "yet to be adopted in the sampled Lawngtlai and Mamit districts", 15 of 18 functions devolved to the Corporation but not "Roads & Bridges, Water supply … and Fire Services", and land use still with the Land Revenue and Settlement Department. No audit of storm drains, AMRUT drainage or the Smart City's drains was found.
Groundwater: no State groundwater Act; the Mizoram Ground Water (Control and Regulation) Bill, 2023 (title page only)	Continue. No State law regulating groundwater was found; "Areas Notified for Regulation of ground water development: NIL" (CGWB, State profile). Every assessment unit is "Safe" (stage of extraction 3.95%, GWRA 2024, as quoted), so recharge is not a design objective of this Manual (Clause 4.11, recharge rule). The IWRD is named in this Manual for groundwater records; no State observation-well network was found.
Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; Wetlands (Conservation and Management) Rules, 2017; the Mizoram Pollution Control Board (MPCB)	Continue. No State Wetland Authority notification was found [TBC]. Pala Wetland (Palak Dil) in Siaha district is a Ramsar site (Chapter 7). dils and springs are governed by Chapters 7 and 8.
Disaster Management Act, 2005; MSDMA, DM&R, the District Disaster Management Authorities and the Deputy Commissioners; the State Disaster Management Plan 2020 (as listed)	Continue. The notification constituting MSDMA was not found [TBC]. No order of the State fixing a date for pre-monsoon desilting was found; the works calendar of Chapter 10 sets this Manual's dates, beginning with 31 March.
IRC:SP:42-2014, IRC:SP:48 (Hill Road Manual), IS 14458 (Parts 1–3) and IS 14496 (Part 2), and the practice of the PWD and the national-highway agencies on road and hill-road drainage	Apply to the drainage of roads and hill roads, cross-referenced from Chapter 6, where they do not conflict with it; the drainage clauses of IRC:SP:48 were not read for this Manual [TBC].
CPHEEO Manual on Storm Water Drainage Systems (2019)	Engineering reference. This Manual sets higher return periods under Clause 1.3.2.

Instrument	Relationship
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 Mizoram is framed as a water supply and recharge measure. It works well for that purpose. It cannot, however, be relied on for flood control in the monsoon, because RWH sumps are usually full or the ground saturated by the time a June to August monsoon storm, such as that of mid-June 2018, 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.

Mizoram has slope rules but no drainage design. The Landslide Policy Committee for Aizawl City asked in 2014 that the Public Health Engineering Department "Adopt and implement a five year capital outlay plan to design and construct facilities to capture and transport rain and waste water away from exposed hillslopes and ejected at locations that will not saturate potentially unstable slopes", that it "eliminate all septic tanks, leach fields and soak pits within Aizawl City" and "Create an office within the Public Health Engineering Department to design and build, monitor and repair or improve drainage systems", and that the Corporation "should have controlling authority for all developmental activities (Roads, Drainage, quarries etc.) within AMC area" (Roadmap to Stability, 2014). The master plan proposes permanent drain alignments, "treatment facilities at the outfall points" and eight check dams, below Zuangtui, Sakawrtuichhun, the Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen (Master Plan for Aizawl: Vision 2030). No storm-drain project of Aizawl Smart City Ltd was found, and the documents found of the ADB's programme for Aizawl cover water supply and sewerage (as summarised). The CAG found that "regular inspection of landslide prone areas and research studies have not been conducted", that there is "no Action Plan for checking unplanned urbanisation" and that the automated landslide monitoring "envisaged in the State Plan since 2015" had not been set up (CAG, Report No. 1 of 2025). None of these states a design storm, and no development-control condition stops new plots from using up the capacity of the drains or putting water into the slopes. Linking Chapters 4–5 to approvals closes that gap.

The State's law holds some of the tools. The slope regulation sets the geometry of the site's drainage, limits what one swale run may drain to 400 m² and makes a site developed downhill carry the drainage from the site above (SD&SM reg. 27); the building regulation requires rainwater harvesting and a drain "of adequate capacity to the nearest public drain" (AMCBR regs. 33 and 37); the Municipalities Act vests the street drains in the Corporation, makes it "provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall" (s.288), lets it require foul water to be drained "as distinct from rain-water" (s.298) and forbids any structure over a municipal drain or storm-water channel (s.300); the Water Resources Act of 2024 sets up WARDMA and committees down to the village and the locality, whose duty includes "Prevent pollution of identified water sources"; and the Village Councils Act of 2025 lets Village Councils declare unsafe sites. The courts and the tribunal have acted too: the High Court froze new construction on either side of the Bawngkawn–Durtlang road in July 2024 and quashed the riverine reserve notification of 1965 in January 2021 (as reported), and the National Green Tribunal's supervision of sewage and polluted rivers (OA 593/2017, OA 673/2018 and OA 606/2018) produced the reports on which Chapter 8 draws. What the law lacks is a design standard. None of these instruments says which storm a drain or down-drain must carry, how much water a hill site may release or put into its slope, what a terrace swale must carry in a 10-year storm, how long a valley-floor outfall is closed by the river, or how far development stays from a lui; the 400 m² rule fixes an area, not a flow; and none applies in the areas of the Autonomous District Councils. This Manual's checks are framed as part of the building permit and the site development permit given by the competent authority for the area, not as a separate no-objection certificate. This

> Manual is offered as a technical companion to these instruments, to the Roadmap's drainage actions and to the orders of the courts and the tribunal: it supplies the design storm, detention, outfall, infiltration, hill-site drainage and corridor numbers they do not set, as a proposal for the Government, the Corporation and the other authorities to consider. Neither UD&PA, the Corporation, the LMC, PHED, PWD, the IWRD, any Village Council, any District Council nor any other body has adopted it.

1.9 Roles and responsibilities

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

Table 1.4 — Roles and responsibilities under this Manual

Agency	Role under this Manual
Urban Development and Poverty Alleviation Department (UD&PA)	Notifies the AMCBR/SD&SM that the Board of Councillors makes under section 371 of the Mizoram Municipalities Act, 2007, holds the master plans of urban areas and the town development plans (Allocation of Business Rules, 2019, as quoted by the CAG) and notifies towns. Would prepare, with the Corporation, the amendment of Clause 1.3.1(a) to AMCBR regs. 5(6), 26, 33 and 37 and SD&SM regs. 6 and 27; could frame the model building bye-laws of section 13(6) of the Mizoram (Village Councils) Act, 2025 with a drainage annex; would show flood-sensitive catchments, drainage reserves, the 1% AEP areas of the valley floors and regional facility sites in the master plans (Chapter 11), issue the model bye-law of Clause 1.3.1(b) and give regional support to Tier B authorities (Table 1.1).
Aizawl Municipal Corporation: its Board of Councillors, Local Councils and Ward Committees	Gives building permits through OBPAS and site development permits under the AMCBR/SD&SM, holds the street drains of its area (s.289) and must "provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall" (s.288); its Local Councils give no-objection certificates and see that the regulations "are strictly observed" (AMCBR reg. 15). Could apply this Manual through OBPAS and the site development permit; would then require the drainage report of Chapter 10, check the hill rule of Clause 4.11 and the SD&SM drainage at the site inspections, apply the Manual to its own drains and works, keep the drain register of Table 1.5, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15).
Lunglei Municipal Council (LMC)	The State's second urban local body (established November 2021; first election 29 March 2023, CAG); no building regulation of its own was found [TBC]. Could adopt this Manual through regulations of its own under the Municipalities Act; would then apply it as the Corporation does.
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).
Village Councils	Under the Mizoram (Village Councils) Act, 2025, "adopt and enforce the model building bye-laws as may be framed by the State Government" (none found) and declare unsafe sites for house construction with the approval of the District Disaster Management Authority (s.13(6)); "Sanitation and drainages", roads and culverts and "Conserve water resources within the village area" are among their duties (ss.14(6), 15(1)); they allot house sites. Could apply this Manual through the model bye-laws once framed, and use its screening of Clause 2.3.6(i) for unsafe-site declarations; would keep village drains and the catchments of tuikhur clear of stormwater outfalls.
Lai, Mara and Chakma Autonomous District Councils, their Executive Committees and Village Councils	Govern their areas under the Sixth Schedule; the State's municipal, village-council and water-resources Acts and the Rivers Bill of 2023 do not extend to them, and no building or drainage regulation of theirs was found [TBC]. The Manual has no force in their areas unless a District Council adopts it. A District Council could adopt it for its area by its own instrument, through its Executive Committee; if it did, it would be the competent authority for the area there. None has. Palak Dil, a Ramsar site, lies in the Mara District Council's area.

Agency	Role under this Manual
Public Works Department (PWD) and the national-highway agencies (NHIDCL among them)	Build and maintain the State roads and the national highways, with their side drains and culverts; roads were not devolved to the Corporation (CAG), and the PWD identifies unsafe buildings outside Aizawl (CAG). Would apply Chapter 6 and the hill-road rules of Clause 6.3.6 to their drains and never discharge a road drain onto an unprotected slope; NH-6 at Hunthar is the standing example.
Public Health Engineering Department (PHED) and the State Investment Programme Management and Implementation Unit (SIPMIU)	PHED runs the water supply, the sewers, bio-digesters and community soak pits; SIPMIU built the 10 MLD sewage treatment plant at Chite and prepared the sewage plan "for Aizawl City and subsequently for the whole state" (MPCB). The Roadmap asks PHED for a drainage office and a five-year plan to carry rain and waste water "away from exposed hillslopes". Would keep sewer and storm networks separate where sewers are built and intercept sullage before storm outfalls (Chapter 8).
Irrigation and Water Resources Department (IWRD); the Mizoram State Water Resources Council (MISWARC), the Water Resources Development and Management Authority (WARDMA), the District Water Resources Committees and the Village and Local Water Resources Committees	Under the Mizoram Water Resources (Management and Regulation) Act, 2024, outside the Autonomous District Councils: the IWRD's Chief Engineer is WARDMA's member secretary, the IWRD is to "promote rain water harvesting to augment ground water recharge" (s.14(1)(b)(viii)), WARDMA may direct "water conservation and groundwater recharge, including rain water harvesting" (s.16(2)(ix)), and the village and locality committees are to "Prevent pollution of identified water sources"; their constitution notifications were not found [TBC]. Would supply river levels and flood marks for Chapter 5, approve the site study of Clause 2.3.6(b) for rural rivers, read rainwater harvesting on hill ground as storage and reuse (Clause 4.11) and protect the catchments of tuikhur.
Environment, Forest and Climate Change Department (EF&CC); the Mizoram River Protection Authority (if constituted)	EF&CC holds the riverine reserves and wetlands and is nodal for the spring-shed pilot (as reported). The Rivers Ordinance and Bill of 2023 would set up a River Protection Authority whose prior approval is needed in a River Conservation Zone; enactment, constitution and any zone are not confirmed. Would apply the corridors of Chapter 7 to riverine reserves; the Authority, if constituted, could use them.
Mizoram Pollution Control Board (MPCB)	Reports to the National Green Tribunal on sewage and polluted rivers (OA 593/2017, OA 673/2018). Would receive the records of sewage found in storm drains under Chapter 8.
MSDMA, the Disaster Management and Rehabilitation Department (DM&R), the Land Revenue and Settlement Department, the Deputy Commissioners and the District Disaster Management Authorities	DM&R "is responsible for prevention, preparedness, mitigation, response, relief and rehabilitation" (CAG) and reports the tolls of floods and landslides; the District Disaster Management Authorities approve the Village Councils' unsafe-site declarations; the Land Revenue and Settlement Department keeps the land records and administers land use, also inside the Corporation's area (CAG). Would supply the landslide and flood inventories used in the screening of Clause 2.3.6(i) and lead post-event reviews with the Authority (Clause 10.16).
Directorate of Geology and Mineral Resources, MIRSAC and the Landslide Policy Committee for Aizawl City	The Directorate investigates landslides and attributed two-thirds of the large ones of 2022-23 to "improper drainage" (as reported); MIRSAC prepared the *Atlas of Micro-level Landslide Hazard Zonation of Aizawl City and Selected Towns* (CAG); the Committee set the standards of the Corporation's Landslide Hazard Maps (SD&SM). Would supply the hazard maps and inventories for Clause 2.3.6(i) and Clause 4.11.
NEEPCO (Tuirial hydroelectric project) and the State's power department (Serlui B)	Operate the Tuirial and Serlui B dams. Would supply reservoir levels, release rules and release records in writing for Chapter 5 and the screening of Clause 2.3.6(i).
Aizawl Smart City Ltd	Set up in November 2017 and incorporated in March 2018 (CAG); no storm-drain project of it was found. Would design any drainage works to this Manual from the dates of Clause 1.11 and hand them over under Clause 10.14.
Central Water Commission (CWC), a body of the Union	Monitors levels at seven sites in the State, five inactive, with no forecasting site (as transcribed by SANDRP). Would supply its records for Chapter 5 and confirm whether a Flood Estimation Report for subzone 2(c) exists or is in preparation (Clause 2.3.6(b)).
Central Ground Water Board (CGWB), North Eastern Region, a body of the Union	Assesses the State's groundwater (every unit "Safe") and published the district booklets on which Clause 4.11 rests. Would supply groundwater records with the IWRD.

Agency	Role under this Manual
IMD (Meteorological Centre Aizawl), the Directorate of Science and Technology (DST), the Agriculture Department and the operator of the Mz-SWIC gauges [U]	Hold the rainfall records of Chapter 2 that are the first data requests of Clause 2.3.6(a). Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

> **Commentary.** Stormwater in Mizoram is split, first, by the three legal geographies: the municipal areas, where the Board of Councillors makes the regulations, UD&PA notifies them and the Corporation grants permission; the Village Council areas, where no building rule has yet been framed; and the areas of the Lai, Mara and Chakma Autonomous District Councils, which none of the State's municipal, village-council, water-resources or river laws reaches. The split is then repeated among the bodies that drain the land: the Corporation for the street drains, which vest in it, the PWD for the drains of the State roads, which were never devolved, the national-highway agencies for NH-6 and NH-306, PHED and SIPMIU for the sewers and the Chite treatment plant, the IWRD and WARDMA for water resources, EF&CC and the Land Revenue and Settlement Department for the riverine reserves and land, NEEPCO for the Tuirial dam, and the courts and the tribunal, which have acted on the Bawngkawn–Durtlang road, the riverine reserves and the polluted lui. Aizawl shows why the split matters. The Chite lui is at once the trunk storm drain of two-thirds of the city's eastern part, the outfall of its one sewage treatment plant, a sewer for the rest of its catchment and a Priority II polluted stretch (CPCB, 2025), and the roadside drains that feed it vest in the Corporation on the statute (s.289(1)) while the PWD maintains the roads they run beside. **No notification divides the drains of any Mizoram town among their owners (NEER reading).** Until the State issues a rule [TBC], this Manual assigns the drainage elements as in Table 1.5, as Chapter 6 does for the drains themselves, and recommends that each town keep a **drain register** giving every reach its owner, the lui it reaches, its class on the landslide hazard map and its outfall (set by this Manual). The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers, and on private land or land held under a pass it is put into effect by reservation in the master plan or by agreement, not by acquisition.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Public drains and drains along public streets in the Corporation's area	the Aizawl Municipal Corporation (Mizoram Municipalities Act, 2007, ss.80(d), 288, 289(1), 290–291), with its Local Councils
Roadside drains of State roads and highways	PWD in practice, because roads were not devolved (CAG), though on the statute the same drains vest in the Corporation (s.289(1)); the overlap is stated, not resolved
Drains of national highways	The national-highway agencies
Natural lui and riverine reserves	EF&CC and the Land Revenue and Settlement Department (NEER reading)
Sewers and the Chite sewage treatment plant	PHED and SIPMIU (s.289(3) allows a hand-over to a Government agency)
Dams and their release reaches	NEEPCO (Tuirial) and the State's power department (Serlui B) (NEER reading)
Village drains outside the municipalities	The Village Council (Mizoram (Village Councils) Act, 2025, s.15(1)(q), "Sanitation and drainages", an assignable duty)
Drains in Lunglei town	The Lunglei Municipal Council under the Municipalities Act (no regulation found [TBC])
Drains in the areas of the Autonomous District Councils	The District Council and its Village Councils [TBC]

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

1.10 Variances and waivers

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

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

1.10.2 **Waiver.** The Authority may waive Chapter 4 detention requirements (not retention) where a hydraulic analysis certified under Clause 10.6 shows that the site discharges directly to the sea, or to a tidal reach with no flood-prone property downstream, and that undetained flow does not worsen the outfall-closed condition of Chapter 5. Mizoram has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to a river in flood beside a valley floor or terrace, such as the Khawthlangtuipui at Tlabung or the Tlawng at Sairang and Bairabi, to the Tuirial reservoir or its backwater, or to a release reach below the Tuirial or Serlui B dam, is in the outfall-closed condition of Chapter 5 whenever the receiving water is high, and detention is not waived for it; nor is it waived for a site because it drains to a steep lui, a gorge or down a slope.

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 (15 m from top of bank, or from the crest of the bank slope where an incised lui's bank is steeper than 10°), 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 Mizoram the one statutory line that once ran along the rivers, the riverine reserved forest of 1965, half a mile either side of 16 rivers, was quashed by the High Court on 27 January 2021 (as reported), the 15 m green buffer along Aizawl's major drainage channels is a recommendation of the master plan only (Master Plan for Aizawl: Vision 2030), the slope regulation's "riverine reserve" is not defined (SD&SM reg. 28), and the State told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (MPCB, OA 593/2017) while Tlabung, Sairang and Bairabi flood from their rivers (as reported).

1.11 Transition provisions

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

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

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

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

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

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

1.12 Review and amendment

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

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

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

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Aizawl Municipal Corporation and of the Aizawl Development Plan Area of the Master Plan for Aizawl: Vision 2030
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model AMCBR/SD&SM 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 Mizoram. Where the Aizawl Municipal Corporation, the Lunglei Municipal Council, a Village Council or an Autonomous District Council has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Mizoram trace to the rainfall input, not the hydraulics. Mizoram shows how. No design storm was found for any town's drains in the State: the Aizawl Municipal Corporation's two regulations set no design storm, return period or runoff coefficient, and its slope regulation leaves "hydrology and hydraulic calculations" to licensed civil engineers (SD&SM, Schedule I); the master plan finds Aizawl's drains "silted up frequently due to insufficiency in the hydraulic design" (Master Plan for Aizawl: Vision 2030). The published sources that serve other States do not reach this one: no Mizoram station is in IMD's *Extremes*, the whole State lies in CWC subzone 2(c), for which CWC has published no Flood Estimation Report, and IMD Das et al. (2022) has no Mizoram panel, so NIH-DHAARA is the only spatial source (Clause 2.3.6). The figures that circulate conflict: the State's mean annual rainfall is printed as 2,056.8 mm, 2,500 mm and 2,794 mm in three sources, and one district booklet gives Serchhip both 1,486.5 mm and about 2,200 mm (CGWB); and the only daily values found are press reports, among them 148 mm at Aizawl in a report that gives no year (as reported). Fixing one transparent source and method for the whole state is the main purpose of this chapter.

2.2 Definitions

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

Term	Meaning in this Manual
Point rainfall	Rainfall at a single location, as measured by a rain gauge.
Design storm	A hyetograph (rainfall depth versus time) of stated AEP, duration and temporal pattern.
Critical duration	The storm duration that produces the largest peak flow, water level or storage requirement for the element being designed.
Areal reduction factor (ARF)	Ratio of catchment-average rainfall to point rainfall for the same AEP and duration.
Monsoon season (as used in this Manual)	1 April to 31 October. In this Manual "the monsoon" and "the monsoon season" mean this wet season, which takes in the pre-monsoon storms of April and May as well as the south-west monsoon from its onset to its withdrawal; it is the Manual's season, not IMD's, and this Manual does not say that the monsoon begins in April in IMD's sense. IMD's normal onset and withdrawal dates for Aizawl were not obtained for this Manual [TBC]; in 2026 the monsoon reached Mizoram about 6 June (as reported). The season begins on 1 April because the State's deadliest dated rain events all fell in May, before or about the onset: the Laipuitlang rockslide in Aizawl, on 11 May 2013 by the press and the AGU Landslide Blog and on 15 May 2013 by one paper (Laldinpuia et al., 2013; conflict); Cyclone Remal on 28 May 2024, with the collapse of the Melthum–Hlimen quarry and other slides in Aizawl; and the storms of 24 May–3 June 2025, with 598 landslides and five deaths (DM&R figures) (all as reported, except the paper); and because storms in April shut schools in five to nine districts on 27–28 April 2026, with 70.5 mm at Serchhip and 55 mm at Hnahthial (as reported). CGWB finds "heavy rainfall during May to late September" (CGWB, Lunglei), and the State's project report for the National Adaptation Fund for Climate Change (NAFCC) "high rainfall during May to September" (Mizoram Agriculture Department, 2016); those are their statements, not IMD's dates. August carries the largest share of the year's rain, 16.8% (Lallawmzuali and Muniyan, 2024). No order of the State fixes a works date, and the master plan says only that "drains need to be cleaned every year before the onset of monsoon" (Master Plan for Aizawl: Vision 2030). A works deadline after the season began would leave the April and May storms uncovered, so the pre-monsoon deadline of 31 March is set before the season begins (Chapter 10). Because the earliest dated deadly event of May fell on 11 May (Laipuitlang, 2013), the mid-season clearance of Chapter 10 is due by 30 April, after the April storms and before every dated May disaster: a clearance due by 15 May could come after Laipuitlang, and one due by 31 May after all three. The State's annual rainfall is printed as 2,056.8 mm (Lallawmzuali and Muniyan, 2024), 2,500 mm (NAFCC project report), 2,794 mm (CGWB, State profile), 2,313.8 mm for Lunglei and both 1,486.5 mm "(As on 2009)" and 2,200–2,216 mm for Serchhip in the same booklet (CGWB), 2,481.9 mm for Serchhip district (MIRSAC) and "209 cm" for Aizawl (Master Plan for Aizawl: Vision 2030); the periods and stations differ, none is picked here, and annual totals do not drive storm-drain design. The antecedent moisture rule of Clause 2.11.4 and the standby period of Chapter 10 refer to this season.
Storms outside the season	Large falls come after the season too: the NAFCC project report finds that "the cyclones of the Post Monsoon season (October to December) are more intense than those of Pre-Monsoon season (April & May)" (Mizoram Agriculture Department, 2016), and Chawngte recorded 130 mm in a day in October 2025, "the highest in the region" (as reported). The October storms fall inside the season to its last day, and those of November and December outside it. Design statistics use annual maxima from all months once a series exists, no works deadline or operating rule shall assume that heavy rain is confined to June–September, and the works calendar of Chapter 10 keeps standby to 31 October and a post-season clearance by 15 November for this reason.
Climate factor (CF)	Multiplier applied to present-day design depths to represent the design-life climate.
Approved source	A rainfall source listed in Clause 2.3.

2.3 Approved sources of design rainfall

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

applies in every sub-area, with the floors, ratios and 72-hour factor that Clause 2.3.6 sets, because no station series, CWC report or published IDF covers any part of the State: NIH-DHAARA is the State's only source of design rainfall, and it has not been tested here.

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

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

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

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

- (a) the IMD isopluvial / IDF values of Das et al. (2022), *MAUSAM* 73(4), for durations of 1–24 h;
- (b) for catchments of 25–5,000 km², the 24-hour point rainfall from the CWC Flood Estimation Report for subzone 2(c) (Barak and others), which covers the whole of Mizoram (Clause 2.3.6(b)) and for which CWC has published no Flood Estimation Report; the report for subzone 2(b) (South Brahmaputra), in which no part of Mizoram lies, is used in its place only for its areal reduction curves and as a check on unit hydrographs, so that no CWC point rainfall exists for the cross-check of Clause 2.3.3(b), as applicable.

Where the design value is lower than the CWC subzone 2(c) (Barak and others) plate (which does not exist: CWC has published no Flood Estimation Report for subzone 2(c), which covers the whole State, and Clause 2.3.6 sets the floors instead) value for the same AEP, the CWC value shall be adopted as a floor.

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

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

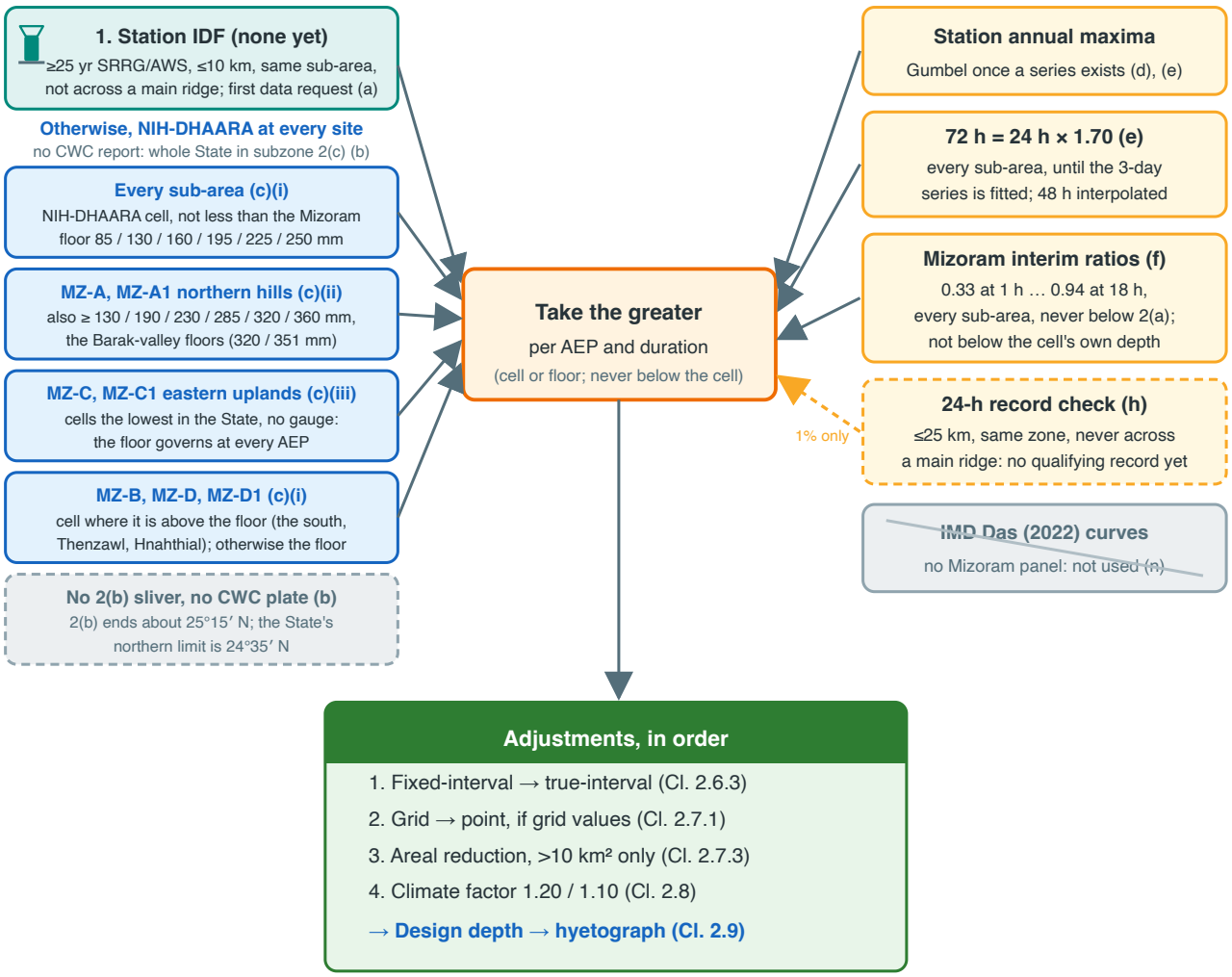

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

2.3.5 **Version control.** Every submittal shall record the source, its version or access date, the coordinates queried, and the values extracted (Clause 2.13).

2.3.6 **Floors, ratios and checks in Mizoram.** Until Annex 2A is published and confirms NIH-DHAARA, or an approved station IDF, for a zone, Clause 2.3.1 applies in every sub-area of the State subject to this clause, and design rainfall shall be taken as follows:

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station and in the same sub-area of Annex 2A, and never across a main ridge, for the durations and AEPs it covers, in place of (f), and subject to the floors of (c)(ii) and (g); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e) and (h). A gauge on one side of the Aizawl ridges, which stand between the Tlawng and Tuirial valleys, does not stand for a site on the other. 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 Mizoram Clause 2.3.2(a) is read with 25 years in place of 30, as in the other editions of this series that have no long recording-gauge fit (set by this Manual). **None exists.** No IDF has yet been published in Annex 2B; no Mizoram station is in IMD's *Extremes of Temperature and Rainfall for Indian Stations (up to 2012)*, whose station index was searched for Aizawl, Aijal, Lunglei, Champhai and Mizoram without a hit (IMD); no IDF paper from NIT Mizoram, Mizoram University or any other institution was found [TBC]; and the only peer-reviewed frequency study of the State's rainfall fits distributions to monthly and annual totals,

not to daily maxima or short durations (Lallawmzuali and Muniyan, 2024, *MAUSAM* 75(3)). The first data requests of this Manual are, in order: (1) the daily series of IMD's **Meteorological Centre Aizawl (ORG)** and **Lengpui (ORG)**, with their annual maxima and start years (IMD's city-weather IDs Aizawl 42726 and Aizawl-Lengpui 42727, as listed); (2) the hourly annual maxima of IMD's automatic weather stations at Mizoram University, Kolasib, Champhai, Khawzawl, Serchhip, Hnahthial, Saiha and Chawnhu; (3) the records of the automatic rain gauges and weather stations of the Mz-SWIC network, about 30 sites on the daily list of the Meteorological Centre Aizawl, with the operator's name, which the source does not expand [U], their start years and their logging intervals; (4) the daily series of the State Meteorological Centre of the Directorate of Science and Technology (DST), from the 1980s to 2021; (5) the ordinary rain gauges of the Agriculture Department at Serchhip, North Vanlaiphai, Lunglei, Haulawng and Tlabung; (6) CWC's rain gauges at Bairabi, Dapchhuah, Mat-1, Tlabung, Tuichawng, Tuipui D, Shitlangpui and its other sites; (7) the rainfall at Aizawl on 27–28 May 2024 and over 24 May–3 June 2025, and the date of the 148 mm day at Aizawl of (h); and (8) NIH-DHAARA's depths at 2 to 18 hours for the 15 cells queried for this Manual, for which only the 1- and 24-hour depths were queried [TBC].

- (b) **Reports, zones and sub-areas. The whole State lies in CWC subzone 2(c), "Barak and others", which Annexure 1.1 of the 2(b) report lists with the "Barak, Kalden and Manipur rivers" (CWC, 2(b), Annexure 1.1), and for which CWC has published no Flood Estimation Report**: the 2(b) report's list of the 21 reports published by 2000 holds none for 2(c), and CWC's archived page of regional reports lists none (CWC; Wayback Machine, 20 March 2024); written confirmation from CWC that none exists or is in preparation is still wanted [TBC]. The Kaladan (the Chhimtuipui, "Kalden" in the list) is named, and so is the Barak, to which the Tlawng (Dhaleswari), the Tuirial (Sonai), the Tuivai, the Serlui and the Langkaih flow; the Karnaphuli (the Khawthlangtuipui), which reaches the sea in Bangladesh, falls under "others" by elimination; and the Tiau joins the Manipur river system in Myanmar (all NEER reading, to be confirmed on CWC's subzone map [TBC]). **No part of the State lies in subzone 2(b)**: the 2(b) report gives its subzone as lying "between … latitude 25° 15' to 28° North approximately" (CWC, 2(b)), and the northern limit of Mizoram is 24°35' N (Lallawmzuali and Muniyan, 2024), 40' further south (NEER arithmetic), so no CWC plate covers any part of the State. In place of the missing report this Manual uses (set by this Manual): for the areal reduction of Clause 2.7.3 on catchments of 25–5,000 km², the areal reduction curves of the 2(b) report, the nearest published CWC report; for rural rivers of 25–1,500 km², a site study (SCS-CN or Clark or Snyder unit hydrograph) calibrated to the gauges of CWC, NEEPCO or the State where any exist, among them the CWC sites and gauges at Sairang, Turial (CWC's spelling of the Tuirial site), Bairabi, Tlabung, Tuichawng, Tuichang and Sihthangpui and NEEPCO's records of the Tuirial reservoir, with the 2(b) unit hydrograph only as a check, because none of its 14 catchments drains Mizoram and its loss rate of 0.35 cm/h is probably too high for the shales of the Surma group (NEER reading) (Chapter 3); and no CWC value exists for the cross-check of Clause 2.3.3(b), which is recorded on Form 2-1 as not available. The rainfall zone and sub-area of the site are those of Annex 2A (set by this Manual, from the gradient of NIH-DHAARA's cells and the river systems of the State): zone **MZ-Z1 Northern hills**, facing the Barak, with sub-areas **MZ-A Northern hills (Kolasib–Kawnpui–Bilkhawthlir)** and **MZ-A1 Northern valley floors (Bairabi–Vairengte)**; zone **MZ-Z2 Central ridges**, with sub-area **MZ-B Central ridges (Aizawl–Sairang–Serchhip–Thenzawl–Hnahthial–Mamit)**; zone **MZ-Z3 Eastern uplands**, towards the Tiau and the headwaters of the Tuipui and the Tuivai, with sub-areas **MZ-C Eastern uplands (Champhai–Khawzawl–Saitual–Ngopa–Zokhawthar)** and **MZ-C1 Champhai flats**; and zone **MZ-Z4 Southern hills**, towards the Karnaphuli and the Kaladan, with sub-areas **MZ-D Southern hills (Lunglei–Lawngtlai–Siaha–Chawngte–Tuipang)** and **MZ-D1 Tlabung valley floor (Tlabung)**. All of them lie in subzone 2(c). They fix the depths of (c), the domain of the check of (h) and the screening of (i); the factor of (e) and the ratios of (f) are the same in all of them. The three sub-areas whose names end in 1 are valley floors: they take their zone's rainfall but differ in infiltration (Clause 4.11, recharge rule), tailwater (Clause 5.8.5) and antecedent moisture (Clause 2.11.4). Any other land below the 1% AEP flood level of a river, such as Sairang on the Tlawng and Chawngte on the Kau and the Tuichawng, is valley-floor land under the same conditions, whatever its sub-area (set by this Manual). A catchment that crosses the line between two zones or two sub-areas of Annex 2A takes, at every duration, the higher value of the two (set by this Manual). The town lists of Annex 2A are a guide; the boundaries follow the main ridges, the river divides and the district lines and are to be confirmed [TBC].

- (c) **24-hour depths, interim, by sub-area.** No CWC plate and no station series covers the State, so the 24-hour depth at every AEP is set as follows (all set by this Manual). The depths are sliding (true-interval) 24-hour depths, and the fixed-interval factor of Clause 2.6.3 is not applied to them. Every depth is then checked under (h).
    - (i) **Every sub-area: NIH-DHAARA with a statewide floor.** The 24-hour depth at each AEP is **the higher of the NIH-DHAARA value for the site's cell and the Mizoram interim floor**:

AEP (return period)	50% (2-yr)	20% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
Mizoram interim floor, 24-hour depth	85 mm	130 mm	160 mm	195 mm	225 mm	250 mm

      The floor is NIH-DHAARA's cell over Aizawl, 84.8, 156.9, 220.1 and 246.8 mm at 2, 10, 50 and 100 years (NIH-DHAARA, queried 14 Nov 2026), with the 5- and 25-year values, 128.2 and 193.2 mm, interpolated on the Gumbel reduced variate, on which the cell's four values lie exactly (NEER arithmetic), rounded up to 5 mm. The capital's cell is the central reference of the State: the floor stops a local dip of the reanalysis grid, whose cells are about 12 km across, from setting a design depth below the capital's on the same ridges, and it lifts the eastern uplands (c)(iii). NIH-DHAARA's behaviour in Mizoram is unknown. In the valley towns of the adjoining editions of this series it ran about 1.3 to 1.5 times the station fits, and in another North-East edition it was of the right order but low against extremes; here the only checks are press values, which Aizawl's cell brackets: its 2-year and 10-year depths, 85 mm and 157 mm, lie either side of the 97.4 mm of 2025 and the 148 mm of 2018 at Aizawl (as reported; NEER comparison). In MZ-B and MZ-D the cells govern where they exceed the floor, as at Thenzawl, Hnahthial, Siaha, Tlabung, Lunglei and Lawngtlai, whose 50-year 24-hour depths are 260, 244, 305, 295, 295 and 271 mm, and the floor governs at Aizawl, Mamit and Serchhip, whose cells give 211–220 mm, except at 2 years at Serchhip, where the cell's 85.4 mm is marginally higher (NIH-DHAARA; NEER comparison). The cell value is recorded on Form 2-1 as NIH-DHAARA returns it, with the coordinates queried (Clause 2.3.5). A station fit under (a) or (d) replaces this rule at the AEPs it covers; where it gives less than the rule at any AEP, the difference and its reason are recorded on Form 2-1, and in MZ-A and MZ-A1 it never brings the 2% and 1% AEP depths below the floors of (c)(ii).
    - (ii) **Northern hills and valley floors (MZ-A, MZ-A1): also not below the Barak-valley values.** The 24-hour depth is also not less than:

AEP (return period)	50% (2-yr)	20% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
MZ-A and MZ-A1, 24-hour depth not less than	130 mm	190 mm	230 mm	285 mm	320 mm	360 mm

      This is the table of the western hills of the adjoining Barak-headwater edition of this series, which carries the floors of the adjoining Barak-valley rule: **320 mm at 2% AEP** (50-yr), the lowest value that Plate 9 of the 2(b) report prints on the 2(b)/2(c) line on the Barail ridge (NEER reading of the plate, as that rule makes it), and **351 mm at 1% AEP** (100-yr), the IMD record of Silchar (Kumbhigram), 350.6 mm on 2 June 1974 (IMD, *Extremes*), rounded up; the other AEPs are scaled from 320 mm by the shape of NIH-DHAARA's growth curve in that edition's western-hill cells and rounded up to 5 mm. The northern hills drain to the same Barak plain, so one storm should read alike on both sides of the State boundary (NEER reading). NIH-DHAARA's cells there, 303 mm at Kolasib, 315 mm at Bairabi and 338 mm at Vairengte at 50 years in 24 hours, are of the same order as the IMD records of the Barak plain, which the research for this Manual places about 60 km to the north: 290.3 mm on 30 May 1893 and 350.6 mm on 2 June 1974 (IMD, *Extremes*). The table governs at Kolasib and Bairabi at every AEP; Vairengte's cell, 241.5, 337.9 and 378.7 mm at 10, 50 and 100 years, exceeds it and governs there (NIH-DHAARA; NEER comparison). A station fit under (d) replaces the 50% to 4% AEP values of the table once it is made and never brings the 2% and 1% AEP depths below 320 mm and 351 mm. The plain downstream lies outside the State, and the adjoining edition governs its reaches.

    - (iii) **Eastern uplands and Champhai flats (MZ-C, MZ-C1): the floor governs.** NIH-DHAARA's eastern cells are the lowest in the State, 181 mm at Saitual, 174 mm at Champhai and 157 mm at Khawzawl at 50 years in 24 hours, consistent with a rain shadow east of the main ridges (NEER reading), but no gauge confirms them, and the evidence points both ways: Khawzawl is reported with 248.3 mm in three days (as reported; the period is not stated [U]), against its cell's 50-year 72-hour depth of 263 mm; Champhai with 1,084 mm in January–July 2025 (as reported); and Champhai district had the most landslides of the storms of 24 May–3 June 2025, 209 of 598 (DM&R figures, as reported), although landslide counts reflect slopes and roads as much as rain. The floor of (c)(i), which exceeds every eastern cell at every AEP, therefore sets the design depth in MZ-C and MZ-C1 until a gauge fit exists (set by this Manual). It is probably conservative there; the records of the automatic weather stations at Champhai and Khawzawl are among the first data requests of (a).

- (d) **Station fits for the 24-hour depth.** The Gumbel (EV1) estimate from the annual maximum daily rainfall series, of all months, of the IMD or State 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, replaces the rule of (c)(i) for the sub-area of the station, and in MZ-A and MZ-A1 the 50% to 4% AEP values of (c)(ii), within the bounds of (a) and with the floors of (c)(ii). No Gumbel fit to the series of any station in the State was found for this Manual, and the record lengths of the State's gauges are not known [TBC]. A day of record excluded under (h) is left out of the series, and the fit with it is reported beside the fit without it on Form 2-1 (set by this Manual).

- (e) **48- and 72-hour depths.** The Gumbel estimate from the annual maximum 2-day and 3-day rainfall series of the station of (d), 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). Until those series are obtained, **the 72-hour depth is the 24-hour design depth of (c) multiplied by 1.70 in every sub-area**, and the 48-hour depth is interpolated between the 24- and 72-hour depths on logarithmic axes (set by this Manual). The factor is the upper envelope, rounded up to 0.05, of the 50-year 72-hour to 24-hour ratios of the 15 NIH-DHAARA cells queried for this Manual, which run from 1.45 at Aizawl and Saitual to 1.70 at Serchhip (NIH-DHAARA, queried 14 Nov 2026; ratios NEER arithmetic), and it is the factor of the adjoining edition on its valley and western hills: the shape, not the values, of the platform. Because the 24-hour design depth is never below the cell's, the product is never below the cell's own 72-hour depth: at 50 years about 382 mm against 319 mm at Aizawl and about 574 mm against 556 mm at Vairengte (NEER arithmetic). The 72-hour depth is needed now because Mizoram's landslide storms last for days: Serchhip district received 677 mm in 1–13 June 2018 (SANDRP, as reported), and 598 landslides came over 24 May–3 June 2025 (DM&R figures, as reported). Slope drainage, culverts and the interception of seepage are designed for a 3-day storm as well as for the 1-hour burst (Chapter 3), and the outfall-closed check of Clause 5.10 on valley-floor land needs a 72-hour depth.

- (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 **Mizoram interim ratios** of Table 2B.1, the same in every sub-area: **0.33 at 1 hour, 0.51 at 2 hours, 0.59 at 3 hours, 0.74 at 6 hours, 0.81 at 9 hours, 0.85 at 12 hours, 0.89 at 15 hours and 0.94 at 18 hours**; and no depth for a duration shall be less than NIH-DHAARA's own depth for that duration at the site (all set by this Manual). The set is the same, value for value, as the interim ratios of the adjoining Barak-headwater edition, which are at each duration the upper envelope, rounded up to 0.01, of the 50-year duration-to-24-hour ratios of eleven cells of the same IMDAA platform across the north-eastern boundary of the State and of the ratios of the CWC report for subzone 2(a), North Brahmaputra: 0.260 at 1 hour, 0.370 at 2 hours, 0.457 at 3 hours, 0.615 at 6 hours, 0.720 at 9 hours, 0.805 at 12 hours, 0.875 at 15 hours and 0.930 at 18 hours, averaged over the frequency analyses of 12 IMD recording gauges and printed for the 50-year depth (CWC, NB/18/1991, §3.1.2, p. 24, and Fig. 10, which gives the 2-hour value); the set therefore never falls below 2(a) at any duration.

  At 1 hour the set's 0.33 equals the highest of Mizoram's cells and exceeds every other: the 50-year 1-hour to 24-hour ratios of the 15 cells run from 0.24 to 0.33, with 0.28 at Aizawl, 0.31–0.33 in the east and at Mamit (Saitual 0.31, Champhai and Mamit 0.32, Khawzawl 0.33) and 0.24–0.25 at Lunglei, Tlabung and Serchhip (NIH-DHAARA, queried 14 Nov 2026; ratios NEER arithmetic). Khawzawl's unrounded ratio, 0.334, is covered by the condition that no depth falls below the cell's own. The proposal of the research for this Manual, a 1-hour depth not less

than the larger of the cell's and 0.30 times the 24-hour depth, is met and exceeded. The 2- to 18-hour durations were not queried for Mizoram, so the set's values there rest on the adjoining cells and on 2(a); querying them for the 15 cells is a data request of (a) [TBC], and once they are queried the condition on the cell's own depth applies at every duration. The 2(b) set (0.48 at 1 hour; CWC, 2(b), Table 4.1) is not used: no part of the State lies in 2(b), and 0.48 is 1.45 times the highest Mizoram cell; the editions of this series that met the same choice on a plateau rejected it there for the same reason, and the adjoining edition uses it only on the Barak plain, which has no counterpart inside Mizoram, where Bairabi and Vairengte are terraces bounded by hills. The 2(a) set is not used alone, because its 1-hour ratio of 0.26 lies below the cells of the east and of Mamit (0.31–0.33). The northern hills, the Tuivai and the Barak headwaters read the same ratios as the adjoining western hills: on the 320 mm floor of (c)(ii) they give about 106 mm in 1 hour at 50 years, as there. On the design depths of (c) the set gives, at 50 years, about 74 mm in 1 hour at Aizawl (cell 62.6 mm), 106 mm at Kolasib (cell 87.5 mm), 112 mm at Vairengte (cell 88.5 mm) and 97 mm at Lunglei (cell 73.1 mm) (NEER arithmetic). Between the tabulated durations the ratio is interpolated on logarithmic axes. The ratios apply to the 24-hour depth of (c) or (d) before the check of (h).

- (g) **Short storms.** No absolute floor in millimetres is set for any sub-area of the State (set by this Manual), because no recording-gauge maximum exists in the State to base one on, and the ratios of (f) already lie at or above the 1-hour ratio of every Mizoram cell and above the 2(a) set at every duration. Where a station fit under (a) later replaces the ratios of (f), its 1-hour depth for every AEP shall be not less than 0.33 times its 24-hour depth for the same AEP until Annex 2B is published (set by this Manual). The depths of (f) are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to NIH-DHAARA's values or to the products of the ratios, which are already sliding, and the climate factor of Clause 2.8 is then applied.

- (h) **24-hour record check, bounded by zone.** The 1% AEP (100-yr) 24-hour depth of (c) or (d) shall be not less than the highest qualifying 24-hour rainfall recorded at any station **within 25 km of the site and in the same zone of Annex 2A**, where that record is higher; the record is used as printed, without the fixed-interval factor, and is treated as a 1% AEP depth; the depths for the other AEPs are then raised in the proportion that the design depths of (c) for the site give them to its 1% AEP depth (all set by this Manual). A record never counts across a main ridge, such as the Aizawl ridges between the Tlawng and Tuirial valleys or the ridges that divide the zones of Annex 2A, so that a gauge in one valley never sets a depth on the far side of the ridge above it (set by this Manual). A record qualifies only when it is printed by IMD (in *Extremes of Temperature and Rainfall for Indian Stations*, a climatological summary of the State, a monthly or seasonal climate summary, a later IMD table or an IMD press release that names the gauge and the day); the number of years of data at its gauge is confirmed by an IMD table as at least 20; it was made in 1901 or later, or IMD has confirmed that the gauge that made it stood where the present gauge stands and was read in the same way; it falls in a month in which a fall of that size is plausible for the station; the location of its gauge is known; and it is not contradicted by another IMD table for the same gauge. A record that fails any test is excluded until IMD confirms what it lacks (set by this Manual). The outcomes at present are:

    - **No record qualifies anywhere in Mizoram.** IMD's *Extremes* prints no station in the State (IMD). The nearest printed records, at Silchar on the Barak plain, 290.3 mm on 30 May 1893, made before 1901, and 350.6 mm at Silchar (Kumbhigram) on 2 June 1974 (IMD, *Extremes*), lie on the plain downstream, in another domain, about 60 km north of the northern towns of the State by the research for this Manual, and so more than 25 km from Vairengte, the nearest Mizoram town; the distance from the Silchar (Kumbhigram) gauge was not computed from IMD's station coordinates, which were not found [TBC], and the outcome would be the same either way. Both records are already reflected in the floors of (c)(ii). The check has nothing to test until the IMD and State series of (a) are obtained, and that is the first data request of this Manual.
    - **Flags only (recorded on Form 2-1; none qualifies, and each lies below the 1% AEP design depth at its place). Aizawl, 148 mm in one day**, "the highest in India" that day, in a report datelined "June 13" with no year, whose villages match the floods of June 2018, so probably 12 June 2018 (as reported; the date a NEER reading), below Aizawl's 10-year depth of 160 mm; **Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm** on one day of late May or early June 2025 (as reported; date not fixed [U]); **Chawngte, 130 mm in a day in October 2025**, "the highest in the region" (as reported); the multi-day totals of **677 mm in Serchhip**

district over 1–13 June 2018 (SANDRP, as reported) and of "Aizawl district 253.7 mm in three days", with Khawzawl 248.3 mm and Siaha 241.5 mm, probably in late May 2025 (as reported; period not stated [U]); and 20 mm at Mizoram University for 28 May 2024 in IMD's press release on Cyclone Remal (as quoted), whose observation window is unclear and which is too small to explain the landslides of that day (NEER reading).

Until Annex 2A is published, the designer lists on Form 2-1 every record and flag within 25 km of the site, with its zone and the tests it passes or fails. The check raises the 24-hour depth and, through (e), the 48- and 72-hour depths. It stops at 24 hours: it does not raise the depths of (f) for 1 to 18 hours, because the records are daily totals and no hourly record of any of them exists.

- (i) **Hazard-first sites.** Mizoram has no snow-fed catchment. No design is complete without a screening, recorded in the drainage report, that identifies the hazards below and states whether the site lies on their path; where it does, the siting, setback, slope-work and floor-level rules of Chapters 4, 6 and 7 govern, because no drain is sized for a landslide or a debris flow (set by this Manual). The hazards are: **mapped landslide hazard zones**, on the Landslide Hazard Maps of the Aizawl Municipal Corporation, "created in 2014 or later to the standards adopted by the Landslide Policy Committee for Aizawl City" (SD&SM, definitions), at 1:5,000 (GeoHazards International, as reported), on MIRSAC's *Atlas of Micro-level Landslide Hazard Zonation of Aizawl City and Selected Towns* (as cited by the CAG), whose map of 2011 rated the Laipuitlang site "Very High" (Laldinpuia et al., 2013), and on MIRSAC's zonation of Serchhip town (Lallianthanga and Lalbiakmawia, 2013); **slopes steeper than 60°**, for which no site development permit is issued (SD&SM reg. 14), and the master plan's "SL" zone of "areas with slope higher than 36°, areas adjacent to major drainage lines" (Master Plan for Aizawl: Vision 2030); **quarries, working or disused**, such as the stone quarry at South Hlimen whose collapse on 9 August 1992 "claimed the lives of almost 100 people" (MIRSAC, 2013, citing earlier work), and the quarry between Melthum and Hlimen, reported disused "for three decades", that collapsed in Cyclone Remal on 28 May 2024 (as reported); **the Hunthar Veng sinking area**, where the soil was tested in 2017 (CAG), and the cuts of NH-6 at Hunthar; **the Bawngkawn–Durtlang (Leitan) road**, on either side of which the High Court froze new construction in July 2024 (as reported); **debris paths below cut slopes, fills and retaining walls**; **valley-floor land** below the 1% AEP flood level, at Tlabung, Bairabi and Vairengte, Sairang and on the Champhai flats; and **the release reaches below the Tuirial dam**, for which a dam-break study routed a peak of 3,035.34 m³/s "near the confluence" (as reported), and below the Serlui B dam [TBC]. The screening draws on these maps, on the landslide records of MSDMA and DM&R [TBC] and on the release records of NEEPCO and the State's power department in writing [TBC].

- (j) **Cloudbursts.** IMD calls a fall of 100 mm or more in one hour over a small area a cloudburst (as quoted; no IMD primary document was found for this Manual [TBC]). No measured cloudburst rate and no hourly value for any gauge in the State was found. The 1-hour depth of (f) at 1% AEP reaches the threshold in the north, about 119 mm at Kolasib and 125 mm at Vairengte, but not on the Aizawl ridges, about 83 mm (NEER arithmetic). What a burst does in a steep catchment that a design storm does not represent is to bring down shale, slope debris and garbage in its first minutes; in such catchments the capacity of inlets, debris racks and culverts to stay open governs more than the conveyance of the drain, and Chapters 6 and 9 size them for it.

- (k) **Durations below 1 hour.** No sub-hourly frequency analysis for any station in the State was found in research for this Manual. Until Annex 2B gives one, the ratio of the depth for a duration below 1 hour to the 1-hour design depth is agreed with the Authority, from a published recording-gauge analysis whose source is stated, and recorded on Form 2-1 [TBC]; the average intensity for a duration below 1 hour shall be not less than the 1-hour design intensity for the same AEP (set by this Manual). The records of IMD's automatic weather stations of (a) are the first source to be analysed for it.

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

- (m) **NIH-DHAARA.** NIH-DHAARA was queried at 15 points in the State on 14 November 2026 (IMDAA dataset), at Aizawl, Kolasib, Bairabi, Vairengte, Mamit, Serchhip, Thenzawl, Hnahthial, Lunglei, Tlabung, Lawngtlai, Siaha, Champhai, Khawzawl and Saitual, for the 1- and 24-hour depths at 2, 10, 50 and 100 years and the 50-year 72-hour depth; all 15 returned data. It is **the design source in every sub-area, under (c), with the floors of (c)(i) and (c)**

(ii); its 72-hour to 24-hour shape is used in (e), and its 1-hour ratios as a check in (f). Its 50-year 24-hour depths run from 157 mm at Khawzawl to 338 mm at Vairengte: about 300–340 mm over the Barak-facing north, 270–305 mm over the south, 210–260 mm on the central ridges and 157–181 mm in the east. No gauge in the State has tested them (Commentary to Clause 2.3). Its projected depths are not used under Clause 2.8.4.

- (n) **IMD Das et al. (2022).** None of the paper's 27 panels is for a Mizoram station (IMD Das et al., 2022, *MAUSAM* 73(4), 887–898; all 27 panels viewed on the page images), and its panels for the nearest cities repeat a generic curve. Nothing in it is cited for Mizoram, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available.

- (o) **Earlier design values.** No design rainfall, return period, runoff coefficient or rule for the time of concentration was found for the drains of any town in the State: none in the Aizawl Municipal Corporation Building Regulations, 2012 or the Site Development and Slope Modification Regulations, 2017, which leave "hydrology and hydraulic calculations" to licensed civil engineers (SD&SM, Schedule I); none in the Master Plan for Aizawl: Vision 2030, whose drainage chapter describes conditions; none in the Smart City documents found; and none in the documents found of the Aizawl tranche of the ADB's North Eastern Region Capital Cities Development Investment Program, which cover water supply and sewerage only (as summarised). Road drainage follows IRC:SP:42-2014 and, on hill roads, IRC:SP:48. A designer who uses any other value reports it on Form 2-1; the return periods of Table 2.1 and the depths of this clause apply.

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

> Commentary. NIH-DHAARA is a national, publicly accessible product from a Government of India institution, and it can be queried at any point in the State. That makes it a reproducible default that an approving authority can check. NIH-DHAARA's sub-daily values are derived from hourly records, not disaggregated from daily totals. That makes it the only public source suitable for sizing drains, which depend on short-duration intensity. Its values should still be checked against the long IMD daily record at 24 hours and longer (Annex 2A). In Mizoram the platform has not been tested, and it is the State's only source. It was queried at 15 points of the State for this Manual, and all returned data. No station series, CWC report or published IDF covers any part of the State, so there is nothing to test it against except press reports of single days, which Aizawl's cell brackets: its 2-year and 10-year 24-hour depths, 85 mm and 157 mm, lie either side of the 97.4 mm of 2025 and the 148 mm of 2018 (as reported). In the valley towns of the adjoining editions of this series the platform ran about 1.3 to 1.5 times the station fits, and in another North-East edition it was of the right order but low against extremes; which way it errs in Mizoram is unknown. Mizoram is the series' fifth North-East edition, and three things set its interim source apart. First, **no record anchors design**: no Mizoram station is in IMD's *Extremes*, the whole State lies in CWC subzone 2(c), for which CWC has published no Flood Estimation Report, and IMD Das et al. (2022) has no Mizoram panel, so NIH-DHAARA is the only spatial source, and Clause 2.3.6 adopts it as the design source in every sub-area, with floors. The adjoining editions met subzone 2(c) with tools they had: the one genuine IMD curve on an escarpment, IMD stations with floors in the Barak valley, and a station fit in a valley with NIH-DHAARA and a floor in its hills; here there is no station to fit. Every one of these methods is set by this Manual, and every one states that CWC has published no report for 2(c). Second, **the floors guard the cells from below**. The statewide floor of Clause 2.3.6(c)(i) is the capital's own cell, so that a local dip of the grid cannot put a design depth below Aizawl's on the same ridges; the eastern uplands take the floor, because their cells are the lowest in the State with no gauge to confirm them, while the reported multi-day totals and the landslides of 2025 there point the other way (Clause 2.3.6(c)(iii)); and the northern hills, which drain to the Barak plain, take the floors of the adjoining Barak-valley rule, so that one storm reads alike on both sides of the State boundary (Clause 2.3.6(c)(ii)). Third, **the ratios are a borrowed shape**. Only the 1- and 24-hour durations were queried in Mizoram; the Mizoram interim ratios of Clause 2.3.6(f) are the adjoining edition's set, built from eleven cells of the same platform across the border and from the 2(a) ratios, and they lie at or above every Mizoram cell at 1 hour, while the 72-hour factor of 1.70 is the upper envelope of the State's own cells. What governs damage in Mizoram is not the peak hour alone: the deadliest storms on record fell for days on shale slopes and loose soil, and two-thirds of the large landslides investigated in 2022-23 were attributed to "improper drainage" (Directorate of Geology and Mining, as

reported), which is why Clause 2.3.6(i) puts siting and slope screening first and Clause 2.3.6(e) asks for a 72-hour depth. The interim floors, the 72-hour factor, the ratio set, the absence of a millimetre floor, the zone-bounded record check, the zones and sub-areas, the hazard-first screening and durations below 1 hour are set by this Manual. Several points are unresolved. NIH-DHAARA was queried at 1 and 24 hours only, and its 2- to 18-hour depths are a data request [TBC]. No series of any Mizoram gauge was obtained, and the start years of the State's gauges are unknown [TBC]. The date of the 148 mm day at Aizawl is a NEER reading, and the Remal rainfall at Aizawl is unknown [TBC]. The distance from the Barak-plain gauges to the northern towns was not computed from IMD's coordinates [TBC]. No storm-drain DPR for any town of the State with its design rainfall analysis was found for this Manual [TBC].

2.4 Design return periods (summary)

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

Table 2.1 — Design return periods (summary)

Element	Design AEP (return period)	Check event	Chapter
Minor drains: Aizawl and Lunglei 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. Mizoram's worst disasters have come when days of rain fall on slopes. Serchhip district received 677 mm in 1–13 June 2018, 345% above normal, and ten people died in landslides on 5 June (SANDRP; as reported); the storms of 24 May–3 June 2025 set off 598 landslides, damaged 171 houses and blocked roads at 257 places (DM&R figures, as reported); and Cyclone Remal brought heavy rain from 27 May 2024 to its peak on 28 May, when the disused quarry between Melthum and Hlimen collapsed (as reported). The slope regulation of the Aizawl Municipal Corporation names the mechanism: "increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner can greatly increase slope instability" (SD&SM, reg. 1). A drain on a ridge fills within minutes of a burst, but the slope it discharges onto, its down-drains and the seepage it collects onto the roads are set by the whole wet spell, and beside the valley floors the rivers rise over the same days and close the outfalls. 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 Mizoram recording gauges. They shall not be lower than the Mizoram interim ratios that Clause 2.3.6(f) sets for every sub-area, which lie at or above the ratios of the CWC Flood Estimation Report for subzone 2(a) at every duration, and no depth shall be lower than NIH-DHAARA's own depth for that duration at the site. The whole State lies in subzone 2(c), for which CWC has published no report; the ratios of the CWC report for subzone 2(b) are not used, and IMD Das et al. (2022) prints no panel for any Mizoram station.

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

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

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

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

> Commentary. The one-third power rule is common in Indian project reports, but no primary IMD source for it was found during research for this Manual. It applies one fixed curve shape everywhere: P(1h)/P(24h) = 0.35, P(3h) = 0.50, P(6h) = 0.63 and P(12h) = 0.79. It cannot represent the difference between a short convective burst and a long monsoon soak, and it tends to understate short-duration depths in convective coastal storms. Annex 2B

shall tabulate the NIH-DHAARA ratios P(t)/P(24h) against these values by zone. That comparison shows whether the rule is acceptable anywhere in the State and corrects older daily-based analyses. The fixed-interval factors are the standard WMO (Hershfield) values. The IMD 2022 study applies similar clock-hour to any-hour corrections.

2.7 Point, grid and areal rainfall

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

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

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

- for 25–5,000 km² in subzone 2(c) (Barak and others), with the report for subzone 2(b) (South Brahmaputra) in place of the 2(c) report that CWC has not published: 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 cell of about 12 km over Aizawl gives 220 mm for the 50-year 24-hour depth, its cell over Khawzawl, on the eastern uplands, 157 mm, and its cell over Vairengte, in the north, 338 mm (NIH-DHAARA, queried 14 Nov 2026), a range of more than two to one that no gauge in the State confirms or corrects. No station series exists in Mizoram to show how far a cell value differs from a point value, or in which direction; in the valley towns of the adjoining editions of this series the platform ran about 1.3 to 1.5 times the station fits. Neither error can be corrected without the factors of Annex 2C. Using grid values as point values without correction would make site-level design unsafe.

2.8 Climate factor

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

Table 2.2 — Interim climate factors

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

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

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

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

Commentary. CPHEEO (2019) considers a fixed climate factor "not feasible" nationally and recommends trend testing instead. That leaves designers without a usable number. The 1.20 short-duration factor matches the UK value cited by CPHEEO itself. No design uplift factor has been adopted in Mizoram. The State Action Plan on Climate Change itself was not read for this Manual [TBC]: the address given for it on the Union ministry's site served instead the State's project report of 2016 on sustainable agriculture for the National Adaptation Fund for Climate Change. That report, citing a "State remote sensing center report", says that "some districts expected to experience nearly 25% increase in rainfall" and that "the number of yearly extreme rainfall events is expected to go up significantly (about 26%)", and that Serchhip and Kolasib are projected to be the most vulnerable to the increase in precipitation (Ravindranath et al., 2010, as cited) (Mizoram Agriculture Department, 2016). These are projections of totals and of the number of events, quoted from a secondary source, not intensity factors, and they are not used as values. For 1986–2005 the same report finds "a remarkable increase during the month of July, with one-day maximum peaks", without printing the values. The North-East district study of CSTEP covers Mizoram, but its figures were not extracted [TBC]. No trend statistic for extreme rainfall in the State was found. As in the other editions of this series, the factors of 1.20 for durations up to 6 hours and 1.10 for longer durations are applied after the record check of Clause 2.3.6(h). NIH-DHAARA's projected depths are not used (Clause 2.3.6(m)). The factors of Table 2.2 are therefore interim values, not Mizoram estimates.

2.9 Temporal patterns (design hyetographs)

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

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

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

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

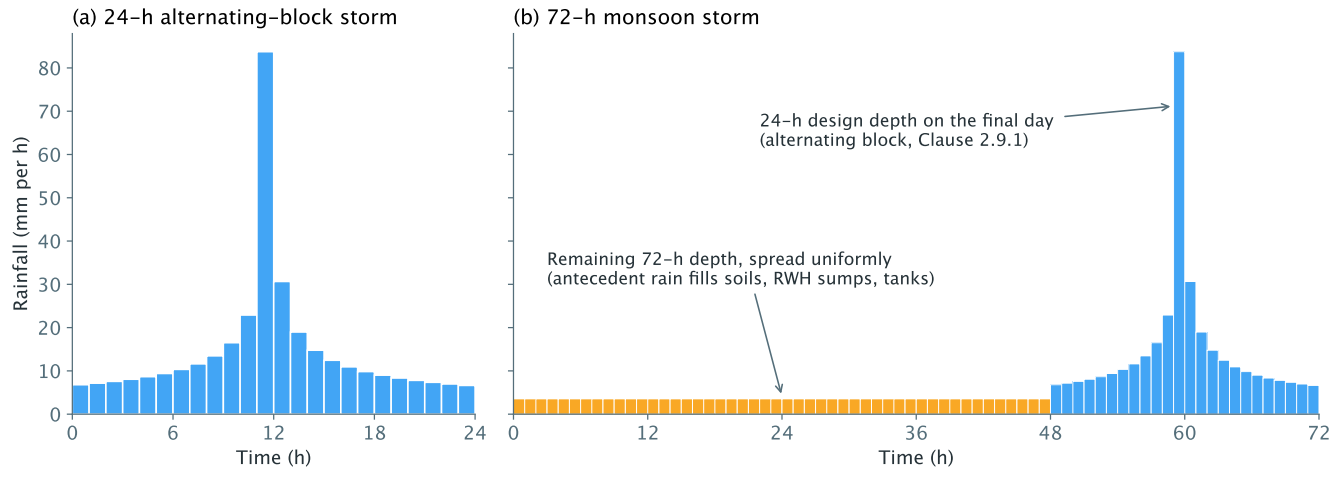

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Mizoram 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 sequence of Mizoram's storms: by the time the largest falls arrive, in a spell of several days in May or June, as in the storms of late May that struck Aizawl in 2024 and 2025, the slopes are wet, the springs and seepage zones are running, and the valley rivers are rising. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Mizoram records.

2.10 Retention rainfall depth

2.10.1 The **retention design depth** is the 24-hour rainfall depth not exceeded on **90%** of days with rain (≥ 2.5 mm) in the long-term record, read from the zone value in Annex 2E.

2.10.2 The site must retain on site the runoff from this depth (Chapter 4). Retention earns a detention credit equal to the reduction in required detention storage found by routing with the retention in place (Clause 4.4.6). The credit is not the retained volume subtracted one-for-one.

> Commentary. This follows the Kansas City Metro APWA 5600 (2025.01) Required Retention Volume concept and Georgia's 1.0-inch runoff reduction standard. Both are based on percentile storms. A percentile depth is a statistic of everyday rainfall, not an AEP value, so it is computed from the daily record rather than from the frequency curves.

2.11 Design storms for pre- and post-development comparison

2.11.1 **Same storm for both scenarios.** Pre- and post-development runs shall use the same design storms:

- same AEP, duration, temporal pattern and climate factor;
- same antecedent moisture condition (Clause 2.11.4).

The two runs differ only in land surface parameters and Tc.

2.11.2 **Standard catchments.** For each of the 50%, 10% and 1% AEP storms and each duration in Clause 2.5.2:

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

2.11.3 **Flood-sensitive catchments** (as listed in Chapter 4: the catchments of Aizawl's Chite lui and Ser lui, of the Hlimen–Melthum quarry belt, of Hunthar Veng and the NH-6 corridor and of Durtlang and the Bawngkawn–Durtlang road at Aizawl, of Sairang, of Bairabi and Vairengte, of Tlabung, of Lunglei, Serchhip and Champhai towns and the Champhai flats, of Siaha and Lawngtlai, and of the release reach below the Tuirial dam, and any catchment notified by the authority). The **mixed-frequency rule** applies:

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

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

2.11.4 **Antecedent moisture.** Use **AMC III** (wet conditions) for every design storm, whatever its duration, from 1 May to 31 October at a site in any sub-area of Annex 2A (MZ-A, MZ-A1, MZ-B, MZ-C, MZ-C1, MZ-D or MZ-D1). Use AMC III for every design storm from 1 April to 31 October on valley-floor land below the 1% AEP flood level of a river or stream, in sub-area MZ-A1, MZ-C1 or MZ-D1 or elsewhere, such as Sairang on the Tlawng and Chawngte on the Kau, and on the margins of a dil. Use AMC III for every design storm at any time of year in a catchment that drains to the Tuirial reservoir or the Serlui B reservoir or its backwater, or to a reach below either dam into which the dam releases water. At any other site or time, use AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm. Use AMC II (average conditions) for every other storm. AMC I is not used for design.

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

Commentary. Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that monsoon extremes arrive after weeks of rain. In Mizoram the season, the ground and the receiving waters together decide how wet a catchment is. The ridges are shale, siltstone and sandstone of the Surma group, of "very low permeability and infiltration", a "run off zone" (CGWB, Lunglei), under soil that is "young and in a loose state" (Master Plan for Aizawl: Vision 2030). The storms that matter last for days: totals of 240–250 mm in three days are reported in ordinary years (Aizawl district 253.7 mm, Khawzawl 248.3 mm and Siaha 241.5 mm, as reported), and Serchhip district received 677 mm in 1–13 June 2018 (SANDRP, as reported); the deadliest dated events all fell in May. On the valley floors and terraces the water stands "within 2.0 m below ground level" in places (CGWB, Lunglei), and the Tuirial and Serlui B reservoirs hold water all year and release it down their reaches. This Manual therefore uses AMC III for every design storm from 1 May to 31 October in every sub-area, the window of the adjoining Barak-valley and western-hill rules of this series; from 1 April to 31 October on valley-floor land below the 1% AEP flood level and on the margins of a dil; at any time of year where the outfall is the Tuirial or Serlui B reservoir, its backwater or a release reach below either dam; and otherwise after a 5-day total of more than 53 mm, the NRCS growing-season threshold for AMC III; AMC II otherwise (Clause 2.11.4). AMC I is not used, because no part of the State is dry enough during the season to justify it. These are interim choices set by this Manual; no study in the State has yet validated AMC classes against observed runoff.

Illustrative scale of the mixed-frequency rule. The values below are not design values. They assume a 2 ha site in a hillside colony in Lunglei town draining to a hill stream (lui) 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.

Mizoram has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. Most of the State's outfalls fall freely to a steep stream (lui), and for them there is no river tailwater: the design case is a free outfall with energy dissipation and a check of the receiving lui to the next confluence (Clause 5.8.5(a)). The tailwater is a river only beside the valley floors and terraces, at Sairang, Bairabi and Vairengte on the Tlawng, on the Champhai flats, at Chawngte on the Kau and the Tuichawng and at Tlabung on the Khawthlangtuipui, and a reservoir only on the Tuirial and the Serlui. For an outfall under river or reservoir backwater, the site storm is combined with the receiving-water level under Clause 5.8.4, which pairs a design event on one side with a 10-yr event on the other in the same way as case (b), and the river and reservoir levels are those of Clause 5.8.2; for an outfall that a flap gate closes, the outfall-closed check of Clause 5.10 also applies. CWC has no flood-forecasting site in the State and prints no warning or danger level for any site. It has seven level-monitoring sites, five of them inactive: Sairang on the Tlawng ("Dhaleswari"), with an active hydrograph and no highest level; Turial on the Tuirial, with a highest level of 149.0 m on 17 June 1995, the only one printed; and Bailley Bridge Tuipui, Sihthangpui on the Kaladan ("Kolodyne"), Keitum on the Tlawng, Tuichang and Tuichawng, with none (CWC data as transcribed by SANDRP, 2018); another list of the same year names eight sites, adding Pangkhuah (as reported). The Tuirial dam of NEEPCO has a full reservoir level of 90.5 m, a minimum drawdown level of 68.0 m and a normal tailwater level at full load of 30.7 m (CERC, Petition 125/MP/2021); how the Turial gauge's 149.0 m relates to these levels is not stated, and it is not inferred here [TBC]. A dam-break study of the Tuirial dam routed a peak of 3,035.34 m³/s "near the confluence" (as reported). The full and maximum water levels of the Serlui B dam were not found [TBC]. The Karnaphuli, the Kaladan and the Tiau leave the State for Bangladesh and Myanmar, and no level downstream is available to designers in the State. The valley rivers rise with the same multi-day storms that saturate the slopes, so beside the valley floors the local storm can fall while the river is already high: at Tlabung the Khawthlangtuipui flooded about 350 houses in the sub-division in June 2017 by one report, or 9 fully and more than 60 partly by district officials, and about 400 houses, 150 of them in the town, in July 2019 (as reported; conflict). No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC], and Chapter 5 sets the interim rule. Every level is stated on a named gauge and datum, as Chapter 5 requires; no source found states the datum of the CWC level quoted here, presumably metres above mean sea level [TBC].

> Commentary. Mizoram has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the level of the river beside a valley floor or terrace, or of the Tuirial reservoir. The coincidence is on record there: in June 2018, during the storm that brought 677 mm to Serchhip district in 13 days, families were stranded at Sairang on the Tlawng and houses were flooded at Tiperabagh, Serhuan and Tlabung (as reported); at Tlabung the Khawthlangtuipui flooded about 400 houses, 150 of them in the town, in July 2019, and 40 families were evacuated in August 2023 (as reported). On the ridges there is no coincident level, because the lui fall freely; the coincident load there is the debris that the same storm brings down. No river level in the State has a stated datum: the only highest level printed for a CWC site is 149.0 m at Turial on the Tuirial (17 June 1995; CWC data as transcribed by SANDRP), and its relation to the reservoir's full level of 90.5 m (CERC) is not stated [TBC], which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather

> cause (in Mizoram, which has no coast, the counterpart of surge is the stage of the valley rivers and of the Tuirial reservoir that receive the drains of the valley floors and terraces, raised by the same multi-day storms that bring the heaviest rain to the towns: in June 2018, when Serchhip district had 677 mm in 1–13 June, families were stranded at Sairang on the Tlawng and houses were flooded at Tlabung, and in July 2019 about 400 houses were flooded at Tlabung (all 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.

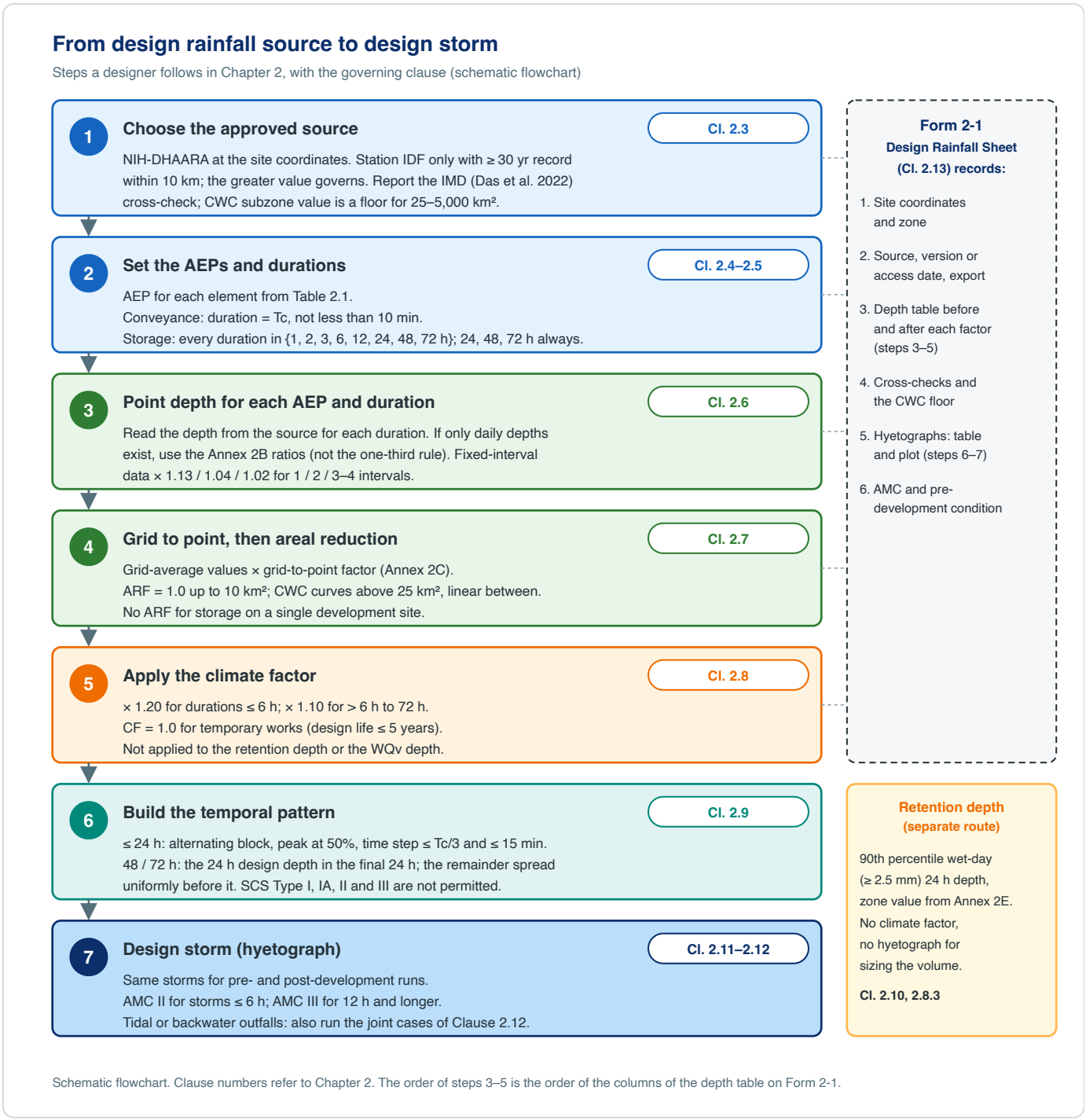

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the 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	Mizoram 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 (dil) 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 (dils) 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 thin hill soils and colluvium over the shales, siltstones and sandstones of the Surma group and the Barail sandstones, and the valley alluvium and terraces of the Champhai flats, Tlabung, Bairabi and the Tlawng, where an HSG A to C jump would be excessive. The 35% minimum imperviousness for unplanned upstream land in 3.3.5(a) is the APWA value (2011, §5602.3E.2). Using the master-plan land use for conveyance follows CPHEEO, which requires C to reflect "ultimate development of the catchment as per the master plan" (CPHEEO 2019, Part A §4.4.1.5).

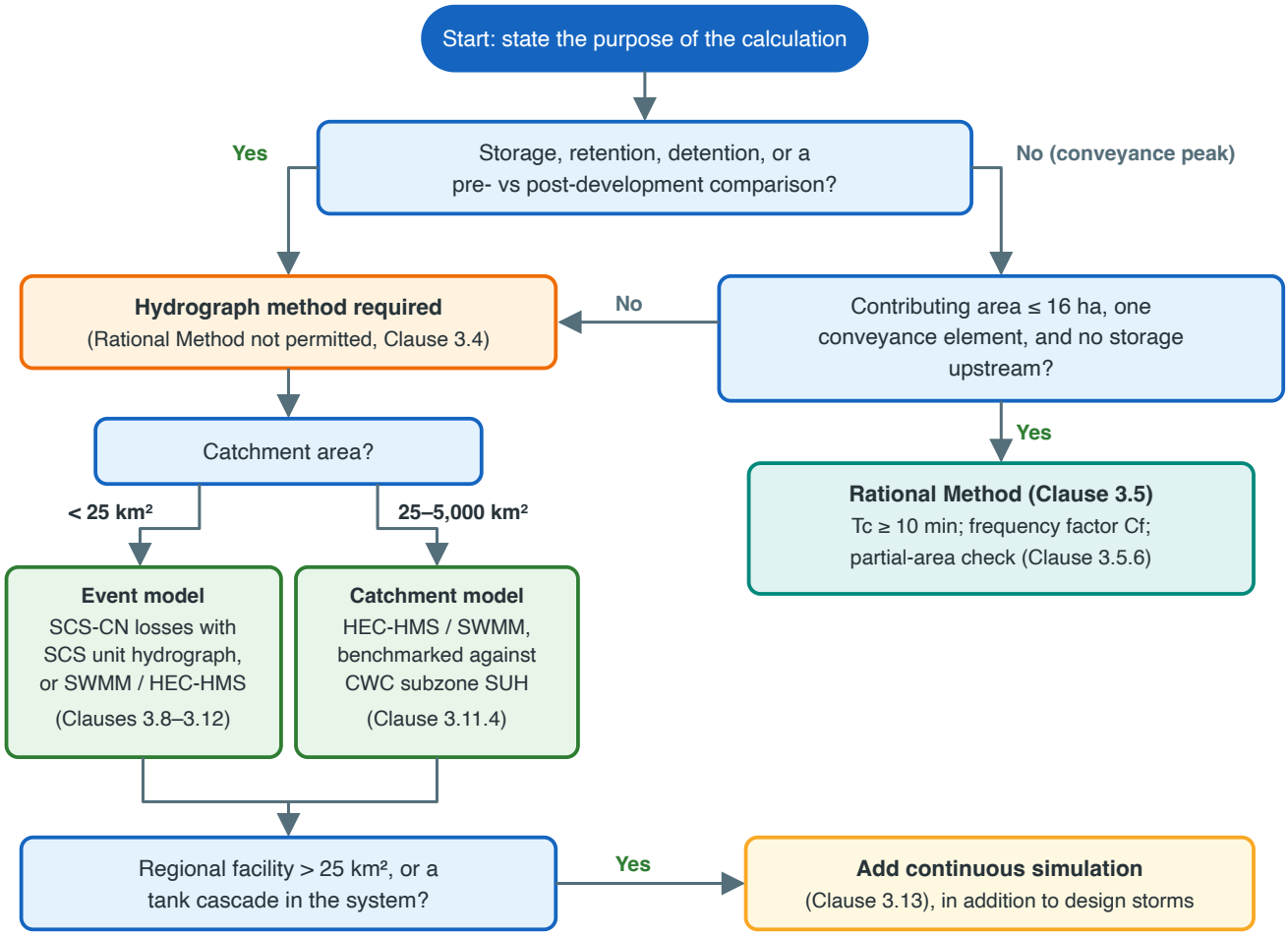
3.4 Selection of method

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

Table 3.1 — Permitted hydrologic methods

Purpose	Catchment / condition	Permitted method	Clause
Peak flow for one conveyance element (inlet, pipe reach, drain reach, culvert)	≤ 16 ha contributing, no upstream storage, no backwater	Rational Method	3.5
Peak flow for conveyance	> 16 ha, or any upstream storage, tank or pond	Hydrograph method (SCS-CN with SCS unit hydrograph, SWMM or HEC-HMS)	3.8–3.12

Purpose	Catchment / condition	Permitted method	Clause
Retention, detention, any storage; pre- vs post-development comparison	Any size	Hydrograph method; **Rational Method not permitted**	3.8–3.12, 3.14
Pipe or drain network with backwater, tidal or tank tailwater	Any size	Hydrograph method with dynamic-wave hydraulic routing	3.12.4; Chapter 5
Catchment-scale flows	25–5,000 km² in CWC subzone 2(c) (Barak and others), with the report for subzone 2(b) (South Brahmaputra) in place of the 2(c) report that CWC has not published	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 (dil) 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



Tidal or backwater outfall: route with a dynamic-wave hydraulic model (Chapter 5).

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

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

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

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

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

> **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 · Cf ≤ 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

Surface or land use	C	Source
Industrial	0.60–0.90	CPHEEO 2019, Table 4.2
Institutional	0.70–0.95	CPHEEO 2019, Table 4.2
Residential, high density	0.60–0.75	CPHEEO 2019, Table 4.2
Residential, low density	0.40–0.60	CPHEEO 2019, Table 4.2
Recreational	0.10–0.25	CPHEEO 2019, Table 4.2
Asphalt	0.70–0.95	CPHEEO 2019, Table 4.2
Concrete	0.80–0.95	CPHEEO 2019, Table 4.2
Brick paving	0.70–0.85	CPHEEO 2019, Table 4.2
Roofs: tiles	0.80–0.90	CPHEEO 2019, Table 4.2
Roofs: metal	0.70–0.90	CPHEEO 2019, Table 4.2
Roofs: concrete	0.70–0.90	CPHEEO 2019, Table 4.2
Lawns, sandy soil, flat (≤ 2%)	0.05–0.10	ASCE/WPCF 1969
Lawns, sandy soil, average (2–7%)	0.10–0.15	ASCE/WPCF 1969
Lawns, sandy soil, steep (> 7%)	0.15–0.20	ASCE/WPCF 1969
Lawns, heavy (clay) soil, flat (≤ 2%)	0.13–0.17	ASCE/WPCF 1969
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 Mizoram's rare storms arrive on wet ground (Clause 2.11.4). The 10-minute minimum Tc matches the minimum design duration of Clause 2.5.1. APWA 2011 bounds inlet time between 5 and 15 minutes (§5602.7A). The partial-area check follows CPHEEO's treatment of "partial area effect" (CPHEEO 2019, Part A §4.4.1.7). This Manual requires the upper half of each range in 3.5.2 because Indian urban plots are typically more densely covered than the US land uses behind the ASCE ranges.

3.6 Time of concentration

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

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

- (a) **Sheet flow:**

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

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

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

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

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

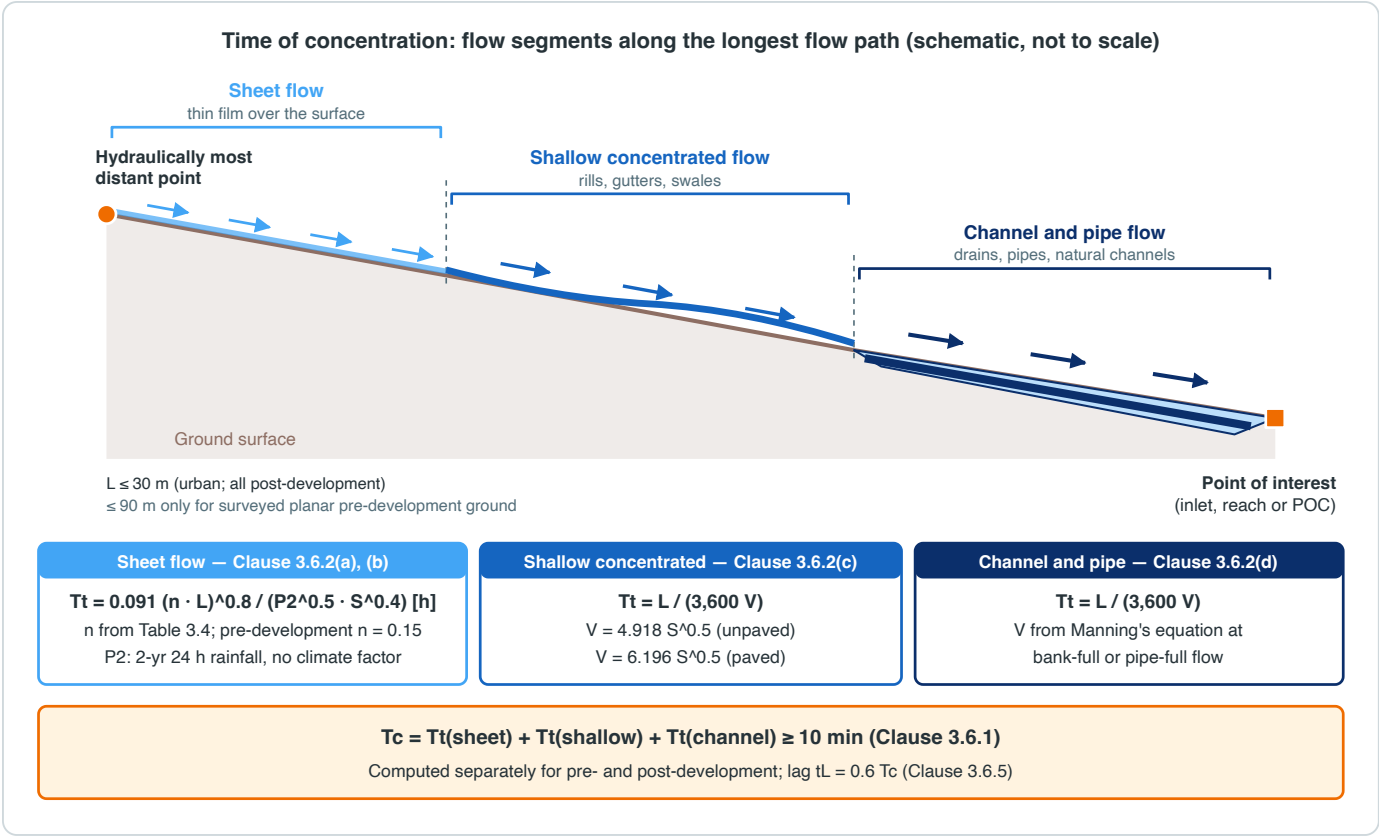


Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986),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

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

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

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

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

tc = 0.0195 L^0.77 S^−0.385

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

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

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

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

3.7 Soils and hydrologic soil groups

3.7.1 **Mapping.** HSG shall be assigned from the soil series mapped by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) or the State soil survey (agency to be confirmed [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 Mizoram: the shale, siltstone and mudstone ridges of the Surma group (the Bokabil shale and the shale units of the Bhuban), with their thin hill soils, HSG D for design, whatever group the soil itself would take; the sandstone ridges (the Bhuban sandstones and the Barail sandstones), HSG C on a site test, and HSG D where the rock is unweathered, with no test pit or infiltration practice above a scarp or a cut slope; colluvium on the slopes, HSG C for runoff, but unstable ground on which no infiltration is credited (Clause 4.11, hill rule); slide debris, HSG D for design, with no infiltration credit; the valley alluvium and river terraces of the Champhai flats (sub-area MZ-C1), of Bairabi and Vairengte (sub-area MZ-A1), of Tlabung (sub-area MZ-D1) and along the Tlawng, HSG B or C by texture on a site test, with the water table checked under Clause 3.10 because it may stand less than 2 m below ground; and urban fill and cut-spoil on the slopes of Aizawl and the other towns, HSG D by default. A field infiltration test is required on every site in the Tier A area and on every other site larger than the limits of the simplified method of Clause 4.14.1, at the depth of the proposed facility; on smaller sites, a soil that has not been tested shall be given the less permeable of the groups listed for it. Whether an infiltration practice may be built at all is governed by the two infiltration rules of Clause 4.11 (the hill rule and the recharge rule), not by its HSG. Clause 3.10.1 applies to all of these groups.

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

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

Commentary. NBSS&LUP soil maps are typically at 1:250,000 to 1:50,000 scale and classify soils by series and taxonomy, not by HSG. A lookup table is therefore needed (Annex 3A). Site tests matter most where one site can span two groups: on the ridges, where shale, siltstone and sandstone alternate within a short distance, as in the Middle Bhuban litho-units of Serchhip town (MIRSAC); on a slope, where colluvium, fill or cut-spoil lies over shale, so that a high rate in a pit dug in it can be water entering a slope that cannot take it (Clause 4.11); and at the edge of a valley floor or terrace, where the terrace soil of cobbles and pebbles passes into colluvium from the slope above and the water table rises towards the river (CGWB, Lunglei district). No soil-series map of Mizoram from NBSS&LUP, no HSG map or table, no SCS-CN calibration and no measured infiltration rate for any site in the State were obtained during research for this Manual [TBC]. The interim groups follow the geology that the regional sources describe. "Geologically, the State is underlain by sedimentary rocks of Tertiary age, which have been tightly folded in a series of anticlines and synclines" (CGWB, *Ground Water Scenario of Mizoram*); in Lunglei district the rocks are the "shale, siltstone, and sandstone of Surma formation of Miocene age", the low ridges of Bokabil shale are "characterized by low permeability and infiltration. It acts as run off zone", and the moderate ridges "which occupy almost the entire district", of the Bhuban group, have "very low permeability and infiltration and acts as run off zone"; the soils are hill soil, "colluvial soil, formed along the steep side slopes", valley soil, "a mixture of colluvial and alluvial materials", and terrace soil, "remnants of deposits of cobbles and pebbles"; and "Most of the rain water flows out as surface run-off" (CGWB, Ground Water Information Booklet, Lunglei district). Serchhip district has the "shale, siltstone, and sandstone of Surma and Barail formations of Oligocene to Miocene age" (CGWB, Serchhip district booklet). In Serchhip town, on the Middle Bhuban Formation, "Lithological units comprising shale and siltstone are more susceptible to landslide than the hard and compact sandstone unit", with crumpled shale weighted highest (Lallianthanga and Lalbiakmawia, 2013, MIRSAC); and the State's terrain is "N-S trending mostly anticlinal strike ridges with steep slopes and narrow intervening synclinal valleys … dissected ridges with deep gorges … Faulting in many areas has produced steep fault scarps" (MIRSAC, 2013). In Aizawl "The soil in and around the city is young and in a loose state" (Master Plan for Aizawl: Vision 2030). The shale ridges may hold a soil that would test as HSG C, but it lies thin over rock that takes little water on steep slopes, so they are designed as D; the colluvium takes water readily, which is why it is not used for infiltration. No primary source was read for the soils of the Champhai flats or of the terraces at Tlabung, Bairabi and Vairengte [TBC]; the groups for them are set from the CGWB's description of valley and terrace soils in Lunglei district and are to be confirmed by tests. The only regional measure of losses is the design loss rate of the CWC subzone 2(b) report, 0.35 cm/h (3.5 mm/h), the modal value of 100 flood events on rural catchments gauged at bridges outside the State, none of which drains Mizoram (Annex 3E). It is likely to be too high for the Surma shale, which the CGWB describes as of "very low permeability and infiltration" (NEER's reading). It shall be used only in a 2(b) SUH check run 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. The interim groups of Clause 3.7.2, the design of the shale ridges, slide debris and urban fill as group D, the treatment of colluvium and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Mizoram. The method rules matter as much as the soil, because nearly every town in Mizoram stands on a ridge or a slope. Aizawl's slopes run at 30°–45° ("300 to 450" in the copy read; Master Plan for Aizawl: Vision 2030), and 89.2% of Serchhip town is steeper than 30° and 38.7% steeper than 45° (NEER's arithmetic from MIRSAC's slope shares: 0–15° 10.51%, 15–25° 0.11%, 25–30° 0.25%, 30–35° 5.13%, 35–40° 14.61%, 40–45° 30.72%, 45–60° 26.59%, above 60° 12.12%). On such slopes the Kirpich and Kerby formulae give times of concentration of 1–5 minutes (NEER's arithmetic), and water on a paved hill street reaches a lui within minutes. The following rules are set by this Manual. (a) Tc shall be found by the velocity-based segment method of Clause 3.6.2, segment by segment, and shall not be taken below the 10-minute minimum of Clause 3.6.1, which matches the shortest design duration of Chapter 2; the research for this Manual proposed a 5-minute minimum

for the ridge towns, which the core's 10-minute minimum does not allow, so on most hill streets the minimum governs; the Kirpich formula, derived from small farm catchments of moderate slope, shall not be used even as a cross-check where the average slope of the flow path exceeds 10%. (b) The sheet-flow segment over bare rock, a cut slope or a paved hill street shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (c) Two design cases are run for every hill drainage system: a short burst, the durations of Clause 2.5.2 up to 6 hours, with the 1-hour depth of Clause 2.3.6(f); and a long storm, the 72-hour storm of Clause 2.3.6(e), for the terrace swales, interceptor drains and down-drains of regulation 27 of the Site Development and Slope Modification Regulations, 2017, for culverts and cross-drainage, and for the interception of seepage from slopes and springs; the larger flow or volume governs each element, because Mizoram's landslide storms last for days, such as the 677 mm that fell over Serchhip district in 1–13 June 2018 (SANDRP, as reported) and the storm that set off 598 landslides from 24 May to 3 June 2025 (DM&R figures, as reported). (d) In a drain or lui steeper than its critical slope the flow is supercritical: the Froude number is reported, hydraulic jumps are located where the slope eases or the flow meets a pool, a structure or a flatter reach, and splash and superelevation at bends are checked against the freeboard; steep drains are lined, stepped or baffled, and every outfall onto a slope has an energy dissipator (Chapters 6 and 9). (e) A catchment that runs from a hill flank onto a valley floor or terrace, such as the lui that reach the terraces at Bairabi, Vairengte, Sairang and Tlabung or the Champhai flats, shall be split at the break of slope and the hill sub-area modelled on its own, so that a flatter lower reach does not average away the fast response of the hill. (f) On valley-floor land and on the terraces at Sairang, Bairabi, Vairengte, Tlabung and Chawngte and on the Champhai flats, the Rational Method under Clause 3.4 sizes single conveyance elements on small sub-catchments only; every system that reaches the river is designed by SWMM with the river level as the tailwater (Clause 5.8.5) and dynamic-wave routing where the outfall is submerged (Clause 3.12.4). (g) Rural catchments of 25–1,500 km² on the Tlawng, the Tuirial, the Serlui, the Tuichang, the Tuichawng, the Khawthlangtuipui and their tributaries have no CWC unit hydrograph of their own, and no catchment area was found for any of the State's rivers [TBC]: they are modelled by a site study (SCS-CN, or a Clark or Snyder unit hydrograph, in HEC-HMS) calibrated under Clause 3.15 to the CWC sites (Sairang, Turial, Bairabi, Tlabung, Tuichawng, Tuichang and Sihthangpui), to NEEPCO's records for the Tuirial reservoir or to State gauges, wherever any exist; the CWC subzone 2(b) unit hydrograph, whose peak depends on area alone and none of whose catchments drains Mizoram, is computed only as the check of Clause 3.11.4 (Annex 3E), and Clause 3.11.4(d) applies as written. Every cross-drainage structure and outfall with a catchment of more than 1 km² needs a site-specific hydrology study. (h) Catchments that drain to the Tuirial or Serlui B reservoir, or to a reach below either dam, are modelled with storage routing and the operator's release scenarios, not by a peak-flow method alone (Clause 3.12; Clause 5.8.5(e)). (i) No method of this chapter predicts a landslide or a debris flow; in the lui and on the slopes the design flow is bulked for sediment and debris, and inlets and culverts are designed for blockage (Clause 6.3.6; Chapter 9), while siting, setbacks and slope works govern where no drain can be sized (Clause 2.3.6(i)).

3.8 SCS curve number (SCS-CN) loss method

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

> Q = (P − Ia)² / (P − Ia + S) for P > Ia; Q = 0 otherwise S = 25,400 / CN − 254

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

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

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

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

3.8.3 **Use of Table 3.5.**

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

3.8.4 **Antecedent moisture.** AMC shall follow Clause 2.11.4: AMC III for every design storm, whatever its duration, from 1 May to 31 October at a site in any sub-area of Annex 2A (MZ-A, MZ-A1, MZ-B, MZ-C, MZ-C1, MZ-D or MZ-D1); AMC III for every design storm from 1 April to 31 October on valley-floor land below the 1% AEP flood level of a river or stream, in sub-area MZ-A1, MZ-C1 or MZ-D1 or elsewhere, such as Sairang on the Tlawng and Chawngte on the Kau, and on the margins of a dil; AMC III for every design storm at any time of year in a catchment that drains to the Tuirial reservoir or the Serlui B reservoir or its backwater, or to a reach below either dam into which the dam releases water; at any other site or time, AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm; and AMC II for every other storm. AMC I is not used. CN for AMC I and III shall be obtained from AMC II by:

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

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

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

3.8.5 **Initial abstraction.**

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

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

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

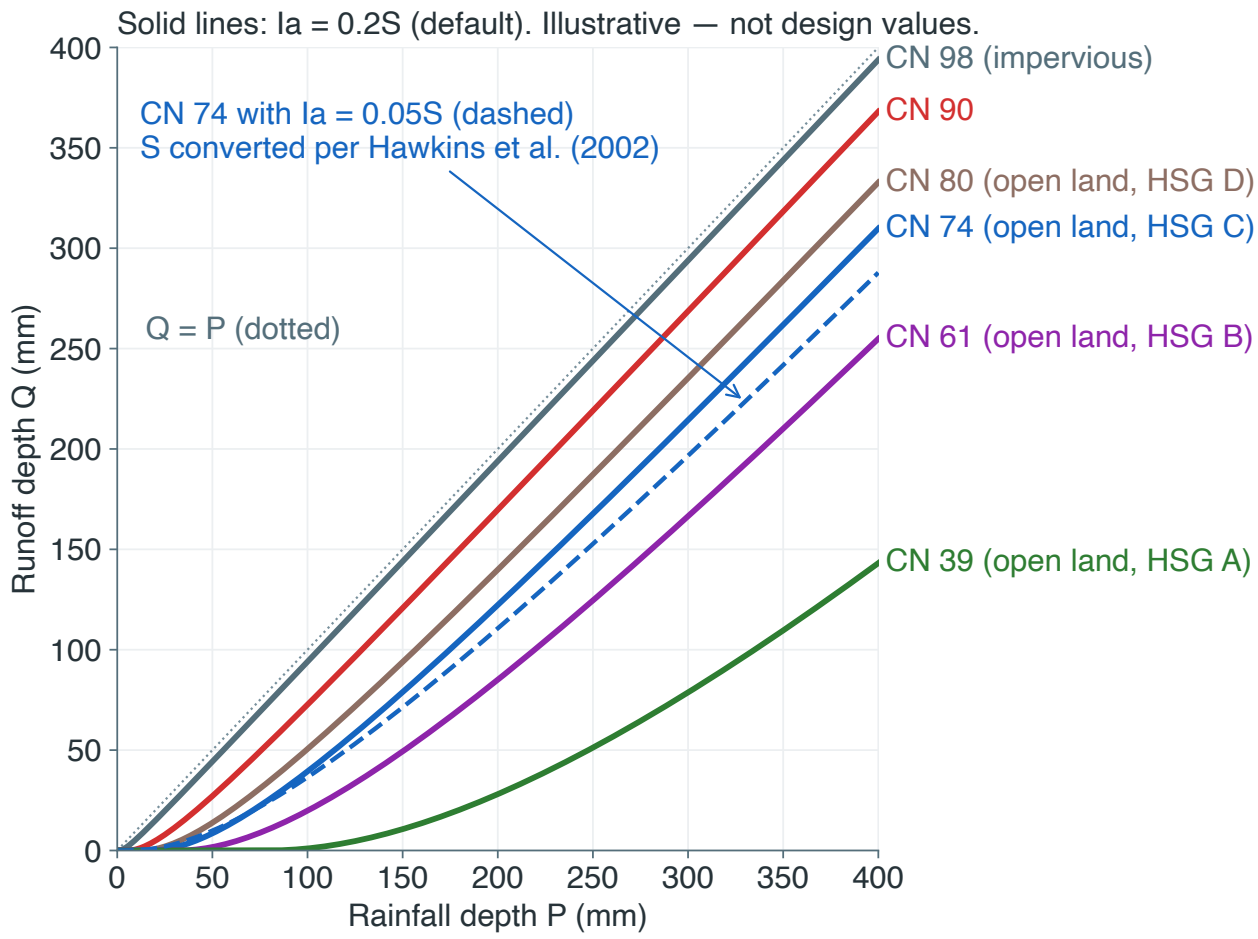


Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion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

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

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

3.9 Impervious connectivity

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

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

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

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

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

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

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

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

3.10 Groundwater, high water table and tank backwater

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

3.10.2 **Water-table data.** The seasonal high water table shall be taken as the highest level recorded in the monsoon season (April–October), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or IWRD 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, dil, 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 where it is needed in Mizoram, which is not on the ridges but on the few low places. On the ridges the rock takes little water: the Bokabil and Bhuban ridges of Lunglei district have "low permeability and infiltration" and act as a "run off zone", "Most of the rain water flows out as surface run-off", "Ground water is used for drinking purpose only", and the stage of groundwater development is 1.37% (CGWB, Ground Water Information Booklet, Lunglei district). Groundwater there lies in fractures, weathered rock and colluvium and comes out as springs: springs rise from "weak zones such as fractures, lineaments and weathered residuum", and "A large number of springs are perennial", with a discharge of "3,000 to 20,000 liters per day during the period of January to March" (CGWB, Lunglei). Water perched in a slope or seeping below a spring is not a water table that a design can use, and it is the hazard that the hill rule of Clause 4.11 guards against. On the valley floors and terraces the case is different: in Lunglei district small valley ponds hold water "within 2.0 m below ground level" (CGWB, Lunglei), so at Sairang, Bairabi, Vairengte, Tlabung and Chawngte and on the Champhai flats the seasonal high water table can be within 0.6 m of the surface in the monsoon season, and Clause 3.10.1 applies wherever a site test or trial pit shows it. No State observation-well network was found; the observation wells in Mizoram are the CGWB's, North Eastern Region, and "Water level trend is also not available due to lack of ground water abstraction" (CGWB, Lunglei). No monsoon water-table depths for individual sites in any town, and no map of the seasonal high water table, were obtained [TBC]; Annex 3A is to supply them. Clause 3.10.4 reflects the State's receiving waters, which are of three kinds. Most town drains discharge to a steep stream (lui) with no backwater: Aizawl drains east to the Tuirial through the Chite lui, which takes "more than two-third of eastern portion" of the city, and west to the Tlawng through the Ser lui and its streamlets (Master Plan for Aizawl: Vision 2030), and the master plan describes the Chite, Chanmari, Theihai, Bethlehem, Tuikhurhlu, Mirawng and Bangla lui as "turbulent with high velocities of currents during the monsoon season". The valley-floor towns discharge to rivers that rise above their drains: Tlabung on the Khawthlangtuipui, where about 350 houses in the sub-division were reported submerged in June 2017 (or 9 fully and more than 60 partly, by the count of disaster-management officials; the reports conflict) and about 400, 150 of them in the town, in July 2019 (as reported), and Sairang and Bairabi on the Tlawng. And catchments in the north drain to the

Tuirial reservoir, which NEEPCO operates between a full reservoir level of 90.5 m and a minimum drawdown level of 68.0 m, with a normal tailwater level of 30.7 m at full load (CERC order in Petition 125/MP/2021), or to the Serlui B reservoir, whose levels were not found [TBC]. CWC has seven level-monitoring sites in the State, five reported inactive, with no forecasting site and no warning or danger level for any of them; the only highest flood level printed is 149.0 m at Turial on the Tuirial, on 17 June 1995 (CWC, as transcribed by SANDRP, 2018), with no datum stated [TBC]. How that level relates to the reservoir levels above is not stated in the sources and is not inferred here [TBC]. A site that drains to a river in flood or to the reservoir drains to a water surface that the river or the dam holds, and Clause 3.10.4(b) applies to the land below the starting level of the receiving water set in the Commentary to Clause 3.12 and the tailwater of Clause 5.8.5.

3.11 Unit hydrographs and runoff transformation

3.11.1 **Permitted transforms.**

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

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

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

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

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

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

3.11.4 **CWC synthetic unit hydrograph.** For catchments of 25–5,000 km² in CWC subzone 2(c) (Barak and others), which covers the whole of Mizoram (Clause 2.3.6(b)) and for which CWC has published no Flood Estimation Report; the report for subzone 2(b) (South Brahmaputra), in which no part of Mizoram lies, is used in its place only for its areal reduction curves and as a check on unit hydrographs, so that no CWC point rainfall exists for the cross-check of Clause 2.3.3(b):

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

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

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

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

> Commentary. The SCS unit hydrograph, the 0.6 lag ratio and the 0.133 Tc interval are from NEH Part 630, Ch. 16 (USDA NRCS, 2007). The interval follows from the unit hydrograph geometry: with tp = Δt/2 + 0.6 Tc and Tc + Δt = 1.7 tp, Δt = 0.133 Tc. The SI constant 0.208 is the direct conversion of 484 (cfs, mi², in, h). APWA uses the SCS dimensionless unit hydrograph as its basis (2011, §5602.5). The CWC Flood Estimation Reports give regression equations for SUH parameters, a design storm duration, a constant loss rate and ARF and time-distribution curves for each subzone (CWC 2000; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the report of 2000 (its 14 gauged catchments are bridge sites outside Mizoram, gauged at railway bridges from 1961 to 1983 and at national-highway bridges from 1981, and none drains Mizoram; CWC has published no report for subzone 2(c), which covers the State), 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 dils, reservoirs and detention ponds at their outlet or operating level in 3.12.5 because in Mizoram the heavy storm comes in a wet spell, not on dry ground: the storms that set off landslides last for days, such as the 677 mm that fell over Serchhip district in 1–13 June 2018 (SANDRP, as reported) and the storm of 24 May–3 June 2025, which brought 598 landslides (DM&R figures, as reported). No tank cascade was found in the State (NEER's reading), and no dil in the State was found to have a documented operating rule, a level record or a stage–storage relation, and none was found to be operated for flood control [TBC]. The starting levels are therefore as follows (set by this Manual):

- **A dil** (Mizo: a lake or pond; *dil té*, a small pond or tank), such as Tam Dil near Saitual, which the Fisheries Department has rebuilt as a fishery reservoir (as reported; area not found [TBC]), or Palak Dil in Siaha district, in the area of the Mara Autonomous District Council (the Pala Wetland, Ramsar site no. 2484, designated on 31 August 2021 by its Ramsar Information Sheet, as quoted, and announced on 26 July 2022, as reported; water body about 135 ha), shall be started full to the level of its outlet or spill throughout the monsoon season. A natural dil keeps its own name and is never turned into a detention pond.
- **A detention pond** that drains through a free outlet is started at the level of its lowest outlet, and one that drains through a flap-gated outfall to a river on a valley floor (Sairang, Bairabi, Vairengte, Tlabung, Chawngte or the Champhai flats) is started full to its outlet whenever the outfall is closed, for the durations of Clause 5.8.5(c) and (d).
- **The Tuirial reservoir** (NEEPCO's Tuirial hydroelectric project on the Tuirial, the Sonai, in Kolasib district) has a full reservoir level of 90.5 m and a minimum drawdown level of 68.0 m, with a normal tailwater level of 30.7 m at full load, behind a 75 m zoned earth-fill dam with an open chute spillway (CERC order in Petition 125/MP/2021). It is started at the maximum water level that its operator publishes in writing and, until then, at its full reservoir level of 90.5 m; the minimum drawdown level is not used as a starting level, because the reservoir is held for power, not for flood storage. No maximum water level, spillway design flood or release rule was found [TBC].
- **The Serlui B reservoir** (Kolasib district; a dam reported 51.3 m high and 293 m long, as reported) is started at its surveyed spillway crest until its operator publishes a full or maximum level; its full and maximum water levels were not found [TBC].
- The releases of both dams are the tailwater of Clause 5.8.5(e), not storage for a town. A dam-break study of the Tuirial dam routed a peak of 3,035.34 m³/s "near the confluence" (IAHR abstract, 2025, as reported); it is not a design flow of this Manual.

A gated reservoir is modelled with its gate rule from its operator, and a waterbody is modelled below these levels only where a continuous simulation under Clause 3.13 or a notified operating rule supports it. The window of 1 April to 31 October in Clause 3.13.5(a) is set by this Manual and is the Manual's monsoon season. It starts on 1 April, not with the south-west monsoon, because the storms of April and May are among the State's most damaging: storms on 27–28 April 2026 shut schools in five to nine districts (Serchhip 70.5 mm and Hnahthial 55 mm, as reported), and the deadliest dated rain events in the State all fell in May, the Laipuitlang rockslide in Aizawl (11 May 2013 by the press, or 15 May 2013 by one paper; the dates conflict), Cyclone Remal on 28 May 2024 and the storm of 24 May–3 June 2025 (as reported). IMD's normal onset date for Aizawl was not obtained [TBC]; in 2026 the monsoon reached Mizoram about 6 June (as reported), and the CGWB describes "heavy rainfall during May to late September" (Lunglei district booklet). It ends on 31 October because the post-monsoon cyclones are a second hazard: "the cyclones of the Post Monsoon season (October to December) are more

> intense than those of Pre-Monsoon season (April & May)" (Mizoram Agriculture Department, NAFCC project report, 2016), and Chawngte had 130 mm in a day in October 2025 (as reported); Aizawl's normal withdrawal date was not obtained [TBC]. Flap gates, racks and any pumps are on standby from 1 April to 31 October (Chapter 10).

3.13 Continuous simulation

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

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

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

3.13.2 **Rainfall input.**

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

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

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

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

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

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

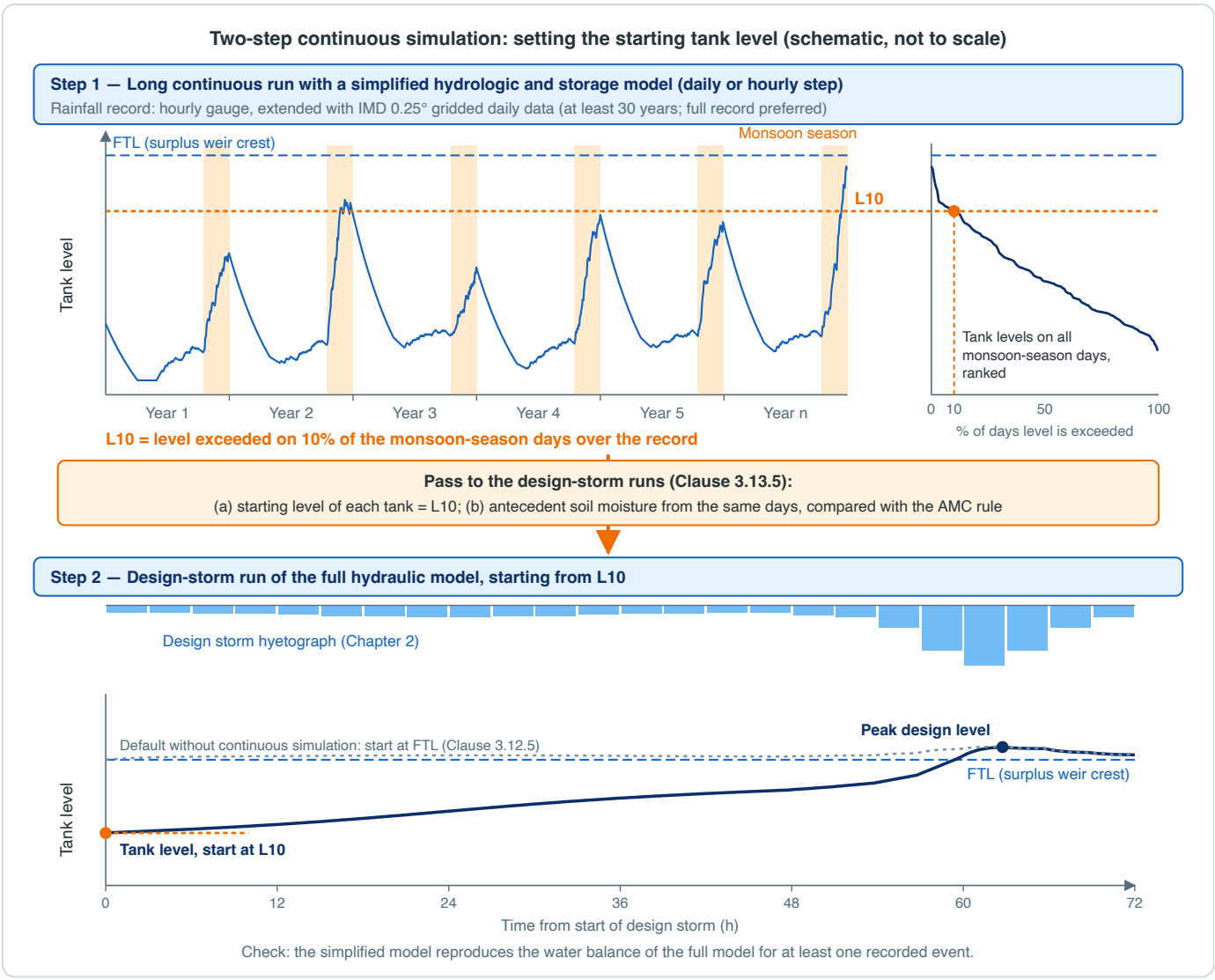


Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 April to 31 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place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

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

wet but not exceptional monsoon, so that the design storm arrives on tanks that are already well filled, as they were in June 2018, when Serchhip district had 677 mm of rain in 1–13 June (SANDRP, as reported), although no level record of any dil or of the Tuirial reservoir for that month was found [TBC].

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.

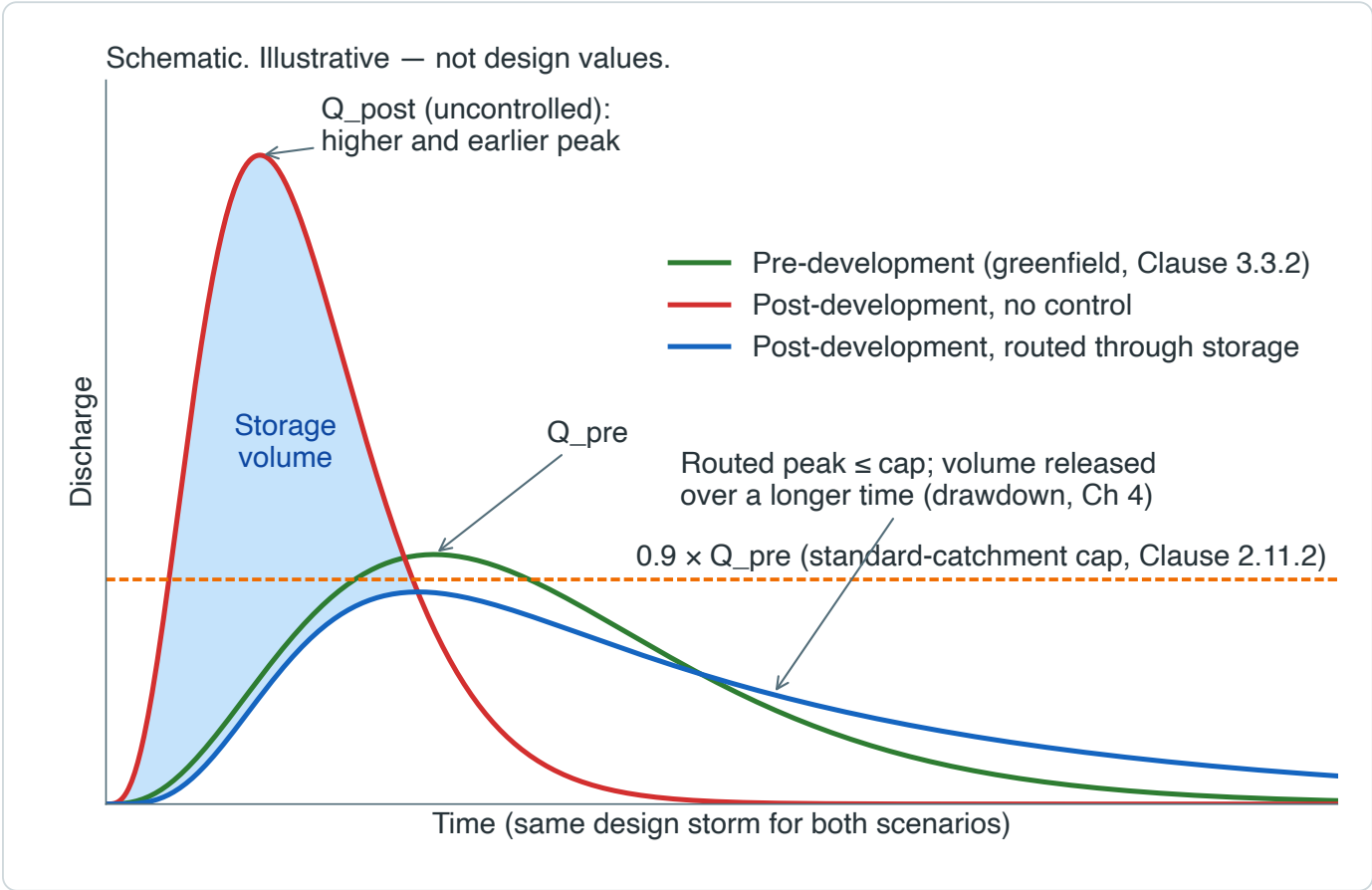


Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro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

3.15.3 **Events.** At least three independent events shall be used for calibration and at least one further event for validation. At least one event shall be a long-duration monsoon or cyclone event (for example 28 May 2024 (Cyclone Remal), 24 May–3 June 2025, June 2018, July 2019 and June 2017, 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	Mizoram soil series to HSG lookup; seasonal high water table map
3B	Mizoram CN calibration and supplementary land covers (hill forest and scrub, shifting-cultivation land, landslide scars and slide debris, hill-road and railway cuts and fills, terraced cut and fill slopes, stone-quarry faces and spoil, the paddy flats of Champhai, and dil and reservoir margins)
3C	Benchmark test problems for software acceptance

Annex / Form	Content
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for subzone 2(b), applied as a check in subzone 2(c), 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 (regulation 33 of the Aizawl Municipal Corporation Building Regulations, 2012, "A suitable rain water harvesting facility shall also be provided in all buildings", with the plans to "include provision for a suitable rain water harvesting facility" under regulation 5(6)(ix), in the area of the Aizawl Municipal Corporation, and the rainwater-harvesting incentive of the Chapter VIIIA that the 2025 amendment added for plots above 100 m²; none sets a volume, and all are discussed in the Commentary to Clause 4.11) continues to apply to every building it covers, whether or not this chapter applies.

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

> Commentary. No Indian national rule or Mizoram rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or a storage volume sized to a storm. No Mizoram document found sets a design storm, a return period, a runoff coefficient or a time of concentration for any town drain: the Master Plan for Aizawl: Vision 2030 describes the city's drains, "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all. Only 15% of the area is provided with pucca drains", and finds them "silted up frequently due to insufficiency in the hydraulic design", but gives no design basis; no storm-drain project of Aizawl Smart City Ltd was found; and the Aizawl documents of the ADB's North Eastern Region Capital Cities Development Investment Program found are for water supply and sewerage only (ADB project documents, as seen in search summaries). The building rules are two, and they apply only in the area of the Aizawl Municipal Corporation. The first is the Aizawl Municipal Corporation Building Regulations, 2012 (AMCBR; UD&PA Notification No. B.13017/8/2012-UD&PA of 20 December 2012; Mizoram Gazette Extraordinary Vol. XLII, Issue No. 4, 10 January 2013), as amended by the Amendment Regulations of 2019 (No. B.13017/8(2)/2018-UD&PA; final gazette not read [TBC]), 2023 (No. B.13017/8/2021-UD&PA/Pt of 14 August 2023, in force 28 August 2023, which renamed "Council" to "Corporation") and 2025 (No. B.13017/8/2021-UD&PA/Loose of 21 November 2025). The second is the Aizawl Municipal Corporation (Site Development and

Slope Modification) Regulations, 2017 (SD&SM; No. B.13017/75/2016-UD&PA of 4 April 2017; Gazette Extraordinary Vol. XLVI, Issue No. 161, 11 April 2017); whether it has been amended is not known [TBC]. Both are made by the Corporation's Board of Councillors under section 371 of the Mizoram Municipalities Act, 2007 and notified by the Urban Development and Poverty Alleviation Department (UD&PA), and both apply only to "all the areas covered by the Aizawl Municipal Council" (AMCBR reg. 1(2)). No statewide building regulation was found, no regulation of the Lunglei Municipal Council was found [TBC], no model building bye-laws under section 13(6) of the Mizoram (Village Councils) Act, 2025 were found, and no building or drainage regulation of the Lai, Mara or Chakma Autonomous District Council was found (Chakma District Council notices on town-planning no-objection certificates at Kamalanagar and on roadside construction are known only from titles and snippets). The AMCBR's drainage hooks protect the building and the plot; none sizes anything to a storm. A "Drain" includes an "open channel used for conveying surface water" (reg. 3(17)); the site plan shows "sewerage and surface drains, position and sizes of septic tank and soak pit" (5(5)(v)), and the building plans a roof plan "indicating drainage and roof slope", "site development and permanent structures like retaining wall, surface drain" and "provision for a suitable rain water harvesting facility" (5(6)(iv), (viii) and (ix)); the site must be "properly drained or capable of being drained" and "not an active hazard-prone area such as landslide, subsidences, mass movement" (21); the plinth is raised "so that adequate drainage of site is assured", "preferably … not less than 0.45 metre" (26(2)(a)); roof water is carried by "rain gutters and closed conduits … discharged at ground level by pipe … and no spout should be allowed to drain into the road or public area or within the adjacent compound or building" (26(2)(b)); every water closet has "A septic tank of appropriate capacity with soak pit", not "within a radius of 15 metres from a water source", and "A suitable rain water harvesting facility shall also be provided in all buildings" (33); and where "in the interest of public safety" rain and waste water must cross another person's land, the owner "shall allow construction of a closed conduit", with a "surface drain/closed conduit of adequate capacity to the nearest public drain" (37(i) and (ii)). The SD&SM Regulations go further than any building rule in the series on drainage geometry, and still set no design storm. Their purpose clause warns that "slope cutting, filling, increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner can greatly increase slope instability". A site development permit is needed "in addition to a building permit" (5(1)), on a regular track only in zones of Low landslide hazard and on an engineered track in Moderate, High and Very High zones, on unmapped slopes of 24° or more, for cuts of 3 m or more, works of more than 200 m³ or works that support a structure; no permit is issued where slopes exceed 60° (14). The engineered plans include "A map showing the drainage area and the estimated runoff of the area served by any drains" and "A drainage plan, including elevations of floors with respect to finish site grade" (6). Regulation 27 sets terraces at least 2 m wide at not more than 10 m vertical intervals on cut and fill slopes; terrace swales at a gradient of at least 1 in 20, paved with reinforced concrete at least 75 mm thick, at least 300 mm deep, with at least 0.7 m² of paved area, and no single run collecting from more than 400 m² (projected horizontally) "without discharging into a down drain"; paved interceptor drains along the top of every cut slope whose uphill drainage path exceeds 10 m, at least 300 mm deep and 800 mm wide; building pads at a gradient of at least 1 in 50 "toward approved drainage facilities"; "non-erosive downdrains"; and a duty on a site developed downhill of another to "convey drainage, sewage or seepage from the adjacent site uphill … in a safe manner to the nearest practicable drainage way". Fill toes are "sloped for sheet overflow or a paved drain" with "energy dissipaters" (25), setbacks may grow "for any required interceptor drains" (26), and the owner maintains the drainage the permit installs (27). Schedule I makes civil-engineer licensees competent for "Design of drainage structures, including hydrology and hydraulic calculations", but nothing in the regulations says what storm those calculations use. This chapter supplies it: the design storm of Chapter 2, the release rates and storage of this chapter, and the capacity, freeboard and debris checks of Chapters 6 and 9; regulation 27's geometry is the minimum conveyance layer, which the design may enlarge but not reduce. The 2025 amendment lets empanelled technical personnel self-certify "ordinary buildings … on plots measuring less than 93 square meters and located within low and moderate geo-hazard zones—as identified by Geo Hazard International and referenced in the AMC SD&SM Regulations, 2017" (Annexure B-I), with a declaration of compliance with "the Aizawl Landslide Hazard Map" (form C-IV). Such a plot is below the threshold of this chapter unless it is part of a larger development; for it this Manual is guidance, the hill rule and the RWH storage of Clause 4.11 with the SD&SM geometry as the practical minimum, and a site of 1 ha or less that this chapter does cover may use the fixed-coefficient route of Clause 4.14.3. The Mizoram Municipalities Act, 2007 vests "all public drains, and all drains in, alongside, or under any public street" in the Municipality (s.289(1)),

which "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall" (s.288); a private drain may empty into a municipal drain only "after obtaining the written permission of the Chairman" (s.295), and no drain into a municipal drain or "any water-course" without consent (s.296); the Municipality may "require separate provisions to be made for drainage or sewage and other offensive matters as distinct from rain-water" (s.298); and no structure may be built over a municipal drain, culvert or storm-water channel (s.300). None of these sets a design storm, a release rate, a detention volume or an overflow path. Basements are not limited for flooding in the regulations read (NEER's reading); on a slope a building has "multiple ground floor levels" (AMCBR reg. 3(11)(iii)), so its lower floors are cut into the hill. This Manual therefore adds its own requirements for every basement and every lower floor cut into a slope: no detention storage in a habitable basement (Clause 4.10.1); the crest of every basement ramp and the sill of every basement opening at least 0.5 m above the 1% AEP flood level, with basement drainage pumped to the surface drain through a non-return valve (Clauses 6.11.1 and 6.11.4); no basement in Zone 2 (Clause 7.5.2); on valley-floor land below the 1% AEP flood level, a basement only where it meets the rules of this chapter for flood-sensitive catchments, is watertight and is checked for flotation with groundwater at ground level (Clause 4.12.1); and, wherever a floor is cut into a slope, the geotechnical certificate of the hill rule of Clause 4.11, with the water behind its walls carried to a lined drain through weep holes and subsurface drains and not left in the ground. For a sloping site, this chapter also supplies what the regulations leave open: runoff from the slope above the site shall be intercepted and carried round the building in the design storms of Chapter 6, and every flow from the site shall discharge to a lined drain or a stable natural channel through an energy dissipator, never onto an unprotected slope or into fill. These are the Manual's proposals, not rules of the regulations. This chapter is written so that it can supply, as a technical companion to the AMCBR, the SD&SM Regulations and the Municipalities Act, the design storm, release rates and storage volumes that they leave open; a competent authority could adopt it for that purpose, but none has. Outside the Corporation's area the chapter reaches public works and any body that adopts the Manual, and for a household it is guidance. In practice the storm drains are the sewers: "In absence of sewerage system, people are using septic tanks and soak pits. In most of the places sewage is discharged into open drains without any treatment, which ultimately gets discharged to rivers" (Master Plan for Aizawl: Vision 2030); the State's sewage was 51.81 MLD, against "Existing Treatment Facilities … 10 [MLD] only for Aizawl city" (State report in NGT OA 606/2018, table as on 31 August 2025); and the CPCB lists the Chite stream and the Tuikual stream in Aizawl at Priority II (CPCB, 2025) (Clause 8.9). Retention and detention apply in full on every site whatever the drain carries: every litre a site releases at the peak of a storm takes up capacity in a drain that is already part-filled with sewage and that discharges onto slopes and into the lui below the town. 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 Aizawl Municipal Corporation in its area, for the building permit through OBPAS, the site development permit under the Site Development and Slope Modification Regulations, 2017 and connections to its drains, with its Local Councils for no-objection certificates; the Lunglei Municipal Council in its area, under the Mizoram Municipalities Act, 2007 (no regulation of its own found [TBC]); in a Village Council area, the Village Council, for building only once the State Government frames the model building bye-laws of section 13(6) of the Mizoram (Village Councils) Act, 2025 (none found); for a public work, the department that executes it; and, in the area of the Lai, Mara or Chakma Autonomous District Council, the District Council and its Village Councils, only if the District Council adopts the Manual (none has), as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Aizawl Municipal Corporation, for its whole area. Tier B: Municipal Councils, Village Councils and Autonomous District Councils.

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, dils, 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 Mizoram, 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) **Aizawl east, the Chite lui catchment**: the land of Aizawl that drains to the Chite lui and its tributaries, the Chanmari, Ramthar, Mirawng, Tlak, Bangla, Taite, Bethlehem veng, Lawibual, Hmawngkawn, Zemabawktuikhur, Zuangtui and Kawmthlang lui, down to the Tuirial;
- (b) **Aizawl west, the Ser lui catchment**: the land of Aizawl that drains to the Ser lui and its streamlets, with the Khatla, Tuikual, Vaivakawn and Chanmari west lui, down to the Tlawng;
- (c) **the Hlimen–Melthum quarry belt**: the land on Aizawl's southern edge that drains across or below the stone quarries of Hlimen and Melthum, active and disused (Clause 2.3.6(i));
- (d) **Hunthar Veng and the NH-6 corridor at Aizawl**: the land that drains to and across the sinking area of Hunthar Veng and the cut slopes of NH-6 at Hunthar;
- (e) **Durtlang and the Bawngkawn–Durtlang road**: the land of Durtlang and of both sides of the Bawngkawn–Durtlang (Leitan) road, with the slopes below them;
- (f) **Sairang on the Tlawng**: the land of Sairang that drains to the Tlawng, with its valley-floor land;
- (g) **Bairabi and Vairengte**: the land of the two towns, on the valley floors and river terraces of sub-area MZ-A1, with the hill slopes that drain onto them;
- (h) **Tlabung on the Khawthlangtuipui**: the land of Tlabung that drains to the Khawthlangtuipui, on the valley floor of sub-area MZ-D1;
- (i) **Lunglei town**: the land of the area of the Lunglei Municipal Council;
- (j) **Serchhip town**: the land of Serchhip town, with the slopes that drain to it;
- (k) **Champhai town and the Champhai flats**: the land of Champhai town and the paddy flats of the Champhai valley floor (sub-area MZ-C1);
- (l) **Siaha and Lawngtlai**: the land of the two towns, in the areas of the Mara and the Lai Autonomous District Councils, where a District Council adopts the Manual for its area (none has);
- (m) **the release reach below the Tuirial dam**: the land that drains to the Tuirial below the dam, as far downstream as the dam's releases raise the river; and
- (n) 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 held up by a river in flood on a valley floor or terrace, such as the Tlawng at Sairang and Bairabi, the Khawthlangtuipui at Tlabung, the Kau at Chawngte or the streams of the Champhai flats, by the Tuirial or Serlui B reservoir near its full level or by releases into a reach below either dam, or that is buried or

blocked by slide debris, boulders and garbage in a steep lui, for part of the monsoon season (Chapter 5);

- (d) loss of more than a quarter of the mapped tank and dil 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 follows Mizoram's two hazards: the landslide that drainage starts, on the ridges where nearly every town stands, and the river that rises above the drains of the few valley-floor towns. In Mizoram a catchment is flood-sensitive less because water ponds in it than because water released from it moves the slopes below: the Directorate of Geology and Mineral Resources (the "Directorate of Geology and Mining" in the press) found that "two-thirds of large-scale landslides" it investigated in 2022-23 "were due to improper drainage" (as reported), and "more than 71 per cent of the total area is in Very High to Moderate Hazard Zone" (CAG, Report No. 1 of 2025). The two Aizawl entries follow the city's two drainage systems: the Chite lui takes "more than two-third of eastern portion" of the city to the Tuirial, and the Ser lui and its streamlets take the west to the Tlawng; the master plan describes the Chite, Chanmari, Theihai, Bethlehem, Tuikhurhlu, Mirawng and Bangla lui as "turbulent with high velocities of currents during the monsoon season and they are very destructive", and the Khatla, Tuikual, Vaivakawn and Chanmari west lui as "the worst destructive streams and nullahs" (Master Plan for Aizawl: Vision 2030); the Chite stream is a CPCB Priority II stretch below the Chite sewage treatment plant, and a "Tuikual stream" is also Priority II (CPCB, 2025; that it is the Tuikual lui of the master plan is NEER's reading, to be confirmed). In Aizawl W-I, 33% of the area is water-logged "for several days or for hours", blamed on solid waste in the roadside drains (master plan). The Laipuitlang rockslide at Ramhlun Venglai, at about 3 a.m. on 11 May 2013 (15 May in one paper; the dates conflict), destroyed 15 houses; 17 bodies were exhumed and 8 people rescued (Science Vision paper), or 8 lives were lost by another review (the counts conflict), on the Middle Bhuban Formation, on ground that MIRSAC's 2011 map had rated "Very High" (Science Vision paper). The quarry-belt entry follows two collapses: the South Hlimen stone quarry on 9 August 1992, which "claimed the lives of almost 100 people" (MIRSAC, 2013, citing earlier work), and the disused quarry between Melthum and Hlimen that collapsed at about 6 a.m. on 28 May 2024 in Cyclone Remal, killing 15 by a later police update, with 5 more killed at Hlimen; the toll for Aizawl district rose through the day to 29 with 7 missing (29 May), a later report gave 34 killed in seven Aizawl areas, and the State toll was given as 27–29 (all as reported: the counts conflict). The master plan proposes check dams below Melthum and Hlimen among eight below the city's streams. The Hunthar entry follows the Hunthar Veng sinking area, where the only soil testing that the CAG found was done (report of 2017), and the NH-6 cuts at Hunthar, which were unstable in June 2018 and failed again in Remal (as reported). The Durtlang entry follows the collapse of 3 of the 20 blocks of the BSUP housing at Durtlang on 2 July 2019, with 3 dead, 11 injured and 140 families relocated, after which the suggestions of an IIT study of 2020 were not carried out (CAG, Report No. 1 of 2025), and the Gauhati High Court's order, in a suo motu public interest litigation reported on 23 July 2024, that "no new construction activity shall henceforth be allowed on either side of the Bawngkawn – Durtlang (Leitan) road" (as reported). The valley-

floor entries follow the river floods: Sairang families were stranded in June 2018; Bairabi and Vairengte, on the river terraces of the north, are "the lowest-lying towns in the State" (NEER's reading), and a landslide at Vairengte killed one boy and injured four in September 2026 (as reported); and Tlabung, on the Khawthlangtuipui, flooded in June 2017, when about 350 houses in the sub-division were reported submerged (or 9 fully and more than 60 partly, by the count of disaster-management officials), again in June 2018, in July 2019 (about 400 houses, 150 of them in the town) and in August 2023, when 40 families were evacuated (all as reported). "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (Mizoram Pollution Control Board, report to the NGT in OA 593/2017 and OA 673/2018); at these valley floors the statement does not hold. The Lunglei entry follows the second municipal body of the State, on ridges of Surma shale with "very steep slopes that are more than 20%" (CGWB, Lunglei district booklet), and Lunglei district's 61 landslides of 24 May–3 June 2025 (DM&R figures, as reported). The Serchhip entry follows the town's slopes, 89.2% of it steeper than 30° (NEER's arithmetic from MIRSAC's slope shares), and the 677 mm that fell over Serchhip district in 1–13 June 2018 (SANDRP, as reported). The Champhai entry follows Champhai district's 209 landslides of 24 May–3 June 2025, the most of any district (DM&R figures, as reported), and the flat valley floor of paddy, which may pond (no record found [TBC]). The Siaha and Lawngtlai entry follows the two towns of the south, where NIH-DHAARA's depths are among the State's highest (50-yr 24-hour: Siaha 304.5 mm, Lawngtlai 270.6 mm); in the areas of the Lai and Mara Autonomous District Councils the State's municipal, village-council and water-resources Acts do not apply and no building or drainage regulation of the District Councils was found, so the entry reaches them only if a District Council adopts the Manual. The release-reach entry follows the Tuirial dam, for which a dam-break study routed a peak of 3,035.34 m³/s "near the confluence" (IAHR abstract, 2025, as reported). Kolasib, Mamit, Khawzawl, Saitual, Hnahthial, Chawngte and Zokhawthar are candidates for notification under Clause 4.5.4. The official final tolls of DM&R were not obtained [TBC]. The notification triggers in 4.5.4.1 have no direct precedent and are set by this Manual. The 6-month lead time follows the update rule of Clause 2.14.2. Clause 4.16 explains why releases below pre-development are needed at all.

4.5.5 Minimum outlet and short-duration 2-yr checks

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

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

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

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

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

4.5.6 Constrained redevelopment sites

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

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

New development on undeveloped land is never eligible.

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

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

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

- (a) paid into the ring-fenced account of the basin in which the site lies;
- (b) spent only on regional detention or on restoring dil 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 IWRD 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 Chanmari, Khatla, Tuikual and Vaivakawn in Aizawl, whose lui the master plan lists among "the worst destructive streams", the part of Aizawl W-I that the master plan reports as water-logged, or the centre of Lunglei [TBC], there is often no space for the full greenfield storage. A rule that cannot be met invites variances and non-compliance, which help no one downstream. This clause follows the approach of the UK Non-statutory Technical Standards for Sustainable Drainage (Defra, 2015, S2–S3). For previously developed sites, those standards require peak runoff "as close as reasonably practicable to the greenfield runoff rate" and never above the pre-redevelopment rate. The fixed 50% minimum reduction has no direct precedent; this Manual sets it to give reviewers a clear number in place of a "reasonably practicable" judgement. The fee-in-lieu turns the shortfall into regional storage in the same basin, so the basin still receives greenfield-equivalent control in total. Retention and water quality get no relief, because they are small volumes that almost every site can hold.

4.6 Detention sizing procedure

4.6.1 Method

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

4.6.2 Steps

1. Delineate the site and sub-areas. Map HSG and confirm by testing (Chapter 3).
2. Extract design rainfall for 50%, 10% and 1% AEP and every duration in Clause 2.5.2, with the climate factor (Chapter 2, Form 2-1).
3. Build design hyetographs: alternating block for ≤ 24 h; the "peak day last" pattern for 48 and 72 h (Clause 2.9).
4. Compute pre-development hydrographs (greenfield CN; AMC III for storms of every duration from 1 May to 31 October in every sub-area, from 1 April to 31 October on valley-floor land below the 1% AEP flood level and on dil margins, at all times in catchments draining to the Tuirial or Serlui B reservoir, its backwater or a release reach below either dam, 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 hillside colony in Lunglei town draining to a hill stream (lui). 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: $CN_{III} = 23 \cdot CN / (10 + 0.13 \cdot CN) = 84.3$ (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: $P(t) = P24 \cdot (t/24)^{0.40}$, 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.

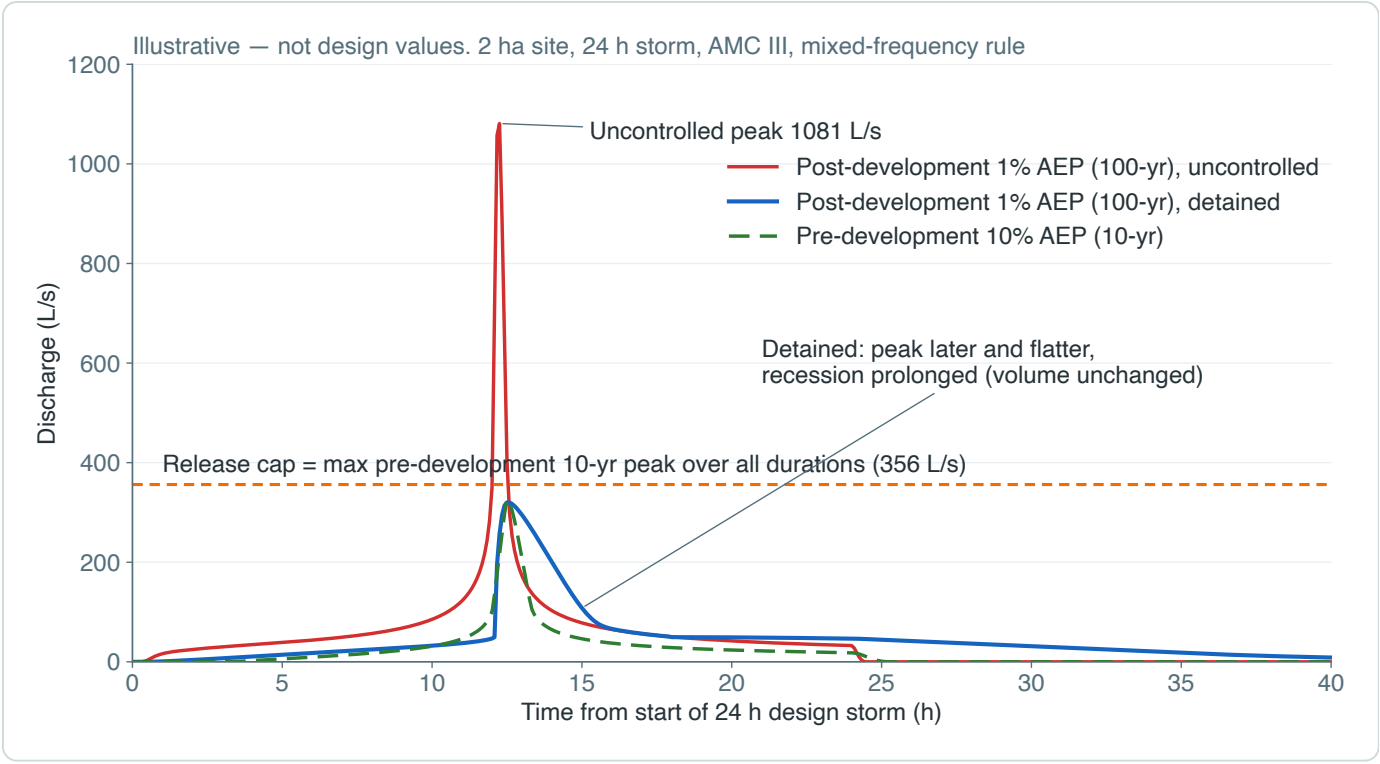


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA 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 Mizoram storage must hold multi-day volumes. It is still short enough that a basin filled by one monsoon depression will have most of its volume back before the next, which in

June 2018, when Aizawl's 148 mm in one day (probably 12 June; as reported) came about a week after the rains that set off landslides killing ten people on 5 June, within a fall of 677 mm over Serchhip district in 1–13 June (SANDRP, as reported), and late May and early June 2025, when the storm of 24 May–3 June brought 598 landslides (DM&R figures, as reported), followed within days.

4.8 Outlet structures

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

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

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

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

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

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

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

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

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

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

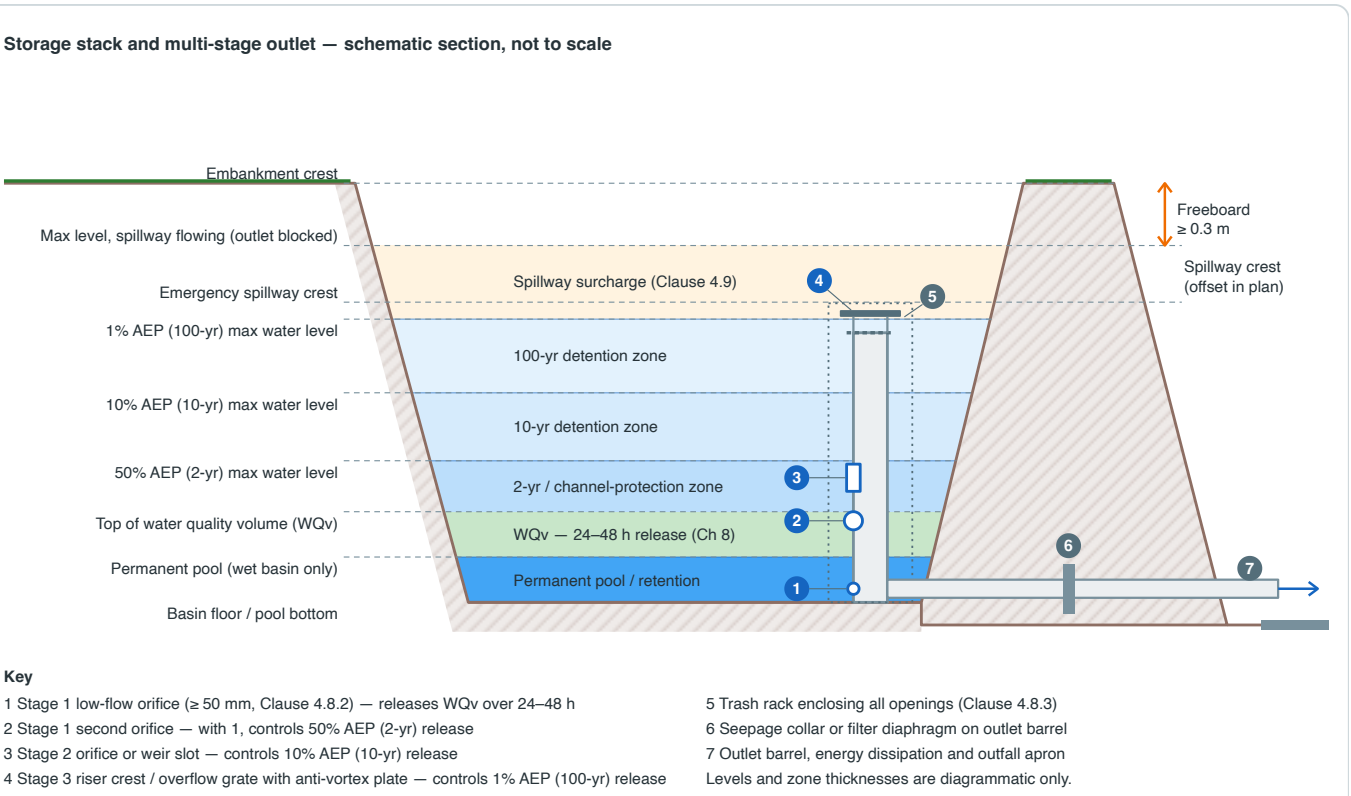


Figure 4.2 — Detention storage stack (permanent pool, WQv, 2-yr, 10-yr and 100-yr zones, spillway surcharge and freeboard) and multi-stage riser outlet. Schematic, not to scale. Original drawing for this Manual, adapted from the multi-stage outlet and storage-zone concepts in MARC/KC APWA Section 5600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

4.9 Emergency spillway, freeboard and embankment safety

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

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

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

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

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

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

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

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

- placed so that its flow does not reach a building.

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

4.9.6 **Embankments.**

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

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

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

4.10 Facility types

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

4.10.2 **Underground tanks and vaults.**

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

4.10.3 **Rooftop detention.**

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

- (c) Roofs used for RWH collection may also provide rooftop detention. The detained volume is released through the control, not into the RWH sump.

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

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

4.10.5 **Parking-lot detention.**

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

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

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

4.10.7 **Ponds and wet basins.**

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

> Commentary.
>
> - The rooftop depth (150 mm) and parking depths (200 and 300 mm) have no direct precedent. This Manual sets them so that a blocked outlet is noticed before it becomes dangerous.
> - The 1.2 m pool depth equals the 4 ft minimum permanent pool of KC APWA 5600 (2006). This Manual adopts it mainly for weed and mosquito control.
> - Pumped detention tanks need maintenance declarations in Singapore (PUB Addendum No. 3, April 2025). This Manual adopts the same approach through Chapter 10.
> - Open space is scarce on Mizoram's ridges, and most of it is slope. The AMCBR allow ground coverage of up to 71% on plots of less than 93 m², falling to 50% on plots of more than 1,000 m² (reg. 39), and set no soft-cover share; the 2025 amendment lists "Reduction of Hardscape" among the green-building measures that earn an incentive on plots above 100 m² (Chapter VIIIA), but does not require it. Multi-use detention under 4.10.6 is therefore possible only on level ground: a playground, a terrace or a building pad on a cut-and-fill site, or open space on a valley floor or terrace. On hill-rule ground, that is natural slopes of more than 10°, Surma-group shale at any slope, colluvium, fill, cut-spoil, slide debris, a mapped Moderate, High or Very High landslide hazard zone and land within twice the height of a cut or wall upslope of it, open space is not used for ponding, and detention is provided in lined, watertight tanks, on rooftops and podiums under 4.10.3 and 4.10.4, or on a level open space only where the hill rule's geotechnical certificate covers it, and in a High or Very High hazard zone in lined tanks only (Clause 4.11). A detention area on a terrace or building

pad keeps the 1 in 50 pad gradient of SD&SM reg. 27 towards its outlet, so that it drains completely (Clause 4.15.7), and its overflow goes to a lined drain, never onto the slope below. On valley-floor land, surface storage is the preferred form (Clause 4.12.4), but its floor is set above the design groundwater level of Clause 4.12.1 or it is lined. Three kinds of land are not open space for this purpose. A dil on the land is preserved under step 1 of Clause 4.3.1 and modelled as a water surface (Clause 3.3.2(e)) that starts at its outlet level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows; a dil is never turned into a detention pond, and engineered storage is called a detention pond, never a dil or a tuikhur. The Manual's stream corridor of Chapter 7 along a lui, and the riverine reserve that SD&SM reg. 28 requires to be maintained, are not counted as detention for the development beside them. And the catchment of a spring (tuikhur) above a water point is not graded or ponded for detention, because no storm outfall, soakaway or drain discharge is made within 15 m of a tuikhur and its catchment is protected under the spring rule of Chapter 8.

- Signs and depth markers under Clause 4.15.5, and the flood-warning signs of 4.10.5(b), are in Mizo and English; in the areas of the Lai, Mara and Chakma Autonomous District Councils they are also in the language in local use where the District Council or the competent authority so directs (set by this Manual). The rule follows the Mizoram Official Language Act, 1974 (Act No. 3 of 1975), which made Mizo the official language of the State, in effect from 1 August 1977 under a notification of 6 May 1996 (No. H.12017/14/90-LJD, a number read from a poor scan); that English may also be used for official purposes is known only as quoted (the section was not read). Mizo is written in the Roman script. The languages in local use in the District Council areas were not researched for this Manual [TBC], and a sign must be readable by the people it warns.

4.11 Rainwater harvesting versus detention accounting

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

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

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

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

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

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

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of regulations 5(6)(ix) and 33 of the Aizawl Municipal Corporation Building Regulations, 2012, the green norms of their Chapter VIIIA (2025) where an owner takes the incentive, any condition of a building permit or site development permit, any model building bye-laws that the State Government frames under section 13(6) of the Mizoram (Village Councils) Act, 2025 (none found [TBC]), any direction of WARDMA under section 16(2)(ix) of the Mizoram Water Resources (Management and Regulation) Act, 2024, the guidelines of the Central Ground Water Authority where they apply, or any rainwater harvesting rule or direction of an approving authority.

Commentary. Rainwater harvesting in Mizoram is required by one instrument, which does not size it. In the area of the Aizawl Municipal Corporation, regulation 33 of the Aizawl Municipal Corporation Building Regulations, 2012 (AMCBR) reads "A suitable rain water harvesting facility shall also be provided in all buildings", and the building plans "include provision for a suitable rain water harvesting facility" (reg. 5(6)(ix)). The 2025 amendment added a Chapter VIIIA, "Green Buildings and Sustainability", under which "all buildings on various plot sizes above 100 sq.m may comply with the green norms", with incentives, such as additional FAR or fee waivers, for "(a) Water Conservation and Management (i) Rain Water Harvesting … (iv) Reduction of Hardscape"; these are incentives, not conditions. The Master Plan for Aizawl: Vision 2030 recommends that RWH be made "mandatory … in all public buildings", a recommendation of the plan. None of these gives a storage volume, a roof-area rate, a drawdown or an infiltration test (NEER's reading), and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 (SD&SM) set no rainwater-harvesting duty. Outside the Corporation's area no rainwater harvesting rule was found; the Mizoram Water Resources (Management and Regulation) Act, 2024, which does not extend to the Autonomous District Councils, has the Irrigation and Water Resources Department (IWRD) "promote rain water harvesting to augment ground water recharge" (s.14(1)(b)(viii)) and lets WARDMA direct "water conservation and groundwater recharge, including rain water harvesting" (s.16(2)(ix)). In Mizoram rainwater harvesting is storage and supply, not recharge. In the Aizawl Urban Area 27.16% of households use rain water and 1.01% spring water (master plan, Table 8.2); the public supply was reported at "44 lpcd", with 35% of the water unaccounted for (as reported; date not fixed); and in the dry months springs give only "3,000 to 20,000 liters per day" (CGWB, Lunglei district booklet). Groundwater is not short: the stage of extraction was 3.52% in 2011 (CGWB, *Ground Water Scenario of Mizoram*) and 3.95% in GWRA 2024, with all 26 assessed units Safe (as quoted), and the areas notified for regulation of groundwater development are "NIL" (CGWB). This Manual therefore sets two infiltration rules and one sizing rule for credit (all set by this Manual), and credits rainwater storage as follows:

- An RWH tank under AMCBR reg. 33 is RWH storage. It is not detention (Clause 4.11.1), and it is assumed full at the start of every storm (Clause 4.11.2), because in the monsoon season it is full after the first heavy rain. A tank may also provide detention only if it is built as a combined tank under Clause 4.11.3, with a detention zone above its RWH overflow level that drains through its own orifice; only that zone counts.
- **RWH credit rule.** Because AMCBR reg. 33 sets no volume, RWH storage shall hold at least 25 L per m² of roof area (about 25 mm of rain over the roof) to earn credit under this Manual. The value is the North-East value of this series; the 20 L per m² of the mountain editions is the precedent, raised because Mizoram's households already store roof water for supply and, in the dry months of January to March, the springs give only 3,000 to 20,000 litres a day (CGWB, Lunglei). It counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or washing, demonstrated under Clause 4.4.3; watering a garden is not a continuous use in the monsoon season. The tank is then modelled under Clause 4.4.6 like any other retention practice; it is assumed full at the start of every monsoon design storm and never counted as detention. The rule makes the regulation's requirement measurable; it does not replace it, and a larger tank is always allowed. On hill-rule ground, which is nearly all of the State, storage and reuse is the way retention is provided, and the 25 L per m² is the first part of it.
- Recharge pits, trenches, shafts and wells count as retention only where they meet Clause 4.11.4 and the recharge rule below: they are credited only to the extent that they drain within 72 hours at half the rate measured in a site test (Clauses 4.4.3 and 4.4.5), with their base at least 1.0 m above the seasonal high water table, and the credit is found by routing under Clause 4.4.6, not by deducting their volume.
- **Hill rule.** In every sub-area of Annex 2A, including the hill slopes inside sub-areas MZ-A1, MZ-C1 and MZ-D1, no deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited: on natural ground sloping more than 10°; on Surma-group shale, siltstone or mudstone, at any slope; on colluvium, fill, cut-spoil or slide debris, whatever its slope; in a mapped Moderate, High or Very High landslide hazard zone (the Landslide Hazard Maps of the Aizawl Municipal Corporation defined in the SD&SM Regulations, MIRSAC's *Atlas of Micro-level Landslide Hazard Zonation of Aizawl City and Selected Towns*, or the zonation of Serchhip town); or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless

a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope; and in a High or Very High landslide hazard zone not at all, whatever certificate is offered. On such sites roof runoff goes to rainwater storage under the credit rule above, with overflow to a lined drain that discharges through a silt trap and an energy dissipator to a stable natural channel, never onto an unprotected slope. The ground gives the reason. The Bokabil and Bhuban ridges are "characterized by low permeability and infiltration" and act as a "run off zone" (CGWB, Lunglei); "Lithological units comprising shale and siltstone are more susceptible to landslide than the hard and compact sandstone unit", with crumpled shale weighted highest (MIRSAC, Serchhip town); and "The soil in and around the city is young and in a loose state" (master plan). Water put into such a slope does not recharge an aquifer; it raises the pore pressure in the slope. The landslide record shows what follows: the Laipuitlang rockslide in Aizawl on 11 May 2013 (15 May in one paper), on the Middle Bhuban Formation, with 17 bodies exhumed (Science Vision paper) or 8 lives lost (another review; the counts conflict); the collapse of the disused quarry between Melthum and Hlimen in Cyclone Remal on 28 May 2024 (as reported); and the finding of the Directorate of Geology and Mineral Resources that "two-thirds of large-scale landslides" it investigated in 2022-23 "were due to improper drainage" (as reported). The hooks are the SD&SM Regulations, whose purpose clause names "increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner" as causes of slope instability, which ask for subsurface drainage "as necessary for stability" and interceptor drains and down-drains (reg. 27), for fill toes "sloped for sheet overflow or a paved drain … with energy dissipaters" (reg. 25), and for "the control of both surface water and subsurface water, such as springs" behind fills (reg. 26), and which require engineered site development, with a geotechnical report, in every Moderate, High and Very High zone; AMCBR reg. 21(iv), under which a site must be "not an active hazard-prone area such as landslide, subsidences, mass movement"; and the Roadmap to Stability of the Landslide Policy Committee for Aizawl City (February 2014), which asks the Public Health Engineering Department (PHED) to "capture and transport rain and waste water away from exposed hillslopes and ejected at locations that will not saturate potentially unstable slopes" and calls to "eliminate all septic tanks, leach fields and soak pits within Aizawl City". On these sites retention is provided by storage and reuse, and detention by lined tanks, not by ponds or basins on the slope (Commentary to Clause 4.10). The 1.0 m groundwater separation of Clause 4.4.3 does not make an infiltration practice acceptable on a slope: perched water and pore pressure in a slope are the hazard, not the depth to the water table.

- **AMCBR reg. 33 and the soak pit: a conflict, stated.** Regulation 33 requires "A septic tank of appropriate capacity with soak pit" for every water closet. On a hazard slope that soak pit is the practice that the Roadmap to Stability would eliminate and that the hill rule forbids for storm water. This Manual does not override regulation 33, which governs sewage, not storm water. It states the conflict plainly: no storm water, roof water or sullage is put into a soak pit under this Manual, and a soak pit earns no infiltration credit; where a soak pit falls on hill-rule ground, the conflict is recorded on the site submission (Chapter 8).
- **Recharge rule.** Recharge is not a design objective in Mizoram. Deliberate recharge is allowed only on tested valley alluvium and river terraces, the Champhai flats (sub-area MZ-C1) and the terraces at Tlabung (MZ-D1), Bairabi and Vairengte (MZ-A1) and along the Tlawng, HSG B or C by texture, on flat ground of 10° or less, away from slopes and above the 1% AEP flood level; there it needs a silt trap, a filter and a first-flush diverter ahead of the structure, a field infiltration test, a seasonal high water table at least 2.0 m below ground and the separation of Clauses 4.11.4 and 4.12. It is never allowed on valley-floor land below the 1% AEP flood level, on the margins of a dil (its Zone 1 and Zone 2 under Chapter 7), within 15 m of a tuikhur (the spring rule of Chapter 8), or wherever the water table stands within 2.0 m of ground: in small valley ponds of Lunglei district water stands "within 2.0 m below ground level" (CGWB, Lunglei). Everywhere else rainwater harvesting is storage and reuse.
- **The Water Resources Act and recharge: a conflict, stated.** Sections 14(1)(b)(viii) and 16(2)(ix) of the 2024 Act speak of rainwater harvesting "to augment ground water recharge" and of "groundwater recharge, including rain water harvesting". On hill ground this Manual reads both as rainwater storage and reuse, which the Act's "water conservation" covers, not as recharge into slopes, and says so; it does not override the Act, and any direction of WARDMA governs where it is issued. On tested valley ground the recharge rule applies.

- **Springs (tuikhur).** A tuikhur (Mizo: a spring or water point; in law, "any place wherein water supply is obtained", Mizoram (Village Councils) Act, 2025, s.2(29)) is protected under the spring rule of Chapter 8: no storm outfall, soakaway or drain discharge within 15 m of it, no storm water routed into or immediately above it, no drain or fill that intercepts, buries or crosses a spring outlet, and no paving and no infiltration of road runoff in its mapped catchment above a water point (set by this Manual). "Mizoram is an abode of springs" (CGWB, State profile), springs are among the "community water resources" of the 2024 Act (s.2(1)(i)), and "Urbanisation has led to drying up of traditional water sources, like tuikhur" (Senhri Journal, as reported). A tuikhur is never used as storage.
- **Polluted runoff.** Runoff from fuel stations, workshops, quarries and the like, and from any drain that carries sewage or sullage, as most of the drains of Aizawl do (Commentary to Clause 4.1), shall not be recharged; road and parking runoff shall be recharged, where the recharge rule allows it at all, only through a surface practice with a filter, such as a vegetated basin or trench, never directly into a pit, bore or well (Chapter 8).

On the ridges, water put into the ground goes into the slope, and on the valley floors it meets a water table that the river raises. In the monsoon season an RWH tank 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 tanks are full at the start of every storm. Applying the assumption to every season keeps one simple rule. The combined-tank provision (4.11.3) lets an owner build one structure, as long as the detention part is empty when the storm arrives. The 25 L per m² credit rule, the hill rule, the recharge rule, the treatment of the AMCBR reg. 33 and 2024 Act conflicts and the polluted-runoff rule are set by this Manual. No Mizoram source sets a slope threshold for infiltration: the 24° of the SD&SM Regulations is the slope above which unmapped ground needs engineered site development, and their 60° and the master plan's 36° are limits on building. The 10° limit is set by this Manual, as in the mountain editions of this series, well below those slopes, because a slope that can carry a building can still be destabilised by water put into it; the shale condition applies at any slope because the CGWB and MIRSAC describe the shale as both impermeable and the most landslide-prone unit; the exclusion of High and Very High zones, with no certificate, is set because those are the zones where the SD&SM Regulations already require engineered site development and where the maps place the slides; and the distance of twice the height of a cut or wall is set by this Manual as a precaution, pending guidance from a geotechnical study for the State [TBC].

4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the valley floors and river terraces at Sairang, Bairabi and Vairengte, at Tlabung on the Khawthlangtuipui and at Chawngte on the Kau, the Champhai flats, the margins of the dils and of the Tuirial and Serlui B reservoirs, and hill sites with perched water, springs (tuikhur) or seepage, or any area where the groundwater table lies within 3 m of the surface at any time of year shall establish a design groundwater level (DGWL) for the facility. The DGWL is the seasonal high level during or after the monsoon, from:

- (a) site piezometer readings over at least one full April–November season; or
- (b) where (a) is not available, the higher of the CGWB or IWRD record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, stream (lui), dil or reservoir.

For the flotation check of 4.12.3 at sites in the valley floors and river terraces of the Tlawng, Tuirial and Khawthlangtuipui (at Sairang, Bairabi, Vairengte and Tlabung), the Champhai flats, the margins of dils and reservoirs, and the seepage zones below springs (tuikhur) on slopes, 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. Mizoram is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3 and the saline exposure of 4.12.5, do not apply in the State, and no saline groundwater was reported in the sources read for this Manual; the springs sampled in Lunglei district had an electrical conductivity of 31–249 µS/cm and a pH of 6.9–8.3 (CGWB, Lunglei district booklet). On the ridges groundwater lies deep or in fractures, but storage on a slope is still kept out of the ground: a deep tank is not preferred on a hill site even where groundwater is deep, because a leaking tank on a slope is an infiltration practice by another name. Storage on a slope shall be lined and watertight, its leakage and overflow taken to a lined drain, and a tank cut into the slope or built against a retaining wall carries the geotechnical certificate of the hill rule of Clause 4.11. The wet cases are the few low places. On the valley floors and river terraces at Sairang, Bairabi, Vairengte, Tlabung and Chawngte and on the Champhai flats the water table may stand within 2 m of ground (in small valley ponds of Lunglei district water stands "within 2.0 m below ground level", CGWB, Lunglei), and when the river is high it rises with it; at the margins of a dil or of the Tuirial and Serlui B reservoirs the ground stands at the water's level; and below a spring (tuikhur) on a slope the ground can be wet all year. There an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when a river in flood, a dil at its outlet level or the reservoir near its full level raises the water table beside it. The design groundwater level of 4.12.1(b) therefore takes the design flood level of the adjacent river, lui, dil or reservoir where that is higher than the well record, and on the valley floors and terraces, the dil and reservoir margins and the seepage zones below springs it is taken as existing ground level for the flotation check unless piezometers show otherwise. Storage there is preferably above ground, on roofs, podiums and landscape (4.12.4), and storage below ground is lined, anchored and checked for flotation empty. The April–November monitoring season of 4.12.1(a) is set by this Manual to cover the Manual's monsoon season of 1 April to 31 October and the high water after it, because the post-monsoon cyclones of October to December (Mizoram Agriculture Department, NAFCC project report, 2016) can raise the rivers after the season ends. The State's observation wells are those of the CGWB, North Eastern Region: no State observation-well network was found, so the IWRD record that 4.12.1(b) refers to does not yet exist [TBC]; the CGWB reports that in Lunglei district "Water level trend is also not available due to lack of ground water abstraction", and no water-table depths for individual town sites were obtained [TBC]. The factor of 1.2, the 0.5 m allowance and the "ground level" default for the valley floors, the waterbody margins and the seepage zones below springs have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Mizoram 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 dil or tank storage identified in the plan.

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

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

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

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

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

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

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

> Commentary. The Malaysian DID (2008) checklist favoured community ponds over on-site detention for sites above 0.1 ha. Studies of on-site detention show that its benefit depends on location and fades with distance downstream (Colorado State University thesis; McEnroe for Kansas City), and that a pond low in the catchment can synchronise with the main-stem peak (*Water* 2016). Regional storage therefore has to be sited by basin modelling, not simply aggregated.
>
> Mizoram has no tank Act and no tank cascade, and no dil in its towns was found to be operated for flood control under a documented rule (NEER's reading). Its regional storage is of three kinds, and none of it is yet a regional detention facility: the dils, among them Tam Dil, about 6 km from Saitual, which the Fisheries Department has rebuilt as a fishery reservoir (as reported; area not found [TBC]), and Palak Dil, the Pala Wetland in Siaha district, in the area of the Mara Autonomous District Council, a Ramsar site (no. 2484) designated on 31 August 2021 by its Ramsar Information Sheet (as quoted) and announced on 26 July 2022 (as reported), of about 1,850 ha with a water body of about 135 ha; the reservoirs of the Tuirial and Serlui B hydroelectric projects in Kolasib district; and the eight check dams that the Master Plan for Aizawl: Vision 2030 proposes "below Zuangtui, Sakawrtuichhun,

Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen", whose design and status were not found (the plan's drainage map, Map 8.3, was not extracted [TBC]). No State Wetland Authority notification was found [TBC]. Four points follow:

- A dil on the record may not be a working store, and a dil is not a detention pond. A dil is credited only after a survey shows its bed, rim and outlet, and only for the storage above its outlet level; a natural dil keeps its own name and is never turned into a detention pond, and engineered storage is called a detention pond, never a dil or a tuikhur.
- A check dam in a lui is first a debris and sediment structure. On the steep, destructive lui of Aizawl a check dam fills with silt and slide debris, so its storage is credited to a development only under a Basin Stormwater Master Plan (Chapter 11), with a design, a stage–storage relation, a cleaning schedule under Chapter 10 and the written agreement of its owner, and only for the volume that the plan shows will be empty when the storm arrives; and no check dam may hold water against a slope that the hill rule of Clause 4.11 protects.
- The reservoirs are not spare capacity. The Tuirial reservoir is held for power by NEEPCO between a full reservoir level of 90.5 m and a minimum drawdown level of 68.0 m (CERC order in Petition 125/MP/2021), its storage below the full reservoir level is not credited (Clause 4.13.2(c)), its level is the tailwater of the land that drains to it and its releases are the tailwater of the reach below (Clause 5.8.5(e)); no level was found for the Serlui B reservoir [TBC]. Storm water spilled to either reservoir can be relied on only with the written agreement of its operator for a stated volume and level (set by this Manual).
- A spring is not a store for storm water. A tuikhur is protected under the spring rule of Chapter 8, and the "community water resources" of the Mizoram Water Resources (Management and Regulation) Act, 2024, which include "springs, ponds, lakes, tanks, traditional water harvesting structures, wells" (s.2(1)(i)), are protected by Village and Local Water Resources Committees that "Prevent pollution of identified water sources" (outside the Autonomous District Councils); none of them is credited as regional detention.

No notification divides the drains of any Mizoram town among their owners (NEER's reading). Until the State issues a rule [TBC], this Manual follows the working assignment of Chapter 1: public drains and drains along public streets in the Corporation's area as the Aizawl Municipal Corporation's, which "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall" (Mizoram Municipalities Act, 2007, ss.80(d), 288, 289(1) and 290–291), with its Local Councils; the roadside drains of State roads and highways as the Public Works Department's in practice, because roads were not devolved to the Corporation (CAG, Report No. 1 of 2025), although on the statute the same drains vest in the Corporation (s.289(1)), an overlap this Manual states and does not resolve; national-highway drains as the national-highway agencies'; the natural lui and the riverine reserves as the Environment, Forest and Climate Change Department's and the Land Revenue and Settlement Department's; sewers and the Chite sewage treatment plant as PHED's and SIPMIU's (s.289(3) allows the hand-over); the dams and their release reaches as NEEPCO's (Tuirial) and the State's power department's (Serlui B); the drains of Lunglei as the Lunglei Municipal Council's under the Municipalities Act (no regulation found [TBC]); village drains outside the municipalities as the Village Council's ("Sanitation and drainages", an assignable duty under s.15(1)(q) of the Mizoram (Village Councils) Act, 2025); and, in the areas of the Autonomous District Councils, the District Council's and its Village Councils' [TBC]. Each town keeps a drain register giving every reach its owner, the lui it reaches, its landslide hazard map class and its outfall. This is the Manual's working assignment, not a statutory one; where land is private or held under a land pass, a drainage corridor or easement is reserved in the master plan or secured by agreement, not taken.

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

4.14 Simplified methods for small sites

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

4.14.2 **Method.**

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
MZ-Z1 Northern hills: MZ-A Northern hills (Kolasib–Kawnpui–Bilkhawthlir), at the depths of Clause 2.3.6(c)(ii); where the site's NIH-DHAARA cell is higher, Clause 4.6 applies	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MZ-Z1 Northern hills: MZ-A1 Northern valley floors (Bairabi–Vairengte), at the depths of Clause 2.3.6(c)(ii); where the site's NIH-DHAARA cell is higher, as at Vairengte, Clause 4.6 applies	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MZ-Z2 Central ridges: MZ-B Central ridges (Aizawl–Sairang–Serchhip–Thenzawl–Hnahthial–Mamit), at the floor of Clause 2.3.6(c)(i); where the site's NIH-DHAARA cell is higher, as at Thenzawl and Hnahthial, Clause 4.6 applies	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MZ-Z3 Eastern uplands: MZ-C Eastern uplands (Champhai–Khawzawl–Saitual–Ngopa–Zokhawthar), at the floor of Clause 2.3.6(c)(i) and (c)(iii)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MZ-Z3 Eastern uplands: MZ-C1 Champhai flats, at the floor of Clause 2.3.6(c)(i) and (c)(iii)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
MZ-Z4 Southern hills: MZ-D Southern hills (Lunglei–Lawngtlai–Siaha–Chawngte–Tuipang)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(i))	—	—	—	—
MZ-Z4 Southern hills: MZ-D1 Tlabung valley floor (Tlabung)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(i))	—	—	—	—

Worked example (illustrative — not design values).

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

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

Then:

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

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

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

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

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

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

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

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

Table 4.3A — Fixed release coefficients (provisional)

Hydrologic soil group	C_{10}	C_2
A (sandy, well drained)	0.05	0.02
B	0.08	0.03
C	0.15	0.08
D (clay, poorly drained)	0.25	0.15

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

4.14.5 **Storage.** The detention storage V (m³) is the larger of V_{100} and V_2, each the largest over the durations d of Clause 2.5.2 (1 to 72 hours):

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

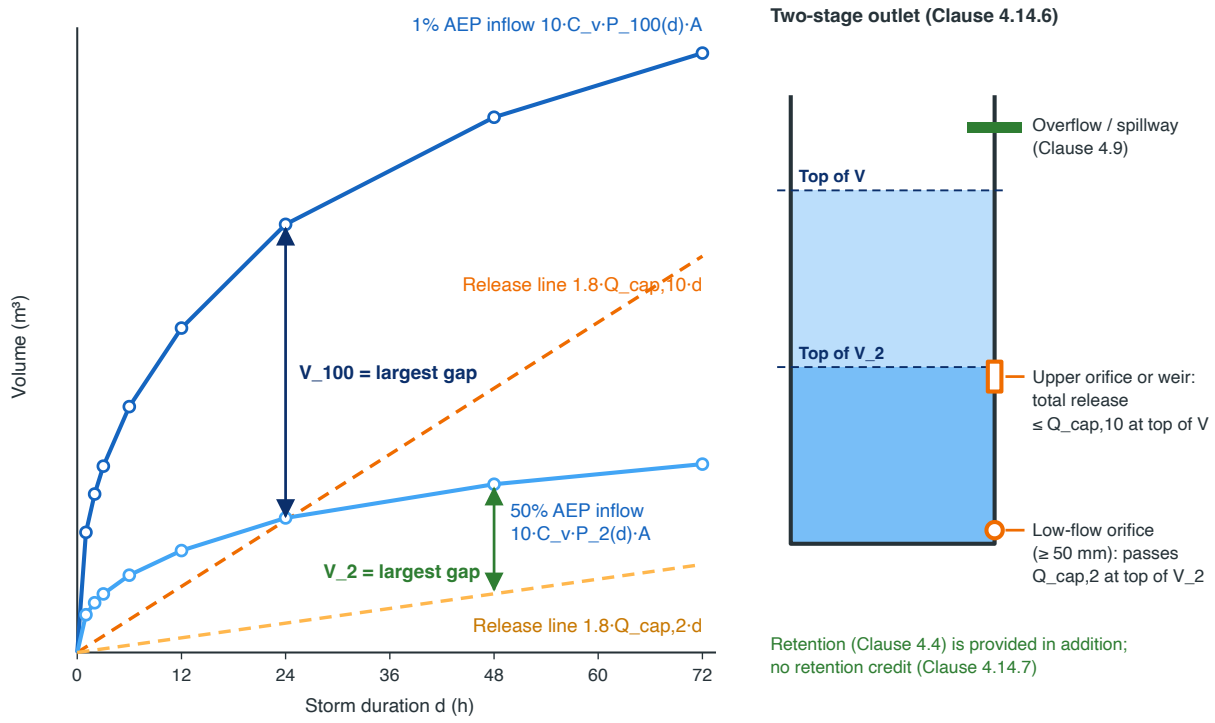
$V_2 = \max_d [\, 10 \times C_v \times P_2(d) \times A - 1.8 \times Q_{cap,2} \times d \,]$

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

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

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

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



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

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

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

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

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

Commentary. The fixed-coefficient route follows Singapore, which caps the peak runoff from every development of 0.2 ha or more with one runoff coefficient, C = 0.55, applied to the 10-yr storm (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5, Addendum No. 3, 2025). It is quick to apply and quick to check: the cap needs only the site area, the soil group and two intensities. PUB's 0.55 is not used here, because Singapore's baseline is the existing urban drainage system, while this Manual's baseline is greenfield land (Clause 4.5.1.2). The coefficients of Table 4.3A are set by this Manual from the greenfield curve numbers of Clause 3.3 (CN 39, 61, 74 and 80 for soil groups A to D). They are the ratios of runoff to rainfall that those curve numbers give for 1-hour depths typical of the Aizawl ridges, 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 Mizo 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 Mizoram most outfalls fall freely to a steep stream (lui), and they close in two ways. On the ridges an outfall is closed by what the storm carries: the master plan finds the city's drains "silted up frequently due to insufficiency in the hydraulic design", and blames the water-logging of 33% of the area of Aizawl W-I, "for several days or for hours", on solid waste in the roadside drains (Master Plan for Aizawl: Vision 2030); slide debris and boulders bury culvert inlets and lui crossings, and NH-6 at Hunthar is reported to block in most storms, as in June 2018 and in Cyclone Remal in May 2024 (as reported). A drain whose outlet is buried in this way stops discharging at the height of the storm, and the water it carries leaves the drain and runs onto the slope below, which is how a blocked drain starts a landslide. On the valley floors an outfall is closed by the river: Tlabung on the Khawthlangtuipui flooded in June 2017, June 2018, July 2019 and August 2023 (as reported), Sairang families were stranded by the Tlawng in June 2018 (as reported), and Bairabi and Vairengte stand on river terraces of the north; there the river can stand above the drains for the length of a multi-day storm, and no downstream Indian control exists on the Khawthlangtuipui (the Karnaphuli, which flows on to Bangladesh), the Chhimtuipui (the Kaladan, which flows on to Myanmar) or the Tiau. Below the Tuirial and Serlui B dams an outfall can be held up by the release itself. What fills behind a closed outlet is storm water mixed with sewage and sullage, because the drains carry them (Commentary to Clause 4.1). No inventory of flap gates or pumps on any Mizoram outfall, no record of how long any outfall stays closed and no operating rule were found [TBC]; Chapter 5 sets the river and reservoir levels and the closure to be assumed (Clause 5.8.5(a) to (e)): not less than 24 hours on a hill lui, not less than 72 hours on the valley floors, at Tlabung and below the dams. A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.

The response in this Manual is layered:

- release below pre-development (Clause 4.5);
- retain the frequent storms (Clause 4.4);
- route long monsoon storms (Clause 4.6.3);

- prefer regional storage in the dil 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 Mizoram.** Mizoram is landlocked and hilly: it has no coast, no tide and no Coastal Regulation Zone, and cyclones such as Remal (28 May 2024) reach it only as rainfall, which is dealt with in Chapter 2, not as a tidal or surge level. No outfall in the State discharges to the sea, a tidal creek or an estuary, so the provisions of this chapter that depend on tide, storm surge, sea-level rise or a river mouth do not apply in Mizoram: Clause 5.7 and Annex 5A, cases J1 to J3 of Table 5.2, the tidal lock windows of Clause 5.10.3, the seawater requirement of Clause 5.11.3(a) (gates and seats shall still be of corrosion-resistant materials, and shall resist abrasion by gravel, stones and slide debris), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Mizoram the receiving water is one of six kinds: a steep hill stream (lui), into which most of the State's outfalls fall freely from a ridge or a slope; the lui of Aizawl, the Chite lui to the Tuirial and the Ser lui to the Tlawng, ungauged, turbulent in the monsoon and carrying the city's sullage; a river under which a valley floor or a terrace lies, such as the Tlawng at Sairang and Bairabi, the Tiau at Champhai and Zokhawthar and the Kau (Tuichawng) at Chawngte; the Khawthlangtuipui at Tlabung, the State's river-flood town; the reservoir of the Tuirial dam or of the Serlui B dam, the reach of river below one of them, or a dil (Mizo: a lake or pond); or a river that leaves the State, for Bangladesh, Myanmar or the Barak plain downstream; and:

- (a) its tailwater is set by Clauses 5.6 and 5.8, including Clause 5.8.5;
- (b) where Clauses 5.10 to 5.12, Form 5-1 or Chapter 6 refer to the J1 tailwater or the J1 tidal curve, the minor-system tailwater of Clause 5.6.2 or 5.8.5 applies, as a time series where the receiving level varies; where they refer to the J2 tailwater or to HAT + surge + SLA, the major-system tailwater applies: the design-AEP river level of Clause 5.8.4(b), or the major-system tailwater of Clause 5.8.5, whichever is higher at the outfall; and
- (c) the outfall-closed check of Clause 5.10 applies where an outfall is closed by a lui in flood, a river, a reservoir or a receiving drain, with the locks and closures of Clause 5.8.5(a) to (f) in place of the tidal lock windows.

Commentary. The drains of Mizoram's towns fail in places that site design does not see, and the failure that matters most is not a flood. Practically every town sits on a ridge or a slope: Aizawl's slopes run at "300 to 450" (30° to 45°, as printed in the master plan), and about 89% of Serchhip town is steeper than 30° (MIRSAC; NEER arithmetic). Water put into those slopes moves them: the Directorate of Geology and Mineral Resources ("Directorate of Geology and Mining" in the press) attributed two-thirds of the large landslides it investigated in 2022-23 to "improper drainage" (as reported), and the Corporation's own slope regulation names "disposing of sewerage and drainage onto slopes in a poorly controlled manner" among the human activities that "can greatly increase slope instability" (SD&SM, reg. 1). So the first question at most outfalls is not the level of the water below it but whether the water reaches a stable channel at all. Aizawl drains east to the Tuirial through the Chite lui, which takes "more than two-third of eastern portion" of the city, and west to the Tlawng through the Ser lui and its streamlets; the master plan calls seven of the eastern lui "turbulent with high velocities of currents during the monsoon season" and "very destructive", and four of the western ones "the worst destructive streams and nullahs" (Master Plan for Aizawl: Vision 2030). None of them is gauged, and there is no river tailwater for most of the city. The valley floors are different. Tlabung on the Khawthlangtuipui flooded in June 2017, when about 350 houses were reported submerged in the sub-division (district officials counted 9 fully and more than 60 partly), in July 2019, when about 400 houses, 150 of them in the town, were affected, and in August 2023, when 40 families were evacuated; Sairang's families were stranded by the Tlawng in June 2018 (all as reported). CWC has seven level-monitoring sites in the State, five of them inactive, no forecasting site, and no warning or danger level for any site; the only highest flood level printed is 149.0 m at Turial on the Tuirial, on 17 June 1995, with no datum stated (SANDRP, 2018, a copy of CWC data, as reported). Below the Tuirial dam the river is NEEPCO's, and a dam-break study is reported to have routed a peak of 3,035.34 m³/s "near the confluence" (as reported). The outfalls also belong to one body while the drains above them belong to others: the street drains vest in the Aizawl Municipal Corporation, the drains of the State roads are PWD's in practice, the lui and their riverine reserves are EF&CC's and the Land Revenue and Settlement Department's, the dams NEEPCO's and the State's power department's, the village drains the Village Councils', and in the south the District Councils' (Chapter 6, Clause 6.9). The State told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (MPCB report in OA 593/2017 and OA 673/2018); that holds on the ridges and not on the valley floors. No document found during research sets a design level for any lui, river or reservoir outfall in the State, or a design standard for any town drain. A detention tank that meets every release rate in Chapter 4 still fails if its overflow runs onto an unprotected slope, if the lui below it cannot carry what it receives, or if the river at Tlabung stands above its outlet. This chapter makes these failure modes part of the design. Mizoram 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, IWRD canal, the Chite lui and its tributary lui through eastern Aizawl and the Ser lui and its streamlets through western Aizawl, the lui of Lunglei and the other ridge towns, every drain that discharges through a flap gate on the valley floors of Sairang, Bairabi, Vairengte, Tlabung, Chawngte or the Champhai flats, any drain built or held by the Aizawl Municipal Corporation, the Lunglei Municipal Council, a Village Council, a District Council, PWD, PHED or a national-highway agency with an internal width of 1.0 m or more, and every lui or other natural channel that drains 8 ha or more, or a tidal creek.
Chart datum (CD)	The datum of the published tide tables and nautical charts, to which tidal heights are referred.

Term	Meaning in this Manual
Mean sea level (MSL)	Average sea level over a long period at a tide gauge.
MHWS	Mean high water springs: the average of high waters at spring tides.
HAT	Highest astronomical tide: the highest level predicted under average meteorological conditions over a full tidal cycle (18.6 years).
Storm surge	The rise in sea level above the astronomical tide caused by wind and low pressure, mainly during cyclones.
Still-water level	Astronomical tide plus surge, excluding individual waves.
Sea-level allowance (SLA)	The allowance added to present-day tidal levels for sea-level rise over the design life (Clause 5.7.4).
Tailwater	The water level at the downstream end of a drain, outlet or storage.
Tide-lock	The condition in which the tailwater is at or above the upstream water level, so a gravity outfall cannot discharge.
Lock window	A period during which the outfall-closed check of Clause 5.10 sets gravity discharge to zero.
Sand bar	A bar of beach sand that partly or fully closes a river mouth or creek inlet.
Project datum	The levelling datum used on the project drawings. It must be tied to a Survey of India benchmark (Clause 5.7.2).

5.3 Extent of the downstream analysis

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

- (a) the point at which the project area is **10% or less** of the contributing catchment;
- (b) the next **tank, dil** 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 dil 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, the Aizawl Municipal Corporation, MSDMA or IWRD; 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.

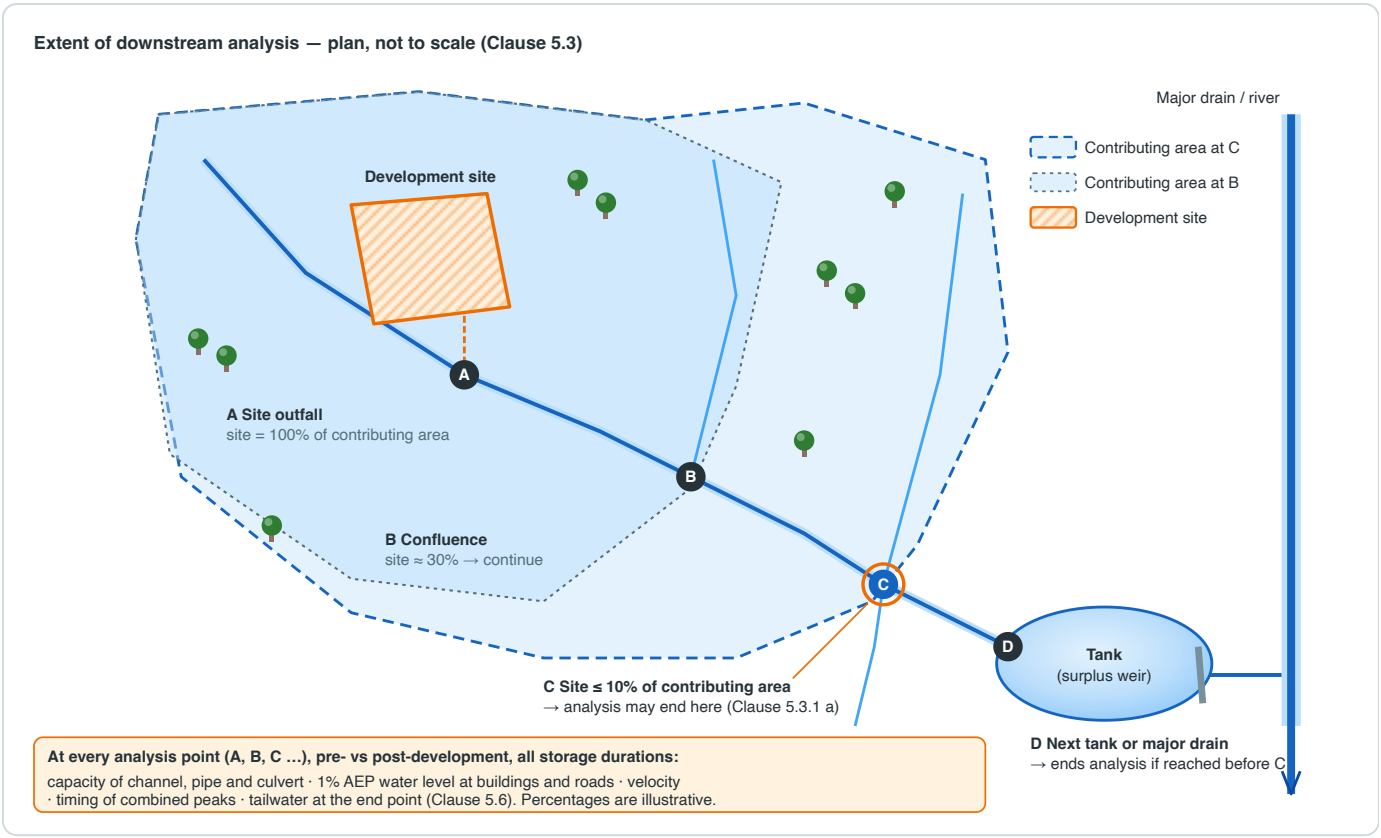


Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next dil or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Mizoram. In the ridge towns, where a colony's drain runs down a lui to a river far below, as Aizawl's drains run east by the Chite lui to the Tuirial and west by the Ser lui to the Tlawng, and the reservoirs of the Tuirial and Serlui B dams lie on the rivers of the north, 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 valley floors of Mizoram whose outfalls lie below rivers held high for hours or days, and the ridge-top drains blocked by waste: at Tlabung the Khawthlangtuipui submerged about 350 houses in the sub-division in June 2017 (district officials counted 9 fully and more than 60 partly) and about 400 houses, 150 of them in the town, in July 2019, and 40 families were evacuated in August 2023 (all as reported), although how

long the water stood was not found [TBC]; at Sairang families were stranded by the Tlawng in June 2018 (as reported); and in Aizawl W-I a third of the area was found water-logged "for several days or for hours", blamed on solid waste in the road-side drains (Master Plan for Aizawl: Vision 2030). 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 Mizoram, 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.

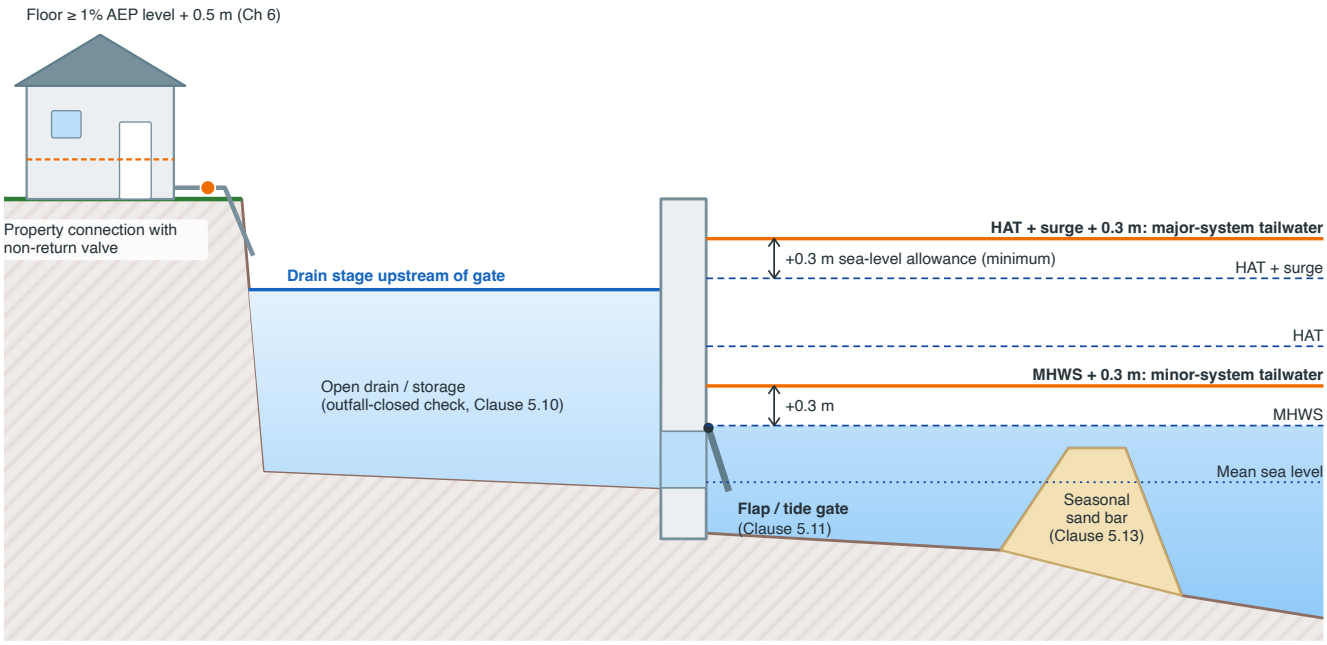
5.7.3 **Storm surge.**

- (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 planning 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.

Tidal outfall — schematic section, not to scale (Clauses 5.6–5.13)



Notes
Levels are diagrammatic. Datums from the current NHO / Survey of India tide tables, reduced to the project datum (Clause 5.7).
Joint case (Clause 2.12 b): 10-yr 48 h storm with the 1% AEP still-water level + 0.3 m. Riverine reaches: see Clause 5.8.
Outfall invert below the 1% still-water level → flap or tide gate required; property connections need non-return valves.

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; Mizoram has no coast, and the surge term does not arise in the State, which cyclones such as Remal reach only as rainfall, and whose outfalls fall freely to steep lui or are held up by the rivers of the valley floors and by the Tuirial and Serlui B reservoirs, not by the sea (Clause 5.8.5).
>
> Indian tide tables have been published by the Survey of India since the nineteenth century (Survey of India, Tidal Predictions). Current Indian tidal predictions also appear in the NHO's tide tables. One port document describes the current edition as covering 95 Indian ports, based on NHO observations and on data from civil ports, NIO and INCOIS (Adani Ports, Dahej tide table 2025, citing NHO INP-12). INCOIS runs coastal tide gauges and issues storm-surge and swell-surge warnings. None of these is used for design in Mizoram, 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 lui of the ridge towns where an outfall's invert is below the lui's design level, among them those of **Lunglei**, **Serchhip**, **Champhai**, **Kolasib**, **Siaha** and **Lawngtlai** (Clause 5.8.5(a));
- in **Aizawl**, the **Chite lui** and its tributaries to the **Tuirial**, with the Muthi and Tuipawl lui, and the **Ser lui** and its streamlets to the **Tlawng** (Clause 5.8.5(b));
- the **Tlawng** at **Sairang** and **Bairabi** and at the CWC site at Keitum, the **Tiau** at **Champhai** and **Zokhawthar**, the **Kau** (Tuichawng) at **Chawngte**, the Tuipui at the CWC's Bailley Bridge site, and the Tuichang and Tuichawng at their CWC sites, with the valley floors and terraces of **Vairengte** and the **Champhai** flats (Clause 5.8.5(c));
- the **Khawthlangtuipui** at **Tlabung** (Clause 5.8.5(d));
- the reservoir of the **Tuirial** dam and the Tuirial below it, the reservoir of the **Serlui B** dam and the Serlui below it, and every dil that receives a town's drains, among them **Palak Dil** and **Tam Dil** (Clauses 5.8.3 and 5.8.5(e));
- the **Khawthlangtuipui** (Karnaphuli) into Bangladesh, the **Chhimtuipui** (Kaladan) at the CWC's Sihthangpui site and into Myanmar, the **Tiau** on the Myanmar border, and the **Tlawng**, **Tuirial** and **Tuivai** where they run north to the Barak plain (Clause 5.8.5(f));
- any drain or channel of the Aizawl Municipal Corporation, the Lunglei Municipal Council, a Village Council, PWD, PHED or a national-highway agency, and any village drain or lui held by a District Council or its Village Councils, that receives storm water (Clause 5.8.5(g)); and
- elsewhere: any river or IWRD channel listed in Annex 5B.

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

- (a) IWRD 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 Tuirial dam of NEEPCO on the Tuirial (Sonai) and the Serlui B dam on the Serlui, both in Kolasib district), 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 **Free outfalls to steep lui, Aizawl's Chite lui and Ser lui, valley floors with river tailwater, Tlabung, the Tuirial and Serlui B reservoirs and their release reaches, dils, transboundary outfalls, and consents and lines.**

- (a) **Free outfalls to steep lui.** For an outfall from a ridge or a slope to a hill stream (lui), directly or through a drain, down-drain or chute that ends in one, as in Lunglei, Serchhip, Champhai, Kolasib, Siaha, Lawngtlai, Mamit, Khawzawl, Saitual, Hnahthial and the other ridge towns, and in Aizawl under item (b):
  - **No gauge, no level.** No lui in the State has a gauge or a published flood level [TBC]. They are steep and short, rise within minutes of a burst of rain and fall within hours of its end, and carry stones, gravel, slide debris and, below the towns, sullage and garbage. Most outfalls in the State fall freely to them: there is no river tailwater on the ridges (NEER reading).
  - **Free-outfall case.** The design case is a free outfall with energy dissipation. The outfall shall end in an energy dissipator designed under Chapter 9, built into the bank of the lui, and shall be reached from the town drain by a lined drain, chute, stepped channel or down-drain, the "non-erosive downdrains" of SD&SM reg. 27, so that no flow of the minor or major system is discharged onto an unprotected slope, fill, retaining wall or the land of a building below (Clause 6.3.6(j)). Where no lui can be reached within the site or the public land beside it, the flow shall be carried in a closed conduit or lined drain to "the nearest practicable drainage way" (SD&SM reg. 27), through the land of another person where AMCBR reg. 37(i) or an easement allows it, and not left at the foot of the slope (set by this Manual).
  - **Design level.** The tailwater for the major-system and storage cases shall be the higher of: (i) the 1% AEP level at the outfall from a study of the lui, made with a hydrograph method of Chapter 3 for the whole catchment above the outfall, with the rainfall of its sub-area under Clause 2.3.6, the AMC of Clause 3.8.4 and the bulking factor of Clause 6.3.6(g) on the peak flow, and routed through a hydraulic model (Clause 5.8.2(b)) of the channel as surveyed, net of encroachment, silt, slide debris and solid waste, with the crossings downstream blocked as Clauses 6.3.6(h) and 6.3.6(m) require; and (ii) the highest flood level surveyed at the outfall from flood marks, such as debris lines, silt and scour marks and the accounts of residents, of the storms of June 2018, May 2024 or May–June 2025 or a later storm, and from the records of the local body, the Local Council or Village Council, DM&R or the Deputy Commissioner, with its source stated. No outfall to a lui shall be designed without both items (set by this Manual).
  - **The lui below the outfall.** The designer shall also check the receiving lui from the outfall to the next confluence with a lui of at least equal catchment or with a river: that it carries the post-development 1% AEP flow of its whole catchment, with the bulking factor, within its banks and below the velocity limits of Chapter 9 for its bed and banks; that no bank or slope along that reach is in a High or Very High zone of the landslide hazard maps, or is undercut, without the geotechnical certificate of the hill rule of Clause 4.11; and that the increase in flow does not reach a road, a building, a tuikhur or a quarry face. Where the lui fails any of these checks, the project shall reduce its peak and volume under Chapter 4 or protect the reach under Chapter 9, with the consent of its owner under item (g) (set by this Manual). The landslide-hazard-map class of the outfall and of the reach shall be stated on Form 5-1 and in the drain register (Clause 6.9).
  - **Bed level, scour and aggradation.** The designer shall survey the bed of the lui at the outfall and for at least 100 m upstream and downstream, and state the range within which the bed has moved, from past surveys, cross-sections, exposed foundations and pipes, and the records of the local body. The outfall invert, and the seat of any flap gate on it, shall stand at least **0.5 m above the highest bed level** found in that range within 50 m downstream of the outfall, and the foundation of the outfall structure and its apron shall be taken below the scour depth computed under Chapter 9 (Clause 9.6) for the 1% AEP flow with the bulking factor (set by this Manual).

    - **Siting.** An outfall shall be built into the bank and shall not project into the bed or the active channel, taken for this Manual as the land flooded once in 5 years (set by this Manual). It shall discharge in the direction of the stream's flow, with the bank protection that Chapter 9 requires, and no pipe, interceptor or chamber of the drainage system shall be laid along the bed of the lui. No muck, spoil or excavated material from the works shall be placed in the lui or where a storm can carry it into one (SD&SM reg. 29; Clause 6.3.6(k)). No outfall shall discharge into or immediately above a tuikhur (Mizo: a spring or water point), within 15 m of one, or onto the protected catchment above it (the spring rule of Chapter 8), or onto or below a quarry face or spoil heap (Clause 6.3.6(m)) (set by this Manual).
    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall-closed check of Clause 5.10 applies with a single lock that lasts for the duration of the design storm plus the lui's recession, computed under item (i) for the coincident cases of Clause 5.8.4 for as long as the lui stays above the invert, and **not less than 24 hours**; where the 48- and 72-hour storms of Clause 5.10.2 are run, the lock lasts for the whole storm (set by this Manual).
- (b) **Aizawl: the Chite lui and the Ser lui.** For an outfall in Aizawl to a lui of the city, or to a drain that ends in one:
    - **The lui.** Aizawl drains east to the Tuirial through the Chite lui, which takes "more than two-third of eastern portion" of the city, with its tributaries the Chanmari, Ramthar, Mirawng, Tlak, Bangla, Taite, Bethlehem veng, Lawibual, Hmawngkawn, Zemabawktuikhur, Zuangtui and Kawmthlang lui, and through the Muthi and Tuipawl lui; and west to the Tlawng through the Ser lui and its streamlets, the Ramri, Tuikal, Vai and Zawngkawt lui. The master plan calls the "Chite-lui, Chanmari-lui, Theihai-lui, Bethlehem-lui, Tuikhurhlu-lui, Mirawng-lui, and Bangla-lui" "turbulent with high velocities of currents during the monsoon season" and "very destructive", and the "Khatla-lui, Tuikual-lui, Vaivakawn-lui, Chanmari west-lui" "the worst destructive streams and nullahs" (Master Plan for Aizawl: Vision 2030, 8.3.1). None of them has a gauge or a published flood level [TBC], and the master plan's map of proposed drains and their catchments (Map 8.3) was not extracted for this Manual [TBC]. There is no river tailwater for most of the city: the Tlawng and the Tuirial lie far below the ridges (NEER reading).
    - **Design level and lock.** Item (a) applies in full, with the rainfall of sub-area MZ-B under Clause 2.3.6(c)(i). The study of item (a)(i) shall cover the lui from the outfall to its confluence with the Chite lui or the Ser lui, or for 1 km, whichever is shorter (set by this Manual), and shall include every crossing, culvert and covered reach on it as surveyed.
    - **Sewage and the polluted stretches.** The Chite stream "near SIPMIU's STP to Armed Veng" and the Tuikual stream are in Priority II of the CPCB's list of polluted river stretches, and the Lawibual stream in Priority III (CPCB, 2025); whether the CPCB's Tuikual stream is the master plan's Tuikual lui is a NEER reading to be confirmed [TBC]. Every public drain that carries sewage and discharges to one of them is dealt with under Clauses 6.3.6(e) and 8.9, and an interception or screening work on a lui or its drains shall not raise the design level of item (a) or reduce the capacity of the drain or lui; it shall stand above that level or be designed to be overtopped without damage.
    - **Check dams.** The master plan proposes eight check dams "below Zuangtui, Sakawrtuichhun, Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen" (4.9.12). A check dam, a stone bund or a debris or waste trap built in a lui shall not raise its 1% AEP level at any outfall upstream, shall be designed to be overtopped without damage, and shall be included, with the sediment it holds, in the model of item (a)(i) (set by this Manual).
- (c) **Valley floors and terraces with river tailwater.** For an outfall on a valley floor or river terrace whose river can rise above the outfall invert, such as Sairang and Bairabi on the Tlawng, Vairengte, the Champhai flats and Zokhawthar on the Tiau, and Chawngte on the Kau (Tuichawng), and for any other outfall on land below the 1% AEP flood level of a river ("valley-floor land", Annex 2A), directly, through a flap gate or through a pumping station, or into a drain that itself discharges in one of those ways:
    - **No flood plain zone, but floods.** MPCB told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (OA 593/2017 and OA 673/2018); that does not hold on these valley floors, where Sairang's families were stranded in June 2018 and Champhai was among the places worst hit in June 2025 (as reported). No flood plain zoning law, no flood zone and no "flood hazard

areas as designated and defined by Aizawl Municipal Corporation", which SD&SM reg. 6 asks a site plan to show, was found during research (NEER reading), and no highest flood level is published for any town (Chapter 6, Clause 6.11) [TBC].

- **Gauges.** CWC has seven level-monitoring sites in Mizoram, five of them inactive, and no forecasting site: Sairang on the Tlawng (listed as the Dhaleswari; an active hydrograph, no highest level printed), Turial on the Tuirial (highest level **149.0 m**, 17 June 1995, the only one printed), Bailley Bridge Tuipui, Sihthangpui on the Chhimtuipui (Kolodyne), Keitum on the Tlawng, and Tuichang and Tuichawng; a list of June 2018 adds Pangkhuah (SANDRP, 2018, a copy of CWC data, as reported). No warning or danger level is printed for any site, and no datum is stated for any level [TBC]. CWC also runs rain gauges at Bairabi and Tlabung and other sites (IMD Meteorological Centre Aizawl, daily list, 2026). Every level used shall state its datum and its connection to the gauge datum of the named CWC gauge, or of the other gauge used, with its operator named, and to a Survey of India benchmark.
- **Design level.** The river level of Clause 5.8.2 at the outfall shall be, for the major-system cases (Clause 5.8.4(b)), the highest of: (i) the **1% AEP river level at the outfall** from a hydraulic model under Clause 5.8.2(b), with the river design flood from a site study under Chapter 3 calibrated to the CWC, NEEPCO or State gauge records where any exist, and the releases of item (e); (ii) the **highest recorded level** at the nearest CWC gauge on the same river, transferred to the outfall with the water-surface slope of the flood that set it, from the gauge record or from the model, where a level is published or obtained from CWC (none is printed for Sairang, Keitum, Bailley Bridge Tuipui, Tuichang or Tuichawng [TBC]); and (iii) the highest flood level surveyed at the outfall from flood marks of the floods of June 2017, June 2018, July 2019, August 2023 and June 2025 or a later flood, and from the records of the local body, the Village Council, DM&R or the Deputy Commissioner, with its source stated. No outfall on valley-floor land shall be designed without items (i) and (iii). The level of the nearest gauge downstream shall not be carried upstream (set by this Manual).
- **10% AEP level.** No CWC site in Mizoram has a warning or a danger level. For the cases with the river at its 10% AEP level (Clause 5.8.4(a)), the level shall be taken from the same model or from a frequency analysis of the gauge record; until such an analysis is accepted, the 10% AEP case shall use the design river level of this item (set by this Manual).
- **Gates and owners.** No flap-gated or pumped storm outfall was found in the State during research [TBC]. Every outfall whose invert is below the design level of this item shall have its own flap gate (Clause 5.11), and the designer shall name the body that will own, operate and maintain it, which is the owner of the drain in the drain register (Clause 6.9), and state its sill, the crest of any bank or wall it passes, and the river level at which it closes, all on the datum of this item.
- **Tailwater and lock.** The tailwater at the outfall shall be the higher of the river level beyond the gate and the maximum level in the drain behind it, computed by routing the drain as a closed storage for as long as the river stands above the level behind it, with the inflow of the whole catchment that drains to it, the hill catchments above the valley floor included, its storage as surveyed in its present condition, net of silt, stones, debris, encroachment and solid waste, 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; portable pumps brought in for an event and capacity not commissioned shall not be counted. The outfall-closed check of Clause 5.10 applies with a single lock that lasts for the **whole of the 72-hour design storm** of Clause 5.10.2, and **not less than 72 hours**, or longer where the river model or a stage record shows the river above the outfall invert for longer (set by this Manual). The lock covers every shorter storm, so that storage and pumping handle the full storm volume (Clause 5.9.4). Pumps (Clause 5.12) 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). A shorter lock may be used only where the outfall invert is above the 1% AEP river level of this item, or where an analysis of the stage record of a CWC gauge under Clause 5.10.6 shows it and the Authority approves it.
- **No Barak lock.** The 7-day lock that the adjoining Barak-valley rule of this series sets on the Barak plain is not used: there is no Barak plain inside Mizoram, and Bairabi and Vairengte are terraces bounded by hills, on rivers that fall steeply to the State boundary (NEER reading).

    - **Gate failure.** Floor levels and pumped outfalls behind a flap gate shall also be checked for the gate jammed open by gravel, debris or waste, with the drain filled to the river level beyond it.
- (d) **Tlabung on the Khawthlangtuipui.** For an outfall in Tlabung (sub-area MZ-D1), or on any other land below the 1% AEP flood level of the Khawthlangtuipui (Karnaphuli):
    - **A river-flood town.** Tlabung floods from its river: about 350 houses were reported submerged in the sub-division in June 2017, against 9 fully and more than 60 partly submerged by the count of district officials, with 8 to 10 dead and more than 1,500 families affected; 30 houses in June 2018; about 400 houses, 150 of them in the town, with more than 350 families evacuated, in July 2019; and 40 families evacuated in August 2023 (all as reported). No CWC level-monitoring site is listed at Tlabung (SANDRP, 2018, as reported); CWC and the Agriculture Department run rain gauges there (IMD Meteorological Centre Aizawl, daily list, 2026). How high and for how long the river stood in any of these floods was not found [TBC].
    - **Design level.** The drains of Tlabung shall be designed for the river at its flood level, with a flap gate on every outfall whose invert is below that level. The design level is the higher of: (i) the 1% AEP level at the outfall from a hydraulic model of the Khawthlangtuipui under Clause 5.8.2(b), with the river design flood from a site study under Chapter 3 and the rainfall of Clause 2.3.6 for its catchment; and (ii) the highest flood level surveyed at the outfall from the flood marks of June 2017, July 2019, August 2023 or a later flood, and from the records of the local body, DM&R or the Deputy Commissioner and the accounts of residents, with its source stated, tied to a Survey of India benchmark. No outfall in Tlabung shall be designed without item (ii) (set by this Manual).
    - **Downstream boundary.** The Khawthlangtuipui runs on into Bangladesh as the Karnaphuli, to the Kaptai reservoir downstream, which was not researched; no level of the river across the border is available to Indian designers, and there is no downstream Indian control on it (NEER reading). The model shall start far enough downstream that its boundary does not govern the level at Tlabung, and shall be run with that boundary at normal depth and at a raised level, the higher result governing and the difference reported on Form 5-1 (set by this Manual).
    - **Lock.** Every outfall whose invert is below the design level of this item is an outfall-closed case with a single lock of **not less than 72 hours**, covering the whole of the 72-hour storm of Clause 5.10.2, and **longer where flood marks or residents' records show the river held up for longer**, or where the model or a stage record shows it (set by this Manual). The tailwater, pumping and gate-failure rules of item (c) apply.
- (e) **The Tuirial reservoir and its release reach, Serlui B, and dils.** For an outfall to the reservoir of the Tuirial dam (NEEPCO's Tuirial hydroelectric project on the Tuirial, also called the Sonai, in Kolasib district) or of the Serlui B dam on the Serlui (Kolasib district), directly or through a drain or lui that ends in one, or to a reach of river below either dam, or to a dil (Mizo: a lake or pond):
    - **Consent.** Storm water shall not be discharged to a reservoir, its drawdown zone or its release reach without the written consent of NEEPCO for the Tuirial dam, or of the State's power department for the Serlui B dam (NEER reading of the owner) [TBC] (set by this Manual).
    - **Design level.** The tailwater for the major-system and storage cases shall be the reservoir's **maximum water level (MWL)** as its operator publishes it, or, where only the full reservoir level (FRL) is published, **FRL plus the surcharge in its design flood**, computed from the rating of its spillway with any gates operated only as the operator's written rule provides. Where neither the MWL nor the surcharge has been published, or where the published MWL is not above the FRL, the tailwater is **FRL + 0.5 m** (set by this Manual) [TBC]. In every case it shall be not less than the highest level recorded at the reservoir. The minor-system tailwater is the FRL. The project's discharge shall be included in the level (Clauses 5.3.2 and 5.12.3).
    - **Tuirial.** The CERC order on the project gives an **FRL of 90.5 m**, a **minimum draw-down level (MDDL) of 68.0 m** and a normal tailwater level at full load of 30.7 m, for a 75 m zoned earth-fill dam with an open chute spillway and two 30 MW units (CERC, Petition No. 125/MP/2021); no MWL, spillway rating or datum was found [TBC]. Until NEEPCO gives them in writing, the reservoir tailwater is **91.0 m** (FRL + 0.5 m), on the datum of NEEPCO's levels, which is to be confirmed with NEEPCO before final design (set by this Manual) [TBC]. CWC's Turial gauge records a highest level of 149.0 m on 17 June 1995 (SANDRP, 2018, as reported); how that gauge and its level relate to the reservoir's levels is not stated in any source found

[TBC], and the two shall not be compared, combined or converted until CWC and NEEPCO state the datum and location of each. The normal tailwater of 30.7 m is a level of normal generation below the power house, not a flood level, and shall not be used as the design level of an outfall on the release reach.

- **Serlui B.** The Serlui B dam is reported as 51.3 m high and 293 m long, with three 4 MW units (as reported); no FRL, MWL, spillway rating or datum was found [TBC]. No outfall to the Serlui B reservoir or its shore shall be designed without the operator's FRL, MWL and spillway rating in writing, or, until it gives them, the higher of the highest water line surveyed on the shore and the crest of the spillway surveyed at the dam, each tied to a Survey of India benchmark, plus 0.5 m (set by this Manual).
- **Releases, not notices.** No design shall rely on a notice or a warning of a release, on a reservoir being drawn down before a storm, or on a gate being opened early, late or partly: the release scenarios of this item govern (set by this Manual). No operating rule or release record of either dam, and no rule linking their operation to the drains above or below them, was found during research [TBC].
- **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall shall be treated as closed for the **whole of the 72-hour storm** of Clause 5.10.2 and of every shorter storm (Clause 5.9.4), with storage and pumping handling the full storm volume, unless the operator's stage record shows the reservoir below the invert at the start of comparable storms and the Authority accepts it (set by this Manual). Every reservoir starts every design storm at its FRL (Clause 7.7.3); the drawdown zone between FRL and MDDL is part of the reservoir, and no outfall structure, pumping station or storage shall be built in it without the operator's consent.
- **Release reaches.** For an outfall to the Tuirial below its dam, or to the Serlui below the Serlui B dam, in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) and the 72-hour storm shall be run with the river at the level that results from the largest recorded release of the dam, routed to the outfall, with the flow of the catchment below the dam as it occurred, and with the release placed before, during and after the site storm, and the lock of item (c) applies for **not less than 72 hours** (set by this Manual). No release record was obtained for either dam [TBC]. Until NEEPCO or the State's power department states the largest recorded release and its duration, the release is the spillway design capacity, and until that is given, the 1% AEP inflow to the reservoir from a site study under Chapter 3, passed with no attenuation by the reservoir (set by this Manual) [TBC]. No attenuation by the storage of either reservoir shall be credited to the river below unless the operator's written rule commits that storage to flood control. A dam-break study of the Tuirial dam, for PMF and 100-year inflow cases, is reported to have routed a peak of **3,035.34 m³/s** "near the confluence" (IAHR, 2025 abstract, as reported); that is a dam-break case, not a design release, and the designer shall record it on Form 5-1 and state whether the outfall lies in the inundation extent of that study, where NEEPCO makes it available [TBC]. The release reach below the Tuirial dam is a hazard-first site under Clause 2.3.6(i).
- **Dils.** No level on a stated datum, and no outlet or overflow level, was found for any dil, among them Palak Dil (the Pala wetland, in Siaha district in the Mara Autonomous District Council area; Ramsar site no. 2484, designated on 31 August 2021 according to its Ramsar Information Sheet and announced on 26 July 2022, as reported) and Tam Dil near Saitual, rebuilt as a fishery reservoir by the Fisheries Department (as reported) [TBC]. Storm water shall not be discharged to a dil without the written consent of its custodian, and, in an Autonomous District Council area, of the District Council [TBC]. Until the custodian gives a level, the tailwater is the level at which the dil spills, from its outlet or overflow crest surveyed and tied to a Survey of India benchmark, plus the head over that crest needed to pass the 1% AEP inflow, and not less than the highest level recorded at it; the dil starts every design storm at its spill level, and an outfall below the tailwater is closed for the whole storm (Clause 5.9.4) (set by this Manual). Every drain that discharges to a dil shall pass a debris and solid-waste trap and a sediment trap (Clauses 6.3.6(f) and 6.3.6(m) and Chapter 8) before it reaches it, no drain that carries sewage shall discharge to one (Clauses 6.3.6(e) and 8.9), and no dil shall be used as a detention pond (Chapter 7).

- (f) **Transboundary outfalls.** For an outfall to a river that leaves the State, or to a drain or lui that ends in one:
  - **Bangladesh and Myanmar.** The Khawthlangtuipui runs into Bangladesh as the Karnaphuli; the Chhimtuipui runs into Myanmar as the Kaladan (towards Paletwa and Sittwe); and the Tiau, the boundary river on the east, flows on in Myanmar (NEER reading, to be confirmed). No downstream gauge or level on any of them is available to Indian designers, and there is no downstream Indian control (NEER reading). CWC's

Sihthangpui site on the Chhimtuipui has no published level [TBC]. The model of an outfall on these rivers shall start far enough downstream that its boundary does not govern the level at the outfall, with the sensitivity run of item (d) (set by this Manual).

    - The Barak plain. The Tlawng, the Tuirial and the Tuivai run north to the Barak plain, and the Assam edition of this Manual governs those reaches. For an outfall in Mizoram on these rivers, a level at the State boundary from that edition, or from a CWC site downstream transferred upstream, is a lower bound on the downstream boundary of the model, not the level at the outfall.

- (g) Consents and lines. No outfall structure, gate, pumping station or drain shall be built in the bed or bank of a lui or river, or in a flood-protection work, without the consent of its owner under the drain register (Clause 6.9), or in a reservoir, its drawdown zone or a release reach without the consent of NEEPCO or the State's power department under item (e). The Mizoram Water Resources (Management and Regulation) Act, 2024 makes WARDMA the "Competent Authority" for water resources outside the Autonomous District Councils, with IWRD's Chief Engineer as its member secretary, and lets it direct "water conservation and groundwater recharge, including rain water harvesting" (s.16(2)(ix)), but no procedure under it for consent to a storm outfall was found during research [TBC]; where WARDMA, a District Water Resources Committee or a Village or Local Water Resources Committee has identified a water source for protection, the outfall shall not discharge to it (set by this Manual). Storm water shall not be discharged to a drain of another body without the written consent of that body: within a municipality, the written permission of the Chairman for a drain into a municipal drain (Mizoram Municipalities Act, 2007, s.295), and the written consent of the municipality for a drain into a municipal drain or "any water-course" (s.296); no structure may be built over a municipal drain, culvert or storm-water channel (s.300); to a road drain or culvert, that of PWD or the national-highway agency, and on a State road within the Corporation's area that of both PWD and the Corporation until the overlap of Clause 6.9 is resolved; to a village drain outside the municipalities, that of the Village Council; and in a Lai, Mara or Chakma Autonomous District Council area, that of the District Council or the body it designates, for which no written procedure was found [TBC] (set by this Manual). Where consent is given, the discharge shall not exceed the rate the consent allows; the tailwater is the higher of the channel's design water level as its owner states it in writing and its level in the coincident case of Clause 5.8.4, computed from all the storm water it receives and with its downstream boundary at the level of items (a) to (f); the channel shall be taken in its present condition, net of silt, stones, debris, encroachment and solid waste and with its narrowest section as surveyed, and a widening, lining or check dam that has been proposed but not completed shall not be counted; and the outfall shall have a flap gate (Clause 5.11) where the design water level or the computed level is above the outfall invert. The designer shall also check the outfall against the lines that bind at the time of design (Chapter 7): the riverine reserve that SD&SM reg. 28 requires to be maintained for plots adjacent to natural streams, which no rule found defines, and the riverine reserves under the Mizo District (Forest) Act, 1955, held by EF&CC, whose extent after the High Court's judgment of 27 January 2021 is to be confirmed with EF&CC, including whether the General Administration Department notification of April 2021, which is reported to set an 800 m restricted zone from mid-river with development by prior approval and was not read, reaches a drain outfall (as reported) [TBC]; the master plan's recommended 15 m green buffer on both sides of major drainage channels; a River Conservation Zone under the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, only if the law is in force and a zone has been notified, neither of which was found, in which no construction or "obstruction or diversion of the water course or channel" may be undertaken without the State Authority's prior approval and whose listed exemptions ("bridges and culverts, check dams, waterholes") do not name a drain outfall; and the 15 m by which AMCBR reg. 33 keeps a septic tank or soak pit from "a water source". The 800 m green belt along the Tlawng in the master plan rests on a notification that was quashed, and this clause does not apply it as a statutory line.

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

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. Mizoram's lui and rivers break that assumption, because their catchments are small and steep and the storms that fill them fall on the towns at the same time and for days. In June 2018 Aizawl recorded 148 mm in one day, reported as "the highest in India" that day (as reported; probably 12 June 2018, NEER reading), while Serchhip district had 677 mm in 1–13 June (SANDRP, as reported), houses were submerged at Tiperabagh, Serhuan and Tlabung and families were stranded at Sairang (as reported). Over 24 May–3 June 2025 the same storm brought 598 landslides across the State and floods in the valleys (DM&R figures, 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 two dams on the rivers of the northern hills, both in Kolasib district. The Tuirial hydroelectric project of NEEPCO, on the Tuirial (the Sonai, "a tributary of river Barak"), has a 75 m zoned earth-fill dam with an open chute spillway and two units of 30 MW, a full reservoir level of 90.5 m, a minimum draw-down level of 68.0 m and a normal tailwater level at full load of 30.7 m (CERC, order in Petition No. 125/MP/2021); a dam-break study for PMF and 100-year inflow cases is reported to have routed a peak of 3,035.34 m³/s "near the confluence" (IAHR, 2025 abstract, as reported). The Serlui B dam on the Serlui is reported as 51.3 m high and 293 m long, with three units of 4 MW (as reported); its FRL and MWL were not found. CWC's Turial gauge on the Tuirial records a highest level of 149.0 m on 17 June 1995, the only highest level printed for any site in the State (SANDRP, 2018, a copy of CWC data, as reported); no source found states where that gauge lies relative to the dam or how its datum relates to NEEPCO's levels, and this Manual does not infer either [TBC]. No MWL, spillway rating, operating rule, release record or datum was obtained for either dam, and no rule linking their operation to the drains above or below them was found during research [TBC]. Until they are available, the spillway design capacity, or failing that the unattenuated 1% AEP inflow, applies as the release, with the flow of the catchment below the dam as it occurred in the same event (Clause 5.8.5(e)). The river levels used in this Manual come from SANDRP's copies of CWC data; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Mizoram the tailwater at a town outfall is set not by the tide but by a lui that no one gauges and whose bed moves, by a valley-floor river held high by a storm that lasts for days, by the Khawthlangtuipui at Tlabung, or by a reservoir at its full level and the releases below its dam, and no document found during research gives a design level for any of them. No design standard for any town drain in the State was found: the Corporation's regulations set drainage geometry but no design storm, return period or runoff coefficient (Chapter 4), the master plan's drainage chapter is descriptive, and no storm-drainage component was found in the Smart City or ADB programmes for Aizawl (Chapter 6). The State has no floodplain zoning law, and no flood level has been published for any reach (Chapter 7).

The first case is the free outfall. Most of the State's outfalls fall from a ridge or a slope to a lui, so item (a) is the general rule and the others are exceptions. Its design case is a free outfall because there is no river tailwater on the ridges, but it does not stop at the outfall: the energy dissipator, the lined path to the lui and the check of the lui to the next confluence are what keep the water off the slopes. The master plan finds Aizawl's drains "silted up frequently due to insufficiency in the hydraulic design" and its lui "very destructive" in the monsoon (Master Plan for Aizawl: Vision 2030), and a drain that empties onto a slope, or into a lui that cannot take it, starts the landslides that two-thirds of the large ones investigated in 2022-23 were attributed to (as reported). The check reach ends at the next confluence because a lui of at least equal catchment, or a river, is the first place where the project's flow is a small part of the whole; it is a check of capacity and stability, not of level. The design level, where the lui can rise above the invert, comes from a study and from flood marks, as for the ungauged hill streams of the mountain editions of this series, with the bulking and blockage of Clause 6.3.6; and the invert stands 0.5 m above the highest bed level surveyed downstream, a margin set by this Manual for the aggradation that a stony bed can show in a single flood. The lock is the storm and the lui's recession, and not less than 24 hours, because the lui are small and fall within hours of the rain stopping, but the State's landslide storms run for days (Chapter 2), and where the longer storms of Clause 5.10.2 are run the lock lasts for all of them. Item (a) also

keeps outfalls away from springs (tuikhur), which "are widely utilized by people for domestic needs" (CGWB), and from quarry faces, which failed at South Hlimen on 9 August 1992 and at Melthum–Hlimen in Cyclone Remal on 28 May 2024 (Chapter 1).

The second is Aizawl. Item (b) names the Chite lui and the Ser lui because the capital drains into them, because the master plan lists their tributaries and singles out the most destructive of them, and because the Chite and Tuikual streams carry the city's sewage onto the CPCB's list of polluted stretches (CPCB, 2025). The rule is that of item (a), with a study long enough to reach the main lui; the master plan's eight proposed check dams are admitted only if they do not raise the lui at the outfalls they are meant to protect.

The third is the valley floor. Item (c) follows the interim river rule of the mountain editions: the design level is the 1% AEP level, never below a level recorded at a CWC gauge where one is published, and never below the surveyed flood marks, because only one highest level is printed for the whole State, 149.0 m at Turial (SANDRP, 2018, as reported), and no warning or danger level exists for any site; so the 10% AEP case uses the design level until a frequency analysis exists. The lock is the whole 72-hour storm, and not less than 72 hours, because the rivers that fill the valley floors are fed by the multi-day storms that also bring the landslides: 677 mm fell in Serchhip district in 1–13 June 2018, and 598 landslides came over 24 May–3 June 2025 (both as reported). The adjoining Barak-valley rule of this series locks outfalls on the Barak plain for at least seven days; Mizoram has no Barak plain inside it, and its valley floors are terraces between hills on rivers that fall steeply, so the seven-day lock is not carried and the 72-hour lock is used instead. Flap gates are required wherever a river can close an outfall, and the owner of the gate is named because no gated storm outfall was found in the State and nobody yet holds one. The State's statement to the National Green Tribunal that it has no flood plain zone is recorded beside the floods of Sairang, Champhai and Tlabung, because it holds on the ridges and not there.

The fourth is Tlabung. Item (d) treats the town as a case of its own because it is the one Mizoram town that floods from its river every few years, in 2017, 2018, 2019 and 2023 (as reported), and because its river runs on into Bangladesh with no level available across the border. Its drains are designed for the river at flood level with flap gates, and the lock is not less than 72 hours and longer where the flood marks or residents show the river held up for longer, because no gauge record of how long the floods lasted was found [TBC].

The fifth is the reservoir and its release reach. A reservoir at its full level does not fall for the rest of the season but passes its inflow over its spillway, and its level rises above FRL by whatever head the flood needs. Item (e) therefore takes the MWL, or FRL plus the design-flood surcharge, and treats an outfall below it as closed for the whole of the 72-hour storm. The Tuirial's MWL was not found, so FRL + 0.5 m, 91.0 m, is set as the interim value: it is the freeboard that this Manual uses for floor levels (Clause 6.11.1), and it is a floor, not an estimate of the surcharge [TBC]. The Turial gauge's highest level of 149.0 m and the reservoir's FRL of 90.5 m are not compared, because no source states how the gauge and its datum relate to NEEPCO's levels, and a relation inferred between them could put a design level badly wrong. No release record was obtained for either dam, so the spillway capacity, and failing that the unattenuated 1% AEP inflow, stands in for the largest release; that is conservative by design: a tailwater set too low floods a reach, while one set too high only costs storage. The dam-break peak reported for the Tuirial is recorded on Form 5-1 but not used as a design release, because it is the result of a failure, not of operation. Dils have no published levels, so item (e) uses their surveyed spill level, as the mountain editions do for their lakes, keeps sewage out of them and does not let one be used as a detention pond.

The sixth is the river that leaves the State, and the seventh is the consents and lines. Item (f) makes the model start far enough downstream that a boundary nobody can measure, in Bangladesh or Myanmar, does not decide the answer, and leaves the Barak plain to the edition that governs it. Item (g) asks for the owner's consent and design level because a design that discharges to a channel or a reservoir cannot be checked without them, and because the drains belong to several bodies, among them PWD and the Corporation for the same State-road drains (Chapter 6, Clause 6.9). The lines of item (g) decide where an outfall can be built, not its level: the master plan's 15 m buffer is a recommendation, the 800 m Tlawng belt rests on a quashed notification, the riverine

reserve of SD&SM reg. 28 is undefined, and a River Conservation Zone exists only if the Rivers law is in force and a zone is notified, and none of these was confirmed; the Manual's own corridor (Clause 7.4) is wider than any line that binds.

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.

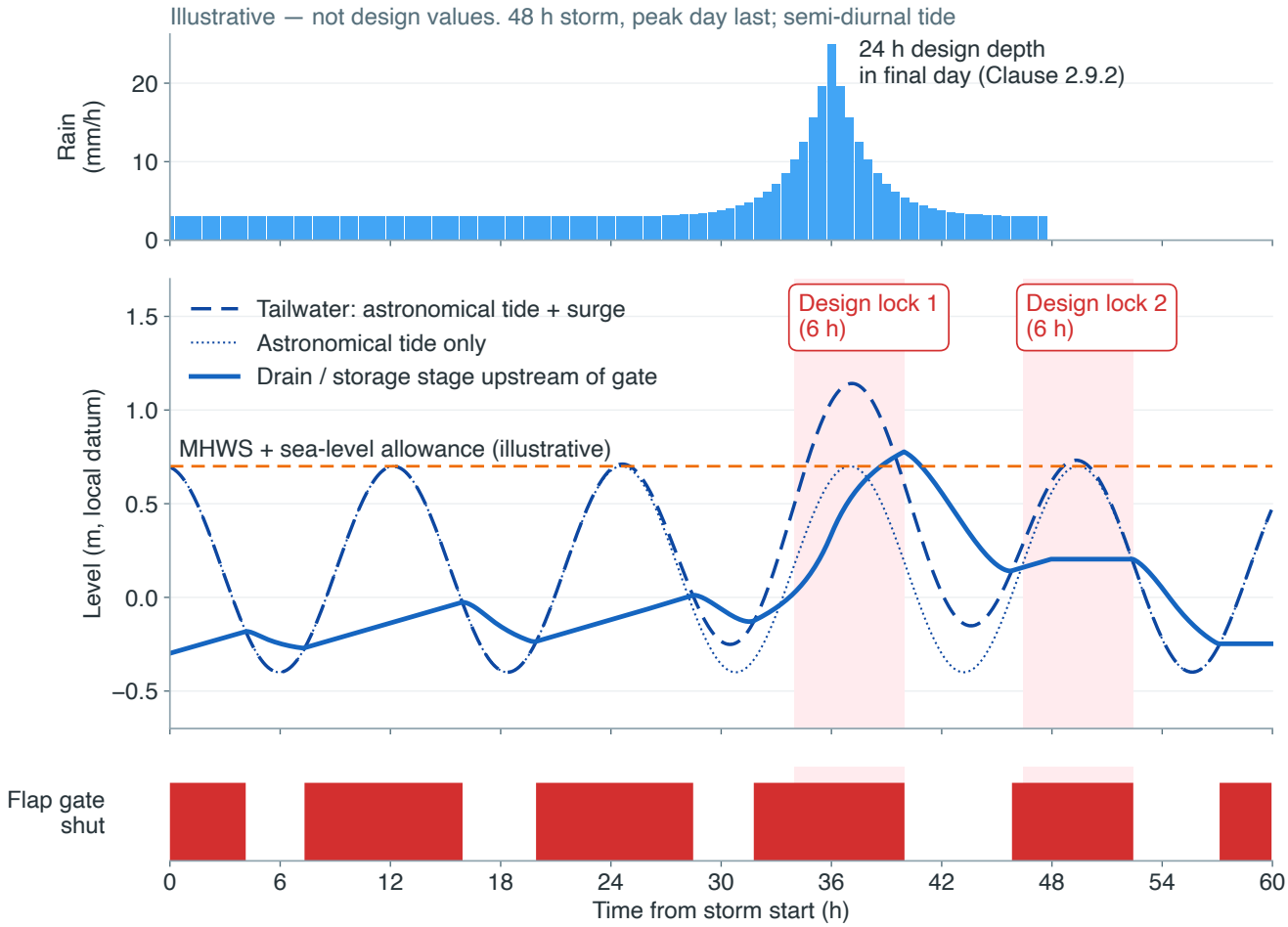


Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal 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 Mizoram requirement in this Manual. In Mizoram it applies where an outfall is shut not by the tide but by a lui that has risen over the outlet or buried it in stones, slide debris and waste, by a valley-floor river held high by a multi-day storm, by the Khawthlangtuipui at Tlabung, or by the Tuirial or Serlui B reservoir at its full level or the releases below either dam. The storms that raise the rivers last for days: Serchhip district had 677 mm in 1–13 June 2018 (SANDRP, as reported), and the landslide storm of 24 May–3 June 2025 brought 598 landslides (DM&R figures, as reported); and Tlabung's houses were reported submerged in June 2017 and July 2019, with families evacuated again in August 2023 (as reported), although how long the water stood was not found [TBC]. The lui of the ridge towns rise within minutes and fall within hours, but they can block an outlet with stones and waste in a single storm. That is why Clause 5.8.5 replaces the two 6-hour windows described below with a lock of the storm and the lui's recession, and not less than 24 hours, at a hill outfall below its design level; the whole 72-hour storm, and not less than 72 hours, on the valley floors; not less than 72 hours at Tlabung, and longer where the flood marks show it; and not less than 72 hours on a release reach, with a closure for the whole storm below the design level of a reservoir. A rate rule cannot help when there is no outlet: an orificed basin behind a closed gate simply fills.

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

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

5.11 Flap gates, tide gates and non-return valves

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

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

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

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

5.11.3 **Construction.**

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

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

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

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

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

- before **31 March** each year;
- after every event in which they closed against a storm flow; and
- as set in the maintenance plan (Chapter 10).

> **Commentary.** The requirement for gates below the 1% still-water level is set by this Manual. The construction details follow common coastal-drainage practice. A gate that is jammed open by debris lets the tide into the drain. A gate held shut by a sand bank turns a gravity outfall into a dead end. In Mizoram the outfalls do not cross a beach. Most fall freely to a lui, and no flap-gated or pumped storm outfall was found in the State during research [TBC]; but the outfalls of the valley floors at Sairang, Bairabi, Vairengte, Chawngte, the Champhai flats and Tlabung need flap gates under Clause 5.8.5(c) and (d), and there a gate jammed open by gravel, slide debris or waste lets the river into the town's drains, and a gate buried by a rising bed turns the outfall into a dead end. Two outfall reaches lie below dams: the Tuirial below NEEPCO's dam, for which a dam-break study is reported to have routed a peak of 3,035.34 m³/s "near the confluence" (as reported), and the Serlui below the Serlui B dam; no operating rule or release record of either was found, and no rule linking the operation of any dam to the levels of the drains above or below it [TBC]. The dams are held by NEEPCO and by the State's power department, while the drains that

> reach the rivers below them belong to the Aizawl Municipal Corporation, PWD, the national-highway agencies, the Village Councils and, in the south, the District Councils, and no notification divides them (Clause 6.9). A gate and the drains behind it can therefore belong to different bodies, and the drain register of Clause 6.9 names the owner of each gate. The 31 March inspection date is set ahead of the monsoon.

5.12 Pumped outfalls

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

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

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

5.12.2 **Capacity.**

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

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

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

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

Changeover shall be automatic.

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

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

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

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

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

The arrangement shall prevent back-siphoning.

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

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

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

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

5.12.9 **Testing.** Every pumped outfall shall be test-run at full duty, including on standby power, before **31 March** each year. Private pumped systems shall be covered by a registered maintenance declaration (Chapter 10).

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

5.13 Sand-bar closure of river mouths

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

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

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

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

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

5.13.4 **No credit for emergency cutting.** Bar cutting or breaching during the storm shall not be assumed in design, unless the IWRD 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. Mizoram 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 stones, slide debris, silt and garbage that the lui leave at an outfall or a gate. The master plan finds Aizawl's drains "silted up frequently due to insufficiency in the hydraulic design", and a third of the area of Aizawl W-I water-logged "for several days or for hours" because solid waste blocked its road-side drains (Master Plan for Aizawl: Vision 2030); the lui below the city carry the debris of every slide upstream. A flap gate held open or shut by gravel, debris or waste, an outlet buried by a rising bed or left hanging by scour, or a gate that cannot be moved, turns a designed outfall into a dead end or a back-flow path. No rule linking the operation of any gate or dam in the State to the levels of the drains above or below it was found during research [TBC]. Clause 5.8.5 deals with both by setting outfalls above the range of bed movement and by giving no credit for a gate operation or a storage that the operator's records do not show. Clause 5.13.2 has no direct precedent. It puts the burden of proof on showing that the mouth is open rather than assuming it.

5.14 Documentation

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

1. a plan of the analysis extent showing:
    - the site;
    - each analysis point with its contributing catchment area and the site's percentage of it; and
    - the end point and the reason it was chosen (Clause 5.3);
2. the model description:
    - software and version;
    - the network schematic, with survey sources for the drains and crossings;
    - land use and CN for off-site areas;
    - any upstream detention included; and
    - calibration or validation evidence where available;
3. for each analysis point, AEP and duration, the existing and with-project:
    - peak flow;
    - time to peak;
    - maximum water level and velocity; and
    - duration of inundation (Clause 5.4);
4. the comparison against Clause 5.5, with each failure identified and the remedy adopted;
5. the tailwater derivation:
    - tide-table edition and port;
    - MHWS, HAT and MSL relative to chart datum;
    - the datum connection to the Survey of India benchmark and the project datum;
    - surge source and value;
    - SLA; and
    - river levels and their sources (Clauses 5.6 to 5.8);
6. the joint-case table of Clause 5.9 with results;
7. the outfall-closed check (Clause 5.10):
    - storm and lock alignment;
    - stage hydrographs; and
    - the volume balance for each lock window;
8. a schedule of flap gates, tide gates and non-return valves, with certified head–discharge data (Clause 5.11);
9. pumped outfall design, power supply, flood immunity and controls, where provided (Clause 5.12);
10. the sand-bar assumption and supporting IWRD 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 hillside colony in Lunglei town draining to a hill stream (lui)
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) Mizoram 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. Mizoram's drains were not designed against any State or municipal standard: none was found during research, and no document found gives a design return period, runoff coefficient or drain size for any town. The Corporation's building regulations defer to the National Building Code ("as amended from time to time" since the amendment of 2019) and, for landslide hazard, to IS 14458 and IS 14496 (Part 2) (AMCBR reg. 33 and Annexure F); its slope regulation fixes the geometry of terrace swales, interceptor drains and down-drains but leaves the "hydrology and hydraulic calculations" to licensed civil engineers (SD&SM reg. 27 and Schedule I). The master plan found that "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all. Only 15% of the area is provided with pucca drains", that the drains are "silted up frequently due to insufficiency in the hydraulic design", and that only 8% of the villages have open drains with regular maintenance, 40% periodic maintenance and 52% none (Master Plan for Aizawl: Vision 2030, 8.3.1–8.3.4). Aizawl Smart City's stated aims include "refining water supply and drainage systems" (as reported), but no storm-drain project of it was found, and the ADB programme for the North Eastern Region's capital cities funded water supply and sewerage in Aizawl, with no drainage component found (ADB documents, seen through search summaries) [TBC]. The drains also work in a setting that the plains editions of this Manual do not meet. They collect water from slopes of 30° to 45° that deliver gravel, stones and slide debris with every storm, and the slopes fail when the water is put into them: two-thirds of the large landslides investigated in 2022-23 were attributed to "improper drainage" (Directorate of Geology and Mineral Resources, as reported), and the Roadmap to Stability (2014) asked PHED to "capture and transport rain and waste water away from exposed hillslopes and ejected at locations that

will not saturate potentially unstable slopes". With sewers in only one catchment of Aizawl, the drains carry the towns' sullage and septic effluent (Clause 8.9). The road drains of the hills are the drains of the land above them. And the drains are divided among owners: the Aizawl Municipal Corporation and its Local Councils, the Lunglei Municipal Council, PWD, the national-highway agencies, PHED and SIPMIU, EF&CC and the Land Revenue and Settlement Department, NEEPCO and the State's power department, the Village Councils and, in the south, the District Councils all build or hold drains and receiving waters, and no notification 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 **Drains that carry sewage, and hill drains.** Outside the one sewered catchment of Aizawl, the public drain that receives storm water from a site or a public drainage project in Mizoram normally also carries sewage and sullage, from septic tanks, soak pits and open connections (Clause 8.9); and on the slopes on which nearly every town in the State is built, the drains also carry silt, gravel, stones, slide debris and waste, and the water they spill or leak moves the slopes. This chapter applies to the storm-water system up to the point of connection and to every public drain, with the following additions (all set by this Manual).

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

- (a) **Separation on site.** Storm water and sewage, sullage included, shall be collected in separate systems within the site, each with its own last inspection chamber at the site boundary, so that the storm-water system can be connected to a separate public storm drain, without rework on the site, when one is built or when the sewers of the area are commissioned. Where the Authority allows only one connection to the receiving drain, the two systems shall meet only in a final chamber after both inspection chambers. The rules that exist have the hooks for this item but do not separate the flows: the site plan shall show "sewerage and surface drains, position and sizes of septic tank and soak pit" (AMCBR reg. 5(5)(v)); a "surface drain/closed conduit of adequate capacity to the nearest public drain shall be provided for proper disposal of surface and waste water" (AMCBR reg. 37(ii)); SD&SM reg. 27 asks for drainage plans "that provide for control of surface runoff, sewage, sullage and seepage from septic systems" together, which this item splits; and a municipality may "require separate provisions to be made for drainage or sewage and other offensive matters as distinct from rain-water and other unpolluted sub-soil water" (Mizoram Municipalities Act, 2007, s.298). In the sewered catchment of the Chite sewage treatment plant, the site's sewage goes to the sewer and its storm water to the storm drain, and the two shall not be joined. Clause 6.13.7 applies to every storm drain within the site. No sullage and no roof or paved-area water shall be led to a soak pit or any other infiltration device on ground where the hill rule of Clause 4.11 bars infiltration; this item does not override the septic tank "with soak pit" that AMCBR reg. 33 requires for every water closet, which is dealt with under Clause 8.9.
- (b) **No rise in the peak inflow.** A development to which Chapter 4 applies shall meet Chapter 4 at each connection to a drain that carries sewage, as at any other site outfall (Clause 4.5.1.3). A development below the thresholds of Clause 1.5.2 shall not raise the peak inflow above that of the site before the development: where it adds impervious area, the roof water of the added area shall pass through the rainwater harvesting or storage tank that AMCBR reg. 33 already requires ("A suitable rain water harvesting facility shall also be provided in all buildings"), sized under the credit rule of Chapter 4, with a controlled overflow before it reaches the connection.

- (c) **Tailwater and backflow.** The HGL of Clause 6.8 shall be started from the level in the receiving drain at the connection in the coincident event, taken from the owner's model where one exists and otherwise at the drain's obvert or top of bank (Clause 5.6.2). Where the receiving drain ends at an outfall that a lui, a river or a reservoir can close, the outfall-closed check of Clause 5.10 applies with the lock of Clause 5.8.5. A non-return valve (Clause 6.8.8) shall be fitted on every connection, storm or foul, to a drain that carries sewage wherever the lowest drainage fitting or opening it serves is below the cover or bank level of the receiving drain at the connection. Where a site downhill carries "drainage, sewage or seepage from the adjacent site uphill" under SD&SM reg. 27, it shall carry the uphill site's storm water in its storm-water system and that site's sewage and sullage in its foul system or a separate closed conduit, never in one channel.
- (d) **Capacity, velocity, access and odour.** A public drain that carries sewage shall be designed as a combined channel until the sewers of its area are connected: its storm capacity used in Clause 6.3.3 shall be the capacity left after its dry-weather flow, measured or estimated from the population served; it shall reach the minimum velocity of Clause 6.7.3(a) at its dry-weather flow, or have a low-flow channel in its invert that does, so that sewage solids do not settle between storms; where it is covered, it shall have the access openings of Clause 6.13.2, with covers and vents placed so that odour does not reach homes, steps and footpaths; and it shall be cleanable by machine from those openings, without anyone entering it. Flow above its storm capacity, or above what the inlets admit, shall be carried on the surface by the major system (Clauses 6.3.2 and 6.9), never onto an unprotected slope, and floor levels shall be set under Clause 6.11 with the drain surcharged.
- (e) **Interception and screens before outfalls; separation planned by the Authority.** Every public drain that carries sewage shall have dry-weather-flow interception and a screen before its outfall to a lui on the CPCB list of polluted river stretches, among them the Chite stream and the Tuikual stream (Priority II), the Lawibual stream (Priority III) and the Tuipui (Priority V) (CPCB, 2025), to a dil, or within the catchment of a tuikhur, designed under Clause 8.9 so that it does not reduce the drain's storm capacity, and no new storm drain shall be brought to a dil without that treatment. No drain that carries sewage, and no storm outfall, shall discharge into or immediately above a tuikhur or within 15 m of one (the spring rule of Chapter 8). Every such screen shall also hold back the solid waste that the drains carry, with machine access and a place to stack what it catches that is not a lui, a slope or a dil margin. The master plan already asks for "treatment facilities at the outfall points to reduce the pollution from storm water which is found containing domestic effluents" (Master Plan for Aizawl: Vision 2030, 8.3.4). The Authority shall identify in its master plan (Chapter 11) the areas where a separate public storm drain is feasible, among them the catchment of the Chite plant as its connections are made; in every town, every public drain below a settlement shall be taken as one that carries sewage until sewers exist; and where a separate public storm drain is available at the site boundary, the site's storm-water system shall be connected to it and not to the drain that carries sewage. The Conveyance Design Report (Form 6-1) shall state whether each receiving drain carries sewage, the source of that information, and how items (a) to (e) are met.

Items (f) to (m) apply to every element of the minor and major systems that receives runoff from a hill catchment, which in this Manual means land in sub-areas MZ-A, MZ-B, MZ-C and MZ-D of Annex 2A, the hill slopes inside the valley-floor sub-areas MZ-A1, MZ-C1 and MZ-D1, any catchment whose natural ground slopes more than 10% on average, and every lui or other stream that comes down from the hills, including where it crosses valley-floor land; in Mizoram that is nearly every catchment (NEER reading). Throughout items (f) to (m), the drainage geometry of SD&SM reg. 27 is the minimum conveyance layer, and this Manual adds the hydrology that the regulation leaves to the designer:

- (f) **Debris racks and traps.** Every inlet, drain or pipe entrance and culvert that receives flow from **1 ha or more** of unbuilt hill land (forest, bamboo, scrub, land under shifting cultivation or other cultivated slope, bare slope, a cut or fill slope, a quarry or its spoil, or a slide scar), or from a lui or other hill stream whatever its catchment, shall have a debris rack or a debris trap upstream of it, designed under Chapter 9 (Clause 9.8), with machine access and a stable place to stockpile what it catches, which shall not be a slope, a lui, a dil margin or the catchment of a tuikhur. With 50% of the rack blocked, the element it protects shall still pass its design flow, and the overflow route shall not send the flow onto a building or an unprotected slope. Racks and traps shall be cleared by 31 March, again by 30 April after the April storms and before the May storms, and after the season by 15 November (Chapter 10). The volume of a debris basin is to be set in Chapter 9 [TBC].

- (g) **Bulking factor.** The design flow of every channel, drain, pipe, culvert and crossing that receives flow from a hill catchment shall be the clear-water peak flow of Chapter 3 multiplied by a bulking factor of **1.25**, for the minor design flow, the check event and the 1% AEP flow; elsewhere the factor is 1.0. The factor applies to capacity, freeboard and velocity; it does not apply to the runoff volume used for storage (Chapter 4). A larger factor shall be used where a sediment study of the catchment gives one. A catchment that the screening of Clause 2.3.6(i) shows to be prone to debris flow or landslides, or that drains a slide scar, a debris path below a cut slope, a fill or a retaining wall, or a quarry face or its spoil, is not designed by a bulking factor: no building, outfall, pumping station or storage shall be placed in that path, and the drains are designed for the bulked flow only [TBC].
- (h) **Blockage.** The blockage check of Clause 6.12.4 shall assume 50% of the inlet area blocked for every culvert and pipe entrance with a span or diameter below **3.0 m**, and 20% for larger ones, whether or not a debris rack is provided. Grate inlets keep the clogging factor of Table 6.5, and kerb openings on grade take the sag value of 20%.
- (i) **Sediment and minimum velocity.** Drains and pipes that receive flow from a hill catchment, or that run across the valley floors and terraces of MZ-A1, MZ-C1 and MZ-D1, shall reach a velocity of at least **1.0 m/s** at the minor design flow, in place of the minimum of Clause 6.7.3(a). Where the gradient does not allow it, a sediment trap shall be provided upstream and the sediment allowance of Clause 6.7.8 doubled (Clause 6.7.4).
- (j) **Steep drains, steep streets and outfalls onto slopes.** 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 or baffled channel or a series of drop structures designed under Chapter 9 for the bulked flow of item (g), with the freeboard of Table 6.7 for steep channels and an energy dissipator at every change to a flatter gradient and at the outlet. **Every outfall onto or down a slope**, of a public drain, a road drain or a site, shall end in an energy dissipator and reach a stable natural channel through a lined chute, a stepped channel or a closed pipe, the "non-erosive downdrains" of SD&SM reg. 27, and shall not discharge onto an unprotected slope, fill or retaining wall. No drain shall be unlined on natural ground steeper than 10°, on Surma-group shale, siltstone or mudstone, or on colluvium, fill or slide debris, because an unlined drain there is an infiltration path that the hill rule of Clause 4.11 does not allow. On a street steeper than 5%, grate-only inlets shall not be used, and inlets shall be placed by the calculation of Clause 6.6.4 with the bypass flows of a steep gutter; on a street steeper than 10%, the flow shall be intercepted by transverse grated channels or kerb inlets at a spacing that keeps the street flow within the limits of Table 6.3 in the check and 1% AEP events, and where the 1% AEP flow cannot be kept within those limits, the excess shall be carried in a lined side channel or stepped drain and the street, unless it is a notified evacuation route, is treated as closed in that event. Steps and footpaths that carry flow shall have a lined side channel.
- (k) **Hill roads as the minor system.** On every road and street in a hill catchment as this clause defines it, among them NH-6 through Aizawl at Hunthar, which is reported to block in most storms (2018 and 2024, as reported), the drainage of a road is the minor system for the land above it as well as for the road. Every such road and street shall have, as works of the road's owner, PWD, a national-highway agency, the Aizawl Municipal Corporation, the Lunglei Municipal Council, a Village Council or a District Council: (i) a lined catch-water drain above every cut slope where the land above drains towards the road, discharging to a natural channel or a cross-drainage work and not over the cut; (ii) lined side drains on the hill side (IRC:SP:42-2014, cl. 8.5.1); (iii) a cross-drainage work at every lui and stream, and culverts or scuppers at intervals such that no side drain exceeds its capacity at the design AEP of Table 6.1 with the factors of items (g) and (h); (iv) at the outlet of every scupper, culvert and side drain on the valley side, a lined chute, cascade or pipe carrying the flow to a stable natural channel or a public drain, with an energy dissipator, so that road runoff is **never discharged onto an unprotected slope**, fill, retaining wall or the land of a building below, by PWD, a national-highway agency or any other owner of a road; (v) culverts of at least the size of Clause 6.12.5, designed under Clause 6.12 and not less than IRC:SP:42-2014 cl. 7.1.4 requires for the road; where the drainage provisions of IRC:SP:48-1998, the Hill Road Manual, which were not read for this Manual [TBC], are stricter than this item, they apply; and (vi) no muck, spoil or excavated material from the construction, widening or maintenance of the road, or from hill cutting beside it, placed in or beside a lui or another line of natural drainage, or on a slope from which a storm can carry it into one, and every natural drain or lui that such material has blocked cleared by 31 March. The same items apply to the drainage of a railway formation in a hill catchment, among them the Bairabi–Sairang line.

- (l) **Sloping sites: the SD&SM layer and the hydrology it leaves out.** On a site where the land above drains towards a building, its cut or its retaining wall, the runoff of that land shall be intercepted above them by a lined diversion drain sized for the minor design flow of Table 6.1 from the land above it, with the factors of items (g) and (h), with a 1% AEP flow path that does not pass through or against the building. The space between a building and the cut or retaining wall above it shall be paved or lined and drained so that water does not stand against the building or soak into the foot of the cut, and both shall discharge to a public drain or a stable natural channel as item (j) requires, not onto the slope below. Every retaining wall that holds up a slope shall have weep holes or weep pipes and a subsurface drain that discharge into a lined drain at its foot, not onto the slope below or into the backfill of a wall below. In the area of the Aizawl Municipal Corporation the regulations already set the minimum geometry, and wherever this Manual is applied elsewhere that geometry is the practical minimum: terraces "at least 2 meters in width" at "not more than 10 meter intervals on all cut or fill slopes", with a terrace 4 m wide at mid-height on slopes 20 to 40 m high; terrace swales with "a minimum gradient of 1 vertical to 20 horizontal", "paved with reinforced concrete not less than 75 mm in thickness", at least 300 mm deep and with a paved area of at least 0.7 m², of which "A single run … shall not collect runoff from a tributary area exceeding 400 square meters (projected horizontally) without discharging into a down drain"; paved interceptor drains "along the top of all cut slopes" whose uphill drainage path is "greater than 10 meters measured horizontally", at least 300 mm deep and 800 mm in paved width, of reinforced concrete or gunite of the thickness printed as "75m" (read as 75 mm); building pads with "a minimum drainage gradient of 1 vertical to 50 horizontal toward approved drainage facilities" (1:100 where the fills and cut and fill faces are 3 m or less); "non-erosive downdrains"; subsurface drainage "as necessary for stability"; a duty on "Sites developed downhill of existing sites" to "convey drainage, sewage or seepage from the adjacent site uphill, as well as from the site being developed, in a safe manner to the nearest practicable drainage way"; and the owner's duty to maintain what the permit installs (SD&SM reg. 27); with fill toes "sloped for sheet overflow or a paved drain" built "with energy dissipaters" (reg. 25), setbacks from a cut that "may need to be increased for any required interceptor drains", and the control of "subsurface water, such as springs" (reg. 26). This Manual adds what reg. 27 leaves to the licensed civil engineer, whose competence includes the "Design of drainage structures, including hydrology and hydraulic calculations" (Schedule I): every terrace swale, interceptor drain, down-drain and conduit that carries a site's or an uphill site's water shall be sized for the minor design flow of Table 6.1 from its whole tributary area, with the rainfall of Chapter 2, the factors of items (g) and (h) and the freeboard of Table 6.7, and checked for a 1% AEP flow path that does not pass onto a building or an unprotected slope; where the section of reg. 27 is larger, it governs; a section that meets reg. 27 but not the design flow shall be enlarged; and the 400 m² of reg. 27 limits the area of one run, not its capacity. The site hooks are AMCBR reg. 26(2)(b), under which roof water is carried "by means of rain gutters and closed conduits … discharged at ground level by pipe" and "no spout should be allowed to drain into the road or public area or within the adjacent compound or building", which this Manual reads as discharge into the site's storage tank or a lined drain at ground level, never onto the ground of a slope; and AMCBR reg. 37, under which an owner shall allow "a closed conduit" through his land where "in the interest of public safety" a neighbour's rain and waste water must cross it, and a "surface drain/closed conduit of adequate capacity to the nearest public drain shall be provided" (37(i) and (ii)). Roof and paved-area runoff on such a site follows the hill rule of Clause 4.11. Outside the Corporation's area no building or site-development regulation was found to apply: this item reaches public works and any body that adopts this Manual, and is guidance for a household elsewhere (Chapter 1).
- (m) **Quarry faces, spoil and garbage-laden flows.** Every quarry, working or disused, and every spoil heap in a catchment that drains to a town drain, a road or a lui shall have a lined cut-off drain above its face, sized for the minor design flow of Table 6.1 from the land above it with the factors of items (g) and (h), discharging through a down-drain and an energy dissipator to a stable natural channel and not over the face or onto the spoil; no drain or flow path of the minor or major system shall be led onto, over or below a quarry face or spoil heap; and no spoil and no construction and demolition waste shall be placed where a storm can carry it into a drain or a lui, or on a drainage course or riverine reserve (SD&SM reg. 29). Every drain outfall to the Chite lui, the Ser lui or a lui on the CPCB list, and every public drain or culvert where a lui below a settlement enters it, shall have a solid-waste trap or screen designed under Chapter 9 (Clause 9.8), with access for cleaning by hand or machine and a place to store what it catches that is not a lui, a slope or a dil margin, cleared on the dates of item (f) and after every heavy-rainfall day (Chapter 10). The blockage of item (h) shall be taken to include solid waste whether or not a trap is provided, and the capacity of an existing drain or channel shall be taken net of the silt and waste surveyed

in it (Clause 6.7.8). A trap, screen or check dam placed in a lui, among them the eight check dams that the master plan proposes in Aizawl, shall not raise its 1% AEP level at any outfall (Clause 5.8.5(a) and (b)) and shall be designed to be overtopped without damage. A trap is not a treatment work: dry-weather flow is intercepted under item (e) and Clause 8.9.

Commentary. The CPHEEO (2019) manual defines major and minor systems in its glossary but gives no return period for the major system. APWA 5600 (2006, 5601.8) requires the system to convey the 1% peak and, where in-system capacity is less, an overflow system to carry the remainder. Clause 6.3.3 subtracts only the *clogged* inlet capacity, not the full pipe capacity, because in practice the pipes cannot take more water than the inlets admit. The fully-blocked check at sags has no direct precedent; this Manual sets it because of the Aizawl 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 Mizoram, and it has two parts because the State's drains fail in two ways that the criteria of this chapter, which assume clear storm water on gentle ground, do not see. The first is sewage. "In absence of sewerage system, people are using septic tanks and soak pits. In most of the places sewage is discharged into open drains without any treatment, which ultimately gets discharged to rivers", and "the sullage (i.e. kitchen and bathroom waste) is discharged into drains which ultimately pollutes the fresh water sources" (Master Plan for Aizawl: Vision 2030). The State estimates 51.81 MLD of sewage, 31.37 MLD of it urban, against "Existing Treatment Facilities … 10 [MLD] only for Aizawl city", from one plant on the Chite, and finds that "Due to peculiar topography of the hilly regions, treatment of Grey Water remains a huge challenge" (State report to the National Green Tribunal in O.A. 606/2018, as on 31 August 2025); and the CPCB lists the Chite stream and the Tuikual stream in Priority II, at a BOD of 29 and 29.1 mg/L (CPCB, 2025). The storm drains are the sewers. The regulations already reach towards separation without requiring it: the site plan shows the sewerage and the surface drains (AMCBR reg. 5(5)(v)), a municipality may require foul and rain water to be drained separately (s.298 of the Municipalities Act), and SD&SM reg. 27 brings "surface runoff, sewage, sullage and seepage from septic systems" into one drainage plan, which on a slope means one channel. Items (a) to (e) follow the combined-sewer rules of the plains editions of this series: a site keeps its storm water separate up to the boundary, so that the town can separate its system street by street as sewers come, without going back into every plot; a development does not add to the peak of a drain that carries sewage; a non-return valve guards every connection, because what comes back up a surcharged drain is sewage; the drain is designed as the combined channel it is, with its capacity taken net of its dry-weather flow and a low-flow channel so that sewage solids do not settle in it between storms; and the outfall to a polluted lui, a dil or a spring's catchment is intercepted and screened. Item (a) keeps sullage and roof water out of soak pits on the slopes because the Roadmap to Stability (2014) asked that "all septic tanks, leach fields and soak pits within Aizawl City" be eliminated, while AMCBR reg. 33 still requires a septic tank "with soak pit" for every water closet; the Manual states that conflict and does not resolve it (Clauses 4.11 and 8.9). Item (e) protects the springs (tuikhur) because "Mizoram is an abode of springs. These springs are widely utilized by people for domestic needs" (CGWB), and its 15 m is the distance that AMCBR reg. 33 already keeps between a soak pit and "a water source". Separation itself is for the Authority to plan, not for each site.

The second is the hills. Aizawl's slopes run at "300 to 450" (30° to 45°, as printed), its soil "is young and in a loose state" (master plan), and about 89% of Serchhip town is steeper than 30° (MIRSAC; NEER arithmetic); the ridges are of Surma-group shale, siltstone and sandstone that CGWB describes as having "very low permeability and infiltration" and acting "as run off zone" (CGWB, Lunglei booklet). The slopes fail when water is put into them: the Corporation's own regulation names "increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner" among the activities that "can greatly increase slope instability" (SD&SM, reg. 1); the Directorate of Geology and Mineral Resources attributed two-thirds of the large landslides it investigated in 2022-23 to "improper drainage" (as reported); the Laipuitlang rockslide of 11 May 2013 (15 May in one paper) killed 17 people by one count and 8 by another (Science Vision; as reported); a stone quarry collapsed at South Hlimen on 9 August 1992, and the disused quarry between Melthum and Hlimen collapsed in Cyclone Remal on 28 May 2024, in a storm whose toll in Aizawl district was

reported on 29 May 2024 as 29 dead with 7 missing (PTI, as reported; other counts differ, among them 15 dead at the quarry and a later 34 in seven areas of Aizawl, as reported); and three of the twenty blocks of the BSUP housing at Durtlang collapsed on 2 July 2019, killing three, and of the suggestions made in 2020 for rock bolts, wire nets and buttressed toe walls, "none of the suggestions were carried out" (CAG, 2025). The roads are where the water is concentrated: NH-6 at Hunthar is reported to block in most storms (as reported), and landslides damaged 219 km of road between 2017-18 and 2021-22 (CAG, 2025). No Mizoram allowance for debris, bulking or blockage was found during research [TBC], and no Indian guidance on bulking factors, debris racks or debris basins [TBC], so each number in items (f) to (m) is the interim value of the hill and mountain editions of this series, with the same reasons. The 1 ha trigger for a debris rack reflects the few minutes' time of concentration on hill slopes. The bulking factor of 1.25 is the factor for a flow that carries a fifth of its volume as sediment (bulking factor = 1 / (1 − sediment fraction by volume)), about the most that a drain can carry and still behave as a water flood; a flow with more behaves as a debris flow, which no drain can be sized for, so item (g) keeps buildings and outfalls out of its path. The 3.0 m limit in item (h) doubles the core's 1.5 m because stones, timber and waste block openings that leaves alone do not. The 1.0 m/s minimum in item (i) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm, because hill drains carry gravel. The mid-season clearance of item (f) is due by 30 April, not by 31 May or 15 May as in the other North-East editions of this series, because the earliest dated deadly storm of May in the State fell on 11 May (Chapter 10). IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently, with lined side drains and culverts "at closer intervals compared to those in plain areas", and item (k) keeps road runoff off unprotected slopes because water discharged onto a slope raises its pore pressure (Clause 4.11). Item (j) bars unlined drains on steep ground, shale and fill, because an unlined drain there is the infiltration that the hill rule forbids. Item (l) takes the drainage rules of SD&SM 2017, which fix drainage geometry in more detail than any other rule found for the State, as the minimum conveyance layer and adds the design storm, capacity and freeboard that the regulation leaves to the licensed civil engineer; the regulation's 400 m² limit on a swale run is a geometry, not a hydraulic check, and a run that meets it can still be overtopped by the 1-hour depths of Chapter 2. Item (m) is added for Mizoram because two of its deadliest slides were quarry collapses, and because the master plan found a third of Aizawl W-I water-logged "for several days or for hours" with solid waste in the road-side drains. The clause deals with sewage, debris, quarries and waste at the drain; it does not ask for the concrete channelisation of the lui, whose problem is the water and debris put into them, not their roughness.

6.4 Design return periods

6.4.1 The minor system, roads and crossings shall be designed for the AEPs of Table 6.1. Where both a land-use row and a road-class row apply to an element, the **rarer** AEP (longer return period) governs.

Table 6.1 — Design AEPs for conveyance (matches Clause 2.4)

Element	Design AEP (return period)	Check event	Basis
Minor system: Aizawl and Lunglei 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

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

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

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

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

- (a) in Aizawl, the localities that the sources name for destructive lui, waterlogging or slope failure: Chanmari, Khatla, Tuikual and Vaivakawn on the "worst destructive" lui of the west, Bethlehem Vengthlang, the site of the Chite sewage treatment plant, and Zemabawk on the Chite lui system, Ramhlun Venglai below Laipuitlang, Hunthar Veng and its sinking area, Durtlang and Bawngkawn on the Bawngkawn–Durtlang road, and Melthum and Hlimen on the city's southern edge (Master Plan for Aizawl: Vision 2030; CAG, 2025; as reported), and Aizawl W-I, a third of whose area the master plan found water-logged; with the boundary of each, and whether it is densely built, to be confirmed by the Aizawl Municipal Corporation and UD&PA [TBC]; and in Lunglei, the town's older, densely built core, to be identified by the Lunglei Municipal Council [TBC];
- (b) in every other municipal area and notified town, the area that the applicable master plan identifies as the core area, old town or central business district, and the main market of a hill town; and
- (c) any area in a Tier A body where the master plan permits a floor space index above the base value for the zone.

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

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

underpasses is likewise set by this Manual, because an underpass is a trapped sag where the failure mode is deep water on a live carriageway. The default high-density areas in Clause 6.4.4 are set by this Manual and apply until the approving authority notifies a map.

6.5 Street hydraulics: spread, depth and flow hazard

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

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

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

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

Table 6.2 — Street flow limits

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

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

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

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

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

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

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

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

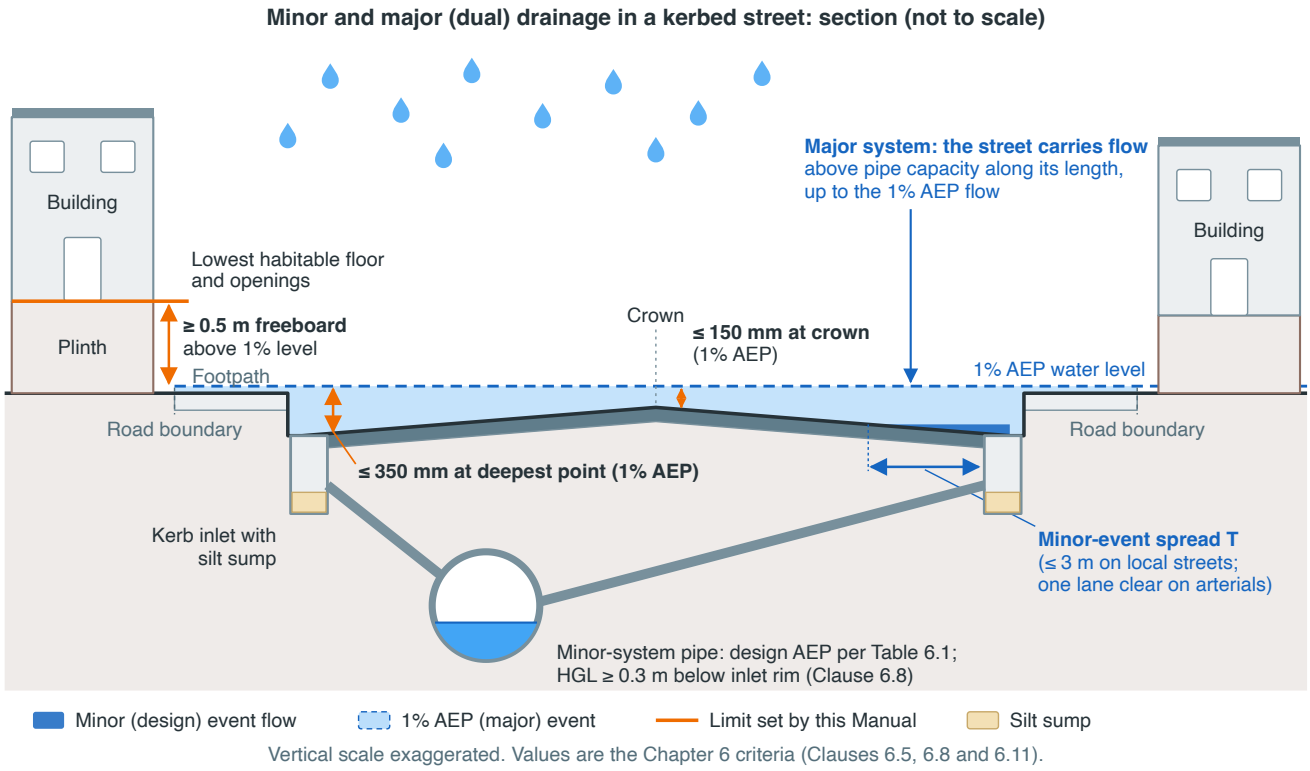


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

Commentary. The Izzard form of Manning's equation with Ku = 0.376 is used both in FHWA HEC-22 and in the CPHEEO (2019) manual (Part A, Example 5.5, where the constant is written Kc = 0.376). The arterial spread rule (one lane clear) and the 3 m spread for local and collector streets are close to the APWA 5600 (2006, 5604.2) limit of 12 ft (3.66 m) from the back of kerb in each outside lane. The cross-flow limit of 0.03 m³/s is the SI equivalent of the APWA limit of 1.0 cfs at intersection sumps and superelevation transitions, with no cross-flow at mid-block sumps. The 150 mm and 350 mm depth limits are close to the APWA 5600 limits for 1% overflow at road crossings (7 in, about 180 mm, at the crown; 14 in, about 360 mm, at the deepest point). Mumbai's criterion of no flooding above 15 cm (IRC:SP:50-2013, §6.4.1) is a local precedent for the 150 mm crown value.

> The hazard classes of Table 6.4 are the combined hazard curves published by the Australian Institute for Disaster Resilience (AIDR Guideline 7-3, 2014), which are modelled after Smith and Wasko (2012). Requiring H2 or better on carriageways means the 1% depth limit of 350 mm (Table 6.2) governs the depth, and the D·V product controls fast, shallow flow on steep streets. H2 is described as "unsafe for small vehicles". Two-wheelers are the dominant vehicles on Mizoram streets, so the 1% event must be treated as a road-closure event on all roads except notified evacuation routes, which must meet H1. The assignment of hazard classes to locations in Table 6.3 has no direct precedent and is set by this Manual.

6.6 Inlets

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

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

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

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

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

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

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

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

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

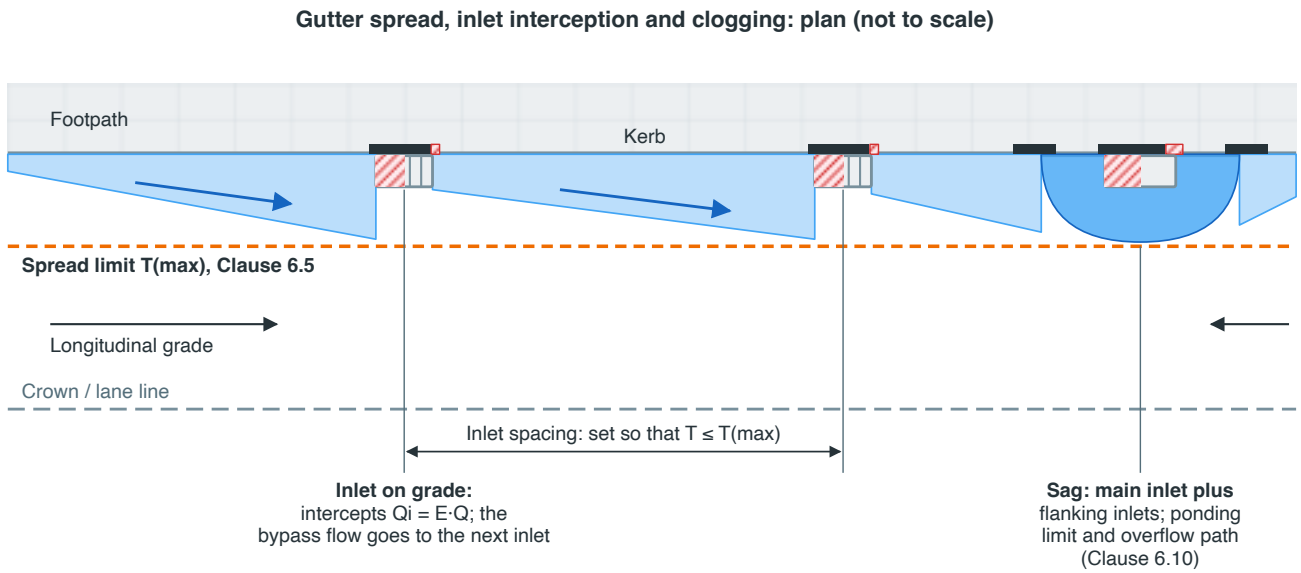
6.6.5 **Sag inlets.** At a sag on a kerbed road:

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

- (c) the ponding at the sag shall comply with Clause 6.10.

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

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



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

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

> **Commentary.** The clogging factors are more severe than the APWA 5600 (2006, 5604.2) rating of sump inlets at 80% of theoretical capacity (a 20% reduction), because grates in Mizoram streets are routinely blinded by plastic and leaves. CPHEEO (2019) Part A shows solid waste dumped in drains as a primary cause of drain failure (Figures 1.2 and 2.1). APWA 5600 (2006) allows only kerb-opening inlets on public streets; Clause 6.6.1(a) is less strict because combination inlets are useful on flat roads. No standard inlet, kerb-channel or covered-drain detail of PWD, of the Aizawl Municipal Corporation or of the Lunglei Municipal Council was found during research [TBC]; the Corporation's building regulations ask only that plans show "site development and permanent structures like retaining wall, surface drain" (AMCBR reg. 5(6)(viii)), and its slope regulation fixes the section of terrace swales and interceptor drains but no inlet (SD&SM reg. 27). 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 valley floors of Tlabung, Bairabi, Sairang and the Champhai flats are flat, which shortens the calculated spacing anyway; on the steep streets of Aizawl, Lunglei and the other ridge towns gutter flow runs fast and passes inlets by, which Clause 6.3.6(j) deals with. A fixed cap stops a single blocked inlet from leaving a long dry gutter run. The 300 mm silt sump is set by this Manual. It matches the 0.3 m sump shown on the CPHEEO catch-basin detail (CPHEEO 2019, Figure 5.9).

6.7 Pipes and open and covered drains

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

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

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

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

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

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

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

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

- (a) minimum (self-cleansing) velocity: **0.6 m/s** in open and covered drains and **0.9 m/s** in pipes;
- (b) maximum velocity: **3.0 m/s** in lined drains and in pipes, unless the drain or pipe is designed as a chute under Chapter 9. CPHEEO permits up to 6.0 m/s in plastic or plastic-lined pipes in hilly regions; this may be used in Aizawl, Lunglei, Serchhip, Champhai, Kolasib, Siaha, Lawngtlai, Mamit, Khawzawl, Saitual, Hnahthial 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

Drain	Minimum freeboard	Source
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.

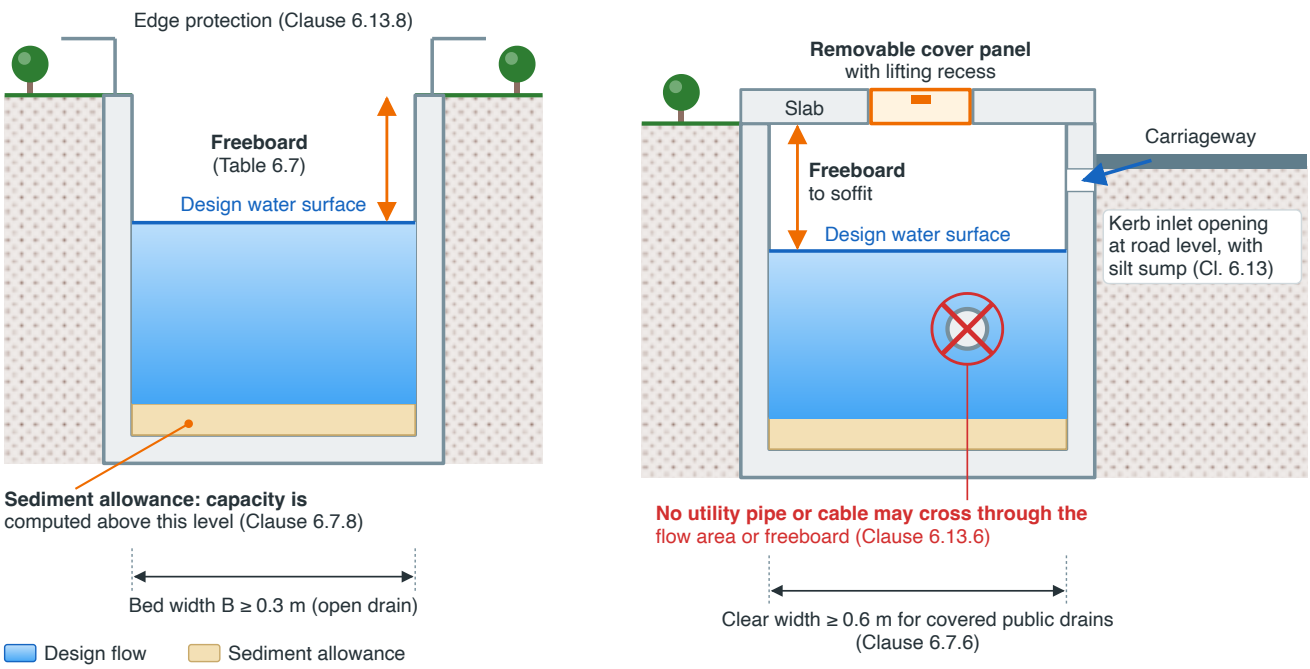


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

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 Mizoram 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 storms of Aizawl, a city where "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all", where the drains are "silted up frequently due to insufficiency in the hydraulic design", and where a third of Aizawl W-I was found water-logged "for several days or for hours" because solid waste blocked the road-side drains (Master Plan for Aizawl: Vision 2030), and after the landslides of 2022-23, two-thirds of the large ones investigated being attributed to "improper drainage" (Directorate of Geology and Mineral Resources, as reported). 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. Aizawl'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 Mizoram most town drains end in a lui that falls freely below the outfall, so the free outfall is usually right, but only after the lui's own 1% AEP level at the outfall has been checked, because the lui rise within minutes, carry stones and slide debris and can stand over a low outlet (Clause 5.8.5(a)). The drains of the valley floors end in rivers held high for days, at Sairang and Bairabi on the Tlawng and at Tlabung on the Khawthlangtuipui, whose houses were reported submerged in June 2017 and July 2019 (as reported); outfalls below the Tuirial dam end in a release reach; and the drains of Aizawl carry sullage into lui that the CPCB lists as polluted (CPCB, 2025). No flood level of any lui or river reach in a town, and no design level of any outfall, was found during research. A drain whose HGL is started from a free outfall without that check, or computed one length at a time without the lui, river or reservoir level, fails in exactly that way. An HGL computed from the outfall, with the tidal tailwater of Chapter 5, exposes those errors at design stage. The MHWS plus 0.3 m starting level is from CPHEEO (2019) Table 6.2. The access-hole method is described in HEC-22 from the 2009 edition onward.

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

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

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

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

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

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

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

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

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

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

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

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

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

6.9.8 **Use and protection.**

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

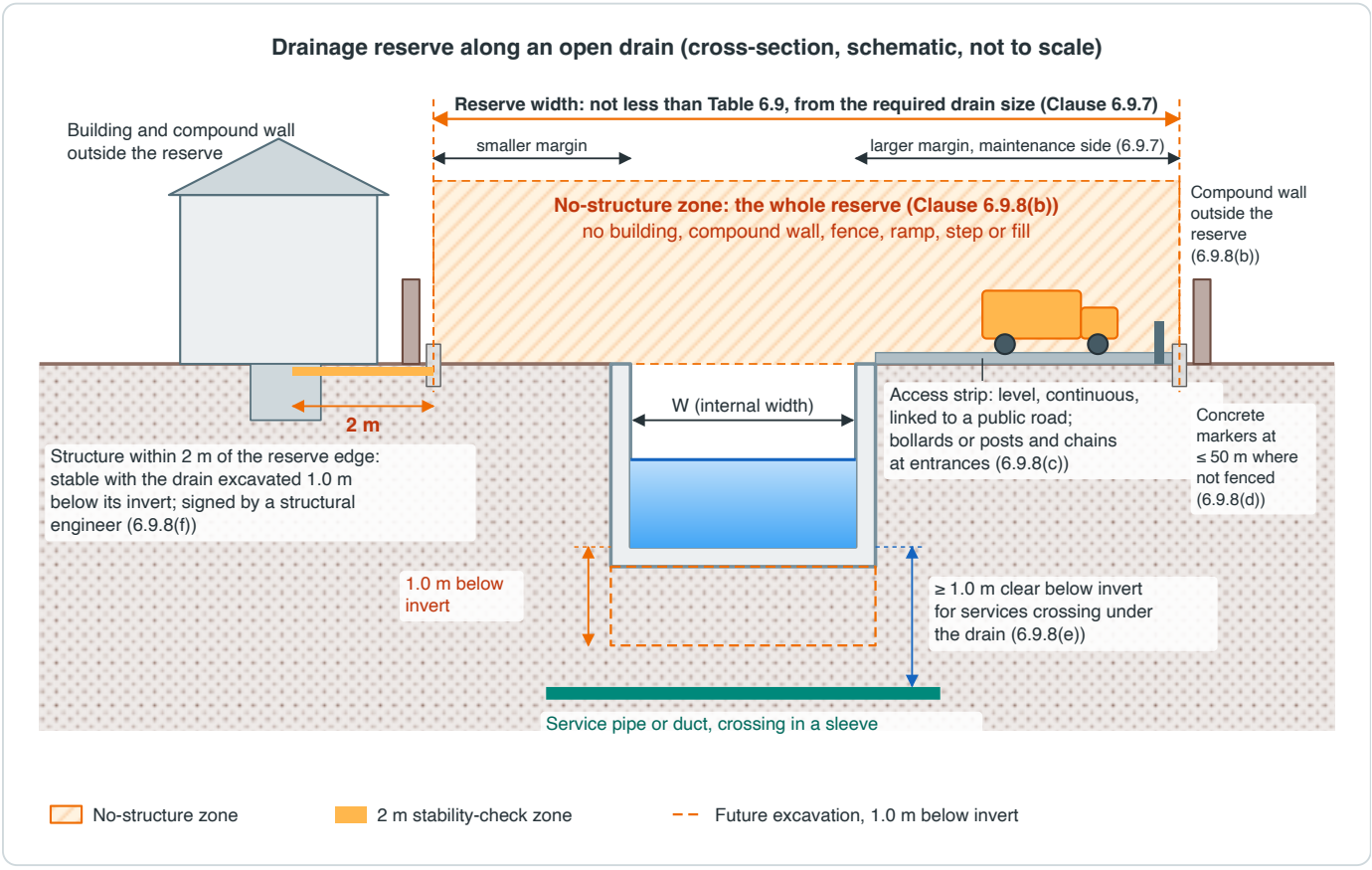


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Mizoram, 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. Mizoram has no statutory width along a drain or a lui, and no floodplain zone of any kind. The lines that exist bind only where they apply, and each has its own status. The Master Plan for Aizawl: Vision 2030 recommends that "all along the major drainage channels, a 15 meters wide green buffer on both sides" be kept, a recommendation of the plan, whose approval notification was not found [TBC], although since the amendment of 2023 the Corporation's online permit system returns any proposal "not as per the provisions of the AMC Building Regulations, 2012 and the Master Plan for Aizawl, Vision-2030"; which channels are "major" is not defined. The plan also keeps "an 800 m green belt on either side from the centre of the river" along the Tlawng "as per the Mizo District (Forest) Act, 1955, section 14 read with section 21", but the notification of 1965 on which that rested, declaring the forest within half a mile of either side of 16 rivers a reserved forest, was quashed by the Gauhati High Court on 27 January 2021; a notification of April 2021 is reported to have set an 800 m restricted zone from mid-river with development by prior approval, and its text was not read; the State's writ appeal was dismissed as withdrawn on 9 November 2022; a special leave petition was filed, with its outcome not found; and the Supreme Court issued notice over works in riverine reserved forests in April 2024 (all as reported). This Manual never treats 800 m as a statutory line and does not use it. SD&SM reg. 28 requires that "For plots adjacent to or including natural streams, the riverine reserve shall be maintained", but no rule found defines "riverine reserve" or gives it a width (NEER reading), and reg. 29 keeps excavated material off "drainage courses or riverine reserves". The Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, provide for River Conservation Zones in which no construction or "obstruction or diversion of the water course or channel" may be undertaken without the State Authority's prior approval; no Protected River or River Conservation Zone has been notified (NEER reading). AMCBR reg. 33 keeps a septic tank and soak pit out of "a radius of 15 metres from a water source". The slope lines are no site development permit above 60° (SD&SM reg. 14), engineered site development in every Moderate, High or Very High landslide hazard zone and from 24° where the plot is unmapped (SD&SM 2017), and the master plan's "SL" zone for "areas with slope higher than 36°, areas adjacent to major drainage lines". No metric setback from a stream appears in either regulation (NEER reading). Within a municipality, public streams and drains vest in the municipality (Mizoram Municipalities Act, 2007, s.80(b) and (d)), and nobody may build over a municipal drain, culvert or storm-water channel (s.300), but neither section gives a width. MPCB told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (O.A. 593/2017 and O.A. 673/2018); that does not hold at Tlabung, Bairabi, Sairang or the Champhai flats, which flood from their rivers (Clause 5.8.5(c) and (d)), and no flood plain zoning law, and no "flood hazard areas as designated and defined by Aizawl Municipal Corporation", which SD&SM reg. 6 asks a site plan to show, was found (NEER reading). None of these gives a reserve width along a lui or a town drain. For this Manual, as its own proposal and not as the meaning of the rules, the bank of a channel is its top of bank, and on an incised lui whose bank is a slope steeper than 10°, the crest of that bank slope; the edge of a dil or reservoir is as Chapter 7 defines it; and every lui and other natural channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whoever maintains it and whether or not it is lined, piped or covered (all set by this Manual). This Manual therefore gives the reserve a width, as its own proposal and not as a statutory width: a **hydraulic corridor** made up of the reserve of Table 6.9, based on the drain size needed to carry the design flow with the bulking factor of Clause 6.3.6(g) (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along every natural channel that drains 8 ha or more and round every dil that this Manual covers, the setbacks of Clause 7.4, with a Zone 1 of **not less than 15 m** from the top of bank, or from the crest of the bank slope of an incised lui steeper than 10°, and a Zone 2 to the 1% AEP extent plus 10 m, which matters on the valley floors and at Tlabung, whichever line is wider governing; where the master plan, a River Conservation Zone if one is ever notified, a notified wetland or a court sets a wider line, that line applies for as long as it binds, and the widest governs (Clause 7.4.5). The corridor is stricter than statute, which sets no distance at all, and extends the master plan's 15 m from major channels to every lui of 8 ha. It applies to new development and redevelopment approved under this Manual, not to existing buildings, and Clause 7.4.7 allows no variance below it. Land records and land use are with the Land Revenue and Settlement Department even inside the Corporation's area (CAG, 2025), much

land is private or held under a land pass, and the Village Councils allot house sites outside the municipalities (Mizoram (Village Councils) Act, 2025), so Zone 1 land and reserve land that is private or held under a land pass is **reserved in the master plan or secured by agreement with the holder**, recorded on the layout approval and in the land records, and not taken; where it is so secured, the transfer of Clause 6.9.8(a) is made by that recorded agreement rather than by a transfer of title; and in a Lai, Mara or Chakma Autonomous District Council area it can be secured only through the District Council [TBC] (set by this Manual). The corridor should be shown in the master plan and in the zonal and ward plans, whose regulations were sent to the Government on 17 May 2023 and had not been approved by September 2023 (CAG, 2025), and checked at OBPAS and at the site development permit, where the plans already have to show the "natural streams, riverine reserves or flood hazard areas" and, for engineered development, "A map showing the drainage area and the estimated runoff of the area served by any drains" (SD&SM reg. 6), rather than made a new NOC.

The reserve matters because the drains of Mizoram's towns are divided among owners, and no notification divides them (NEER reading). On the statute, "All public drains, and all drains in, alongside, or under any public street, whether made out of Municipal Fund or otherwise", vest in the municipality (s.289(1)), which "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall in or outside the municipal area" (s.288), and all drains, "whether private or public, shall be under the survey and control of the Board of Councillors", which shall cleanse them (ss.290–291). But "Roads & Bridges, Water supply … and Fire Services were not devolved" to the Aizawl Municipal Corporation (CAG, 2025), so the drains of the State roads are built and kept by PWD in practice (NEER reading), and the same drains vest in the Corporation on the statute. The Roadmap to Stability (2014) proposed that the Corporation "should have controlling authority for all developmental activities (Roads, Drainage, quarries etc.) within AMC area" and that an office be created "within the Public Health Engineering Department to design and build, monitor and repair or improve drainage systems"; whether either was done was not found [TBC]. No drain inventory of any town was found [TBC], and the master plan's map of proposed drains (Map 8.3) was not extracted for this Manual [TBC]. For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: the public drains and the drains along public streets in the Corporation's area to the **Aizawl Municipal Corporation** (ss.80(d), 288, 289(1) and 290–291), with its **Local Councils**; the roadside drains, catch-water drains, scuppers and culverts of the State roads and highways to **PWD**, the overlap with the Corporation's statutory vesting being stated here and not resolved, so that both are recorded in the register and both consent to a connection (Clause 5.8.5(g)); those of the national highways, among them NH-6, to the **national-highway agencies**; the natural lui and the riverine reserves to **EF&CC** and the **Land Revenue and Settlement Department** (NEER reading); flood-protection and minor-irrigation works on the rivers to the **IWRD** (NEER reading); the sewers and the Chite sewage treatment plant to **PHED** and **SIPMIU**, as s.289(3) allows (Clause 8.9); the Tuirial dam, its reservoir and its release reach to **NEEPCO**, and the Serlui B dam to the **State's power department** (NEER reading); in Lunglei, the municipal drains to the **Lunglei Municipal Council** under the Municipalities Act (no regulation of the Council found [TBC]); the village drains outside the municipalities to the **Village Council**, among whose assignable duties are "Sanitation and drainages" (Mizoram (Village Councils) Act, 2025, s.15(1)(q)); and in a Lai, Mara or Chakma Autonomous District Council area, to the **District Council** and its Village Councils [TBC] (set by this Manual). Each town shall keep a **drain register** that gives every reach its owner under this assignment, the lui or river it reaches, its class on the landslide hazard maps, whether it carries sewage, any flap gate on it and the body that holds the gate, and its outfall (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to the IWRD is transferred to, or secured for, the IWRD. Where a channel's status is disputed, the corridor follows the channel and not its name: Aizawl's lui are at once natural streams, storm drains and carriers of sewage, two of them on the CPCB's list (Clause 8.9). No approved drainage master plan with a design return period was found for any town in the State. A drain sized to fit the land left beside it cannot be enlarged, which is why the reserve is based on the required size. Until a Basin Stormwater Master Plan is adopted (Clause 6.9.6(b)), the required drain size of Clause 6.9.7 is the size computed by the designer under this chapter. This Manual does not prescribe a lined or an unlined section, except where Clause 6.3.6(j) and Chapter 9 require lining on steep gradients, on shale and on fill. 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, where one is allowed, 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 Mizoram and are one of the most common ways that overland flow paths get blocked. The 50% blockage assumption for wall openings is set to match the grate clogging factor of Clause 6.6.3. The 3.5 m access width is set by this Manual, sized for a small excavator or desilting vehicle. For comparison, APWA 5600 (2006, 5608.4) requires a 15 ft (about 4.6 m) maintenance access strip for detention facilities.

6.10 Ponding at sags and low points

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

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

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

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

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

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

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

> **Commentary.** The fully-blocked check, the trapped-sag rule and the underpass requirements have no direct precedent and are set by this Manual. No record of a flooded road underpass in the State was found during research [TBC]. The roads already act as the major system, and in the hills as its steepest part: NH-6 at Hunthar in Aizawl is reported to block in most storms, its cuts were reported unstable in June 2018 and were cut again in Cyclone Remal on 28 May 2024 (all as reported; the press uses the NH-6 and old NH-54 numbers interchangeably); the storm of 24 May–3 June 2025 caused 257 road blockages (DM&R figures, as reported); and landslides from 2017-18 to 2021-22 damaged 219 km of road (CAG, 2025). 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.

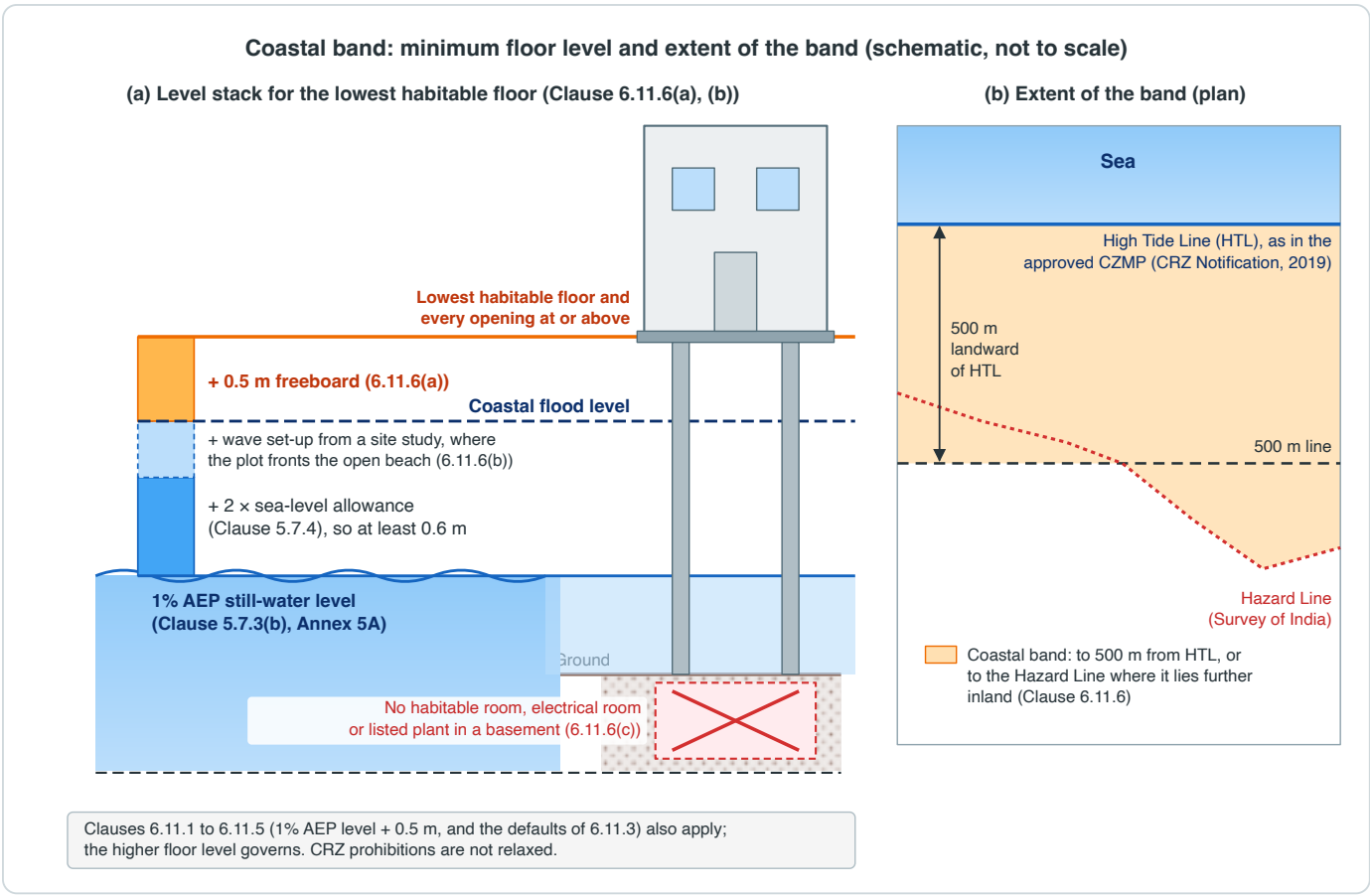


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Mizoram 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 only floor-level rule found is the plinth of the Corporation's building regulations: a plinth "raised above ground level or road level so that adequate drainage of site is assured. This may preferably be not less than 0.45 metre" (AMCBR reg. 26(2)(a)), a drainage rule with no flood level behind it; and engineered site development needs "A drainage plan, including elevations of floors with respect to finish site grade" (SD&SM reg. 6). No highest flood level has been published for any town in the State [TBC], no flood plain zone exists in law (the State told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area"), and the "flood hazard areas as designated and defined by Aizawl Municipal Corporation" that SD&SM reg. 6 asks a site plan to show were not found designated (NEER reading); yet Tlabung, Sairang and the other valley floors flood from their rivers (Clause 5.8.5(c) and (d)). For this Manual, on valley-floor land the 1% AEP flood level of Clause 6.11.2 is computed with the river levels of Clause 5.8.5(c) or (d), or, where none has been computed, taken as the highest flood level surveyed from flood marks with its source stated, and the floor levels of Clause 6.11.1, 0.5 m above the 1% AEP level, govern where they are higher than the plinth of reg. 26(2)(a) (set by this Manual). Clause 6.11.3, which sets the lowest habitable floor and every opening 0.65 m above the road crown where no flood level has been computed, and Clause 6.11.4, which applies the same level, or 0.5 m above the 1% AEP flood level, to the crest of every basement ramp and the sill of every basement opening, are set by this Manual and add to the regulations. On a hillside the road crown is not always the right reference: a building below a road takes the road's runoff, and a building on a slope has "multiple ground floor levels" (AMCBR reg. 3(11)(iii)), so Clause 6.11.2(a) sets the level of each floor and opening on the uphill side from the 1% AEP level of the flow path past it, with the uphill diversion and the drained space against the cut of Clause 6.3.6(l) in place, and a floor or basement cut into a slope also needs the geotechnical certificate of the hill rule of Clause 4.11 and, in the Corporation's area, the engineered site development of SD&SM 2017 wherever its triggers apply. Along the lui and rivers, round the dils and springs (tuikhur) and on the shores of the reservoirs, 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 Mizoram construction-practice requirements

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

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

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

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

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

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

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

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

- (a) be designed under Chapter 9, Clause 9.8;
- (b) have a bypass or overflow, so that a fully blinded screen does not flood properties or the road beyond the limits of this chapter; and

- (c) be checked hydraulically with 50% of its area blocked.

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

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

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

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

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

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

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

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

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of Mizoram 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. In Mizoram the drains are not yet mostly covered: in the Aizawl Urban Area 67% of the area has kutcha drains, 18% has no drainage at all and only 15% has pucca drains (Master Plan for Aizawl: Vision 2030), so the covered roadside drain described above is the drain that Clause 6.13 is written for, not yet the State's usual one, and Clause 6.13 applies to every covered drain built from now on. NDMA (2010) recommends that pre-monsoon desilting be complete by 31 March. In Mizoram that date is also the start of the wet season as this Manual defines it, 1 April to 31 October. IMD's normal date for the onset of the south-west monsoon at Aizawl was not obtained [TBC]; in 2026 the monsoon reached Mizoram about 6 June (as reported), and the normal date of its withdrawal was not obtained either [TBC]. The damaging storms come before the onset: storms on 27–28 April 2026 shut schools in five to nine districts, with 70.5 mm at Serchhip and 55 mm at Hnahthial (as reported); and the deadliest dated rain events in the State all fell in May, the Laipuitlang rockslide in Aizawl on 11 May 2013 (15 May in one paper), the slides of Cyclone Remal on 28 May 2024, among them the collapse of the disused Melthum–Hlimen quarry, and the 598 landslides of 24 May–3 June 2025 (all as reported, the paper excepted). CGWB finds "heavy rainfall during May to late September" (CGWB, Lunglei booklet). Storms also come after the season: "the cyclones of the Post Monsoon season (October to December) are more intense than those of Pre-Monsoon season (April & May)" (NAFCC DPR, 2016), and Chawngte had 130 mm in a day in October 2025 (as reported). The master plan says only that "drains need to be cleaned every year before the onset of monsoon"; no desilting order of UD&PA, the Corporation, a Village Council or a District Council with a completion date was found during research [TBC]. So Clause 6.13.10 refers to the monsoon season as this Manual defines it, and Chapter 10 requires desilting and the clearance of debris, garbage and slide material from drains, lui inlets, catch-pits, racks and culverts, and of the terrace swales, interceptor drains and down-drains of SD&SM reg. 27, to be complete by 31 March, with retaining-wall weep holes and subsurface drains inspected and cleared and flap gates and any pumps certified ready on the same date (Clauses 5.11.5 and 5.12.9); a mid-season clearance of drains, swales, interceptor drains, racks,

culvert inlets and catch-pits by 30 April, after the April storms and before the May storms; standby from 1 April to 31 October; and a post-season clearance of slide debris and silt, with a survey of cut slopes, terraces and retaining walls, by 15 November, so that the drains are clear for a late cyclone. The mid-season clearance is due by 30 April, not by 31 May or 15 May as in the other North-East editions of this series, because the earliest dated deadly storm of May fell on 11 May: a clearance due by 15 May could come after it, and one due by 31 May after all three. These dates are set by this Manual. Mizoram's towns have no snow regime.

Within a municipality no person may build "over any municipal drain, culvert or gutter or bed, bank or embankment of any sewage works or storm water channel vested in the Municipality" (Mizoram Municipalities Act, 2007, s.300). Natural lui are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over: the master plan asks that the "existing drainage alignment within urban area be made permanent and also the natural drainage system be improved and protected" (Master Plan for Aizawl: Vision 2030, 8.3.4). Where a drain is covered, Clause 6.13.2 applies to it in full; where it is open beside a footpath or a carriageway, Clause 6.13.8 applies. In the ridge towns many drains run beside steps and footpaths on steep ground, where an open drain is a fall hazard and a covered one cannot be cleared of stones and waste without its access openings.

Clause 6.13.7 is not yet the practice, and outside one catchment of Aizawl it cannot be until sewers exist. "In absence of sewerage system, people are using septic tanks and soak pits. In most of the places sewage is discharged into open drains without any treatment, which ultimately gets discharged to rivers", and "the sullage (i.e. kitchen and bathroom waste) is discharged into drains which ultimately pollutes the fresh water sources" (master plan). The State estimates 51.81 MLD of sewage against "Existing Treatment Facilities … 10 [MLD] only for Aizawl city", from one plant on the Chite (State report to the National Green Tribunal in O.A. 606/2018, as on 31 August 2025), and the CPCB lists the Chite and Tuikual streams in Priority II (CPCB, 2025). Clause 8.9 sets how dry-weather flow in storm drains is surveyed and intercepted until the connections are removed, including the rule that interception shall not reduce the capacity of the drain (Clause 8.9.5(b)).

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

6.14 Outfalls

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

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

6.15 Submittal requirements

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

1. a catchment plan showing sub-catchments, the minor system, inlet locations and the major-system overland flow paths for the 1% AEP event (Clause 6.3.2);
2. the land-use and road-class AEP adopted for each element (Table 6.1), and the high-density area status;
3. design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3;
4. gutter spread, depth and D·V checks for the minor, check and 1% events (Tables 6.2 and 6.3);
5. an inlet schedule with clean capacity, clogging factor, design capacity and bypass flow (Clause 6.6);

6. pipe and drain design tables with n, velocity, sediment allowance and freeboard (Clause 6.7);
7. HGL profiles for the minor and check events, with the tailwater used (Clause 6.8);
8. sag ponding levels, including the fully-blocked check (Clause 6.10);
9. a floor-level schedule for every building (Clause 6.11);
10. culvert and crossing calculations (Clause 6.12 and Chapter 9); and
11. a utilities-crossing schedule and access-opening layout for covered drains (Clause 6.13).

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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Mizoram 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, Dils (Lakes and 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 (dil) 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 Mizoram, a landlocked State, means Palak Dil, the Pala wetland in Siaha district, the State's one Ramsar site (no. 2484, designated on 31 August 2021 according to its Ramsar Information Sheet, seen only as cited, and announced on 26 July 2022, as reported), Tam Dil near Saitual and the other dils, the Tuirial and Serlui B reservoirs with their drawdown zones, the seepage ground below springs (tuikhur), any marsh or waterlogged ground on the valley floors, such as the Champhai flats, where it holds water (none was surveyed for this Manual [TBC]), and any wetland notified under the 2017 Rules (none was found notified);
- (h) the interface with encroachment and its removal;
- (i) fee-in-lieu contributions to regional tank storage (with Chapter 4); and
- (j) the safety of tank bunds and other embankments.

7.1.2 This chapter applies to every development and public work to which this Manual applies under Chapter 1 and that:

- (a) adjoins a waterbody or lies wholly or partly within its setback (Clause 7.4);
- (b) discharges to a waterbody, directly or through a drain, within the downstream analysis extent of Chapter 5; or
- (c) alters a waterbody, its bund, sluice, surplus weir, supply channel or surplus course.

7.1.3 Where a statute or statutory rule sets a wider setback or a stricter restriction, the statute governs (Clause 1.3.3). Nothing in this chapter authorises any work that the Mizoram Municipalities Act, 2007 and the Aizawl Municipal Corporation Building Regulations, 2012 and Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 made under it, the Mizoram Water Resources (Management and Regulation) Act, 2024, the Mizoram (Village Councils) Act, 2025, the Mizo District (Forest) Act, 1955, the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, if it is in force, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Mizoram has no Act for the protection of lakes, ponds, tanks or springs as such. Its waterbodies are protected, where they are protected at all, by a slope regulation, a building regulation and a municipal Act that reach only the municipal areas, by a water-resources Act and a Village Councils Act that reach the rest of the State outside the three Autonomous District Councils, by a Rivers Ordinance and Bill whose enactment was not confirmed, by the forest law of riverine reserves, by the wetland rules and by the courts. The **Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017** (No. B.13017/75/2016-UD&PA of 4 April 2017) require that for plots beside natural streams "the riverine reserve shall be maintained" (reg. 28), keep

excavated material off "drainage courses or riverine reserves" (reg. 29), and ask site plans to show any "natural streams, riverine reserves or flood hazard areas as designated and defined by Aizawl Municipal Corporation" (reg. 6), but define neither the reserve nor a flood hazard area, and no flood hazard area has been designated (Clause 7.3, Commentary). The **Aizawl Municipal Corporation Building Regulations, 2012**, as amended, keep a septic tank and soak pit 15 m from "a water source" (reg. 33) and set no distance from a stream. Within the Corporation's area "all public tanks, streams, reservoirs, and wells" vest in the Municipality (**Mizoram Municipalities Act, 2007**, s.80(b)). The **Mizoram Water Resources (Management and Regulation) Act, 2024** (Act No. 1 of 2024) defines "community water resources" as "customary common water resources such as springs, ponds, lakes, tanks, traditional water harvesting structures, wells, groundwater or local water bodies by whatever name" (s.2(1)(i)), and gives the Village and Local Water Resources Committees the duty to "Prevent pollution of identified water sources of the village / locality" (ss.9–12); it is the nearest thing in Mizoram to a waterbody Act, but it sets no distance from water and does not extend to the Autonomous District Councils. The **Mizoram (Village Councils) Act, 2025** (Act No. 7 of 2025) makes "tuikhur" a word of the law, "any place wherein water supply is obtained" (s.2(29)), and asks every Village Council to "Conserve water resources within the village area" (s.14(6)). The **Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed**, provide for Protected Rivers and River Conservation Zones in which no construction, obstruction or diversion of a watercourse is allowed without the prior approval of a State Authority; no such Authority is known to have been constituted and no zone has been notified (Clause 7.4, Disclosure). Under the **Mizo District (Forest) Act, 1955** the forest within half a mile of either side of 16 rivers was declared a riverine reserved forest in 1965; that notification was quashed by the Gauhati High Court on 27 January 2021 (as reported). Wetlands come under the **Wetlands (Conservation and Management) Rules, 2017**; no notification constituting a State Wetlands Authority for Mizoram was found [TBC], and the State's one Ramsar site, Palak Dil, lies in the Mara Autonomous District Council area (Clause 7.12, Commentary). In this chapter **IWRD** means the Irrigation and Water Resources Department, whose Chief Engineer is member secretary of WARDMA under the 2024 Act, and **NEEPCO** means the North Eastern Electric Power Corporation Ltd, which holds the Tuirial reservoir, the State's largest standing water, and is the only custodian in the State whose reservoir levels were found in writing (CERC); no tank register of the IWRD was found. Where this chapter speaks of NEEPCO's records, rules or freeboard, the same applies to the custodian of any other reservoir, dil or check-dam pool whose storage is counted: the Serlui B reservoir is taken to be the State power department's (NEER reading [TBC]), and the custodians of the dils and tuikhur are recorded one by one in the inventory (Annex 7A). Who regulates where in the municipalities, the Village Council areas and the Lai, Mara and Chakma Autonomous District Councils, and who is the competent authority for the area in each, is set out in Chapter 1.

This Manual treats every recorded waterbody as drainage infrastructure. Five features set Mizoram apart. The first is the **stream (lui)**: every ridge town drains down its slopes into steep streams, such as the Chite lui, which takes "more than two-third of eastern portion" of Aizawl to the Tuirial, and the Ser lui, into which the western streamlets fall on their way to the Tlawng; the master plan calls the Chite, Chanmari, Theihai, Bethlehem, Tuikhurhlu, Mirawng and Bangla lui "turbulent with high velocities of currents during the monsoon season" and "very destructive", and the Khatla, Tuikual, Vaivakawn and Chanmari west lui "the worst destructive streams and nullahs"; these lui also carry the towns' sewage (Clause 8.9, Commentary). The second is the **spring (tuikhur)**: "Mizoram is an abode of springs", whose water is "widely utilized by people for domestic needs" (CGWB), and in Aizawl "Urbanisation has led to drying up of traditional water sources, like tuikhur" (as reported). The third is the **slope**: in Mizoram the hazard that drainage starts is the landslide, and the bank of a lui is often the foot of a slope that a cut, a fill or a soak pit can bring down, so the corridor along an incised lui is measured from the crest of its bank slope (Clause 7.4). The fourth is the **reservoir**: the Tuirial reservoir of NEEPCO in Kolasib district (full reservoir level 90.5 m) and the Serlui B reservoir, with the reaches below their dams. The fifth is the **valley floor**: the few level places, the river terraces at Tlabung, Sairang, Bairabi and Vairengte and the Champhai flats, are the only places where a river can flood a town, and Tlabung was flooded by the Khawthlangtuipui in 2017, 2019 and 2023 (as reported). The **dils**, the lakes and ponds, are few: Palak Dil, a Ramsar site in Siaha district, and Tam Dil near Saitual, rebuilt as a fishery reservoir (as reported), are the best known. Mizoram has no irrigation tank cascades; the tank clauses of this chapter apply to dils, check-dam pools and reservoirs, and the master plan proposes eight check dams on Aizawl's streams, "below Zuangtui, Sakawrtuichhun, Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen" (Clause 7.7). This chapter gives the

design rules that protect the storage and conveyance of these waterbodies. It does not replace the regulations and Acts above, the customary rules of the villages, the instruments of the District Councils, the wetland rules, or the directions of the Gauhati High Court (Aizawl Bench), the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river or stream (lui in Mizo; lui-pui, a river), such as the Tlawng (Dhaleswari) and the Tuirial (Sonai), which receive Aizawl's streams on the west and the east, the Chite lui, which drains more than two-thirds of eastern Aizawl to the Tuirial, the Ser lui, into which the city's western streamlets fall on their way to the Tlawng, the Tuivai, the Serlui and the Langkaih in the north, the Tiau on the eastern border, the Khawthlangtuipui (Karnaphuli) at Tlabung, the Chhimtuipui (Kaladan), the Tuichang, the Tuichawng and the Mat; drain or ditch (tui luankawr or tui-hawr in Mizo); dil (a lake or pond, natural or dug; dil té, a small pond or tank), such as Palak Dil, the Pala wetland in Siaha district, and Tam Dil near Saitual; reservoir, such as the Tuirial reservoir of NEEPCO and the Serlui B reservoir in Kolasib district, with its drawdown zone; the pool behind a check dam; spring or spring-fed water point (tuikhur in Mizo; hna or tuihna, the source of a stream) with its protected catchment; wetland, marsh or seepage ground; supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (dil)	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 (spillway, overflow or outlet) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling.
Maximum water level (MWL)	The highest water level in a tank when the surplus weir passes the tank's design flood. For this Manual, it is the greater of the level recorded by the IWRD 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 (stream (lui) or feeder channel)	A channel that brings water from a river, anicut or upstream tank into a tank.
Surplus course	The channel that carries the overflow of a surplus weir to the next tank, a river, a drain or the sea.
Sluice (sluice, spillway gate or regulator)	A controlled outlet through a tank bund, usually to an irrigation channel.
Top of bank	For a channel, the break in slope at the edge of the channel. Where it cannot be identified, the edge of the water surface at the 50% AEP (2-yr) flow.
1% AEP flood extent	The land flooded by the 1% AEP (100-yr) flood with the climate factor of Clause 2.8, from a hydraulic model that meets Chapter 3 and Chapter 5, or from a map adopted by the Authority under Clause 7.3.4.
Floodway	The waterbody and the adjoining land that must be kept free of obstruction to pass the 1% AEP flood without raising the 1% AEP water level by more than **0.1 m** at any point (Clause 7.6.1). For a tank, all land below MWL.
Flood fringe	The part of the 1% AEP flood extent outside the floodway.

Term	Meaning in this Manual
Zone 1 (waterbody protection zone)	The inner setback zone defined in Clause 7.4.3.
Zone 2 (flood fringe setback)	The outer setback zone defined in Clause 7.4.4.
Setback	Zone 1 and Zone 2 together.
Compensatory storage	Excavated storage that replaces flood storage lost to fill, under Clause 7.6.4.
Flood cushion	Storage below FTL kept empty, under a documented operating rule, to absorb a flood (Clause 7.8).

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

Term	Meaning in this Manual
Dil	A lake or pond, natural or dug: "(s.) a lake", with *dil té* "(s.) a pond, a tank", in Lorrain and Savidge's *Grammar and Dictionary of the Lushai Language* (1898), and "lake: dil" and "pond: dil, tui tling reng" in Pachuau's *English–Mizo Dictionary* (1997) (Annex 7E). First used in this Manual as "dil (Mizo: a lake or pond; *dil té*, a small pond or tank; plural dils)". The plural "dils" is this Manual's English form, to be confirmed by a Mizo editor: Mizo marks plurals with *-te*, which would be confused with *té*, "small". A dil with a controlled outlet is a tank under Clause 7.2: its outlet gate is its sluice, and its FTL is the level at which it spills over its outlet with any gate closed, found by survey. A dil with an uncontrolled outlet has its FTL at the crest of that outlet. Natural lakes keep their own names, such as Palak Dil and Tam Dil. Engineered storage built under this Manual is a "detention pond", never a dil and never a tuikhur.
Tuikhur	A spring or spring-fed water point: "(s.) a well, a waterhole" (Lorrain and Savidge, 1898) and "fountain: tuikhur" (Pachuau, 1997); in law, "any place wherein water supply is obtained" (Mizoram (Village Councils) Act, 2025, s.2(29)). First used in this Manual as "tuikhur (Mizo: a spring or water point)", and used only for springs and the water points built on them. A tuikhur is a waterbody for Clause 7.3, and its Zone 1 under Clause 7.4 is measured from its outlet or the edge of its tank or chamber. The spring rule of Clause 8.8.1 applies round it: no storm outfall, soakaway or drain discharge within 15 m; no stormwater routed into it or onto the slope immediately above it; no drain, cut or fill that intercepts its flow, buries its outlet or is laid across it; and its catchment above a water point, as a hydrogeologist maps it, is a protected catchment. A tuikhur is protected from stormwater and is never used as storage. These rules are set by this Manual.
Stream (lui); incised lui	A stream or river is a *lui* in Mizo; a large river is a *lui-pui* (Annex 7E). Every lui that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whatever its name, whether it is dry for most of the year, and whether it is lined, piped or covered. An incised lui is one whose channel runs at the foot of a bank slope steeper than 10°; for Clauses 7.4.3 and 7.13.1 its top of bank is the crest of that bank slope, the first marked break in slope above the channel at the top of the bank that the stream has cut, found by survey and shown on Form 7-1, and not the edge of the water or of the active bed. Where no such break can be identified, the top of bank is taken at the edge of the active bed, and the geotechnical report of an engineered site development (SD&SM reg. 26) states whether a wider line is needed. A lui carries boulders, slide debris and garbage in flood: its inlets and culverts take the racks, bulking and blockage of Clause 6.3.6. This definition is set by this Manual.
Reference lines for setbacks	Two lines are used, and the setback that reaches furthest from the water governs: (a) the top of bank of a channel (on an incised lui, the crest of its bank slope), the FTL of a dil or reservoir, or the outlet of a tuikhur, with Zone 1 of Clause 7.4.3 measured from it; and (b) the 1% AEP flood extent of Clause 7.3.4, with the 10 m of Clause 7.4.4 added. Any wider line of a statute, regulation, plan, approval or court governs for the uses it restricts (Clause 7.4.5); the lines that exist, and their status, are in the Disclosure to Clause 7.4. This rule is set by this Manual.
Boundary of a dil or reservoir	For this Manual, the boundary of a dil under Clauses 7.3.3 and 7.13.1 is the largest of its recorded boundary, its surveyed FTL and the outer edge of its water in the season of 1 April to 31 October shown by dated imagery or survey of recent years; and the boundary of a reservoir is the higher of its full reservoir level and the highest level its operator states, stated to the datum of Clause 7.3.5. For the Tuirial reservoir the full reservoir level is 90.5 m and the minimum drawdown level 68.0 m (CERC order in Petition 125/MP/2021), with the datum not stated [TBC]; for the Serlui B reservoir no level was found [TBC], and until its operator states one the boundary is fixed by survey of the highest water line. The drawdown land of a reservoir below that level is part of the reservoir. This reading is set by this Manual.

Term	Meaning in this Manual
Floodplain clauses on the hills	On the hills, which are most of Mizoram, Clauses 7.4 to 7.6 are read as a **stream-corridor and debris-flow** regime: the floodway of a lui is its channel, its bank slopes up to the crest and any debris fan or slide path that reaches it, Zone 1 is the corridor along it, and the hazard to be kept clear is the debris and slide material the lui carries as much as the water. Only on valley-floor land (Annex 2A: land below the 1% AEP flood level of a river, as in sub-areas MZ-A1, MZ-C1 and MZ-D1, at Sairang on the Tlawng and at Chawngte on the Kau) are they read as a floodplain regime, with the 1% AEP extent, the floodway and the flood fringe mapped from a river model. This reading is set by this Manual.
Check-dam pool	The pool behind a check dam on a lui, such as the eight check dams the master plan proposes on Aizawl's streams. It is a tank for this chapter only where its storage is counted under Clause 7.7.1; otherwise it is modelled as an existing feature, assumed full of sediment and water at the start of every design storm, and kept clear under Clause 7.9.
Landholder	The holder of the land of a waterbody or its setback where it is not public land: a private owner, the holder of a land pass or settlement from the Land Revenue and Settlement Department, the holder of a site allotted by a Village Council, or, in the Lai, Mara and Chakma Autonomous District Council areas, the holder under the District Council's land law [TBC]. Zone 1 land that is not public land is reserved in the master plan or secured for this Manual by a written agreement with the landholder, and is not taken; in an Autonomous District Council area this is done only through the District Council [TBC]. This rule is set by this Manual.

7.3 Inventory and mapping of waterbodies

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

- (a) its type (Clause 7.2), name and survey numbers;
- (b) its custodian (the Aizawl Municipal Corporation (for the public tanks, streams, reservoirs and wells and the public drains within its area, which vest in it under sections 80 and 289 of the Mizoram Municipalities Act, 2007), the Lunglei Municipal Council (in its area), PWD or a national-highway agency (for the drains and culverts of their roads), the IWRD (for rivers, minor irrigation and flood works), PHED (for water-supply sources and intakes), NEEPCO (for the Tuirial reservoir and the reach below its dam), the State's power department (for the Serlui B reservoir and the reach below its dam [TBC]), the Fisheries Department (for Tam Dil, as reported), EF&CC (for forest land, riverine reserves and wetlands), the Land Revenue and Settlement Department (for land records and land passes), a Village Council with its Village or Local Water Resources Committee under the Mizoram Water Resources (Management and Regulation) Act, 2024 (for the tuikhur, drains and water bodies of a village or notified town outside the municipalities), in the Lai, Mara and Chakma Autonomous District Council areas the District Council and its Village Councils (for Palak Dil, which coincides with the Pala Wetland Reserve Forest in the Mara Autonomous District Council area, the forest authority and the District Council [TBC]), a private owner or land-pass holder, a developer (for the drains of a layout until they are handed over), the State Wetlands Authority (for a notified wetland; none was found), or another body);
- (c) its boundary as recorded in Revenue records;
- (d) for tanks: FTL, MWL, TBL, the surplus weir crest length and type, sluices, the supply channel and the surplus course, each with its datum;
- (e) its position in any tank cascade, with the upstream and downstream tanks;
- (f) the 1% AEP flood extent, where mapped; and
- (g) known encroachments, with the date recorded.

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

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

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

- the Revenue record boundary;
- the surveyed FTL or top of bank;
- the MWL contour (tanks) and the 1% AEP flood extent;
- Zone 1 and Zone 2 (Clause 7.4); and
- every supply channel, surplus course, sluice and surplus weir.

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

- (a) land records and maps of the Land Revenue and Settlement Department, which keeps the land records and still administers land use inside the Aizawl Municipal Corporation's area (CAG, 2025), with the land passes and settlement records it issues (none of them was read for this Manual [TBC]); the allotments of house sites and other land made by Village Councils under the Mizoram (Village Councils) Act, 2025; in the Lai, Mara and Chakma Autonomous District Council areas, the land records of the District Councils, which hold and settle the land there (the Lai Autonomous District Council (Land Holding and Settlement) Act, 2002 is known only from a snippet, and none of these records was read [TBC]); the public tanks, streams, reservoirs, wells and drains that vest in the Aizawl Municipal Corporation under sections 80 and 289 of the Mizoram Municipalities Act, 2007; the land use maps of the Master Plan for Aizawl: Vision 2030, with its "W" use zone of rivers, streams, springs, ponds, lakes, wetland and water catchment area, its streams, which the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 take as the definition of a "Stream", and its map of drains and catchments (Map 8.3, not extracted for this Manual [TBC]); the Corporation's Landslide Hazard Maps and MIRSAC's landslide hazard zonation atlas for Aizawl and selected towns; the water-resources mapping that the Mizoram Water Resources (Management and Regulation) Act, 2024 requires within five years (s.17), when it is done; NEEPCO's records of the Tuirial reservoir's levels and land; any inventory of springs (tuikhur), of which none was found for Aizawl [TBC]; and each town's drain register (Chapter 6);
- (b) NEEPCO and Village Council 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 NEEPCO records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> **Commentary.** Mizoram has no flood map, no flood line and no flood plain law. The State told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area and hence actions pertaining to such flood plain zones is irrelevant" (MPCB's report in O.A. 593/2017 and 673/2018). That holds for the ridges, but not at the valley floors: the Khawthlangtuipui flooded Tlabung in June 2017, when about 350 houses in the sub-division were reported submerged (another report counts 9 fully and more than 60 partly submerged), in July 2019, when about 400 houses, 150 of them in the town, were reported flooded, and in August 2023, when 40 families were evacuated; in June 2018 families were stranded at Sairang on the Tlawng; the

Tlawng at Bairabi and the Tiau at Champhai also flood (all as reported). No flood plain zoning law was found, and the "flood hazard areas as designated and defined by Aizawl Municipal Corporation" that SD&SM reg. 6 asks site plans to show have not been designated (none was found); the master plan leaves "Regulations for land use zoning for natural hazard prone areas", shown as "no development zone", to the Zonal Development Plans, whose regulations were sent to the Government on 17 May 2023 and had not been approved by September 2023 (CAG, 2025). What exists is a landslide map, not a flood map: the Corporation's Landslide Hazard Maps, "created in 2014 or later to the standards adopted by the Landslide Policy Committee for Aizawl City", decide the track of every site development permit, and MIRSAC's atlas of landslide hazard zonation covers Aizawl and selected towns. The rivers are hardly gauged: CWC has seven level-monitoring sites in Mizoram, five of them inactive, no forecasting site, and no warning or danger level for any of them; the only highest flood level printed is 149.0 m for the Tuirial at "Turial", set on 17 June 1995 (SANDRP's transcription of CWC tables, as reported). No source read for this Manual states the datum of that level, and how it relates to the Tuirial reservoir's full level of 90.5 m (CERC) is not stated [TBC]; neither is inferred here. No highest flood level has been published for any Mizoram town [TBC], and the only floor rule in the regulations is a plinth "preferably … not less than 0.45 metre" above ground or road level "so that adequate drainage of site is assured" (AMCBR reg. 26(2)(a)). The best evidence of flood extent on the valley floors is therefore on the ground: the flood marks at Tlabung, Sairang and Bairabi and the evidence of residents. Clause 7.3.4 lets the Authority adopt flood maps once they exist; until then the Applicant produces the 1% AEP extent for valley-floor land and for larger and flood-sensitive sites, with the bulking of Clause 6.3.6 on the lui and the surveyed flood marks and tailwater of Clause 5.8.5(c) and (d). This Manual maps the 1% AEP extent on valley-floor land and offers it as an input to any future designation, not as a zone; on the hills its corridor is a stream corridor measured from the crest of the bank slope (definitions after Clause 7.2). Levels shall be stated to one datum (Clause 7.3.5), and the gauge and datum named for every level used. Clause 7.3.3 makes the larger of the recorded and surveyed extents govern, because the Revenue boundary and the surveyed water edge often differ, and either may have been reduced by encroachment. The 100 m search band in Clause 7.3.2 is set by this Manual.

7.4 Setbacks

7.4.1 **Waterbodies to which setbacks apply.** Setbacks apply to:

- (a) every waterbody recorded under Clause 7.3.1 or found under Clause 7.3.3, whatever its size; and
- (b) every natural channel, whether recorded or not, that drains **8 ha** or more at the site.

7.4.2 **Two zones.** The setback has two zones, shown in Figure 7.1:

- **Zone 1 (waterbody protection zone)**, next to the waterbody; and
- **Zone 2 (flood fringe setback)**, outside Zone 1.

7.4.3 **Zone 1 width.** Zone 1 is measured outward from the FTL contour (tanks, lakes and ponds) or from the top of bank (channels). Where both apply, use whichever gives the wider zone. Zone 1 extends to the **greatest** of:

- (a) **15 m**, the minimum set by this Manual along every natural channel draining 8 ha or more and round every dil, reservoir and spring (tuikhur), measured from the top of bank or, on an incised stream (lui) whose bank is a slope steeper than 10°, from the crest of that bank slope (wider lines govern under Clause 7.4.5 where they bind: neither the Aizawl Municipal Corporation Building Regulations, 2012 nor the Site Development and Slope Modification Regulations, 2017 set a distance from a stream, and the second requires only that "the riverine reserve shall be maintained" (reg. 28), without defining it; the master plan's 15 m green buffer along major drainage channels is a recommendation; the 800 m belt along the Tlawng lost its legal basis when the Riverine Reserved Forest notification of 1965 was quashed in 2021 (as reported) and is not used; no River Conservation Zone has been notified under the Rivers Ordinance and Bill of 2023, whose enactment was not confirmed; and no flood plain zone or flood hazard area has been designated; 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 prior approval of the State Authority for construction, obstruction or diversion of a watercourse in a River Conservation Zone under the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed (no Mizoram River Protection Authority is known to have been constituted and no zone has been notified); a direction of WARDMA or of a District, Village or Local Water Resources Committee for a community water resource, such as a spring or pond, under the Mizoram Water Resources (Management and Regulation) Act, 2024 (outside the Autonomous District Councils); the written permission of the Aizawl Municipal Corporation for a drain into one of its drains or into any water-course (sections 295 and 296 of the Mizoram Municipalities Act, 2007); a condition of the Corporation's site development permit, including the riverine reserve of SD&SM reg. 28 and the setbacks of reg. 26; a declaration by a Village Council, with the District Disaster Management Authority's approval, of an unsafe site for house construction (s.13(6) of the Mizoram (Village Councils) Act, 2025); the consent of NEEPCO or of the State's power department for a work that drains to, or lies next to, the Tuirial or Serlui B reservoir or the reach below its dam; the consent of EF&CC for a work in a riverine reserve, reserve forest or wetland; a condition of a District Council in its area (none was found [TBC]); or a direction of the Gauhati High Court (Aizawl Bench), the National Green Tribunal or the Supreme Court sets a setback wider than Zone 1 or Zone 2, the wider setback governs for the uses it restricts.

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

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

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

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

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

> Commentary. The 15 m minimum is set by this Manual, as the floor of a hydraulic corridor where no wider line binds. Mizoram has no metric distance from a stream or spring in its building or site-development regulations; the lines that exist are a recommendation, an undefined reserve, a belt whose basis was quashed and a Bill. The Master Plan for Aizawl: Vision 2030 recommends "a 15 meters wide green buffer on both sides" of the major drainage channels; the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 require that "the riverine reserve shall be maintained" for plots beside natural streams (reg. 28) but do not define it; the master plan's 800 m green belt on either side of the Tlawng rested on the Riverine Reserved Forest notification of 1965, which the Gauhati High Court quashed on 27 January 2021 (as reported), and is not used in

this Manual; and the River Conservation Zones of the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, have not been notified. The only distance from water in the regulations is the 15 m that a septic tank and soak pit keep from "a water source" (AMCBR reg. 33). The 15 m floor takes the master plan's figure for major channels and extends it to every natural channel draining 8 ha or more and round every dil and spring. On an incised stream (lui) whose bank is a slope steeper than 10°, the threshold of the hill rule of Clause 4.11, it is measured from the crest of that bank slope, not from the edge of the water, because a slide of the bank starts at its crest and a cut, a fill or a soak pit near the crest can bring it down (set by this Manual). It applies to new development and redevelopment approved under this Manual, not to existing buildings; and where Zone 1 land is private or held under a land pass, it is reserved in the master plan or secured by agreement with the holder, not taken (in an Autonomous District Council area, only through the District Council [TBC]). It is this Manual's proposal, not a statutory width, and it never reduces a wider line (see the Disclosure below). Extending the setback to the mapped 1% AEP extent plus a margin follows the Kansas City Metro APWA Section 5600 (2025.01) two-zone structure:

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

(MARC, APWA 5600 Policy Supplement, Nov 2025.) Clause 7.4.1(b) adopts the 8 ha trigger. This Manual's 10 m margin is wider than APWA's 10 ft and has no direct precedent. This Manual sets it because Mizoram flood maps are mostly coarser than US maps, where they exist at all (none was found for any Mizoram town), and the only level land in a Mizoram town is usually a river terrace or valley floor, such as those at Tlabung, Sairang, Bairabi and Vairengte, the paddy flats of the Champhai valley, or the margin of a dil or reservoir (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).

Mizoram's lines along water are a plan recommendation, an undefined reserve, a forest belt whose basis was quashed, a Bill, a septic-tank distance and a set of slope lines; neither of its regulations sets a metric distance from a stream (NEER reading). Each binds only where it applies, and its status is stated here as this Manual uses it. **(a) The master plan's 15 m.** "All along the major drainage channels, a 15 meters wide green buffer on both sides have also been recommended" (Master Plan for Aizawl: Vision 2030). It is a recommendation of the plan. No approval notification of the plan was found (one source says it was approved in March 2013; unverified), but since the amendment of 2023 the Corporation's online permit system returns any proposal "not as per the provisions of the AMC Building Regulations, 2012 and the Master Plan for Aizawl, Vision-2030", so the plan is checked against in practice; which channels are "major" is not defined. **(b) The 800 m belt along the Tlawng.** "All along the river Tlawng an 800 m green belt on either side from the centre of the river has been kept reserved as per the Mizo District (Forest) Act, 1955, section 14 read with section 21" (master plan). Its legal basis, the notification of 28 January 1965 that declared the forest within half a mile of either side of 16 rivers a reserved forest, was quashed by the Gauhati High Court (Aizawl Bench) on 27 January 2021 on petitions by land-pass holders; an executive notification of April 2021 is reported to have set an 800 m restricted zone from mid-river with development by prior approval (its text was not read); the State's writ appeal was dismissed as withdrawn on 9 November 2022; a special leave petition was filed, with its outcome not found; and the Supreme Court issued notice to the State and

NHIDCL in April 2024 over works in riverine reserved forests (all as reported). The 800 m is **never a statutory buffer** in this Manual and is not used to set Zone 1; an Applicant states on Form 7-1 whether any restriction from the April 2021 notification applies to the site. **(c) The riverine reserve.** "For plots adjacent to or including natural streams, the riverine reserve shall be maintained, and measures shall be taken to prevent erosion of materials or sediment from the site into the stream or riverine reserve" (SD&SM reg. 28); excavated material is kept off "drainage courses or riverine reserves" (reg. 29). "Riverine reserve" is not defined in the regulations (NEER reading), and no width was found. **(d) River Conservation Zones.** The Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, would bar any person from constructing or undertaking "any developmental activity … including obstruction or diversion of the water course or channel, or issue or obtain land pass of any kind in the protected river or river conservation zone" without the State Authority's prior approval, with exemptions that include "bridges and culverts, check dams, waterholes" (s.15(1)(a) of the Bill), and would let the State regulate catchments beyond the zone "for the prevention of landslips or of the formation of ravines and torrents" and "for the maintenance of water supply in springs, streams and rivers" (s.16); they do not extend to the Autonomous District Councils. No Protected River or River Conservation Zone is known to have been notified. **(e) The septic-tank distance.** A septic tank and soak pit "shall not be located within a radius of 15 metres from a water source" (AMCBR reg. 33). It is the only metric distance from water in the regulations, and it governs septic systems, not buildings or drains. **(f) The slope lines.** No site development permit is issued "for a project located in an area with slopes greater than 60 degrees" (SD&SM reg. 14); site development is engineered, with a geotechnical report, in Moderate, High and Very High landslide hazard zones, where the plot is unmapped and its slope is 24° or more, and for large or high cuts and works that support a structure, and no exemption is allowed "within three meters of any slope of 24 degrees or more" (SD&SM reg. 4); and the master plan's "SL" zone covers "areas with slope higher than 36°, areas adjacent to major drainage lines", with "development on slope more than 36 degree should be strongly discouraged", words the High Court quoted in July 2024 (as reported). Outside the Corporation's area none of these regulations applies: no Lunglei Municipal Council regulation was found [TBC], the model building bye-laws of the Village Councils Act have not been framed (none was found), and no instrument of the Lai, Mara or Chakma Autonomous District Council on building or drainage was found. Clause 7.4.7 makes 15 m the floor of Zone 1 wherever this Manual applies.

Disclosure. Mizoram **has no metric distance from a stream, dil or spring in any statute or regulation found**: its building and site-development regulations set none (the second asks only that "the riverine reserve shall be maintained", without a width); the master plan's 15 m along major drainage channels is a **recommendation**; the 800 m belt along the Tlawng **lost its legal basis** when the riverine reserved forest notification of 1965 was quashed in 2021 (as reported); **no River Conservation Zone has been notified** under the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed; and **no flood plain zone or flood hazard area has been designated** anywhere in the State. The **15 m minimum** Zone 1 of Clauses 7.4.3 and 7.4.7, and every value derived from it in Table 7.1, is **set by this Manual** as a hydraulic corridor where nothing wider binds: along every natural channel draining 8 ha or more, round every dil, reservoir and spring (tuikhur), and, **on an incised lui whose bank is a slope steeper than 10°, measured from the crest of that bank slope**. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, this Manual's two reference lines, its reading of the boundary of a dil or reservoir and of the core's floodplain clauses on the hills as a stream-corridor and debris-flow regime, and the spring rule (definitions after Clause 7.2; Clause 8.8.1). They are **this Manual's proposal, not a statutory width or rule**, and no government body, municipal body, Village Council or District Council has adopted or endorsed them. The 15 m is the master plan's figure for major channels, extended to every channel the Manual covers and to dils and springs. It applies to **new development and redevelopment approved under this Manual, not to existing buildings**; Clause 7.4.7 allows no variance below it; and where Zone 1 land is private or held under a land pass, it is **reserved in the master plan or secured by agreement with the holder, not taken** (in an Autonomous District Council area, only through the District Council [TBC]). The setback is applied

as **whichever of the two reference lines and its setback reaches furthest**, so the Manual is **stricter than statute** along every stream, dil and spring, and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The regulations of the Aizawl Municipal Corporation.** The riverine reserve of SD&SM reg. 28, wherever the Corporation fixes its width for a site; the setbacks of SD&SM reg. 26 from the top of a cut and the toe of a fill, which "may need to be increased for any required interceptor drains"; the permit tracks of SD&SM regs. 4 and 14 (engineered development in Moderate, High and Very High landslide hazard zones and on unmapped slopes of 24° or more; no permit above 60°); and the 15 m between a septic tank or soak pit and "a water source" (AMCBR reg. 33), which this Manual's spring rule also takes as its distance for storm outfalls. They apply only in the Corporation's area.
- **The master plan.** The 15 m green buffer along major drainage channels, the "SL" zone of slopes above 36° and of "areas adjacent to major drainage lines", and the "W" use zone of rivers, streams, springs, ponds, lakes, wetland and water catchment area (Master Plan for Aizawl: Vision 2030): **recommendations of the plan**, checked against by the Corporation's online permit system since 2023; the Applicant states them on Form 7-1. The 800 m belt along the Tlawng is **not used**: its legal basis was quashed in 2021, and any restricted zone under the executive notification of April 2021 (text not read [TBC]) is stated on Form 7-1 if it applies to the site, never as a statutory buffer.
- **The Rivers law, if it is in force.** A River Conservation Zone, with the State Authority's prior approval for construction, obstruction or diversion of a watercourse in it, governs as a statutory line under Clause 7.4.5 only once the law is confirmed in force and a zone is notified; neither has been confirmed.
- **The water-resources and village laws.** The duties of the Village and Local Water Resources Committees to "Prevent pollution of identified water sources" and to protect catchments under the Mizoram Water Resources (Management and Regulation) Act, 2024, and any declaration by a Village Council, with the District Disaster Management Authority's approval, of an "unsafe site for house construction for mitigation of landslide" (Mizoram (Village Councils) Act, 2025, s.13(6)); neither sets a distance, and neither extends to the Autonomous District Councils.
- **Wetlands, forests, courts and custodians.** Any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was found) and the Pala wetland, a Ramsar site (Clause 7.12); reserve forest and forest land under EF&CC; the orders of the Gauhati High Court (Aizawl Bench), the National Green Tribunal and the Supreme Court as they stand; NEEPCO's lines at the Tuirial reservoir and the State power department's at Serlui B; and any line of a District Council (none was found [TBC]).

This Manual sets 15 m as the floor because Mizoram's regulations give its streams no distance at all, because a lui in a ridge town is the end of every drain above it and carries their water, sewage and slide debris in the same channel (Clause 8.9, Commentary), because 15 m is the master plan's own figure for major channels and the regulations' own distance from a water source, and because 15 m is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled. The crest of the bank slope is the line on an incised lui because a slope that fails into a stream fails from its crest: the Directorate of Geology and Mining attributed two-thirds of the large landslides it investigated in 2022-23 to "improper drainage" (as reported), and the purpose clause of SD&SM 2017 names "disposing of sewerage and drainage onto slopes in a poorly controlled manner" among the activities that "can greatly increase slope instability". Until a statute, rule, notification, master plan, District Council instrument or court adopts it, the 15 m minimum is this Manual's recommended standard, and the instruments above remain the only legal minimum. Approving authorities should state in each approval which was applied.

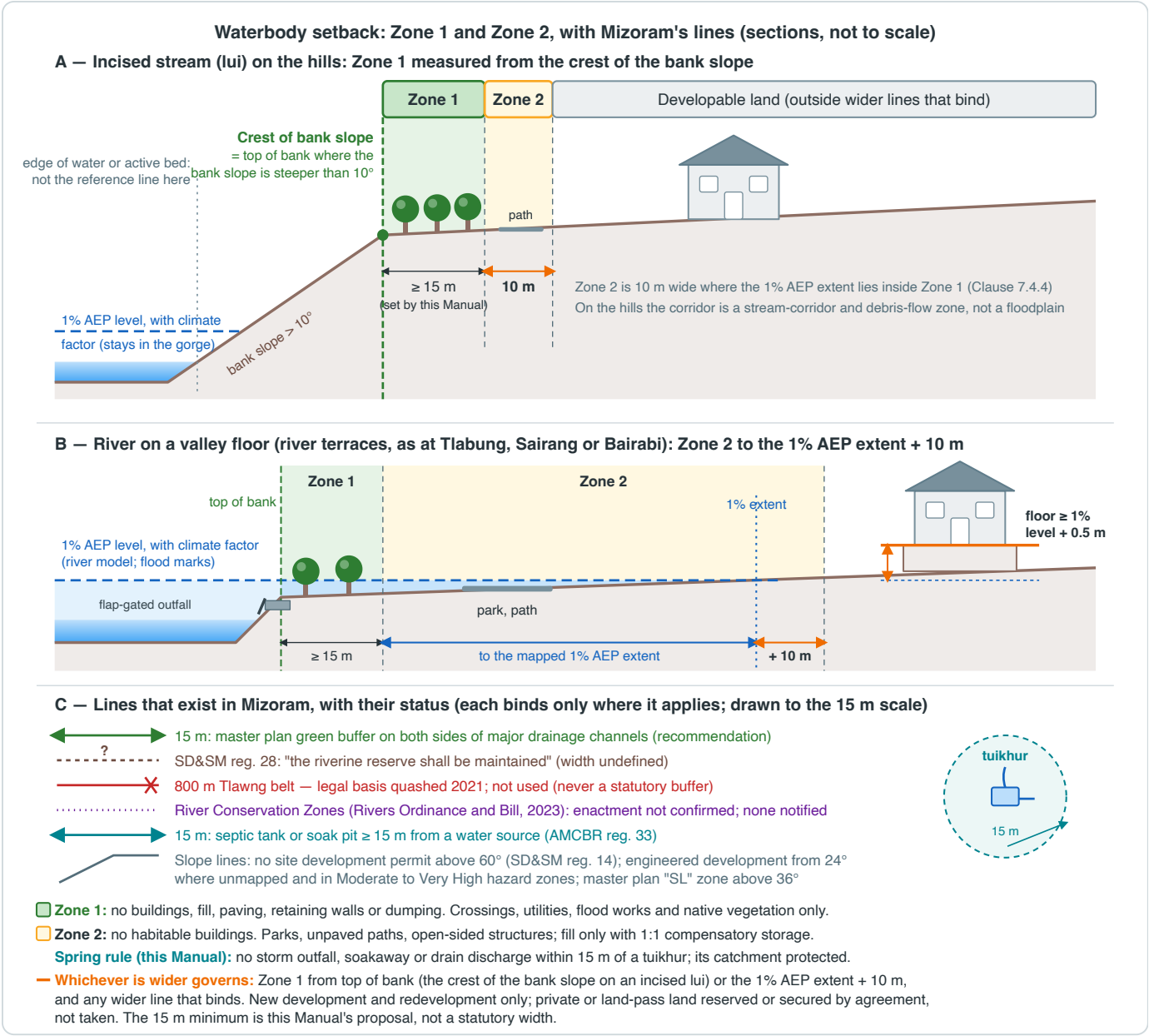

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

7.5 Uses permitted in each zone

7.5.1 **Zone 1.** No building, fill, paving, retaining wall, boundary wall, compound wall, dumping of earth, debris or solid waste, storage of materials, or construction-stage stockpile shall be placed in Zone 1. Only the following are permitted, each subject to the custodian's NOC:

- (a) road, rail and utility crossings that meet Clause 7.10.3;
- (b) flood and drainage works: outfalls, inlet structures, gross pollutant traps, sluices, surplus weirs, bund strengthening and bank protection;
- (c) native vegetation, planting and habitat works;
- (d) unpaved or permeable footpaths and maintenance tracks at existing ground level; and
- (e) waterbody restoration under Clause 7.9.

7.5.2 **Zone 2.** No habitable building, basement, school, hospital, fuel store or hazardous-material store shall be placed in Zone 2. The following are permitted:

- (a) all uses permitted in Zone 1;
- (b) parks, playgrounds, open-air sports fields and urban agriculture;
- (c) open-sided structures (shelters, pavilions) with no walls that obstruct flow;
- (d) surface parking with permeable surfacing at existing ground level, where the 1% AEP flood depth is not more than 0.3 m;
- (e) retention, detention and water quality facilities under Chapters 4 and 8, provided they are outside the floodway and their storage is not counted twice (Clause 7.6.5); and
- (f) fill, only for (a) to (e) or for essential public infrastructure, and only with compensatory storage under Clause 7.6.4.

7.5.3 **Fences.** Fences in Zone 1 and Zone 2 shall be open (chain-link or railing) with no plinth wall above existing ground level, so that they do not obstruct flow or trap debris.

7.5.4 **Open space reservation.** Zone 2 land may be counted toward the open space required by the Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017, where the Authority agrees. Zone 1 land shall be handed over to the custodian or kept free of private use, as the Authority decides.

> **Commentary.** The permitted uses follow APWA 2025.01: in Zone 1, only utility and road crossings; in Zone 2, linear utilities, trails and open-sided structures; no clearing, grading, fill or paving in either zone without approval (MARC Supplement, 2025). Clause 7.5.2 adds parks and playgrounds, the uses URDPFI (2015) allows in the 10-year flood zone. The ban on walls in Clauses 7.5.1 and 7.5.3 responds to hill-town 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. Mizoram's valley floors, the river terraces at Tlabung, Sairang, Bairabi and Vairengte and the Champhai flats, are flat, unlike the slopes around them, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Mizoram no high water level has been mapped for any dil, and no statute measures a setback from one, so the line from which a dil's or reservoir's setback is measured must come from this Manual. The difference matters most at the reservoirs, whose levels move through the year: the Tuirial reservoir is operated between a full reservoir level of 90.5 m and a minimum drawdown level of 68.0 m (CERC order in Petition 125/MP/2021; datum not stated [TBC]), so a line drawn from the edge of the water at a low level would leave up to 22.5 m of the reservoir's own drawdown land open to building, and no level at all was found for the Serlui B reservoir [TBC]. The same is true, on a smaller scale, of a dil that shrinks in the dry months from November to March. This Manual gives every dil and reservoir a boundary measured from a high level, not from the water's edge on the day of survey: the edge of a dil in the season and the full or highest stated level of a reservoir 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 valley-floor towns, whose houses stand on river terraces that the rivers have flooded, though no flood extent has been mapped for any of them (NEER reading), such as Tlabung on the Khawthlangtuipui, where about 350 houses in the sub-division were reported submerged in June 2017 (another report counts 9 fully and more than 60 partly submerged) and about 400 houses, 150 of them in the town, in July 2019 (as reported), Sairang on the Tlawng,

Bairabi and Vairengte in the north, and the Champhai flats, 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.

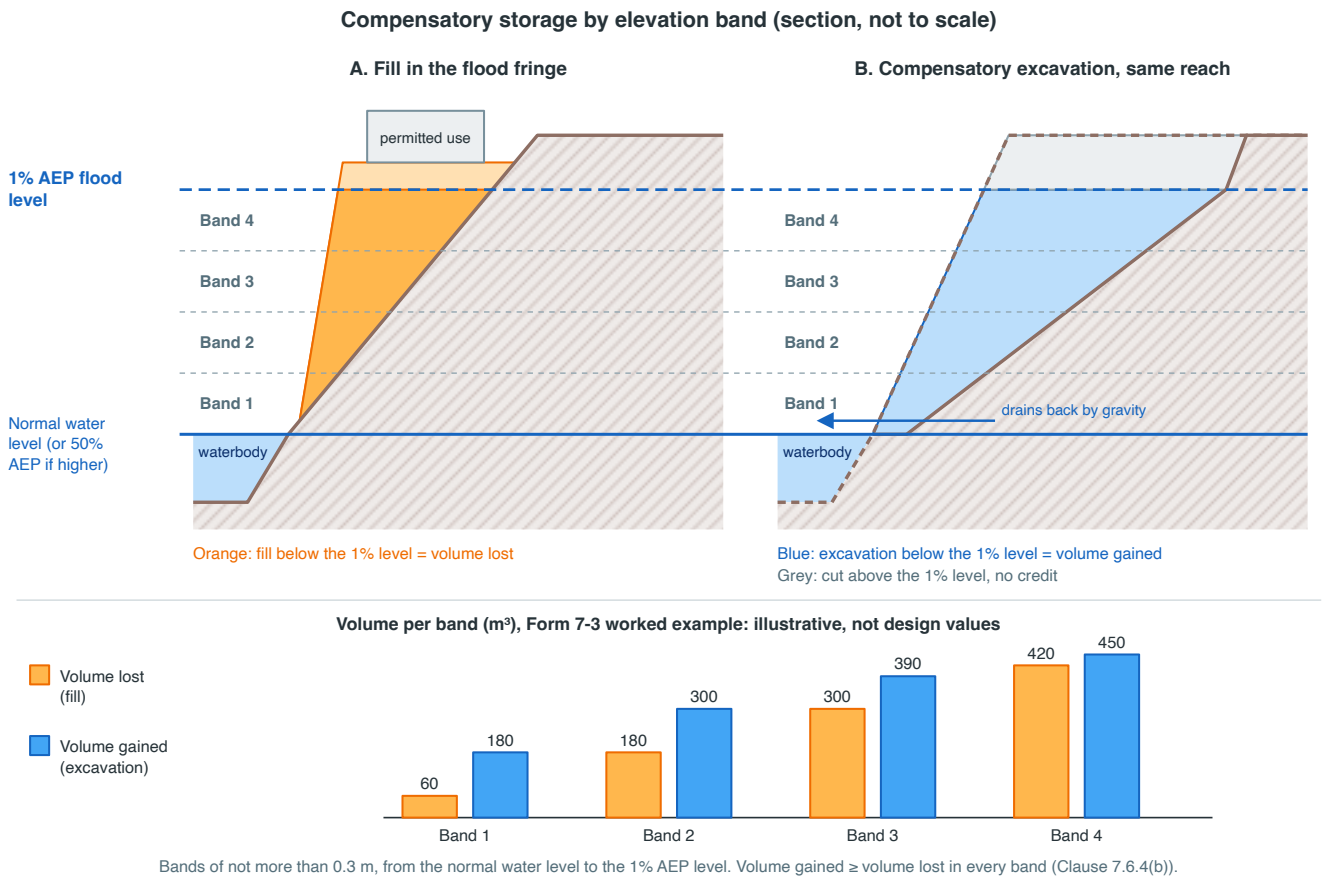

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation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

Mizoram has no tank Act and no irrigation tank cascades, and its standing waters range from the small tanks of spring water points to the Tuirial reservoir. The storages that matter for urban drainage are of five kinds. The first is the reservoirs, the State's largest waterbodies: the **Tuirial reservoir** of NEEPCO's Tuirial hydro-electric project on the Tuirial (Sonai) in Kolasib district, held by a zoned earth-fill dam 75 m high with an open chute spillway, with a full reservoir level of 90.5 m, a minimum drawdown level of 68.0 m and a normal tailwater level at full load of 30.7 m (CERC order in Petition 125/MP/2021; datum not stated [TBC]); and the **Serlui B reservoir** on the Serlui in Kolasib district, behind a dam reported to be 51.3 m high and 293 m long (as reported), for which no full or maximum level was found [TBC]. Their releases enter a design as inflow and tailwater (Clause 5.8.5(e)), and they are not tanks for these clauses unless their storage is counted. The second is the **dils**: Palak Dil, the Pala wetland in Siaha district, a Ramsar site of about 1,850 ha with a water body of about 135 ha and an average depth of about 20 m (as cited from its Ramsar Information Sheet and as reported), and Tam Dil, about 6 km from Saitual, rebuilt as a fishery reservoir by the Fisheries Department (as

reported; area not found [TBC]); no levels, outlet records or areas at FTL were found for either [TBC], so their storage is modelled as an existing feature and not counted unless Clause 7.7.1 is met, and Palak Dil, a Ramsar site, is never used as storage for a development. The third is the **check-dam pools**: the master plan proposes eight check dams on Aizawl's streams, "below Zuangtui, Sakawrtuichhun, Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen", and the Rivers Bill would exempt "check dams" from its ban on works in a River Conservation Zone; no design, height or storage was found for any of them [TBC], and on a steep lui a check-dam pool fills with sediment and debris, so it is modelled as full and is not counted as flood storage unless Clause 7.7.1 is met. The fourth is the **village and town ponds and tanks** (dil té), which are modelled as existing features where they intercept runoff but are never counted as storage, because they are not surveyed, have no controlled outlet and are full by the time of the peak storm. The fifth is the **springs (tuikhur)** and the tanks built on them, which are protected for their water and never counted as storage. These are the waterbodies for which Figure 7.3 and Clause 7.8 matter: in a ridge town every drain ends in a lui and every lui in a river, a reservoir or a valley floor. Any dil, check-dam pool or reservoir whose storage is to be counted is subject to Clause 7.7.1 in full, with its custodian (NEEPCO, the State's power department, the IWRD, the Fisheries Department or another), and the custodian of each dil shall be confirmed for the inventory (Annex 7A) [TBC].

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

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

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

7.7.2 **Modelling.** Tank cascades shall be modelled under Clause 3.12.5 (level-pool routing of each tank, with surplus weir and sluice ratings) and Clause 3.13 (continuous simulation). The whole cascade, from the uppermost tank whose surplus can reach the site or facility to the next river, major drain or sea outfall, shall be modelled together, including, for a ridge town, every drain, terrace swale and down-drain that falls from the ridge and its slopes to the stream (lui) below, any dil or check-dam pool with its inlets and outlet, the springs (tuikhur) on the slope with their protected catchments, and the stream itself down to the river, reservoir or valley floor whose level sets its tailwater (Clause 5.8.5), as shown in Figure 7.3.

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

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

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

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

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

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

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

> Commentary. This Manual allows tank cascades to be used as design storage subject to three basic conditions (surveyed FTL, a documented operating rule and maintained surplus weirs). Clause 7.7.1 adds the stage–storage survey and the custodian's concurrence, because the storage a tank actually offers depends on its silt level and on who controls the sluices. The 5-year survey interval is set by this Manual.
>
> The FTL starting level follows Clause 3.12.5. In Mizoram a dil, check-dam pool or reservoir may be full at any time in the Manual's season of 1 April to 31 October, and the storms that matter come in runs of days. The deadliest dated rain events fell in May, before or at the monsoon's onset (the Laipuitlang rockslide in Aizawl, 11 May 2013 in the press and 15 May 2013 in one paper; Cyclone Remal, 28 May 2024; and the storm of 24 May to 3 June 2025, with 598 landslides in eleven days, as reported); Serchhip district had 677 mm in 1–13 June 2018 (SANDRP, as reported); and the cyclones of October to December "are more intense than those of Pre-Monsoon season (April & May)" (NAFCC DPR, 2016). No record of how long Palak Dil, Tam Dil or any village dil stays at or above its outlet level in a wet spell was found, and NEEPCO's operating levels for the Tuirial reservoir through the season were not obtained [TBC]. While a dil or reservoir is full, it stores nothing more below FTL, the lui that flow into it discharge against its level, and its release adds to the flow in the stream below it. 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.

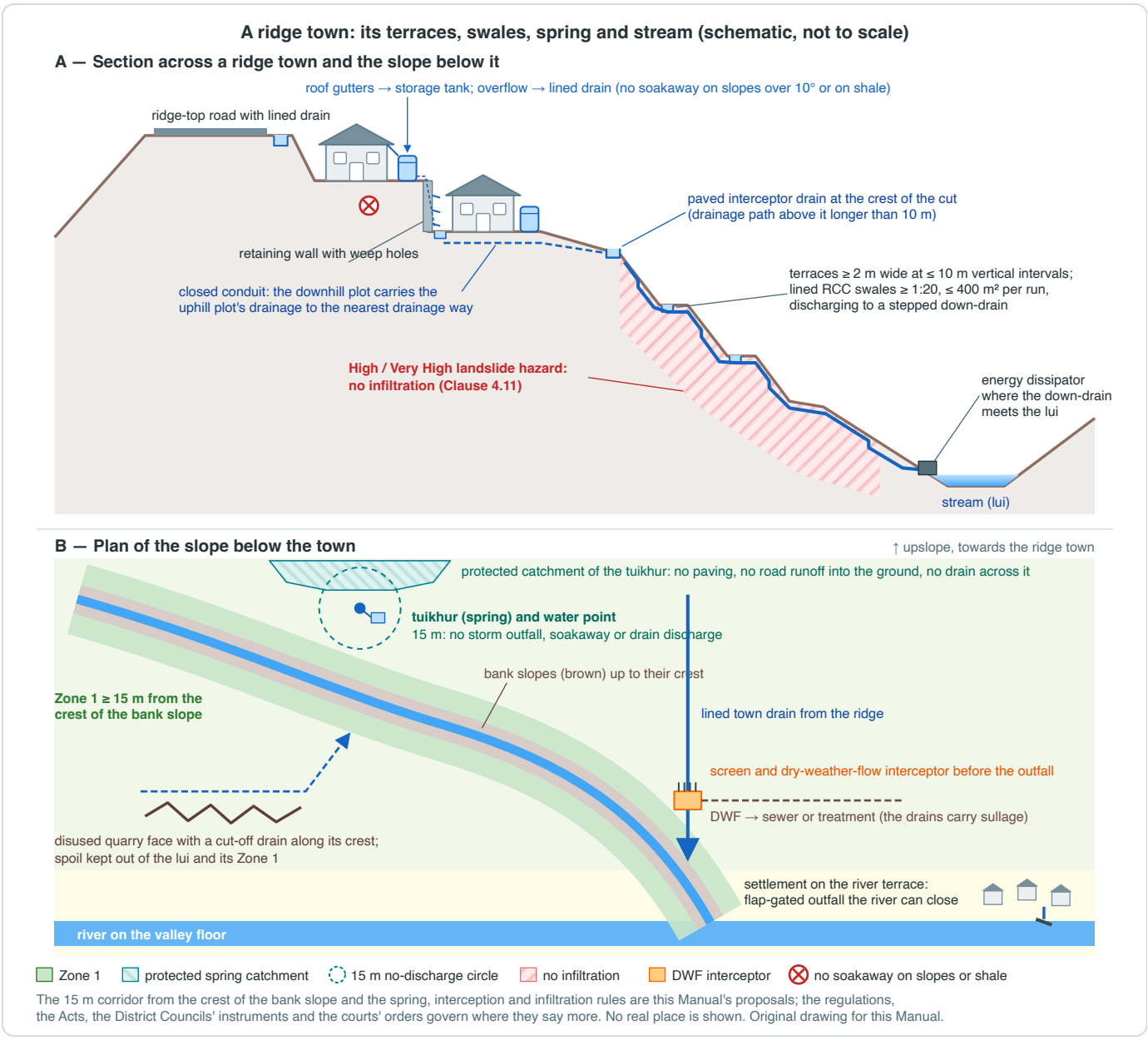

Figure 7.3 — A ridge town: its terraces, swales, spring and stream (schematic, not to scale; no particular town, stream, spring or landmark is shown). A: in section, the town stands on a ridge, the catchment divide, with its road along the crest and plots stepping down the slope. The road drain is lined. Roof water goes by gutters to a storage tank on each plot (Chapter 4), and the tank's overflow goes to a lined drain, because no soakaway is placed on a slope steeper than 10° or on shale (Clause 4.11, hill rule). A cut slope has a paved interceptor drain along its crest where the drainage path above it is longer than 10 m, and the cut and fill slopes have terraces at least 2 m wide at vertical intervals of not more than 10 m, with lined swales at a gradient of at least 1:20, no single run draining more than 400 m², discharging to a stepped down-drain (SD&SM reg. 27). Retaining walls have weep holes. A downhill plot carries the drainage of the plot above it in a closed conduit to the nearest drainage way (SD&SM reg. 27; AMCBR reg. 37). The down-drain ends in an energy dissipator where it meets the stream (lui), because every outfall onto a slope or into a steep lui needs one (Clause 6.3.6). Ground in a High or Very High landslide hazard zone receives no infiltration at all. B: in plan, below the town a spring (tuikhur) supplies a water point; its catchment above, as a hydrogeologist maps it, is protected, with no paving and no road runoff led into it, no drain is laid across it, and no storm outfall, soakaway or drain discharge lies within 15 m of it (Clause 8.8.1). The lui has Zone 1 of at least 15 m measured from the crest of its bank slope (Clause 7.4). The outfall to the lui carries a dry-weather-flow interceptor and a screen, because the drains carry sullage (Clause 8.9). A disused quarry face above the stream has a cut-off drain along its crest, and its spoil is kept out of the lui. The lui runs down to a river on a valley floor, where a settlement on the river terrace drains through a flap-gated outfall that the

river can close (Clause 5.8.5(c)). The 15 m corridor from the crest of the bank slope, the spring, interception and infiltration rules are this Manual's proposals; the regulations, the Acts, the District Councils' instruments and the courts' orders govern where they say more. Original drawing for this Manual.

7.8 Operating rules and pre-monsoon flood cushion

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

- (a) the levels and dates for filling, holding and drawdown through the year;
- (b) the sluice and regulator settings at each level;
- (c) who operates the sluices and regulators, and who may order a release;
- (d) the maximum release rate, set so that the release, added to the flow from the downstream catchment, does not cause flooding of buildings downstream;
- (e) the forecast and warning triggers (IMD district warnings, MSDMA alerts, and city forecast systems where available) and the actions taken at each trigger;
- (f) communication with downstream ULBs and residents before any release; and
- (g) the records to be kept: daily levels in the monsoon, releases, and gate settings.

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

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

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

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

> **Commentary.** No dil in Mizoram was found with a written operating rule, and most dils have no gates to operate. NEEPCO's operating rules for the Tuirial reservoir and the State power department's for Serlui B were not obtained [TBC]; the only levels found are the Tuirial reservoir's full and minimum drawdown levels (CERC). A dam-break study of the Tuirial dam is reported to have routed a peak of 3,035.34 m³/s "near the confluence" (IAHR abstract of 2025, as reported); no release schedule or warning procedure for either dam was read. Without an agreed rule with dates, levels, release rates and a named operator, storage in a dil or reservoir cannot be relied on, and a release made without warning to the settlements downstream is itself a flood. Clause 7.8.2 turns that principle into a rule that can be checked, with a reliability test, because a cushion that is refilled by the April and May storms gives no protection when a June to August monsoon storm, such as that of mid-June 2018, arrives after weeks of rain. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.
>
> For a natural dil, Clause 7.8.3 is the governing condition: with no controllable outlet, no cushion is assumed, a design that relies on the dil routes the storm through it from its outlet level, and the outflow over the outlet is limited by the lui below it, which shall be shown to carry it with the debris of Clause 6.3.6. For a reservoir, a design takes the operator's level and release for the storm being checked (Clause 5.8.5(e)), not a drawdown the operator

has not agreed to in writing. Palak Dil is a Ramsar site and is not drawn down for flood storage; Tam Dil is a fishery reservoir, whose drawdown would need the Fisheries Department's acceptance under Clause 7.8.2(d); and the tanks of springs (tuikhur) are water supply, never flood storage. That is why no detention pond built under this Manual is called a dil or a tuikhur.

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 Mizoram Pollution Control Board (MPCB) directs.

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

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

> Commentary. No Mizoram order fixing a date for the pre-monsoon cleaning of drains, lui or dils was found; the master plan says only that "drains need to be cleaned every year before the onset of monsoon", finds that Aizawl's drains are "silted up frequently due to insufficiency in the hydraulic design", and records that only "8% of the villages have open drains with regular maintenance and 40% with periodic maintenance" while 52% have none. In the ridge towns the material to be removed is slide debris and garbage as much as silt: the master plan blames the water-logging of 33% of Aizawl's ward W-I "for several days or for hours" on solid waste in the road-side drains. The date of 31 March in this Manual is set by this Manual, before its season begins on 1 April, because

> Mizoram's deadliest dated rain events came in May and storms that shut schools in five to nine districts came on 27–28 April 2026 (as reported); because the earliest of the May events, the Laipuitlang rockslide, came on 11 May 2013, the drains, racks, inlets and check-dam pools are cleared again by 30 April, and after the season by 15 November, before most of the October to December cyclone window (Chapter 10). Excavation to "increase capacity" is governed by Clause 7.9.3. In a dil fed by springs in its bed, deepening can cut the springs off or break the silt and clay that hold the water; this Manual allows no spring-fed dil and no tuikhur tank to be deepened below its original bed or its bed to be lined or cemented, and no work in Palak Dil, a Ramsar site, under this clause except as the wetland authority and the District Council permit. The 31 March deadline matches the pre-monsoon inspection date of Chapter 10. The limits on deepening are set by this Manual. Deepening tanks to "increase capacity" is common, but it can breach the silt and clay layer that holds water in the tank, it can let polluted urban water reach the aquifer, it can draw salt water toward the coast, and it creates storage below the sluice sill that never empties and gives no flood benefit. Deep pits with steep sides are also a drowning hazard. The slope and bench values in Clause 7.9.4 are adapted from common pond-safety practice; they have no Mizoram 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 Mizoram the drains and streams within the Corporation's area vest in it: "all public tanks,

streams, reservoirs, and wells" and "all public sewers and drains channels, tunnels, culverts and watercourses in, alongside, or under, any street" (Mizoram Municipalities Act, 2007, s.80(b) and (d)), and "All public drains, and all drains in, alongside, or under any public street, whether made out of Municipal Fund or otherwise" (s.289(1)). The Municipality "shall provide and maintain a system of drainage or sewerage as well as a safe and sufficient outfall" (s.288); all drains, private or public, are "under the survey and control of the Board of Councillors" (s.290); no drain may enter a municipal drain or "any water-course" without written consent (s.296); and no building, wall, fence or other structure may be built "over any municipal drain, culvert or gutter or bed, bank or embankment of any sewage works or storm water channel" vested in the Municipality (s.300). Roads were never devolved to the Corporation (CAG, 2025), so PWD builds and keeps the drains of State roads in practice, though on the statute the same drains vest in the Corporation; this Manual states the overlap and does not resolve it. Outside the municipalities "Sanitation and drainages" is a duty that may be assigned to a Village Council (Mizoram (Village Councils) Act, 2025, s.15(1)(q)); in the Autonomous District Council areas the drains are the District Councils' and their Village Councils' [TBC]. No rule or order dividing streams (lui) from municipal drains was found; Chapter 6 gives this Manual's working split and each town's drain register. The record of Aizawl shows a network that is mostly unbuilt and that runs into the lui: "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all. Only 15% of the area is provided with pucca drains" (master plan), and the plan proposes that the "existing drainage alignment within urban area be made permanent and also the natural drainage system be improved and protected with treatment facilities at the outfall points". None of these keeps a lui at its recorded width once it has been lined, piped, covered, built over or filled with debris or garbage, which is the failure Clauses 7.10.2 and 7.10.3 are written to prevent. Clause 7.10.3(b) prevents a crossing from narrowing a channel to its current, encroached width.

7.11 Fee-in-lieu and regional tank storage

7.11.1 Where a basin plan has been notified, and the Authority has adopted alternative S-5 of the Policy Supplement (Clause 1.7), a development may pay a fee in lieu of on-site detention under Chapter 4. The fee shall be applied to restoring or creating storage in a tank, pond or regional facility in the same basin.

7.11.2 Tank storage funded by fee-in-lieu shall:

- (a) meet Clause 7.7.1 in full before it is counted;
- (b) be downstream of the contributing development and upstream of the flood-prone area it is meant to protect;
- (c) be created, or under construction, before the development it serves is occupied, or within a period the basin plan fixes; and
- (d) be recorded in the register of Clause 10.17 with the developments that funded it, so that the same volume is not sold twice.

7.11.3 Fee-in-lieu does not replace:

- (a) the retention requirement of Chapter 4, which is always met on site; or
- (b) the water quality requirement of Chapter 8, which is met on site or in a regional facility treating the same runoff before it reaches the tank.

Commentary. Chapter 4 provides for fee-in-lieu toward restored dil 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 Mizoram no shared form of storage is required by the regulations: regulation 33 of the 2012 Building Regulations requires "a suitable rain water harvesting facility" in all buildings but sets no volume, the green-building chapter of 2025 makes rainwater harvesting an incentive, and neither regulation has a detention, peak-flow or design-storm rule (Chapter 4). The plans for Aizawl's streams are for conveyance and check dams, not regional storage: the master plan proposes permanent drain alignments, "treatment facilities at

> the outfall points" and eight check dams, and no storm-drain project of the Smart City, AMRUT or the ADB programme for Aizawl was found. In the ridge towns there is little flat land on which a regional pond could be built, and none may be built on a slope where Clause 4.11 bars infiltration; a regional facility there is a lined tank or a lined detention structure, not a pond, and it is never called a dil. 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 State Wetlands Authority that those Rules provide for (no notification constituting one for Mizoram was found [TBC]);
- (b) any wetland notified under the 2017 Rules, to its notified boundary (none was found notified in Mizoram), and Palak Dil, the Pala wetland in Siaha district, a Ramsar site (no. 2484), to the boundary of the Ramsar site;
- (c) Tam Dil and the other dils, the Tuirial and Serlui B reservoirs with their drawdown zones, the seepage ground below springs (tuikhur), and any marsh or waterlogged ground on the valley floors, such as the Champhai flats, where it holds water, within the 1% AEP extent of Clause 7.3.4 (a river, stream or reservoir itself is a waterbody under the rest of this chapter); and
- (d) any other dil, marsh or wetland that the Authority notifies, that the wetland authority lists, or that the Gauhati High Court, the National Green Tribunal or the Supreme Court directs to be protected.

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

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

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

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

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

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

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

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

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

Commentary. Mizoram's one Ramsar site is **Palak Dil**, the Pala wetland in Siaha district, in the Mara Autonomous District Council area: Ramsar site no. 2484, designated on 31 August 2021 according to its Ramsar Information Sheet (seen only as cited) and announced on 26 July 2022 (as reported), a site of about 1,850 ha that coincides with the Pala Wetland Reserve Forest of 1998, with a water body of about 135 ha and an average depth of about 20 m (as cited and as reported). The full Information Sheet was not read [TBC]. **Tam Dil**, about 6 km from Saitual, was rebuilt as a fishery reservoir by the Fisheries Department (as reported); its area and status were not found [TBC]. No notification constituting a State Wetlands Authority for Mizoram, and no wetland notified under rule 4 of the Wetlands (Conservation and Management) Rules, 2017, was found [TBC]. The master plan puts rivers, streams, springs, ponds, lakes, wetland and "Water catchment area" in its "W" use zone and recommends stopping the dumping and earth filling of water bodies; it gives rivers, streams and water bodies 585 ha, 3.83% of the plan area. The springs are the State's most used waterbodies, and spring-shed work has begun: a study of 20 springs supported by GIZ, with the Forest Department as nodal agency for a pilot of 100 springs and technical partners for the hydrogeology, and the revival of six springs in Serchhip and Lunglei districts by a non-government programme (all as reported); no count of Aizawl's tuikhur was found [TBC]. A drain outfall, desilting, diversion or gate operation in or next to Palak Dil, a notified wetland or forest land therefore needs the views or permission of the wetland authority, EF&CC or the District Council where they reach it, as well as compliance with this chapter; for the dils, springs and marshes that no rule reaches, this chapter and the duties of the Water Resources Committees under the 2024 Act are the only controls. Clause 7.12.2 targets a specific risk: drains built to relieve flooding next to a marsh can drain the marsh itself, and once it is dry it is encroached. Sewage reaches Mizoram's lui and rivers through the drains (Clause 8.9, Commentary). The State has 10 MLD of treatment, "only for Aizawl city", against 51.81 MLD of sewage, and the CPCB's list of 2025 names the Chite and Tuikual streams in Priority II, the Lawibual stream in Priority III and the Tuipui in Priority V. Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by most existing outfalls in Aizawl. In Mizoram they apply in full to every new outfall, and every existing outfall to a lui on the CPCB list, to a dil or within the catchment of a tuikhur is taken to carry dry-weather flow and comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed. In the catchment of a dil, every drain that enters the water also passes a sediment trap and a solid-waste trap first (Figure 7.3; Clause 6.3.6), because the dil is the end of the slope's drainage and has no other way to lose the silt and garbage; and no drain discharges within 15 m of a tuikhur at all (Clause 8.8.1).

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. Mizoram's controls on building beside its streams and on its slopes have come partly from the courts. In a suo motu public interest litigation on a letter from the INTACH Mizoram Chapter, the Gauhati High Court (Aizawl Bench) directed in July 2024 that "no new construction activity shall henceforth be allowed on either side of the Bawngkawn – Durtlang (Leitan) road", kept in abeyance the Corporation's approvals beyond the first floor, exempted retaining walls built to prevent landslides, and quoted the master plan's "development on slope more than 36 degree should be strongly discouraged"; a single-bench order of 23 November 2023 in a petition of 2020 had asked UD&PA, the Revenue Department and the Corporation to consider whether construction should be allowed on that road (all as reported; case numbers not found [TBC]). On the rivers, the High Court quashed the riverine reserved forest notification of 1965 on 27 January 2021 on petitions by land-pass holders, the State's writ appeal (W.A. 8 of 2021) was dismissed as withdrawn on 9 November 2022, and the Supreme Court issued notice to the State and NHIDCL in April 2024 over works in riverine reserved forests (all as reported). Before the National Green Tribunal, in O.A. 593/2017 and O.A. 673/2018, MPCB reported a River Rejuvenation Committee constituted on 5 December 2018 and reconstituted on 12 May 2020, a State Level Monitoring Committee under the Chief Secretary (No. C.18013/2/2020-I&WR/243 of 21 July 2020), an action plan for the State's polluted rivers, and a compensation regime adopted on 5 May 2020 under which "no compensation has been levied till date" (MPCB report, February 2021). In the Corporation's area no structure may be built over a municipal drain or storm-water channel (Mizoram Municipalities Act, 2007, s.300), and the Ward Committees are to detect "illegal construction, encroachments on municipal and public properties" (Ward Committee and Local Council Rules, 2010); the master plan recommends stopping the dumping and earth filling of water bodies. No record of encroachment on any lui, dil or tuikhur was found [TBC]. This Manual cannot evict anyone. It can stop designs from treating encroachment as permanent (Clause 7.13.2), make public works restorable to full width (Clause 7.13.3), and make the setback visible on the ground and in property documents so that new buyers know it is there (Clause 7.13.4). The 30 m marker interval is set by this Manual.

7.14 Safety of tank bunds and embankments

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

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

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

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

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

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

- (a) the surplus weir or spillway shall pass the 1% AEP inflow at MWL with the freeboard of Clause 7.7.4(b), and shall be checked for the 0.2% AEP (500-yr) inflow without overtopping the bund (as for detention basins in Chapter 4);
- (b) a breach analysis shall map the area flooded by a breach at MWL;
- (c) an emergency action plan shall be prepared, with the warning and evacuation arrangements for the breach area; and
- (d) the design shall be certified and independently checked under Clause 10.6.

7.14.4 **Inspection.** Every tank whose storage is counted under Clause 7.7, and every high-hazard embankment, shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Chapter 10) for seepage, slips, cracks, animal burrows, trees on the bund, and blockage of the weir and sluices.

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

> Commentary. The definition of a specified dam is quoted from the Dam Safety Act, 2021 (Act 41 of 2021). The Act defines a "dam" as an artificial barrier constructed across rivers or tributaries to impound or divert water. It excludes flood embankments, dikes and guide bunds. No dil in Mizoram was found to be held by a bund high enough to be a specified dam, though the bunds and outlets of Tam Dil and the other dils were not surveyed for this Manual [TBC]; each outlet work, bund and check dam shall be screened under Clause 7.14.1, and none of the eight check dams that the master plan proposes for Aizawl has a known height [TBC]. The dams of the Tuirial and Serlui B reservoirs are dams across rivers under the Act: the Tuirial dam, a zoned earth-fill dam 75 m high (CERC), and the Serlui B dam, reported to be 51.3 m high (as reported), are both above the 15 m of Clause 7.14.1(a). Where the storage of a dil, check-dam pool or reservoir is counted under Clause 7.7, its bund, outlet works 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 Mizoram the embankments that matter to the towns and villages are the dams of the Tuirial and Serlui B reservoirs, and the hazard below them is the release and the breach. A dam-break study of the Tuirial dam is reported to have routed a peak of 3,035.34 m³/s "near the confluence" (IAHR abstract of 2025, as reported); its inundation map, NEEPCO's emergency action plan, and any release schedule or warning procedure for either dam were not read for this Manual [TBC]. A failed or overtopped bund floods the land below it, and a release made without warning floods it too, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments, why the release reach below the Tuirial dam is a flood-sensitive catchment (Chapter 1), and why Chapter 5 treats every release reach as a flood-sensitive outfall (Clause 5.8.5(e)). 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.

References (chapter)

- Government of Mizoram, Urban Development and Poverty Alleviation Department. *Aizawl Municipal Corporation Building Regulations, 2012* (published as the Aizawl Municipal Council Building Regulations, 2012), Notification No. B.13017/8/2012-UD&PA of 20 December 2012 (Mizoram Gazette Extraordinary Vol. XLII, Issue No. 4, 10 January 2013), regs. 1, 3, 5, 21, 22, 26, 33 and 37, https://amcmizoram.com/uploads/files/amc-building-regulations_21042017023756.pdf ; as amended in 2019 (No. B.13017/8(2)/2018-UD&PA; draft public notice of 10 April 2019 read, final gazette not read), 2023 (No. B.13017/8/2021-UD&PA/Pt of 14 August 2023; Gazette Extraordinary Vol. LII, Issue No. 459, 28 August 2023), https://amcmizoram.com/uploads/files/Building%20Regulation%20Amendment%202023_31102023011032.pdf , and 2025 (No. B.13017/8/2021-UD&PA/Loose of 21 November 2025), https://amcmizoram.com/uploads/files/Notification-%20AMC%20Building%20(Amendment)%20Regulations,%202025_20012026031957.pdf
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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

Annex / Form	Content
7E	Glossary of Mizo waterbody terms and regional variants
Form 7-1	Waterbody Sheet
Form 7-2	Tank Storage Credit Sheet
Form 7-3	Compensatory Storage Calculation (by elevation band)

CHAPTER 8

Water Quality and Recharge

8.1 Purpose and scope

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

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

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

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

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

8.2 Definitions

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

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

8.3 Objectives and pollutants of concern

8.3.1 Stormwater treatment under this Manual shall aim to:

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

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

Table 8.1 — Pollutants of concern, sources and primary controls

Pollutant	Main sources in Mizoram 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 Mizoram 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 Mizoram, 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 Mizoram 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 Mizoram, 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.

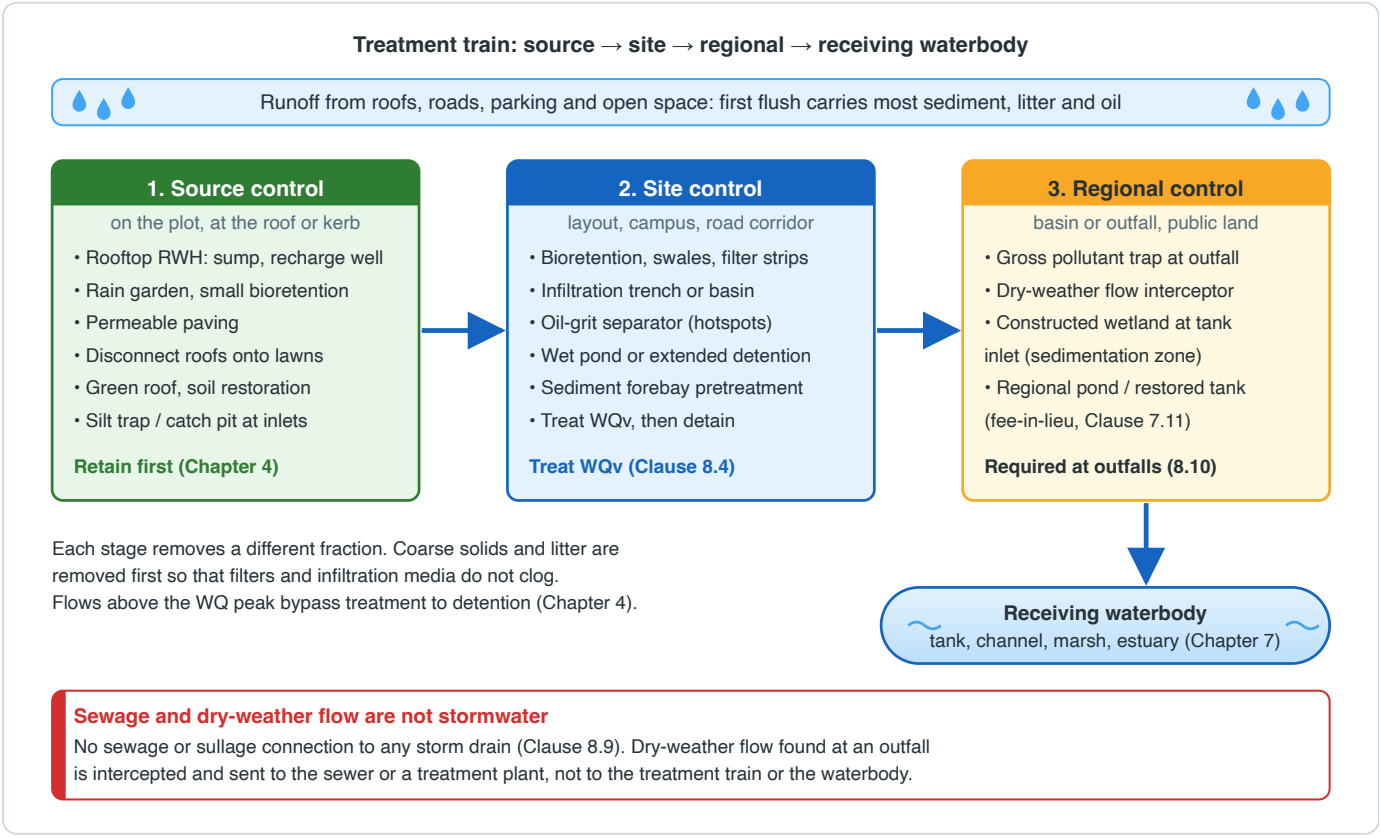


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater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

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Valley alluvium and river terraces	Laterite / hard rock	Hill slopes over 10°, shale, colluvium and fill / high water table	Mizoram 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	Valley alluvium and river terraces	Laterite / hard rock	Hill slopes over 10°, shale, colluvium and fill / high water table	Mizoram 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 Mizoram 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. Mizoram 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.

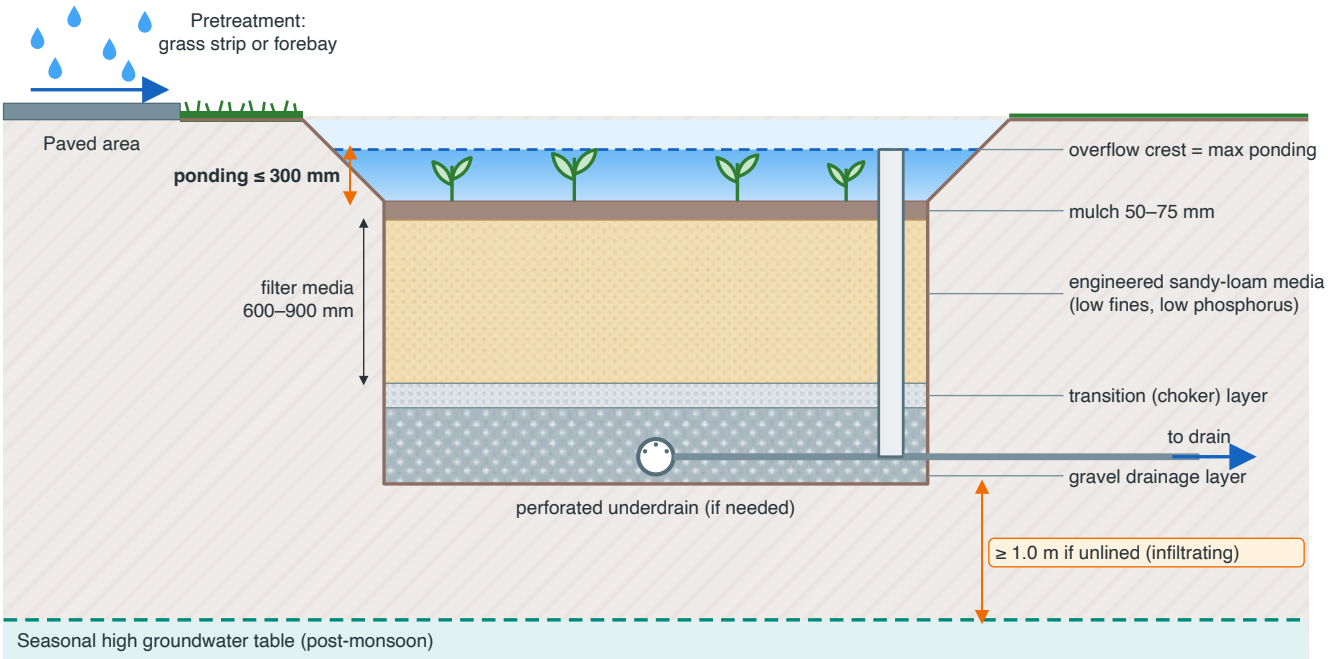
> **Commentary.** The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in Mizoram. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Mizoram. 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 Mizoram's rain falls in the monsoon season of 1 April to 31 October: the CGWB records "heavy rainfall during May to late September" (Lunglei), August brings the largest share of the year's rain, 16.8%, and January the smallest, 0.4% (Lallawmzuali and Muniyan, 2024), so the months from

November to March are nearly dry (NEER reading). In those months the springs still give "3,000 to 20,000 liters per day" in January to March (CGWB, Lunglei); 27.16% of the households of the Aizawl Urban Area use rain water and 1.01% spring water (master plan), so stored roof water and springs carry the towns through the dry months. In the towns the feed of a drain, lui or dil in the dry months is often sewage, because the drains carry it (Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool through the dry months on its own catchment's runoff is not to be used; in the ridge towns, where Clause 4.11 bars infiltration on slopes and shale and there is little flat land, the practical forms are lined bioretention with an underdrain, swales on gentle ground, storage for use, and lined extended dry detention. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage or spring water; dils, tuikhur, reservoirs and wetlands are waterbodies under Chapter 7 and are not to be used as treatment for a development. Wet ponds that dry out turn into stagnant pools or are used for dumping. Clause 8.7.8 requires a water balance and bans topping up with sewage, which is a common practice for keeping urban ponds "full".

- **Litter and silt.** GPTs and silt traps are treated as essential, not optional, because Mizoram drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

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

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



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

Dimensions as set in Clause 8.7.2.

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

8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Mizoram, which has no coastal sand areas (Clause 8.8.9). For this Clause the seasonal high groundwater table is the highest level found from April to November, which covers the season of 1 April to 31 October and the month after it (Clause 3.10.2). Mizoram needs the two rules of Clause 4.11 here, and the spring rule of this Manual, and Clause 8.8.1 applies with the following. **(i) No infiltration on hill ground (Clause 4.11, hill rule).** No deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, unlined bioretention, or permeable paving with an exfiltrating base) shall be built or credited on natural ground sloping more than 10°; on the shale, siltstone or mudstone of the Surma group, at any slope; on colluvium, fill, cut-spoil or slide debris, whatever its slope; in a mapped Moderate, High or Very High landslide hazard zone; or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope; and in a High or Very High landslide hazard zone not at all, whatever certificate is offered. The ridges of the Bokabil and Bhuban units are "characterized by low permeability and infiltration" and act as a "run off zone" (CGWB), and "Lithological units comprising shale and siltstone are more susceptible to landslide than the hard and compact sandstone unit" (MIRSAC). On such sites roof runoff goes to rainwater storage credited under Chapter 4, and its overflow and all other runoff go by a lined drain through a silt trap and an energy dissipator to a stable natural channel, never onto an unprotected slope; the exception for roof water in Clause 8.11.3(c) does not apply, and no infiltration is credited toward retention or the WQv. The hooks are the purpose clause of the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017, which names "increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner" among the human activities that "can greatly increase slope instability", its regulation 27 (subsurface drainage "as necessary for stability") and regulation 26 (control of "subsurface water, such as springs"), and the Roadmap to Stability (2014), which asks that "all septic tanks, leach fields and soak pits within Aizawl City" be eliminated. Regulation 33 of the Aizawl Municipal Corporation Building Regulations, 2012 requires "a septic tank of appropriate capacity with soak pit" for every water closet, which on hazard slopes is the practice the Roadmap would eliminate: this Manual puts no stormwater into a soak pit and says so; it does not override regulation 33. **(ii) Recharge only on tested valley alluvium and terraces (Clause 4.11, recharge rule).** Recharge is not a design objective in Mizoram: the State drew 3.52% of its groundwater in 2011 (CGWB) and 3.95% in the assessment of 2024, with all 26 assessed units Safe (as cited), and the "Areas Notified for Regulation of ground water development" are "NIL" (CGWB). Deliberate recharge is allowed only on tested valley alluvium and river terraces (the Champhai flats, and the terraces at Tlabung, Bairabi and Vairengte and along the Tlawng), on flat ground of 10° or less away from slopes and above the 1% AEP flood level, with pretreatment, the field test of Clause 8.8.3, a seasonal high water table at least 2.0 m below ground and the separation of this Clause; never on valley-floor land below the 1% AEP flood level, in Zone 1 or Zone 2 of a dil (Chapter 7), within 15 m of a tuikhur, or where the water table is within 2.0 m of the ground, as it is in the small valley ponds where CGWB found water "within 2.0 m below ground level" (Lunglei). The Mizoram Water Resources (Management and Regulation) Act, 2024 has the IWRD "promote rain water harvesting to augment ground water recharge" (s.14(1)(b)(viii)) and lets WARDMA direct "water conservation and groundwater recharge, including rain water harvesting" (s.16(2)(ix)); on hill ground this Manual reads both as storage and reuse, not recharge, and says so. **(iii) Springs (tuikhur): the spring rule.** No storm outfall, soakaway or drain discharge lies within 15 m of a tuikhur; stormwater is not routed into a tuikhur or onto the slope immediately above it; no drain, cut or fill intercepts the flow to a spring, buries its outlet or is laid across it; and the catchment of a spring above a water point, as a hydrogeologist maps it, is a protected catchment, in which no paving is laid except for access, no road runoff is led into the ground, and no soak pit or septic tank is placed. The 15 m is set by this Manual on the 15 m that regulation 33 keeps between a septic tank or soak pit and "a water source"; the hooks are the Village and Local Water Resources Committees' duty to "Prevent pollution of identified water sources" under the 2024 Act, whose "community water resources" include springs (s.2(1)(i)), and the Village Councils' duty to "Conserve water resources within the village area" (Mizoram (Village Councils) Act, 2025, s.14(6)). **(iv) Quality.** No runoff from quarries, quarry spoil, industrial yards or roads with heavy traffic is led to any recharge structure, and a recharge well or shaft on the valley alluvium is used only for roof water or for runoff that has passed a filtering BMP, after a hydrogeologist's report confirming the depth to water, the receiving zone, and that no drinking-water well, spring or intake within 30 m will be harmed. The 10° trigger, the shale condition, the distance of twice the wall height, the 2.0 m limit, the spring rule and

these conditions are set by this Manual; no Mizoram rule fixes a slope or a ground on which infiltration is barred (the 24° of the Site Development and Slope Modification Regulations, 2017 triggers engineered site development, not a limit on infiltration). 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. Mizoram has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The alluvium of the Champhai flats and the river terraces at Tlabung, Bairabi and Vairengte and along the Tlawng are not coastal sand areas: Clause 8.8.1 applies there in full, with the recharge rule of Clause 4.11, and the reduced separation of item (d) does not. In coastal sand areas:

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

8.8.10 **Laterite and hard-rock areas.** In laterite and hard-rock terrain (for example the hard and compact sandstones of the Surma group and the Barail sandstones of the ridges, where groundwater is held in fractures, lineaments and weathered zones and comes out as springs (CGWB); on any slope in these areas the hill rule of Clause 4.11 applies first under Clause 8.8.1, so this Clause has effect only on flat, tested ground away from slopes):

- (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.

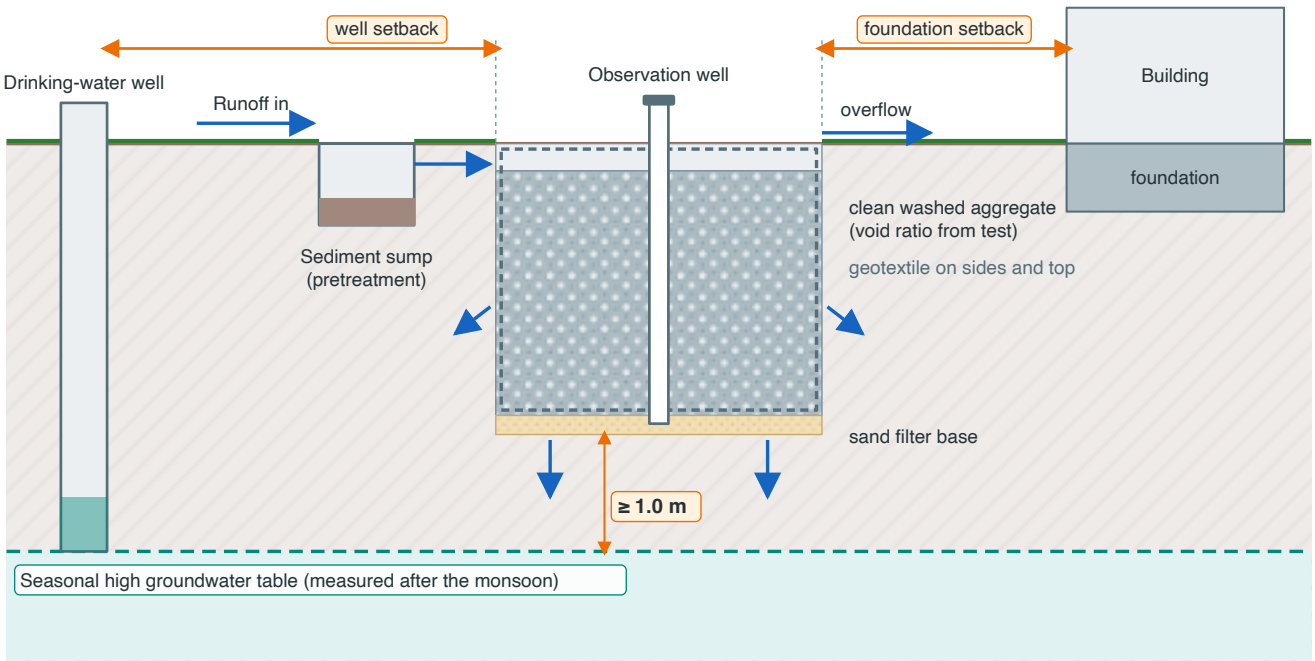
8.8.11 **Delta clays and black cotton soils.** In the shales, siltstones and mudstones of the Bokabil and Bhuban units of the Surma group, which CGWB describes as of "very low permeability and infiltration", the silted beds of dils, the margins of reservoirs, and the clayey colluvium, fill, cut-spoil and slide debris of the hills, 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 Mizoram precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Mizoram RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.
>
> No map of hydrologic soil groups for Mizoram, no measured infiltration rate and no curve-number calibration anywhere in the State was found [TBC]. "Geologically, the State is underlain by sedimentary rocks of Tertiary age, which have been tightly folded in a series of anticlines and synclines" (CGWB, State profile): the shale, siltstone and sandstone of the Surma group, with the Barail sandstones in places. The "low linear ridges" of the Bokabil shale are "characterized by low permeability and infiltration. It acts as run off zone", and the "moderate linear ridges which occupy almost the entire district" of Lunglei, alternations of the Bhuban group, have "very low permeability and infiltration and acts as run off zone"; the hill soil is "colluvial soil, formed along the steep side slopes", and "Most of the rain water flows out as surface run-off" (CGWB, Lunglei booklet). Groundwater is drawn

almost entirely from springs: "Mizoram is an abode of springs" (CGWB), which come from "weak zones such as fractures, lineaments and weathered residuum" and give "3,000 to 20,000 liters per day" in January to March (CGWB, Lunglei). The State drew 3.52% of its groundwater in 2011 (CGWB) and 3.95% in the assessment of 2024, with all 26 assessed units Safe (as cited), "Ground water is used for drinking purpose only" in Lunglei, and no water-level trend is available "due to lack of ground water abstraction" (CGWB, Lunglei). Water put into the ground is a hazard as well as a resource: on the ridges it raises the water pressure in soils and weathered shale on slopes of 30° to 45° in Aizawl (NEER reading), and about 89% of Serchhip town is steeper than 30° (MIRSAC, NEER arithmetic); the purpose clause of SD&SM 2017 names "increasing the amount of groundwater penetrating into slopes" among the causes of instability, and the Directorate of Geology and Mining attributed two-thirds of the large landslides it investigated in 2022-23 to "improper drainage" (as reported). This Manual's interim soil groups follow from these: the shale, siltstone and mudstone ridges D, the sandstone ridges C (D where unweathered), colluvium C in its hydraulics but unstable, the valley alluvium and terraces B to C, and urban fill and cut-spoil D (Chapter 3), each to be confirmed by site testing. **The State therefore needs two rules and a spring rule, not one** (Clause 4.11; Clause 8.8.1). On the tested valley alluvium and river terraces, recharge is allowed, with pretreatment, as a choice rather than a duty, because groundwater is not short. On hill ground, on shale, on colluvium and fill and in landslide hazard zones, no water is put into the ground on purpose, under the hill rule. Round every tuikhur and in its catchment, no storm water is discharged, under the spring rule. Everywhere, runoff from roads and open land goes to surface systems and never directly to a recharge well, borewell or shaft (Clause 8.11.3(b)). Clause 8.8.9 has no effect in Mizoram, which has no coast.

Infiltration trench: section, not to scale



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

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

8.9 Sewage cross-connections and dry-weather flow

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

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

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

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

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

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

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

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

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

> **Commentary.** The prohibition of sewage connections and the removal of existing cross-connections as a condition of approval are core requirements of this Manual, and Clause 1.10.3 allows no variance from them. Sewage in storm drains is the single largest water quality problem of urban drainage in Mizoram. 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 Mizoram the storm drains are the sewers. "In absence of sewerage system, people are using septic tanks and soak pits. In most of the places sewage is discharged into open drains without any treatment, which ultimately gets discharged to rivers"; "the sullage (i.e. kitchen and bathroom waste) is discharged into drains which ultimately pollutes the fresh water sources"; and septic effluent finds its way "through drains and cross drains to the rivers, which are the sources of water supply" (Master Plan for Aizawl: Vision 2030). The State put its sewage at 51.81 MLD (31.37 MLD urban and 20.44 MLD rural), 16.34 MLD of it urban sewage in Aizawl district, against "Existing Treatment Facilities" of 10 MLD "only for Aizawl city" (Government of Mizoram's report to the National Green Tribunal in O.A. 606/2018, table as on 31 August 2025): one sequencing batch reactor plant of 10 MLD at

Chite (Bethlehem Vengthlang), built by SIPMIU, whose trial run began on 6 February 2021 with 3,033 households connected (MPCB's report in O.A. 593/2017 and 673/2018). The plant serves one catchment: 5,207 household connections and 45.95 km of sewers are reported (as cited from the 2025 report); PHED's bio-digesters (3.35 MLD) and community soak pits (3.2 MLD) take some of the rest; 23 sewage treatment plants (27 MLD) and 23 faecal sludge treatment plants (0.33 MLD) are planned under SBM-U, and an AMRUT 2.0 sewerage and septage project of ₹39.22 crore (as read) is reported; and "Due to peculiar topography of the hilly regions, treatment of Grey Water remains a huge challenge" (O.A. 606/2018 report). The CPCB's list of 2025 names four Mizoram stretches among the polluted rivers: the Chite stream "near SIPMIU's STP to Armed Veng" in Priority II, with a BOD of 29 mg/L; the Tuikual stream at Reiek Kai in Priority II, with 29.1 mg/L upstream and 5.5 mg/L downstream near the PHE water-treatment plant; the Lawibual stream in Priority III (14.3 mg/L); and the Tuipui in Priority V (5.6 mg/L); the Tlawng, Tiau, Tuivawl, Mat, Saikah and Tuirial stretches of the 2018 list were dropped (CPCB, 2025). Whether the CPCB's "Tuikual stream" is the Tuikual lui that the master plan counts among Aizawl's "worst destructive streams" is a NEER reading to be confirmed. The site rules keep sewage and storm water together: regulation 27 of the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 asks for drainage plans "that provide for control of surface runoff, sewage, sullage and seepage from septic systems", and a site developed downhill "shall convey drainage, sewage or seepage from the adjacent site uphill"; this Manual separates them. The statutory hook is section 298 of the Mizoram Municipalities Act, 2007, under which the Municipality may "require separate provisions to be made for drainage or sewage and other offensive matters as distinct from rain-water and other unpolluted sub-soil water". In Mizoram, therefore: **(i)** every storm-drain outfall to a stream (lui) on the CPCB list (the Chite, Tuikual and Lawibual streams and the Tuipui), to a dil, or within the catchment of a tuikhur is taken to carry dry-weather flow until the survey of Clause 8.9.4 shows that it does not, and has a DWF interceptor and a screen under Clause 8.9.5 before it reaches the water, and before any detention or infiltration device; **(ii)** on every site approved under this Manual, storm water and sullage are collected separately, each with its own last inspection chamber at the boundary, so that the site can be connected to a separate storm drain without rework when one is built, and no septic tank overflow, soak-pit overflow or sullage pipe is connected to a storm drain (Clauses 6.3.6(a), 8.9.1 and 8.9.2), with section 298 of the Act as the hook; **(iii)** no sullage or roof water is put into the ground on Moderate, High or Very High landslide hazard ground, on a slope steeper than 10° or on shale (Clause 4.11, hill rule), and no storm outfall, soakaway or drain discharge lies within 15 m of a tuikhur (the spring rule, Clause 8.8.1); and **(iv)** until sewers exist, a drain or lui that receives the drains of a settlement is designed as a combined channel: for velocities that keep sludge moving in dry weather as well as for the storm flow, with access for cleaning along it, and with covers or screens where it passes homes, because of the smell and the risk to health (Clause 6.3.6(d)). Every interceptor is sized from the measured dry-weather flow of its drain, does not reduce the drain's capacity for the minor and major events (Clause 8.9.5(b)), and passes the storm flow above its capacity on down the drain; on a steep lui that carries boulders and slide debris in flood, it and its chamber are placed above the stream's 1% AEP level or protected against the scour and debris of that flood (Chapter 9). These conditions are set by this Manual.

8.10 Outfalls to waterbodies: first flush, gross pollutant traps and screens

8.10.1 **Requirement.** Every new storm drain outfall to a waterbody, and every existing outfall on a drain that is rebuilt, widened or extended, shall have:

- (a) a GPT designed under Clause 8.7.10; and
- (b) first-flush treatment: treatment of the WQv (or Q_wq) of the contributing catchment by the BMPs of Clause 8.7, either on the contributing sites or at the outfall.

8.10.2 **Where treatment at the outfall is impracticable.** Where land is not available at a public outfall, first-flush treatment may be provided by:

- (a) a proprietary first-flush or hydrodynamic device sized for Q_wq; or
- (b) a treatment wetland or forebay within the waterbody setback (Clause 7.5.1(b)), outside the waterspread.

8.10.3 **Screens and trash racks.** Screens at outfalls, culvert inlets and pump sumps shall:

- (a) be designed with **50% blockage** for hydraulic capacity;
- (b) have an overflow or bypass path so that a fully blocked screen does not flood property;
- (c) have bar spacing chosen for the hazard: closer spacing for litter capture, wider spacing where blockage would cause flooding; and
- (d) be cleanable from a safe platform, with vehicle access.

8.10.4 **Existing outfalls.** Each ULB shall prepare a programme to fit GPTs and DWF interceptors to its existing outfalls to waterbodies, starting with outfalls to tanks used for drinking water supply and to notified wetlands (Clause 7.12), and shall report progress in the register of Clause 10.17.

> Commentary. This Manual requires first-flush treatment and gross pollutant traps at outfalls to waterbodies. Gross pollutants are the most visible form of pollution in Mizoram 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 (regulation 33 of the 2012 Regulations, under which "A suitable rain water harvesting facility shall also be provided in all buildings", and regulation 5(6)(ix), under which the plans "include provision for a suitable rain water harvesting facility"; the chapter on green buildings and sustainability (Chapter VIIIA) inserted in 2025 makes rainwater harvesting and "Reduction of Hardscape" incentives for plots above 100 m², not conditions; neither sets a volume, and the 2017 Regulations require no harvesting) continues to apply, subject to the limits of Clause 8.8.1: in Mizoram harvesting is storage for use, not recharge, on every slope steeper than 10° and on shale (Clause 4.11, hill rule), and where section 14(1)(b)(viii) or 16(2)(ix) of the Mizoram Water Resources (Management and Regulation) Act, 2024 speaks of rainwater harvesting for groundwater recharge, this Manual reads it on hill ground as storage and reuse, states the conflict and does not override the Act (Chapter 1). This Clause sets how RWH structures are counted under this Manual.

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

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

8.11.3 **Recharge structures.**

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

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

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

- (c) it has pretreatment.

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

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

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

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

> Commentary. The rule that RWH storage does not count as detention is set in Chapter 4. In Mizoram rainwater harvesting is water supply first. In the Aizawl Urban Area 27.16% of households use rain water and 1.01% spring water (master plan, Table 8.2); the PHED supply was reported at "44 lpcd" with 35% of the water unaccounted for (as reported; date not fixed); and the CGWB lists 300 roof-top rainwater-harvesting structures and 200 spring developments among the recharge and conservation works feasible in the State. The regulations make harvesting compulsory but set no volume and no detention rule: "A suitable rain water harvesting facility shall also be provided in all buildings" (AMCBR reg. 33), and the plans "include provision for a suitable rain water harvesting facility" (reg. 5(6)(ix)); since 2025, rainwater harvesting and "Reduction of Hardscape" are incentives, rewarded with additional floor area or fee waivers, for plots above 100 m² that "may comply with the green norms" (Chapter VIIIA); and the master plan recommends harvesting "mandatory … in all public buildings", a recommendation. The Site Development and Slope Modification Regulations, 2017 require none. The Mizoram Water Resources (Management and Regulation) Act, 2024 has the IWRD "promote rain water harvesting to augment ground water recharge" (s.14(1)(b)(viii)) and lets WARDMA direct "water conservation and groundwater recharge, including rain water harvesting" (s.16(2)(ix)); on hill ground this Manual reads both as storage and reuse, not recharge, and says so. None of these gives litres per m² of roof, a tank volume, a recharge rate, a test of a recharge pit or a limit on soak pits on slopes, and no audit of what has been built was found. This Manual credits storage of at least 25 L per m² of roof (Clause 4.11), the value of the North-East editions of this series, as retention only through reuse, and assumes it full at the start of every monsoon design storm, never counting it as detention. On the tested valley alluvium and river terraces, recharge may be one function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); on hill ground, on shale, on colluvium and fill and in landslide hazard zones, harvesting is for storage and use only, and its overflow goes to a lined drain. RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a June to August monsoon storm, such as that of mid-June 2018, arrives after weeks of rain, which is why it cannot be counted as detention.
>
> Clause 8.11.3(b) has no direct precedent; this Manual sets it because road runoff carries oil, metals and pathogens. A recharge shaft or borewell bypasses the soil that would otherwise filter it and delivers it straight to the aquifer that supplies wells nearby. The CGWB *Manual on Artificial Recharge of Ground Water* (2007) gives recharge structure types and filter designs; this Manual adds the source-water restrictions.

8.12 Construction-stage erosion and sediment control

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

- (a) the sequence of clearing, earthworks and stabilisation;

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

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

- (a) the area exposed during the monsoon (April to October) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **31 March**; and
- (c) any area exposed between 1 April and 31 October has sediment controls in place before it is cleared.

8.12.3 **Measures.**

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

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

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

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

> **Commentary.** The 0.1 ha threshold is the applicability threshold of Chapter 1. The sediment basin volume of 250 m³/ha is the US EPA Construction General Permit minimum of 3,600 ft³ per acre drained, converted to SI (US EPA, 2022 CGP); the CGP allows the alternative of the 2-year, 24-hour runoff. This Manual requires the greater of the two, because Mizoram's 2-year 24-hour depths are high and construction sites are commonly left exposed through the monsoon. The 2 ha division between traps and basins, the 31 March stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 31 March date matches the pre-monsoon deadline of Chapter 10. Construction sediment is a direct flood hazard as well as a pollutant: it fills drains, culverts and tanks, and in Mizoram slide debris, quarry spoil and garbage travel with the sediment: the master plan finds Aizawl's drains "silted up frequently due to insufficiency in the hydraulic design" and blames the water-logging of a third of ward W-I on solid waste in the road-side drains, and the collapse of a disused stone quarry between Melthum and Hlimen in Cyclone Remal on 28 May 2024 and of the South Hlimen quarry on 9 August 1992 show what quarry faces and spoil do on these slopes (the first as reported, the second in the *Senhri Journal*; Chapter 1). The regulations already ask for part of this. Fills are not placed on natural slopes steeper than 2:1 without benching, and "The area beyond the toe of the fill shall be sloped for sheet overflow or a paved drain shall be provided. Such drains shall be constructed with energy dissipaters and shall discharge into an approved area" (SD&SM reg. 25); for plots beside natural streams "measures shall be taken to prevent erosion of materials or sediment from the site into the stream or riverine

reserve" (reg. 28); excavated material is kept off "drainage courses or riverine reserves" and disposed of at a place the Corporation approves (reg. 29); and since 2025 an Occupancy Certificate is issued only after excess materials have been removed from the public roads and damage to public property restored (AMCBR, as amended in 2025). They give no size, date or inspection, which Clause 8.12 supplies. The stabilisation date of 31 March is set by this Manual, before its season begins on 1 April, because Mizoram's deadliest dated rain events came in May and storms came in late April (Chapter 2). The reason given above for the larger basin volume, that the 2-year 24-hour depths are high, holds in Mizoram: the 2-year 24-hour design depth is never below the interim floor of 85 mm (Clause 2.3.6(c)), and NIH-DHAARA gives 107 to 131 mm in the north and south (Kolasib, Bairabi, Vairengte, Lunglei, Tlabung, Siaha) and 130 mm is the floor in sub-areas MZ-A and MZ-A1; on a bare construction site on hill soils of group D with AMC III, which applies from 1 May (Chapter 3), 85 mm gives a runoff of the order of 70 mm, or about 700 m³ per hectare, so the 2-year runoff governs over the 250 m³ per hectare (NEER arithmetic), and the rule of Clause 8.12.3(c) is kept unchanged. In Mizoram the outlet of a sediment basin or trap under Clause 8.12 discharges to a lined drain or a stable channel with an energy dissipator and never onto an unprotected slope; no sediment basin or trap is designed to infiltrate where Clause 4.11 bars infiltration, which includes every slope steeper than 10° and all shale; no spoil, debris or garbage from a site, and no spoil from a quarry, is placed in a lui or dil, within its Zone 1, on a slope below the site, or in the catchment of a tuikhur, and a quarry face above a lui has a cut-off drain along its crest; and a construction site in the catchment of a dil or tuikhur keeps its sediment out of every drain that reaches the water.

8.13 Monitoring

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

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

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

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

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

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

Commentary. No Mizoram 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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- Government of Mizoram. *Mizoram Municipalities Act, 2007*, s.298; *Mizoram Water Resources (Management and Regulation) Act, 2024*, ss.2(1)(i), 9–12, 14(1)(b)(viii) and 16(2)(ix); *Mizoram (Village Councils) Act, 2025*, s.14(6) (Chapter 7 references).
- Aizawl Development Authority. *Master Plan for Aizawl: Vision 2030*, §8.3 (drainage, sewerage and sullage) and Table 8.2 (Chapter 7 references).
- Landslide Policy Committee for Aizawl City (2014). *Roadmap to Stability: Actions to Reduce the Landslide Risk in Aizawl* (Chapter 7 references).
- National Green Tribunal. O.A. 606/2018: six-monthly progress report of the Government of Mizoram, January–June 2025 (liquid-waste table as on 31 August 2025), https://www.greentribunal.gov.in/sites/default/files/news_updates/SIX%20MONTHLY%20PROGRESS%20REPORT%20FOR%20MONTH%20OF%20JANUARY%20TO%20JUNE%202025%20BY%20CS,%20GOVT.%20OF%20MIZORAM%20IN%20OA%20NO.%20606%20of%202018%20(COMPLIANCE%20OF%20MSW%20MGT%20RULES,%202016%20AND%20OTHER%20ENVIRONMENTAL%20ISSUES).pdf ; O.A. 593/2017 and O.A. 673/2018: MPCB report of February 2021 (Chapter 7 references).
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Annexes and forms

Annex / Form	Content
8A	3-month ARI 24-hour depth and IDF by zone
8B	Redevelopment LoS table and treatment-train composite VR
8C	Mizoram 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, stream (lui), dil or reservoir whose level can rise above the outfall invert shall be analysed with the tailwater conditions of Chapter 5: the non-tidal tailwater of Clause 5.6 for minor- and major-system design; the riverine backwater of Clause 5.8, including the flood released from a dam upstream, the Tuirial dam of NEEPCO on the Tuirial and the Serlui B dam on the Serlui (Clause 5.8.5(e)); and the outfall-closed check of Clause 5.10 wherever the receiving water can rise above the outfall invert, which is the case for the drains of the

valley floors and river terraces that outfall to the Tlawng at Sairang and Bairabi, to the rivers at Vairengte, Chawngte and the Champhai flats (Clause 5.8.5(c)), and for those of Tlabung, which outfall to the Khawthlangtuipui (Clause 5.8.5(d)). Most outfalls in the State, those of the ridge towns and of Aizawl among them, fall freely to a steep lui with no river tailwater (Clause 5.8.5(a) and (b)); for them the tailwater is the level of the 1% AEP flood in the lui at the outfall, computed with the sediment, debris and garbage allowances of Chapter 6 (Clause 6.3.6) and checked against surveyed flood marks, with the outfall invert at least 0.5 m above the highest surveyed bed and the receiving lui checked for capacity and stability to the next confluence. For an outfall to a reservoir, the tailwater is its maximum water level, or its full reservoir level plus the surcharge in the design flood, as Chapter 5 sets it, or, where neither is published, the full reservoir level plus 0.5 m (set by this Manual): for the Tuirial reservoir, NEEPCO's full reservoir level of 90.5 m (minimum drawdown level 68.0 m; normal tailwater level at full load 30.7 m; CERC, Petition No. 125/MP/2021), its maximum water level not having been found [TBC]; for Serlui B, whose full and maximum water levels were not found, the level that the State's power department states on a named datum [TBC]. For an outfall to a dil, the tailwater is its surveyed spill level; for a river reach without a CWC site, the flood-mark profile of the reach; and for a drain held up by a check dam, weir, flap gate or pumping station downstream of the outfall, that control at its gate-closed level, its weir crest or the start level of its pumps; with the joint case of Clause 2.12 in every case. No CWC site in Mizoram has a warning or a danger level, and none forecasts floods; CWC monitors levels at seven sites, five of them inactive, and only one has a published high flood level, 149.0 m at Turial on the Tuirial (17 June 1995) (CWC levels as transcribed by SANDRP, as reported; the datum of none is stated [TBC]); how that level relates to the levels of the Tuirial reservoir is not stated and is not to be inferred [TBC]. The reaches of the Tlawng, the Tuirial and the Tuivai below the State's border lie on the Barak plain, which the Assam edition governs, and the Khawthlangtuipui, the Chhimtuipui and the Tiau leave India with no downstream gauge or level available to a designer (Clause 5.8.5(f)). No document found sets a design river, reservoir, dil or lui level at any outfall in Mizoram, and no flood zone, flood plain or flood hazard area has been designated; until one is, 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:

> $$HW_o = h_o + H - L \cdot S$$

> $$H = \left[1 + k_e + \frac{19.63\, n^2 L}{R^{1.33}}\right] \cdot \frac{V^2}{2g} \quad \text{(SI units, full barrel)}$$

> h_o = the greater of TW and $(d_c + D)/2$

where h_o 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), k_e 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), d_c 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 k_e (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.

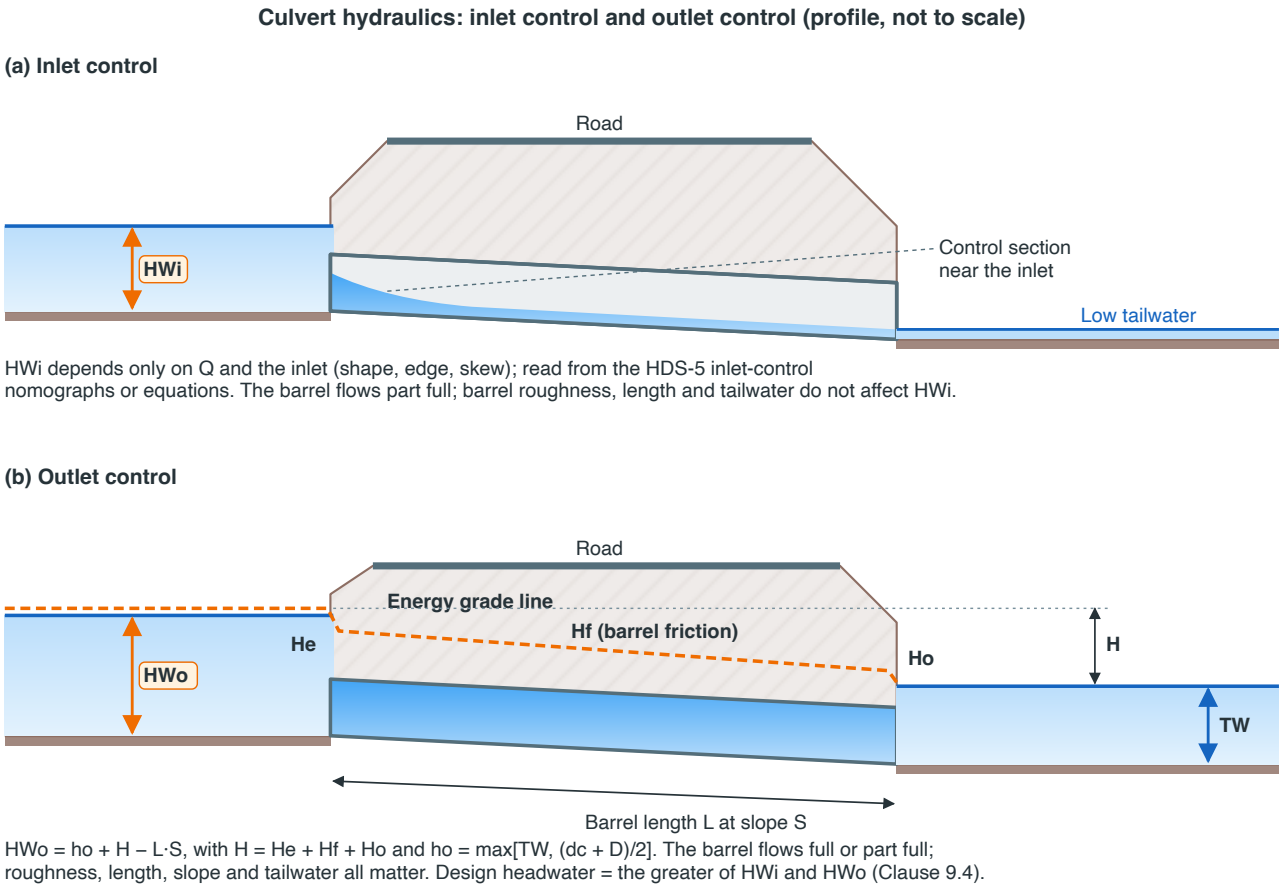

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

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

9.5 Open channels

9.5.1 **Flow computation.** Open channels shall be designed by Manning's equation for uniform flow, with the n of Table 6.6. Water levels shall be computed by gradually varied flow (standard step) analysis where tailwater, bridges, culverts, bends or changes of section affect them, which on the drains of the valley floors and river terraces at Sairang, Bairabi, Vairengte, Chawngte and Tlabung and on the Champhai flats, whose outfalls a river in flood can close, on the drains below the Tuirial and Serlui B dams, whose receiving levels the releases set, and on the steep drains, down-drains, terrace swales, lui and streets of Aizawl, Lunglei, Serchhip and the other ridge towns, stepped by drop structures and chutes and passing through critical depth at every step, 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 Mizoram (the thin hill soils and colluvium of the steep side slopes over the shales, siltstones, mudstones and sandstones of the Surma group (its Bhuban and Bokabil units) and the Barail sandstones, the mixed colluvial and alluvial soils of the valleys, the cobble and pebble deposits of the river terraces (CGWB, Lunglei), and the fill and cut-spoil of the town slopes, on which the gravel, boulders, slide debris and garbage a flow carries, rather than the soil itself, decide what a channel bed must withstand (this Manual's reading)). 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 Mizoram 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

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

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

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

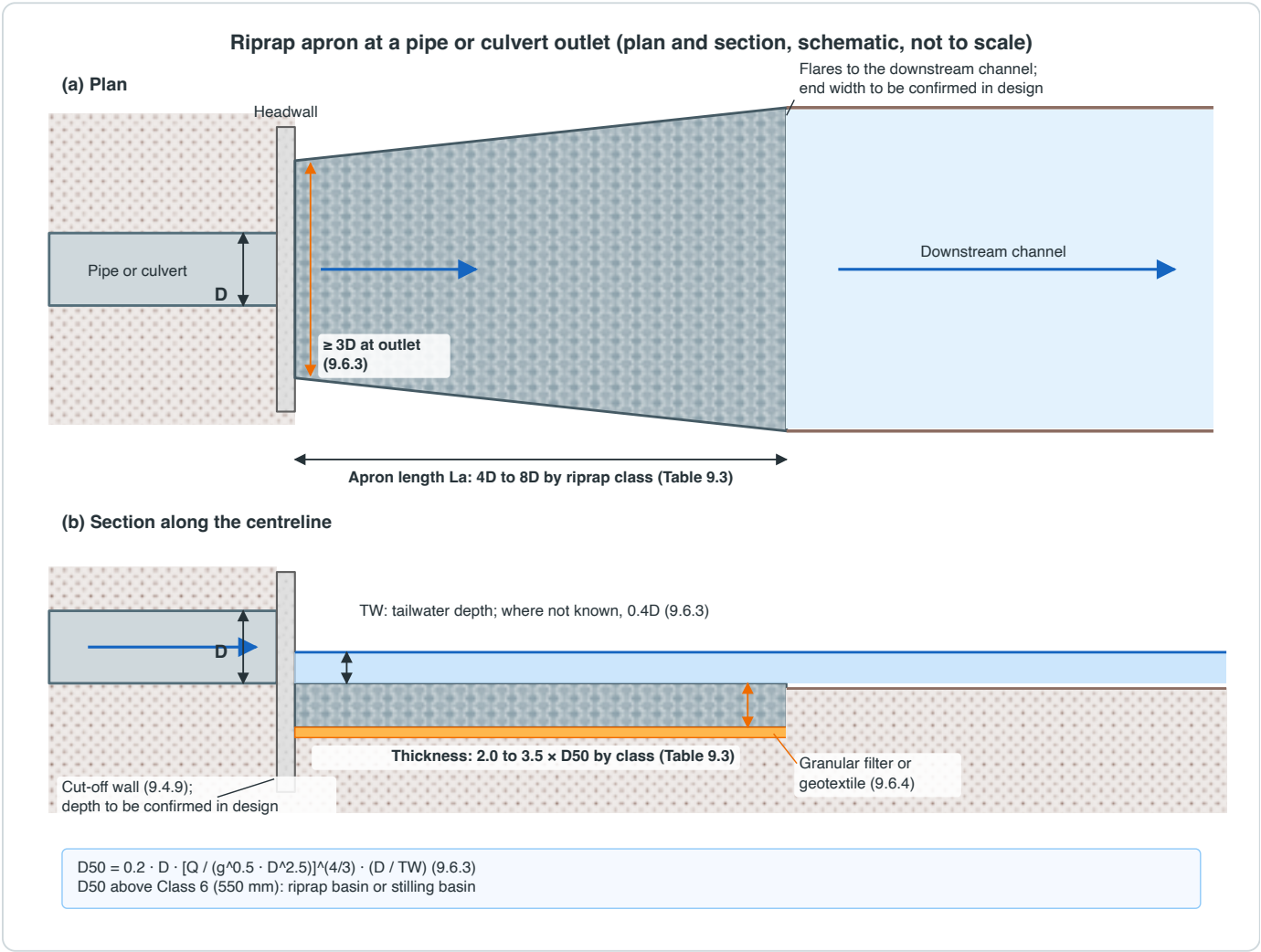

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design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

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

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

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

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

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

9.7 Detention outlet structures

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

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

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

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

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.

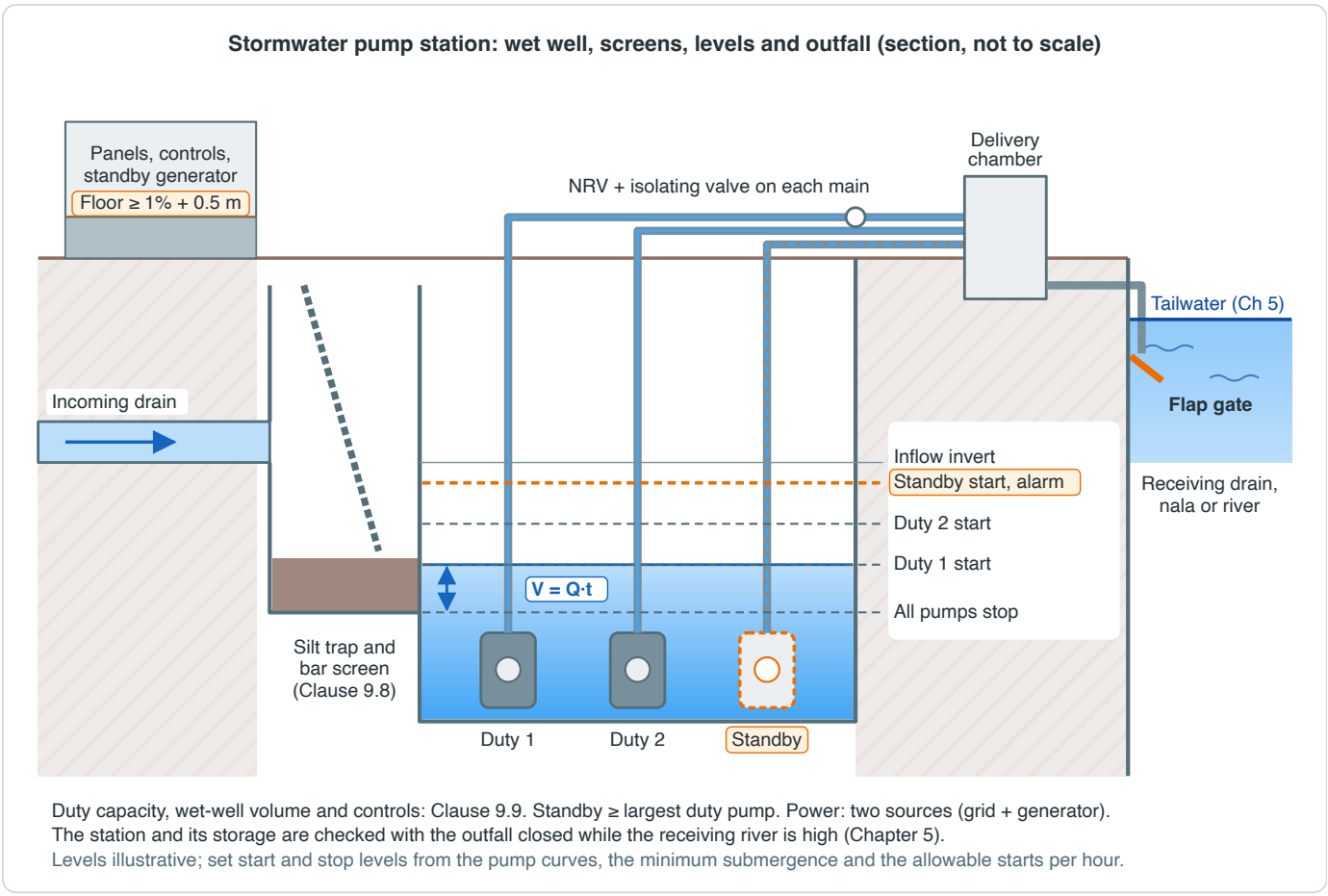

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **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". Mizoram has no coast, so no outfall in the State is closed by the tide, and the beach, estuary, tidal and coastal provisions of Clauses 9.6.7, 9.9.2(b), 9.10.5 and 9.13.6, and the coastal and tidal rows of Table 9.5, do not arise; in Clause 9.9.2(c) the highest tailwater is the highest river, lui, reservoir or dil level of Chapter 5. No pumping station on a storm drain was found anywhere in the State, and most outfalls, those of Aizawl among them, fall freely to steep lui with no river tailwater (Clause 5.8.5(a) and (b)), so pumps and sumps under Clause 9.9 are needed only where the outfall-closed check of Chapter 5 shows that gravity cannot drain a site on valley-floor land: at Tlabung on the Khawthlangtuipui, where about 350 houses in the sub-division were reported submerged in June 2017 (9 fully and more than 60 partly by the count of district officials), about 400 houses, 150 of them in the town, in July 2019, and 40 families were evacuated in August 2023 (all as reported) (Clause 5.8.5(d)); at Sairang on the Tlawng, where families were stranded in June 2018 (as reported), and on the river terraces at Bairabi and Vairengte in sub-area MZ-A1 (Clause 5.8.5(c)); and on the Champhai flats and at Chawngte, where a survey shows a river closing an outfall. Gates are required below the 1% still-water level there, because those outfalls end in rivers that rise above them, and the storage or pumps behind them are sized for an outfall closed for not less than 72 hours, and at Tlabung for longer where flood marks or residents' records show the river held up for longer (Clause 5.8.5(c) and (d)). No CWC site in the State has a warning or a danger level, and the only published high flood level is 149.0 m at Turial on the Tuirial (17 June 1995; CWC level as transcribed by SANDRP, as reported; the datum is not stated), so a gate sill and a pump start level on a valley floor are set from surveyed flood marks on a named datum. The drains that reach the Tuirial below NEEPCO's dam (a 75 m zoned earth-fill dam with an open chute spillway; full reservoir level 90.5 m, minimum drawdown level 68.0 m (CERC, Petition No. 125/MP/2021)) are checked against the largest recorded release or, until NEEPCO gives one, the spillway capacity (Clause 5.8.5(e)), and a dam-break study is reported to have routed a peak of 3,035.34 m³/s "near the confluence" (as reported), which belongs in the hazard screening of Clause 2.3.6(i); the levels of Serlui B were not found [TBC]. These dams are designed to dam-safety standards, not to this chapter, but their levels and releases are its boundary conditions. Most of the State drains steeply. Aizawl's slopes run "300 to 450", that is 30° to 45° as read from the scanned text of the Master Plan for Aizawl: Vision 2030; 89.2% of Serchhip town is steeper than 30° and 38.7% steeper than 45° (this Manual's arithmetic on MIRSAC's slope classes for the town); and SD&SM 2017 refuses a site development permit only above 60° (reg. 14). These slopes are far beyond the 0.4% and 0.2% of Clause 9.5.4, so drop structures (Clause 9.6.6), stepped channels, baffled chutes and stilling basins (Clauses 9.6.5 and 9.6.6(b)) and supercritical chutes designed under Clause 9.5.2 are the normal case, not the exception, as IRC:SP:42-2014 (§8.5.1) already asks for lined, stepped or baffled drains on hill roads. SD&SM 2017 fixes the geometry of the smallest of these structures: terrace swales and ditches paved with reinforced concrete at least 75 mm thick, at least 300 mm deep and at a gradient of at

least 1 in 20, no single run collecting from more than 400 m² without discharging into a down drain, paved interceptor drains at least 300 mm deep and 800 mm wide along the top of every cut slope whose uphill drainage path exceeds 10 m, drains below fills "constructed with energy dissipaters", and "non-erosive downdrains" where drainage is discharged (regs. 25 and 27); it leaves their "hydrology and hydraulic calculations" to licensed civil engineers (Schedule I), and this chapter supplies them. In Mizoram the following are set by this Manual, as in the mountain editions of this series, for a structure on a drain whose catchment includes an undeveloped hill slope, a cut slope or a lui: (a) a drop, chute or down-drain shall end in an energy dissipator and discharge to a lined drain or a stable natural channel, never onto an unprotected slope, a fill or a cut face; every pool of a stepped channel shall be shaped to drain dry and be reachable for cleaning; no single vertical drop shall exceed the 1.5 m of Clause 9.6.6(c); and a swale, interceptor drain or down-drain of SD&SM reg. 27 shall be sized for the design storm of Chapter 2 with the freeboard of Chapter 6, and never made smaller than the regulation's minimum; (b) where such a drain enters a pipe, covered drain or culvert, at the catchment size and with the sediment bulking and blockage factors that Chapter 6 sets (Clause 6.3.6(f)–(h)), a debris rack, inclined so that the flow lifts debris onto it, shall stand upstream of the inlet, with a clear bar spacing chosen from a survey of the boulders and the garbage in the bed and not less than that of Clause 9.8.2(a), and a debris basin or sediment trap upstream of the rack; the basin volume shall be estimated from the debris and garbage deposited at the site in past floods and a stated debris-yield method, counting every slide scar, road cut, quarry face, spoil heap and garbage dump in the catchment as a source, because no Indian or Mizoram guidance on sizing debris basins was found [TBC]; its spillway shall pass the 1% AEP inflow with the basin full of debris, as for Clause 9.7.6, and it shall have a ramp for the machines that empty it; (c) a culvert on a lui shall have a single barrel where possible (Clause 9.4.8(a)), an armoured headwall and apron at the inlet with a deflector against boulders, an invert that follows the bed (Clause 9.4.8(c)), and an outlet protected under Clause 9.6 and led to a stable natural channel, never onto an unprotected slope, and it shall also pass the 72-hour storm of Clause 2.3.6(e), because the State's landslide storms last for days; (d) every retaining wall that holds back a slope or a fill shall have weep holes and a subsurface drain behind it, with a filter against the fines of the backfill, discharging to a lined drain and never onto the slope below, inspected and cleared by 31 March each year (Chapter 10), because SD&SM 2017 asks for subsurface drainage "as necessary for stability" (reg. 27) and for the control of "subsurface water, such as springs, which may exert undesirable pressures on the fill slope" (reg. 26); (e) every lined drain that receives runoff from unpaved slopes, hill roads, quarries or building sites shall have a sediment trap before it joins a public drain, a lui or a dil, and every drain outfall to the Chite, Tuikual and Lawibual streams, and every lui below a settlement, a solid-waste trap or screen (Clause 6.3.6(e) and (m)); and (f) a lining in a steep drain shall be designed for the abrasion of the gravel and boulders it carries as well as for the velocity of Table 9.2. On hill ground no structure of this chapter shall be built to exfiltrate: no soakaway, soak pit, exfiltrating chamber, perforated pipe or open-jointed drain on natural ground sloping more than 10°, on Surma-group shale, siltstone or mudstone at any slope, on colluvium, fill, cut-spoil or slide debris, in a mapped Moderate, High or Very High landslide hazard zone, or upslope of a cut slope or retaining wall within twice its height, unless a geotechnical certificate allows it, and in a High or Very High zone not at all (Clause 4.11, hill rule); pipes, chambers and channels there are watertight, because SD&SM 2017 names "increasing the amount of groundwater penetrating into slopes, and disposing of sewerage and drainage onto slopes in a poorly controlled manner" among the human activities that "can greatly increase slope instability" (reg. 1). The need is shown by the record. A team of the Directorate of Geology and Mineral Resources (the "Directorate of Geology and Mining" in the press) inspected 55 locations in 2022-23 and found that "two-thirds of large-scale landslides … were due to improper drainage" (as reported). The Laipuitlang–Ramhlun Venglai rockslide in Aizawl, after "heavy rainfall, thunderstorm" on ground that MIRSAC's map of 2011 had rated "Very High", destroyed 15 houses at about 3 a.m. on 11 May 2013 (15 May in one paper), with 17 bodies recovered and 8 people rescued by that paper's count and 8 lives lost by another review. In Cyclone Remal on 28 May 2024 a stone quarry between Melthum and Hlimen, reported disused for three decades, collapsed, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen (all as reported). At the Durtlang BSUP housing complex three of 20 blocks collapsed on 2 July 2019, killing three, and none of the measures that IIT suggested in 2020, rock bolts, wire nets and buttressed toe walls, was carried out (CAG, Report No. 1 of 2025). NH-6 at Hunthar, in Aizawl, "blocks in most storms" (2018 and 2024, as reported), so a road drain or culvert of PWD or the national-highway agencies never discharges onto an unprotected slope (Clause 6.3.6(k)). No structure of this chapter is designed to pass a debris flow or a landslide: on any drain below a mapped

landslide hazard zone, a slope above 60°, a quarry face, the Hunthar Veng sinking area, a cut slope, a fill or a retaining wall, or in the release reach below the Tuirial dam, the screening of Clause 2.3.6(i) comes first, and a structure is sited out of the hazard. Screens matter as much as gates, because the drains also carry garbage and sewage: the State generates 51.81 MLD of sewage against treatment capacity of 10 MLD "only for Aizawl city" (State report to the National Green Tribunal in O.A. No. 606 of 2018, as on 31 August 2025), CPCB placed the Chite and Tuikual streams in Priority II of its polluted river stretches (2025), and the master plan blames the water-logging of a third of the Aizawl W-I area on solid waste in the roadside drains, so a rack on a lui below a settlement is checked in the blocked case of Clause 9.8.4. No inventory of the flap gates, debris racks, sediment traps, check dams and pumping stations on the drains of any Mizoram town, with their capacities and operating rules, no operating rule for the gates of the Tuirial or Serlui B dam linked to the reaches below them, and no design river, reservoir, dil or lui level at any outfall was found in the public domain. Clauses 9.10.3 and 9.10.5 are set by this Manual because a flap gate or penstock that fails, or is jammed open by silt, gravel, boulders, slide debris or garbage, lets a river in flood back into the drain network of a valley floor, and one jammed shut blocks it. The lui and drains of Mizoram carry slide debris and garbage as well as silt: the Master Plan for Aizawl: Vision 2030 found the drains "silted up frequently due to insufficiency in the hydraulic design" and blamed the water-logging of a third of the Aizawl W-I area on solid waste in the roadside drains, and the same drains carry the sullage of towns in which only one catchment of Aizawl is sewered (Chapter 8, Clause 8.9), so a gate, its screen and the debris rack above it are exposed to the same load and must be kept clear together; and because no rule was found that links the releases of the Tuirial or Serlui B dam to warnings for the reaches below them [TBC], a gate on an outfall to such a reach must be taken as 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 Mizoram 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 Mizoram 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 Mizoram locations

Location	Minimum IS 456 exposure class
Inland drains and structures	Moderate
Drains and structures in the coastal environment, and any drain that carries or may carry sewage-mixed flow	Severe
Structures exposed to sea-water spray, or in contact with saline or aggressive groundwater	Very severe
Structures in the tidal zone	Extreme

9.13.2 **Concrete.** Minimum concrete grade, maximum water–cement ratio, minimum cement content and nominal cover to reinforcement shall be those of IS 456 for the exposure class. For the reader's convenience, IS 456 sets the minimum reinforced-concrete grades as M25 (moderate), M30 (severe), M35 (very severe) and M40 (extreme), and the nominal covers as 30, 45, 50 and 75 mm respectively.

9.13.3 **Aggressive ground.** Groundwater and soil at every structure in coastal and delta areas shall be tested for chlorides and sulphates. Cement type and concrete mix shall be chosen to suit the results under IS 456.

9.13.4 **Sewage-mixed flow.** Pipes and covered drains that carry, or may carry, sewage-mixed flow shall be protected against sulphide (crown) corrosion, by a sacrificial concrete thickness, a corrosion-resistant lining or a non-concrete pipe material.

9.13.5 **Pipes.** Concrete pipes shall comply with IS 458, with the class selected by structural design. Other pipe materials (for example ductile iron, HDPE or structured-wall plastic pipes) shall comply with the applicable Indian Standard and be approved by the approving authority.

9.13.6 **Metalwork.** Within 5 km of the coast, and in all tidal and saline locations:

- (a) fixings, hinges, ladders, handrails and screen frames shall be stainless steel grade 316, or hot-dip galvanised steel with a protective coating, or a non-metallic material; and
- (b) dissimilar metals shall be isolated from each other.

9.13.7 **Masonry.** New public drains in Tier A bodies shall be in reinforced or plain concrete. Brick or stone masonry may be used for drains in Tier B bodies only if it is plastered on the wetted face and meets the n value of Table 6.6.

> **Commentary.** The IS 456 exposure classes and the grade and cover values are quoted from IS 456: 2000 (Tables 3, 5 and 16) for convenience. The standard governs, and designers shall use its current amendment. Assigning Mizoram 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 Mizoram the failure is one of missing criteria and of an approval system that reaches one city. No document of UD&PA, the Aizawl Municipal Corporation, the Lunglei Municipal Council, PWD, PHED or IWRD stating a design return period, intensity or runoff coefficient for the storm drains of any town was found, and the Master Plan for Aizawl: Vision 2030 found 67% of the Aizawl Urban Area with kutcha drains, 18% with none and 15% with pucca drains. The approval route shapes this chapter. Both the AMCBR and SD&SM apply only to the Corporation's area (AMCBR reg. 1(2)). A building permit is applied for through the Corporation's online building permission system, OBPAS, in use since June 2018 and made the route by the 2023 amendment, which "shall return" any proposal not as per the regulations and the master plan; the Local Council's no-objection certificate goes with the application (AMCBR regs. 4–5; SD&SM Form 1). The AMCBR already ask for much of what a drainage submittal needs: a site plan showing "sewerage and surface drains, position and sizes of septic tank and soak pit" (reg. 5(5)(v)), a roof plan "indicating drainage and roof slope" (reg. 5(6)(iv)), "site development and permanent structures like retaining wall, surface drain" (reg. 5(6)(viii)), a rainwater harvesting facility (regs. 5(6)(ix) and 33), roofs drained "at ground level by pipe" with no spout into the road or a neighbour's compound (reg. 26(2)(b)), and a surface drain or closed conduit "of adequate capacity to the nearest public drain" (reg. 37(ii)). SD&SM 2017 adds a site development permit "in addition to a building permit" (reg. 5(1)), on two tracks: regular site development, on Form 1 with a site plan, cut and fill quantities, title and the Local Council's no-objection certificate, "allowed ONLY in zones of Low landslide hazard"; and engineered site development, required in mapped Moderate, High and Very High hazard zones, on unmapped ground of 24° or more, for cuts of 3 m or more, for works above 200 m³ and for works that support a structure, with a geotechnical report, "Detailed plans of all surface and subsurface drainage devices", "A map showing the drainage area and the estimated runoff of the area served by any drains" and "A drainage plan, including elevations of floors with respect to finish site grade" (reg. 6); its Schedule I makes licensed civil engineers competent for "Design of drainage structures, including

hydrology and hydraulic calculations". Since the 2025 amendment, ordinary buildings "on plots measuring less than 93 square meters and located within low and moderate geo-hazard zones" may be self-certified by empanelled technical personnel, with a declaration of compliance with "the Aizawl Landslide Hazard Map" (Annexure B-I and form C-IV), and the Occupancy Certificate follows an inspection within 7 working days. A private drain may be connected to a municipal drain only with the written permission of the Chairman (Mizoram Municipalities Act, 2007, s.295), and no drain may be led into a municipal drain or any water-course without written consent (s.296). Outside the Corporation's area no building regulation was found: none for the Lunglei Municipal Council [TBC]; the Village Councils may declare unsafe sites for house construction with the District Disaster Management Authority's approval and are to enforce model building bye-laws once the State frames them (Mizoram (Village Councils) Act, 2025, s.13(6); none found); WARDMA may direct rainwater harvesting outside the Autonomous District Councils (Mizoram Water Resources (Management and Regulation) Act, 2024, s.16(2)(ix)); the Mizoram River Protection Authority would approve works in a River Conservation Zone only if the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, are in force and a zone has been notified (neither is confirmed); and in the Lai, Mara and Chakma Autonomous District Councils no building or drainage instrument was found, beyond notices of the Chakma District Council on no-objection certificates of the Kamalanagar Town Planning Committee and on roadside construction, known from their titles (as reported). No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a design storm. Every stormwater item in this chapter is therefore written so that the licensed civil engineer on record can certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the Corporation can check it, if it adopts the Manual, with the drawings that the AMCBR and SD&SM already require through OBPAS: the Stage 1 and Stage 2 submittals of Table 10.1 go with the building permit and, where one is needed, the engineered site development permit, whose runoff map and drainage plan are the hook for the drainage report of this chapter, and the regular-track Form 1 is the hook for the simplified drainage plan; a self-certified plot of less than 93 m² carries a simplified drainage declaration, covering roof storage, the connection to the public drain and the hill rule of Clause 4.11, signed by the empanelled technical person; Stage 4 goes with the Occupancy Certificate inspection; and drain connections go with the permission of ss.295 and 296. 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 (Table 10.1):

Table 10.1 — Submittal stages and linked approvals

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

10.3.2 **Stage 0 is mandatory** for:

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

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

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

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

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

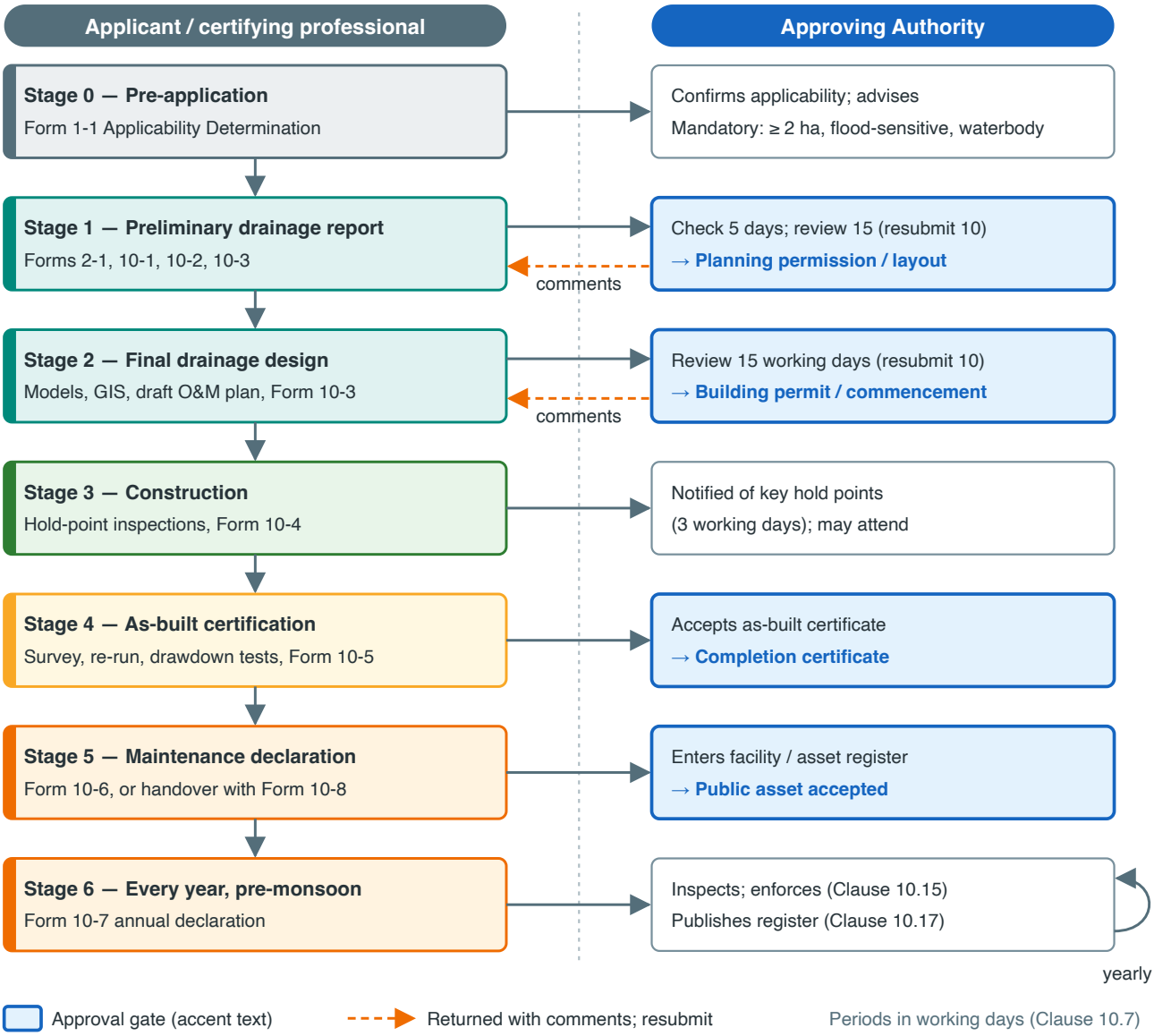

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **Commentary.** The stages follow the APWA 5600 sequence of preliminary and final stormwater studies, construction inspection and maintenance agreements (APWA 5600, 2006, §5608 and §5609), mapped onto the AMCBR/SD&SM steps a Mizoram applicant already follows. Linking Stage 4 to the completion certificate copies the MBBL 2016 RWH model, which requires inspection before the completion certificate (MBBL 2016, §9.6). The 2 ha and 1 ha limits in Clauses 10.3.2 and 10.3.3 have no direct precedent and are set by this Manual.

10.4 Required contents and checklists

10.4.1 **Preliminary drainage report (Stage 1).** The report shall contain at least:

- (a) Form 1-1 and, where applicable, Form 1-2 (Variance / Waiver Request);
- (b) a site plan with existing and proposed levels, impervious areas, and the catchment boundaries draining to and through the site;
- (c) soils (HSG), the seasonal high groundwater table, and infiltration test results or a test plan (Chapter 3);

- (d) the **Design Rainfall Sheet (Form 2-1)**, completed as Clause 2.13 requires;
- (e) the pre-development condition and hydrologic method (Chapter 3);
- (f) how the hierarchy of Clause 1.2 has been applied: areas preserved, retention method, detention concept and conveyance;
- (g) preliminary retention, water quality and detention volumes, and release rates, from the compliance calculator (Clause 10.5);
- (h) the downstream extent and tailwater case (Chapter 5);
- (i) waterbodies, setbacks and the 1% AEP level (Chapters 6 and 7); and
- (j) the land reserved for facilities and maintenance access (Clause 10.13).

10.4.2 **Final drainage design (Stage 2).** The final design shall contain, in addition to updated Stage 1 contents:

- (a) the final calculations for every storage duration of Clause 2.5.2 and every AEP required by Chapter 4, including the outfall-closed check of Chapter 5;
- (b) stage–storage–discharge tables for each facility, and the emergency spillway design (Chapter 4);
- (c) hydraulic design of conveyance elements, inlets and structures (Chapters 6 and 9);
- (d) the water quality design and the first-flush or gross pollutant trap where required (Chapter 8);
- (e) construction drawings, details and specifications of every facility;
- (f) the construction sequence, including protection of retention and infiltration areas from sediment and compaction (Clause 10.8.3);
- (g) the hold-point schedule (Clause 10.8);
- (h) the draft O&M plan (Clause 10.11) and draft maintenance declaration (Clause 10.10);
- (i) the model input files and the GIS data of Clause 10.4.4; and
- (j) the certificates of Clause 10.6.

10.4.3 **Checklist.** Each submittal shall include the **Drainage Report Checklist (Form 10-1)**, showing for each item of Clauses 10.4.1–10.4.2 the page or sheet where it is addressed, or the reason it does not apply. The Authority shall not start technical review of a submittal without a completed Form 10-1.

10.4.4 **Digital submittal.**

- (a) Reports and drawings shall be submitted as searchable PDF.
- (b) Hydrologic and hydraulic models shall be submitted in their native, runnable format (for example SWMM .inp, HEC-HMS or HEC-RAS project files), with the version of the software used.
- (c) Facilities, outfalls, flow paths and catchment boundaries shall be submitted as GIS data (GeoPackage or shapefile) in WGS 84 (EPSG:4326) or the applicable UTM zone (46N for the whole State, which lies within 21°58'–24°35' N and 92°15'–93°29' E (Lallawmzuali and Muniyan, 2024), inside zone 46N (90°–96° E), so that no project needs another zone (this Manual's reading)), with attributes as listed in Annex 10B.
- (d) Levels shall be stated relative to a named vertical datum. The relationship to the river datums of the CWC level-monitoring sites on the receiving rivers (not stated in any source found), of the reservoir levels of the Tuirial dam published by NEEPCO in metres (datum not stated) and of Serlui B (not found), and of the flood marks surveyed on ungauged lui, rivers and dils 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. Mizoram has no notified design return period or design storm for its urban drains, and no document of UD&PA, the Aizawl Municipal Corporation, the Lunglei Municipal Council, PWD, PHED, IWRD or Aizawl Smart City Ltd stating a return period, a runoff coefficient, an intensity–duration–frequency relation or a rule for the time of concentration was found. The documents found for the Aizawl tranche of the ADB's North Eastern Region Capital Cities Development Investment Program cover water supply and sewerage, not storm drainage (as summarised), and no storm-drain project of Aizawl Smart City Ltd was found. The building regulations defer to the National Building Code (2005, "as amended from time to time" since the 2019 amendment) and, for landslide hazards, to IS 14458 and IS 14496 (Part 2) (AMCBR Annexure F). SD&SM 2017 fixes the geometry of terrace swales, interceptor drains, down-drains and building-pad gradients (reg. 27) and asks an engineered application for "A map showing the drainage area and the estimated runoff of the area served by any drains" (reg. 6), but sets no design storm, return period or runoff coefficient; it leaves the "hydrology and hydraulic calculations" to licensed civil engineers (Schedule I). The master plan found Aizawl's drains "silted up frequently due to insufficiency in the hydraulic design", with 67% of the Aizawl Urban Area served by kutcha drains, 18% by none and only 15% by pucca drains. Road drains follow IRC:SP:42-2014 and IRC:SP:48. The rainfall studies do not supply a design storm either. No Mizoram station is in IMD's *Extremes* (data to 2012), so no official 24-hour record exists for any town; the only peer-reviewed frequency study (Lallawmzuali and Muniyan, *MAUSAM*, 2024) fits monthly and annual totals only; IMD's national study (Das et al., 2022) has no Mizoram panel; and the whole State lies in CWC subzone 2(c), for which CWC has published no Flood Estimation Report. The largest daily falls known are press values: 148 mm at Aizawl in one day, probably 12 June 2018 (this Manual's reading of the report's date), and 130 mm at Chawngte in October 2025 (both as reported). The State's design values are therefore those of Chapter 2: NIH-DHAARA in every sub-area, with the statewide floor of Clause 2.3.6(c)(i), the Barak-valley floors of Clause 2.3.6(c)(ii) in sub-areas MZ-A and MZ-A1, the 72-hour factor of Clause 2.3.6(e) and the interim ratios of Clause 2.3.6(f), and each submission must state its own design basis. Form 2-1 and Form 10-2 ensure that every design states its inputs.

10.5 Compliance calculator

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

- (a) applies the applicability tests of Clause 1.5;
- (b) computes the retention volume from the Annex 2E depth, and the water quality volume (Chapter 8);
- (c) applies the credits for preserved areas and retained volume against detention (Chapter 4);
- (d) on the design-aid route (Clause 1.7, S-1), gives retention and detention volumes from the unit-storage tables;
- (e) on alternative S-2, gives the permissible site discharge for each AEP; and

- (f) produces the **Compliance Calculator Summary (Form 10-2)**.

10.5.2 **Use.**

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

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

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

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

10.6 Professional certification

10.6.1 **Who may sign.** Drainage reports and designs shall be prepared and signed by a registered professional (Clause 1.4) competent in hydrology and hydraulics. For any of the following, the signatory shall be a civil engineer **empanelled as a Stormwater Design Professional** by the Authority or UD&PA:

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

10.6.2 **Empanelment criteria** shall be issued by UD&PA 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

AMCBR/SD&SM registration and adds empanelment for the higher-risk cases. The 1 ha limit is set by this Manual.

10.7 Review procedure and timelines

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

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

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

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

10.7.4 **Review capacity.** A Tier B authority, or a Tier A authority for overflow work, may use an empanelled reviewer from the UD&PA 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 approval of the Irrigation and Water Resources Department (IWRD) for a work on, or a discharge to, a river or flood work in its charge, or a direction of WARDMA under the Mizoram Water Resources (Management and Regulation) Act, 2024 outside the Autonomous District Councils' areas, the consent of NEEPCO for a work that drains to the Tuirial reservoir or to the reach below its dam, and of the State's power department for Serlui B [TBC], the written permission of the Aizawl Municipal Corporation, or of the Lunglei Municipal Council in its area, to connect a drain to a municipal drain or to lead one into any water-course (Mizoram Municipalities Act, 2007, ss.295 and 296), the views of the Environment, Forest and Climate Change Department (EF&CC) for a work in a riverine reserve or a wetland, the prior approval of the Mizoram River Protection Authority for a work in a River Conservation Zone, only if the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, are in force and a zone has been notified (neither is confirmed), the consent of PWD, or of the national-highway agency, for a discharge to a side drain, catch-water drain or culvert of one of their roads, the consent of MPCB for a discharge that carries effluent, the consent of the Village Council for a work on a village drain outside the municipalities, the views of the Village or Local Water Resources Committee for a work that drains towards an identified water source such as a tuikhur, the consent of the District Council for a work in an Autonomous District Council area, if the District Council adopts the Manual, and the consent of the body that owns or runs the receiving drain where that body is not the Authority (for example PHED or SIPMIU for a sewer), or another agency's concurrence is required (Chapter 7), the Authority shall forward the submittal on the day it is accepted for review, and the review periods shall run concurrently.

10.7.6 **Fit with permit timelines.** The periods in Clauses 10.7.1–10.7.2 run within, and do not extend, the overall time limits for planning permission and building permits set by the Government.

10.7.7 **Reasons.** Every refusal or condition shall state the clause of this Manual on which it is based.

> Commentary. The review periods have no direct precedent and are set by this Manual. A single consolidated comment list and the "no new comments" rule follow common good practice for engineering review.

10.8 Construction inspection

10.8.1 **Hold points.** The approved hold-point schedule (Form 10-4) shall include at least:

- (a) the excavated base of each retention, infiltration and detention facility, before any media, liner or structure is placed;
- (b) the outlet structure, orifice and trash screen, before backfill or before the facility is first allowed to fill;
- (c) the infiltration tests of Clause 10.9.3;
- (d) the outfall, flap or tide gate and non-return valve, before the downstream connection is made; and
- (e) pumps and controls, at commissioning.

10.8.2 Each hold point shall be inspected by the certifying professional and recorded on Form 10-4 with dated, geotagged photographs. For sites under Clause 10.6.1, the Authority shall be given at least 3 working days' notice of hold points (a) and (b), and may attend.

10.8.3 **Protection during construction.**

- (a) Retention and infiltration areas shall be fenced off from construction traffic and stockpiles.
- (b) Infiltration facilities shall not be brought into service until the area draining to them is stabilised.
- (c) Sediment shall be removed from any facility used for temporary sediment control before the as-built survey.

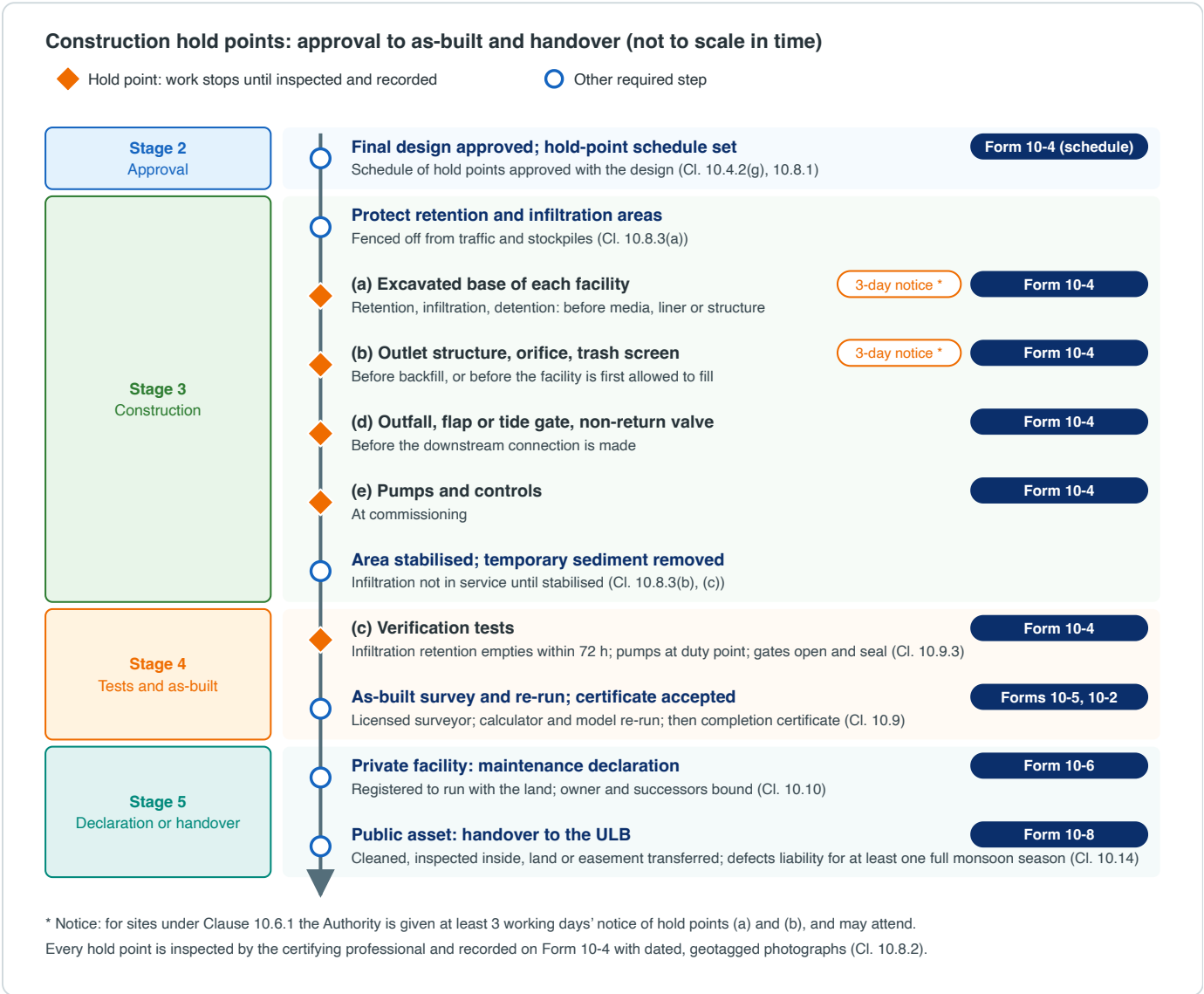

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement sequence of APWA Section 5600 (2006), §5608.

> Commentary. Infiltration facilities fail most often in construction, when they are compacted or filled with silt before they ever operate. Hold points (a) and (c) target that failure. The 3-day notice is set by this Manual.

10.9 As-built certification

10.9.1 Before the completion certificate is issued, the certifying professional shall submit the **As-built Certificate (Form 10-5)** with:

- (a) an as-built survey by a licensed surveyor of each facility's levels, storage volume, outlet dimensions and inverts, and the outfall;
- (b) a re-run of the compliance calculator, and of the model where one was used, with as-built values;
- (c) the completed hold-point records (Form 10-4); and
- (d) the final O&M plan and the executed maintenance declaration or handover documents (Clauses 10.10 and 10.14).

10.9.2 **Acceptance.** The as-built facility is accepted where:

- (a) the as-built storage volume at each design level is not less than the volume required by Chapter 4;
- (b) the outlet dimensions and inverts match the approved design; and
- (c) the re-run shows compliance with every criterion of Chapters 4 and 5.

Any deviation shall be corrected, or re-certified as compliant under Clause 10.3.5.

10.9.3 **Verification tests.** Every retention facility that relies on infiltration shall be tested after construction to show that it empties within **72 hours**, as Chapter 4 requires. Pumped facilities shall be tested at their design duty point. Tide gates and non-return valves shall be shown to open and seal.

10.9.4 The Authority shall not issue the completion certificate until Form 10-5 is accepted.

> Commentary. The 72-hour retention drawdown is the criterion of Chapter 4. This Manual requires it to be tested after construction, rather than relying on pre-construction tests alone, because compaction during construction can cut infiltration rates far below the design values.

10.10 Maintenance declarations and covenants

10.10.1 **Declaration.** The owner of every private stormwater facility shall execute a **Maintenance Declaration (Form 10-6)** before the completion certificate is issued. The declaration shall:

- (a) identify each facility, its location and the approved O&M plan;
- (b) bind the owner and successors in title to operate, inspect and maintain the facility under the O&M plan;
- (c) grant the Authority a right of entry to inspect, and to carry out works in default under Clause 10.15;
- (d) prohibit removal, filling, covering, reduction or change of use of the facility without the Authority's approval; and

- (e) be registered so that it runs with the land and is disclosed to purchasers.

10.10.2 **Multi-owner developments.** For apartments, layouts and gated communities, the declaration shall name the association or body responsible after handover by the developer. The developer remains responsible until that body is legally constituted and has accepted the declaration in writing.

10.10.3 **Annual declaration.** Every owner of a facility in a Tier A area, and of any pumped facility, tide gate or regional facility anywhere, shall submit an **Annual Maintenance Declaration and Inspection Report (Form 10-7)** by **31 March** each year. The report shall be signed by the owner and, for facilities under Clause 10.6.1(c) and (d), by an empanelled professional. It shall state that the pre-monsoon inspection of Clause 10.12 has been done and any defects corrected.

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

> Commentary. Singapore requires owners of pumped detention systems to file yearly declarations and documents with PUB (PUB Detention Tank Guide, citing Code of Practice §13.2). Addendum No. 3 to the Code of Practice (16 Apr 2025) introduced annual maintenance declarations for flood barriers and pumped detention tanks, following amendments to the Sewerage and Drainage Act. APWA 5600 (2006, §5608) required easements and maintenance provisions for detention facilities. A registered declaration matters in Mizoram because detention tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 31 March date is set by this Manual to fall before the monsoon season (April–October), when most Mizoram 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. Mizoram has no dated State order fixing pre-monsoon desilting: the Master Plan for Aizawl: Vision 2030 says only that "drains need to be cleaned every year before the onset of monsoon", and found that only 8% of the villages in its area have open drains with regular maintenance, 40% periodic maintenance and 52% none at all. No notification divides the drains among their owners (this Manual's reading), and they are run by several hands: the Aizawl Municipal Corporation, with its Local Councils, for the public drains and the drains along public streets, which vest in it (Mizoram Municipalities Act, 2007, s.289(1)); PWD in practice for the side drains of the State roads, which were never devolved to the Corporation (CAG), although the same drains vest in the

Corporation on the statute, an overlap this Manual states and does not resolve; the national-highway agencies for NH-6 and the other national highways; PHED and SIPMIU for the sewers and the Chite sewage treatment plant; the Lunglei Municipal Council in Lunglei; the Village Councils for village drains, a duty the State may assign to them ("Sanitation and drainages", Mizoram (Village Councils) Act, 2025, s.15(1)(q)); and, in the Autonomous District Council areas, the District Councils and their Village Councils [TBC]. Owners maintain the terrace swales, interceptor drains and down-drains built under a site development permit (SD&SM 2017, reg. 27). The Roadmap to Stability (Landslide Policy Committee for Aizawl City, 2014) asked PHED to "Create an office within the Public Health Engineering Department to design and build, monitor and repair or improve drainage systems", and said that the Corporation "should have controlling authority for all developmental activities (Roads, Drainage, quarries etc.) within AMC area"; whether either was done was not found [TBC]. The gates that matter most are run for other purposes: the Tuirial dam is operated by NEEPCO for power, and no rule linking its releases, or those of Serlui B, to warnings for the reaches below was found [TBC]. No operating rule for any flap gate, check dam or pumping station in a Mizoram town, linking it to a river level, a dam release or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

10.12 Inspection frequencies

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

Table 10.3 — Minimum owner inspection frequencies

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

A heavy-rainfall event, for this Clause, is a day on which the nearest approved gauge records rainfall at or above the IMD "heavy rainfall" category, or a day for which a red alert is issued for the district. In Mizoram, the pre-monsoon inspection of flap gates, non-return valves, debris racks, sediment traps, debris basins, culvert inlets and any pumped facilities, including the gates on outfalls that the Tlawng, the Khawthlangtuipui at Tlabung or another valley river can close, with the desilting and the clearance of debris, garbage and slide material from every drain, lui inlet, catch-pit, rack, trap, basin and culvert, the clearance of the terrace swales, interceptor drains and down-drains of SD&SM reg. 27, the inspection and clearance of the weep holes and subsurface drains of retaining walls, and the pump duty and gate seal tests, shall be completed by **31 March**; racks, culverts, flap gates and any pumped facilities, with their standby power, shall be certified ready on the same date, because the season of this Manual begins on 1 April and storms come in April. Flap

gates, racks and any pumps shall then be kept on standby, with the monthly test run, from **1 April to 31 October**, and at an outfall to the Tuirial reservoir or to a reach below the Tuirial or Serlui B dam until the releases have ended, if that is later. Drains, terrace swales, interceptor drains, racks, culvert inlets and catch-pits shall be cleared again by **30 April**, of the debris, garbage and slide material of the April storms, before the May storms that brought the State's deadliest dated rain events, and every public drain, lui inlet, rack, trap, basin and culvert in every town shall be cleared of the sediment, slide debris and garbage of the season by **15 November**, with a survey of the cut slopes, terraces and retaining walls above them, so that the drains are clear for the post-monsoon cyclones of October to December.

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

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

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

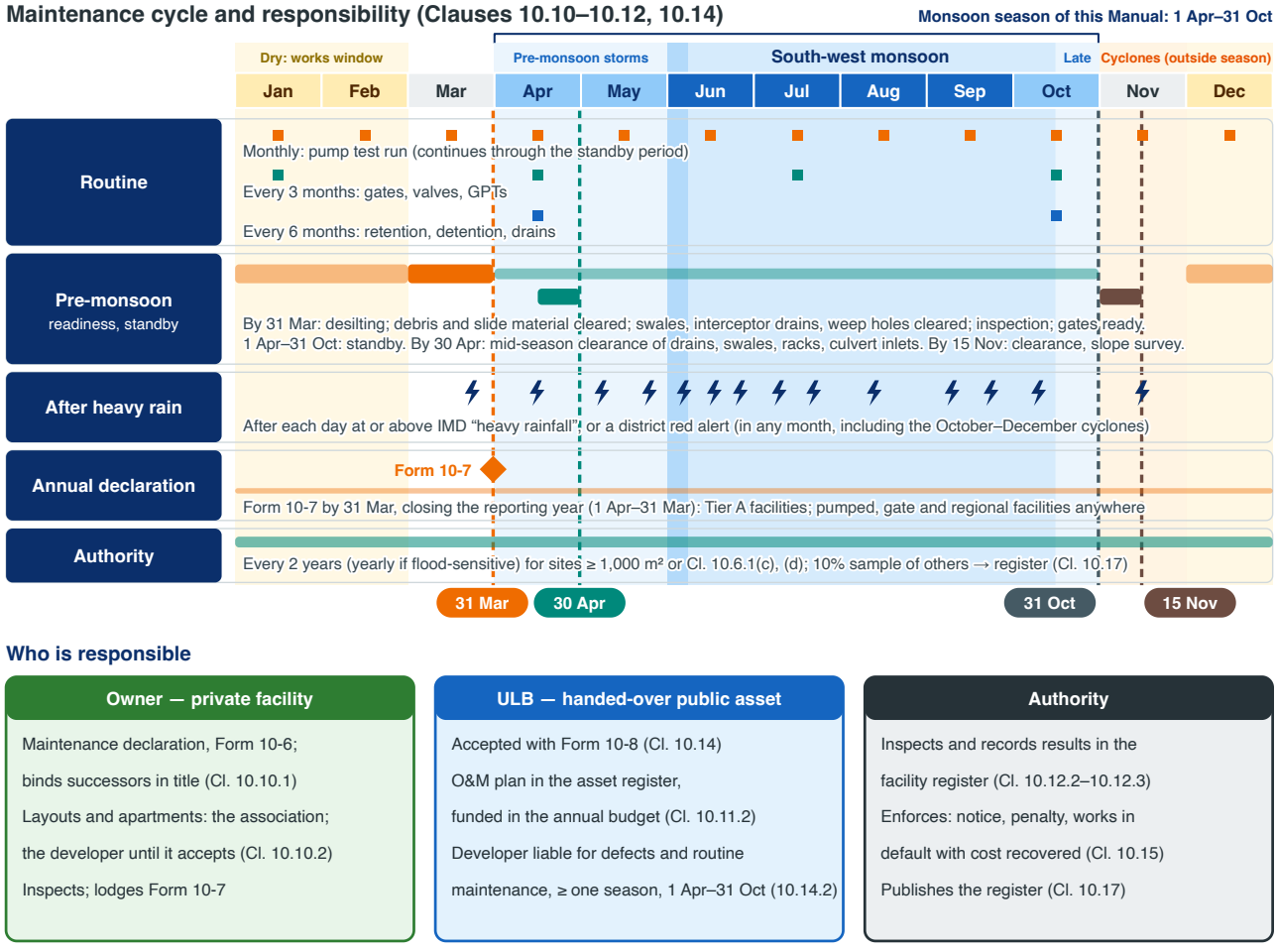

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 March) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the monsoon season (April–October);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

Commentary. The split in Clause 10.12.2 follows the MBBL 2016 inspection regime for RWH, which requires 100% monitoring of buildings over 1,000 m² and a 10% random check below that (MBBL 2016, §9.6). The inspection intervals in Table 10.3 are set by this Manual. The 31 March deadline is set by this Manual for a wet season that begins before the south-west monsoon. In this Manual the monsoon season runs from 1 April to 31 October, and its first two months bring the State's deadliest dated rain events: the Laipuitlang–Ramhlun Venglai rockslide in Aizawl (11 May 2013 by the press and the AGU Landslide Blog, 15 May 2013 by one paper), the Melthum–Hlimen quarry collapse in Cyclone Remal (28 May 2024) and the 598 landslides of 24 May–3 June 2025 (DM&R figures, as reported). April storms shut schools in five to nine districts on 27–28 April 2026, with 70.5 mm at Serchhip and 55 mm at Hnahthial (as reported). CGWB finds "heavy rainfall during May to late September" (Lunglei booklet), and the Agriculture Department's project report for NAFCC "high rainfall during May to September" (2016). NDMA (2010) sets 31 March for pre-monsoon desilting nationally, and this Manual keeps that date, as the other North-East editions of this series do. December to February is the works window. No Mizoram order fixing a date for desilting drains or readying slope drains, racks and gates was found; the Master Plan for Aizawl: Vision 2030 says only that "drains need to be cleaned every year before the onset of monsoon". This Manual therefore takes 31 March for desilting and the clearance of debris, garbage and slide material, the clearance of the terrace swales, interceptor drains and down-drains of SD&SM reg. 27, the inspection and clearance of the weep holes and subsurface drains of retaining walls, the pre-monsoon inspection, the annual declaration and the readiness of racks, culverts, flap gates and any pumps, with no later readiness date. The research's suggestion of 15 April for slope drains and weep holes is not used, because the Manual's season begins on 1 April and the April storms of 2026 came on 27–28 April. The normal onset and withdrawal dates of the south-west monsoon at Aizawl were not obtained [TBC]; in 2026 the monsoon reached Mizoram about 6 June (as reported). Here Mizoram's own record moves one date. The other North-East editions of this series clear racks, culverts and inlets a second time by 31 May, or by 15 May, but the earliest of the State's dated deadly May events fell on 11 May (Laipuitlang, 2013), so a clearance due by 15 May could come after it, and one due by 31 May after all three. Drains, terrace swales, interceptor drains, racks, culvert inlets and catch-pits are therefore cleared again by 30 April, after the April storms and before every dated May disaster in the record. Storms continue after the season: the same 2016 report finds that "the cyclones of the Post Monsoon season (October to December) are more intense than those of Pre-Monsoon season (April & May)", and Chawngte had 130 mm in a day in October 2025, "highest in the region" (as reported). Flap gates, racks and any pumps are therefore kept on standby to 31 October (Figure 10.3), and every town clears its drains a second time, and surveys its cut slopes, terraces and retaining walls, by 15 November. The research's 30 November is not used: 15 November, the series' date, clears the drains before most of the cyclone window rather than after it. The post-event inspections of Table 10.3 cover storms at any time of year. The reporting year runs from 1 April to 31 March, so that the annual declaration of 31 March closes it.

10.13 Maintenance access

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

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

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

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

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

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

> Commentary. APWA 5600 (2006, §5608) required a 15-ft (about 4.5 m) maintenance access strip for detention facilities. Plot sizes in Mizoram towns make a fixed width hard to apply to every site, so this Manual sets functional requirements. Annex 10C covers maintenance access dimensions.

10.14 Handover of public assets to the ULB

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

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

10.14.2 **Defects liability.** The developer shall remain responsible for defects and for routine maintenance for a defects liability period that includes at least **one full monsoon season, from 1 April to 31 October,** after handover. The ULB may hold a security deposit for this period.

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

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

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

10.15 Enforcement

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

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

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

Table 10.4 — Graduated enforcement response

Step	Action
1	Written notice stating the contravention, the clause breached, the remedy and a compliance period.
2	Stop-work order, or withholding of the completion certificate, for development not yet complete.
3	Penalty under the applicable Act or rules.
4	Works in default by the Authority, with the cost recovered from the owner.
5	Disconnection of the private drain connection to the public system, where this causes no hazard to others.
6	Report of the certifying professional to the registering authority, and suspension from the empanelled list.

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

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

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

> **Commentary.** Penalties are referred to generically. This Manual cannot itself create offences or fines, and the powers come from the Acts under which the Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 are made and from the municipal Acts. The graduated steps are set by this Manual. In Mizoram the courts and the National Green Tribunal have become working regulators of slopes and streams, while the statutes carry powers that are little used on record. The Gauhati High Court (Aizawl Bench), in a suo motu public-interest case on a letter of the INTACH Mizoram Chapter, directed in July 2024 that "no new construction activity shall henceforth be allowed on either side of the Bawngkawn – Durtlang (Leitan) road", kept the Corporation's approvals beyond the first floor "in abeyance" and exempted retaining walls built to prevent landslides, quoting the master plan's "development on slope more than 36 degree should be strongly discouraged" (as reported; the case number was not found [TBC]); the same Court quashed the Riverine Reserved Forest notification of 1965 on 27 January 2021, and the State's appeal was dismissed as withdrawn on 9 November 2022 (as reported). The Tribunal supervises sewage and polluted stretches: in O.A. No. 593 of 2017 and O.A. No. 673 of 2018 MPCB reported the trial run of the Chite sewage treatment plant from 6 February 2021, a River Rejuvenation Committee, and a compensation regime adopted on 5 May 2020 under which "no compensation has been levied till date" (MPCB report, February 2021); in O.A. No. 606 of 2018 the State reports its sewage and treatment capacity every six months. The statutes give the Corporation the powers this chapter needs, but no record of their use on drainage was found, so they are untested: all drains in the municipal area, "whether private or public, shall be under the survey and control of the Board of Councillors" (Mizoram Municipalities Act, 2007, s.290); the Corporation cleanses them (s.291) and may drain a sudden water-logging across private land without notice (s.294); a private drain may enter a municipal drain only with the Chairman's written permission (s.295), and no drain may be led into a municipal drain or any water-course without written consent (s.296); the Corporation may require foul water to be drained apart from rain water (s.298); the State may take control of "imperfect, inefficient or unsuitable" drainage works (s.299); and no structure may be built over a municipal drain, culvert or storm-water channel, on pain of a fine of up to ₹500 and ₹100 a day (s.300). A regulation made under the Act may provide fines of up to ₹1 lakh, with ₹1,000 a day after conviction (s.374), but whether the AMCBR or SD&SM do so was not checked [TBC]. SD&SM 2017 makes "The owner … responsible for maintaining drainage facilities installed under their permit" (reg. 27), with no inspection regime stated, so the duty is nominal until someone inspects it. The AMCBR work through the permit: OBPAS, which since 2023 "shall return" any proposal not as per the regulations and the master plan, and, since 2025, an

> Occupancy Certificate issued after an inspection within 7 working days and only once excess materials are removed from public roads; of 15,162 OBPAS applications from June 2018 to 1 April 2024, 7,159 were valid and 6,214 had expired (CAG). The Mizoram Water Resources (Management and Regulation) Act, 2024 provides penalties of up to 3 months or ₹10,000 for a first offence and 6 months or ₹25,000 for a later one, with the Deputy Commissioner as penal authority (s.20), but the notifications constituting MISWARC and WARDMA were not found [TBC] and the Act does not extend to the Autonomous District Councils, so for drainage it is nominal so far. The Mizoram (Village Councils) Act, 2025 lets a Village Council declare an area "unsafe site for house construction for mitigation of landslide" with the approval of the District Disaster Management Authority, and adopt and enforce model building bye-laws "as may be framed by the State Government" (s.13(6)), but no model bye-laws were found, so building control for drainage outside the municipalities is untested; in the Lai, Mara and Chakma Autonomous District Councils none of these Acts applies, and no District Council instrument on building or drainage was found. The CAG's Report No. 1 of 2025 found that "regular inspection of landslide prone areas and research studies have not been conducted", that there was "no Action Plan for checking unplanned urbanisation", that automated landslide monitoring "envisaged in the State Plan since 2015" had not been set up, that the National Building Code for seismic zone V was "yet to be adopted in the sampled Lawngtlai and Mamit districts", and that none of the measures IIT suggested for the Durtlang BSUP complex after its collapse of 2 July 2019 was carried out; no audit of storm drainage in Mizoram was found. This shows that a rule without routine enforcement does little, and that where the State has not drawn a line on the ground the courts have. Professional accountability (step 6) is often more effective than fines on owners, because it acts on the person who signs the design.

10.16 Monitoring and post-event review

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

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

- (a) rainfall at the nearest approved gauges, by duration, compared with the design depths of Chapter 2;
- (b) the level of the receiving river at the nearest CWC level-monitoring site, where there is one (Sairang on the Tlawng, or Turial on the Tuirial, the only site with a published high flood level, 149.0 m on 17 June 1995; no site in the State has a warning or danger level), or of the Tuirial reservoir as NEEPCO records it, each on a named datum, and, where it is gauged, at the outfall; for an ungauged lui, river or dil, such as the Chite lui and the Ser lui in Aizawl and the Khawthlangtuipui at Tlabung, the flood marks surveyed after the event and the boulders, slide debris and garbage deposited at crossings, racks and culverts; the state of every flap gate, debris rack, sediment trap, debris basin, check dam and pumping station on the outfall and on the drain upstream of it, with the volume of debris and garbage removed from each and the hours any pump ran; the slides, slope failures and blocked down-drains, interceptor drains and weep holes in the catchment of the outfall, located on the landslide hazard maps; and the gate openings and releases of the Tuirial or Serlui B dam where they 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), MSDMA, 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. Mizoram's landslides and floods have been counted more often than they have been reviewed, and the counts conflict. In Cyclone Remal on 28 May 2024 the tolls were reported rising through the day, to 29 dead in Aizawl district with 7 missing by 29 May; a later report gave 15 dead at the Melthum–Hlimen quarry and 5 at Hlimen, another 34 killed in seven Aizawl areas, and the State's toll was put at 27 to 29 (all as reported). The Laipuitlang–Ramhlun Venglai rockslide is dated 11 May 2013 by the press and 15 May 2013 by one paper, and killed 17 by that paper's count or 8 by another review. For 24 May–3 June 2025 DM&R counted 598 landslides, five dead, 171 houses damaged and 257 road blockages (as reported). The Tlabung flood of June 2017 submerged about 350 houses in the sub-division by one count, or 9 fully and more than 60 partly by the district officials' (as reported). Over 2017-18 to 2021-22 landslides affected 661 villages and killed 41 people, and floods affected 434 villages and killed 12 (CAG, Report No. 1 of 2025). Heavy rain brought landslides to Aizawl, Champhai, Lawngtlai and Hnahthial in August 2026 with no casualties, and a landslide at Vairengte in September 2026 killed one boy (both as reported). DM&R's final tolls for these events were not obtained [TBC]. No review of any landslide or flood in a Mizoram town, and no record of flood extents, depths or durations kept by the Aizawl Municipal Corporation, the Lunglei Municipal Council or MSDMA, was found, and for most of these events no gauge recorded the rain: the rainfall at Aizawl in Cyclone Remal is not known, and the 20 mm at Mizoram University in IMD's release of 28 May 2024 is for an unclear window. NDMA (2010) called for automatic rain gauges at "1 in every 4 sq km" in Class I, II and III cities. Clause 10.16.1 asks only for gauges where they serve design and review. The report and sampling intervals are set by this Manual.

10.17 Data publication

10.17.1 Each Authority shall publish, on a public website, and update at least quarterly:

- (a) a **facility register**: location, type, design volume, release rate, owner, date of as-built acceptance, and the latest inspection result for every facility approved under this Manual;
- (b) a summary of each approved drainage report, with Forms 2-1 and 10-2;
- (c) the register of variances and waivers (Clause 1.10);
- (d) the alternatives adopted under the Policy Supplement (Clause 1.7);
- (e) enforcement actions (Clause 10.15.5); and
- (f) event reports and post-event reviews (Clause 10.16).

10.17.2 The State Stormwater Technical Committee shall publish the compliance calculator, all Annexes, the flood-sensitive catchment maps and the State-level summary of facility registers as open data.

10.17.3 Personal data other than the name of a corporate owner or association shall not be published. Security-sensitive details of critical infrastructure may be withheld, with the reason recorded.

10.17.4 Published data shall be machine-readable (for example CSV and GeoPackage) and released under the Government Open Data Licence – India or an equivalent open licence.

> Commentary. Transparency is a design criterion in its own right here. Much of Mizoram's drainage record is public: the Aizawl Municipal Corporation publishes on its website the AMCBR and their amendments, SD&SM 2017, the Mizoram Municipalities Act, 2007 and the Local Council Rules, the Master Plan for Aizawl: Vision 2030, the draft zonal regulations of 2015 and the Roadmap to Stability; the Village Councils Act, 2025, the Water Resources Act, 2024 and the Rivers Ordinance and Bill, 2023 are in the State's published texts; the CAG's Report No. 1 of 2025, the State's and MPCB's reports to the National Green Tribunal, CPCB's list of polluted river

stretches (2025), CERC's order on the Tuirial project, CGWB's State profile and district booklets, and IMD's daily rainfall list for the Meteorological Centre Aizawl are online. Much else could not be found in the public domain: the approval notification of the Master Plan for Aizawl: Vision 2030 and its Map 8.3 of proposed drains, which is in the plan but was not extracted [TBC]; the final gazette of the 2019 amendment of the AMCBR and any amendment of SD&SM 2017; the Landslide Hazard Maps of the Corporation and MIRSAC's atlas as published layers; any building or drainage instrument of the Lunglei Municipal Council or of the Lai, Mara and Chakma Autonomous District Councils, and the model building bye-laws of the Village Councils Act; the notifications constituting MISWARC, WARDMA and MSDMA, and whether the Rivers law was enacted; the design basis of any storm drain, including the Smart City and AMRUT works; the daily and hourly records of any Mizoram rain gauge with its start year; CWC's site sheets and gauge datums; the maximum water level, spillway data and release rules of the Tuirial dam and any level of Serlui B; DM&R's final tolls; and an inventory of the gates, racks, check dams and drains of any town. Publishing inputs and facility records lets the public, researchers and other agencies check that the city's growing stock of private storage actually exists. The open-format requirement is set by this Manual.

10.18 Review of this chapter

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

References (chapter)

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Annexes and forms

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

Annex / Form	Content
Form 10-1	Drainage Report Checklist
Form 10-2	Compliance Calculator Summary
Form 10-3	Professional Design Certificate
Form 10-4	Hold-Point Inspection Record
Form 10-5	As-built Certificate
Form 10-6	Maintenance Declaration
Form 10-7	Annual Maintenance Declaration and Inspection Report
Form 10-8	Asset Handover Certificate
Form 2-1	Design Rainfall Sheet (Chapter 2)

CHAPTER 11

Basin and City Stormwater Master Plans

11.1 Purpose and scope

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

11.1.2 A BSMP shall:

- (a) map flood hazard for the basin under existing and future conditions;
- (b) set the level of service each part of the drainage system must achieve (Clause 11.6);
- (c) identify the works, storage and land needed to reach that level of service, and rank them (Clauses 11.7 and 11.8);
- (d) reserve land for regional storage, dil 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. No Mizoram town has a published storm-drainage master plan with a design storm. The Master Plan for Aizawl: Vision 2030, prepared for the Aizawl Development Authority by the Department of Architecture and Regional Planning of IIT Kharagpur (Chief Minister's message of 11 September 2012), is the only city plan found; OBPAS checks every proposal against it (AMCBR, 2023 amendment), but its approval notification was not found, and a date of March 2013 given in one source is unverified [TBC]. Its drainage chapter describes and proposes; it does not design. It finds that "67% of Aizawl Urban Area is having kutcha drains and 18% are without any drainage system at all. Only 15% of the area is provided with pucca drains"; that there is "no major water logging in Aizawl as it is situated in sloppy ground", yet 33% of the Aizawl W-I area is water-logged "for several days or for hours", which it blames on solid waste in the roadside drains; that drains are "silted up frequently due to insufficiency in the hydraulic design"; and that only 8% of the villages in the plan area have drains with regular maintenance. It proposes that the existing drainage alignments be made permanent and the natural drainage protected "with treatment facilities at the outfall points", a network of drains and catchments on its Map 8.3, which was not extracted [TBC], and eight check dams, below Zuangtui, Sakawrtuichhun, Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen; it sets no design storm, return period or runoff coefficient and sizes no drain. The zonal and ward development plans that are to carry its hazard zoning were not yet in force: their regulations were sent to the Government on 17 May 2023 and had not been approved by September 2023 (CAG), and the draft regulations of 2015 remain a draft. The Roadmap to Stability (Landslide Policy Committee for Aizawl City, 2014) asked PHED to "Adopt and implement a five year capital outlay plan to design and construct facilities to capture and transport rain and waste water away from exposed hillslopes and ejected at locations that will not saturate potentially unstable slopes", and to "eliminate all septic tanks, leach

fields and soak pits within Aizawl City"; no such plan was found [TBC]. No storm-drainage project of the ADB, Aizawl Smart City Ltd or AMRUT was found, and no plan of any kind was found for Lunglei beyond a Development Planning Area notification known by its title [TBC]. No published document sets a design return period for the storm drains of any Mizoram town. 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 UD&PA, the Aizawl Municipal Corporation, the Lunglei Municipal Council, PHED, IWRD, MSDMA, any Village Council or District Council, or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, slopes that open drains, soak pits and uncontrolled discharges saturate until they slide, as at Laipuitlang in 2013 and on the Melthum–Hlimen quarry face in Cyclone Remal in 2024, drains that are kutcha or absent over 85% of the Aizawl Urban Area and end in steep lui that are "turbulent with high velocities of currents during the monsoon season", drains that carry the sullage and septic effluent of towns with one sewered catchment to the Chite and Tuikual streams and on to the rivers that supply them, river floods on the few valley floors, Tlabung, Sairang and Bairabi among them, and single lui split between the Aizawl Municipal Corporation, PWD, the national-highway agencies, the Village Councils and, in the south, the District Councils, 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 Mizoram, the series' fifth North-East edition and its steepest: to towns built on ridges and slopes, Aizawl on ridges between the Tlawng and Tuirial valleys with no valley floor of its own, where the binding stormwater hazard is the landslide that drainage starts rather than the flood, and where drains end in steep lui; to a few valley floors and river terraces, Tlabung, Sairang, Bairabi, Vairengte, Chawngte and the Champhai flats, that flood from rivers in a State officially said to have no flood plain; to a State that lies wholly in CWC subzone 2(c), for which CWC has published no Flood Estimation Report, and in which no rain gauge has a published 24-hour record, so that NIH-DHAARA with the floors of Clause 2.3.6 is the design source everywhere; to ground that will not take water, the Surma-group shales and siltstones that CGWB calls a "run off zone", where water is drawn from springs (tuikhur) and roofs rather than wells; to drains that are the sewers of towns with one sewered catchment; to a slope regulation that fixes the geometry of swales, interceptor drains and down-drains but gives no design storm, in one city only; to three legal geographies, the municipalities, the Village Council areas and the Lai, Mara and Chakma Autonomous District Councils, which no State building, water-resources or rivers law reaches; and to a wet season whose deadliest storms come in May, before the south-west monsoon, so that in every basin a BSMP begins with the hazard, not the storm (Clause 11.3.3).

11.2 Definitions

Term	Meaning in this Manual
Basin	The land draining to one outfall to the sea, a river, or a major waterbody, as delineated under Clause 11.3.
Basin Stormwater Master Plan (BSMP)	The plan for one basin prepared under this chapter.
Lead Authority	The body responsible for preparing a BSMP (Clause 11.4).
Level of service (LoS)	The flood performance a part of the drainage system must achieve, expressed as an AEP and an outcome (Clause 11.6).

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

11.3 Planning unit: the basin, not the ward

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

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

11.3.3 No basin delineation has been published for any Mizoram town. For the urban areas where the evidence identifies them, the basins are at least the following, in the order of the flood-sensitive catchments of Clause 4.5.3.2:

- **Aizawl east, Chite lui:** the catchment of the **Chite lui** to the **Tuirial**, with its tributaries, the Chanmari, Ramthar, Mirawng, Tlak, Bangla, Taite, Bethlehem veng, Lawibual, Hmawngkawn, Zemabawktuikhur, Zuangtui and Kawmthlang lui, and the Muthi and Tuipawl lui that also drain the east of the city (Master Plan for Aizawl: Vision 2030); the destructive reaches named in the plan shown, the Chite sewage treatment plant and the Priority II stretch of the Chite stream in the 1D network, and surveyed flood marks and the 1% AEP level of the lui with its sediment, debris and garbage as the boundary condition, since no lui has a gauge;
- **Aizawl west, Ser lui:** the catchment of the **Ser lui** to the **Tlawng**, with its streamlets, the Ramri, Tuikal, Vai and Zawngkawt lui, and the Khatla, Tuikual, Vaivakawn and Chanmari west lui, "the worst destructive streams and nullahs" of the west (the same plan), with the same boundary conditions;
- **Aizawl, hazard areas within these basins:** the **Hlimen–Melthum quarry belt** on the city's southern edge, the **Hunthar Veng** sinking area and the cuts of **NH-6** at Hunthar, and **Durtlang** with the **Bawngkawn–Durtlang road**, each mapped with its debris paths in whichever of the two basins it drains to [TBC];
- **Sairang, Tlawng:** the catchments of Sairang that drain to the **Tlawng**, with the CWC level-monitoring site at Sairang (no high flood level published) and surveyed flood marks as the boundary, and the outfall-closed case a design case (Clause 5.8.5(c));
- **Bairabi and Vairengte, northern valley floors:** the catchments of the two towns in sub-area MZ-A1, with surveyed flood marks of the receiving rivers as the boundary for at least the 72-hour storm, the adjoining Barak-valley rule of the series governing the reaches downstream;
- **Tlabung, Khawthlangtuipui:** the catchments of Tlabung that drain to the **Khawthlangtuipui**, in sub-area MZ-D1, with the river at its surveyed flood level as the boundary for not less than 72 hours (Clause 5.8.5(d)), the floods of June 2017 and July 2019 as calibration evidence, and no downstream Indian control;
- **Lunglei town:** the catchments of Lunglei and the lui that receive them, whose names and outfalls are to be confirmed in the first BSMP [TBC];
- **Serchhip town:** the catchments of Serchhip, 89.2% of whose area is steeper than 30° (this Manual's arithmetic on MIRSAC's slope classes), with the lui that drain towards the Mat [TBC];
- **Champhai town and the Champhai flats:** the catchments of the town and the paddy flats of sub-area MZ-C1, draining towards the Tiau, with surveyed flood marks as the boundary and the Myanmar reaches beyond any Indian gauge;
- **Siaha and Lawngtlai:** the catchments of the two Autonomous District Council towns in sub-area MZ-D, through the District Councils only, if they adopt the Manual; and

- **Tuirial release reach:** the catchments that drain to the **Tuirial** below the NEEPCO dam, with the largest recorded release or, until NEEPCO gives one, the spillway capacity, as the boundary (Clause 5.8.5(e)).

Hazard first in every sub-area (set by this Manual). In every sub-area of Annex 2A, because the State's binding stormwater hazard is the landslide that drainage starts, every BSMP begins with a hazard screening for landslides, debris flows, quarry faces, sinking ground, river floods on valley-floor land and dam releases, made with the Corporation's Landslide Hazard Maps and MIRSAC's zonation where they exist, the inventories of MSDMA and DM&R where they exist [TBC], and NEEPCO's release reach below the Tuirial dam, and uses site-specific hydrology in place of a CWC report, which subzone 2(c) does not have (Clause 2.3.6(b), (c) and (i)), with the 72-hour storm of Clause 2.3.6(e) as well as the short storms. The record is why: "more than 71 per cent of the total area is in Very High to Moderate Hazard Zone", and landslides in 2017-18 to 2021-22 affected 661 villages and killed 41 people (CAG, Report No. 1 of 2025); a team of the Directorate of Geology and Mineral Resources found that "two-thirds of large-scale landslides … were due to improper drainage" (2022-23, as reported); and the State's deadliest dated rain events, Laipuitlang in 2013, Cyclone Remal in 2024 and the storm of 24 May–3 June 2025, were landslides, not floods. The hazard zones are shown on the 1% AEP map, no drain, storage or pumping station is sited in them, no water is put into the ground on hill ground (Clause 4.11, hill rule), and no work in the CIP is sized to carry a debris flow or a landslide. Other towns define their basins in the first BSMP that covers them. Where CWC, NEEPCO, a master plan or a court has a high flood level, a reservoir level, a line or an operating rule for a dam, gate or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

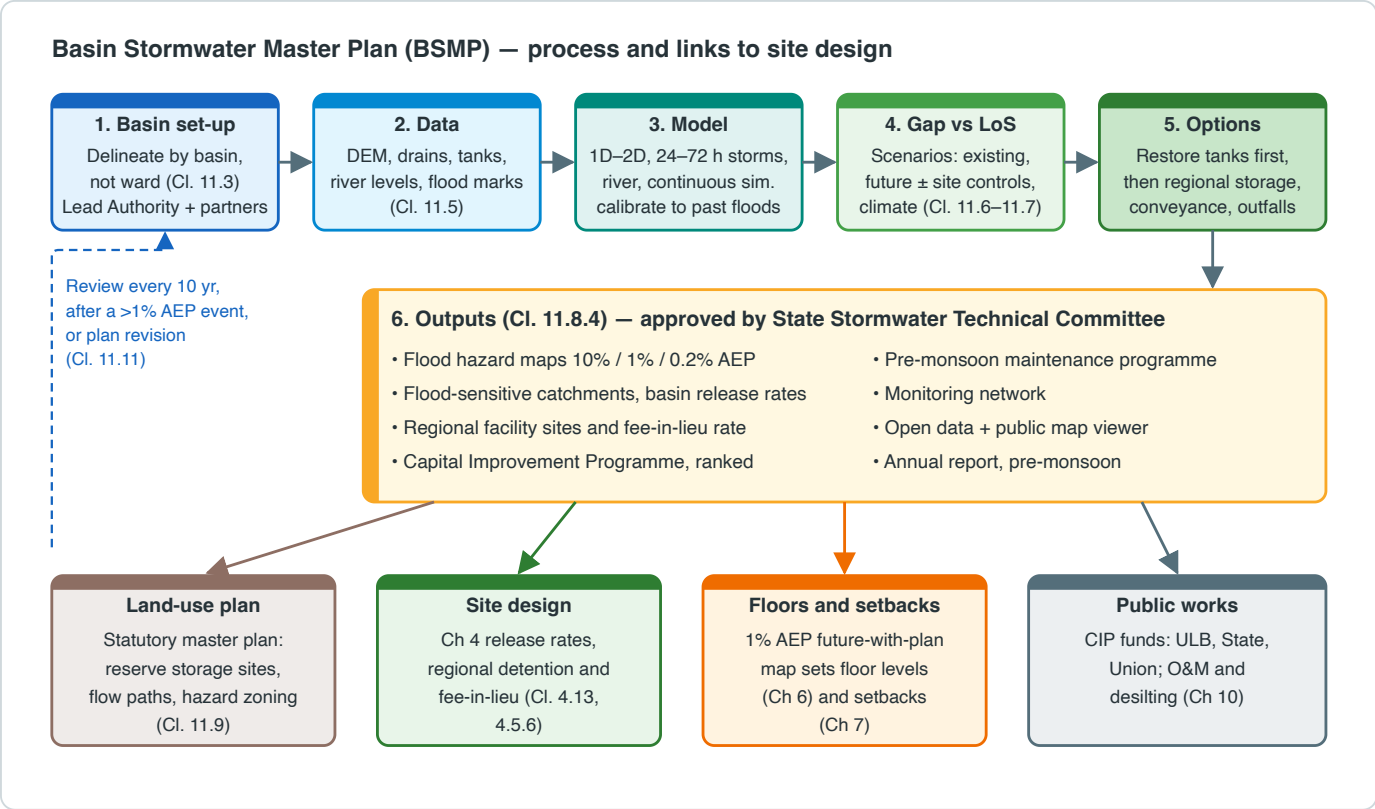

Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

> **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 Mizoram a single lui passes through many hands on its way from a ridge to a river. Aizawl drains east to the Tuirial through the Chite lui, which takes "more than two-third of eastern portion" of the city with its tributaries, the Chanmari, Ramthar, Mirawng, Tlak, Bangla, Taite, Bethlehem veng, Lawibual, Hmawngkawn, Zemabawktuikhur, Zuangtui and Kawmthlang lui, and through the Muthi and Tuipawl lui; and west to the Tlawng through the Ser lui and its streamlets, the Ramri, Tuikal, Vai and Zawngkawt lui (Master

> Plan for Aizawl: Vision 2030). The same lui are at once storm drains, sewers and the feeders of rivers that supply the city: CPCB placed the Chite stream "near SIPMIU's STP to Armed Veng" and the Tuikual stream in Priority II of its polluted river stretches (2025), and the master plan finds septic effluent finding its way "through drains and cross drains to the rivers, which are the sources of water supply". Along one lui the public drains and the drains of public streets vest in the Aizawl Municipal Corporation (Mizoram Municipalities Act, 2007, s.289(1)), the side drains of State roads are PWD's in practice and those of NH-6 the national-highway agencies', the sewers and the Chite sewage treatment plant are PHED's and SIPMIU's, the natural channel and any riverine reserve fall to EF&CC and the Land Revenue and Settlement Department (this Manual's reading), and below the city the lui crosses Village Council land. Beyond the towns the rivers leave the State: the Tlawng, the Tuirial and the Tuivai north to the Barak plain, the Khawthlangtuipui south-west to Bangladesh, the Chhimtuipui south to Myanmar, and the Tiau, on the eastern border, into Myanmar (this Manual's reading); in the south the Lai, Mara and Chakma Autonomous District Councils lie outside the municipal, village-council and water-resources Acts alike. No rule divides the lui from the municipal drains (as this Manual reads the record). This clause makes the basin the planning unit, so that one model carries each lui from its head on the ridge to the river or reservoir whoever owns each reach, and so that the sewage it carries is separated before it reaches the river (Chapter 8, Clause 8.9.5).

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of the Aizawl Development Plan Area: the **Aizawl Municipal Corporation**, in which the public drains and the drains of public streets vest (Mizoram Municipalities Act, 2007, s.289(1)) and whose Board of Councillors makes the AMCBR and SD&SM (s.371), with its **Local Councils**, jointly with the **Urban Development and Poverty Alleviation Department (UD&PA)**, which holds master planning for urban areas and into whose plans, the Master Plan for Aizawl: Vision 2030 and the zonal and ward plans that are to follow it, the BSMP is taken (Clause 11.9). For the basins of Lunglei: the **Lunglei Municipal Council**, with UD&PA. Each role is the one the body would have if the Manual were adopted. Where a basin extends beyond the municipal limits, the Village Councils of the villages it crosses are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the lui and natural streams from the municipal drains, or the drains of the local bodies from the rivers and reservoirs, 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: **IWRD** for the rivers and their flood works; the **Aizawl Municipal Corporation** and the **Lunglei Municipal Council** for the drains that vest in them; **PWD** for the side drains, catch-water drains and culverts of the State roads, and the **national-highway agencies** for those of NH-6 and the other national highways, with the spoil of their works; **PHED** and **SIPMIU** for the sewers and the Chite sewage treatment plant; **NEEPCO** for the Tuirial reservoir, its levels and its releases, and the State's power department for Serlui B; **EF&CC** and the **Land Revenue and Settlement Department** for the natural lui and any riverine reserve (this Manual's reading); the **Village Councils** for the village drains outside the municipalities; and **MSDMA**, with DM&R, the Corporation's Landslide Hazard Maps and MIRSAC's zonation, for the mapping of landslide, debris and sinking hazards that a BSMP must show.
- In the notified towns without an urban local body, Serchhip, Champhai and Kolasib among them (this Manual's reading of the CAG's count of 13 such towns), and in other Tier B bodies: the Lead Authority is named by UD&PA, with the Village Councils of the town; in an Autonomous District Council area, Siaha and Lawngtlai among them, it is the District Council, only if the District Council adopts the Manual (none has). Basins draining to a common river reach or reservoir may be grouped into one district-level plan.

MSDMA and the Deputy Commissioner shall be consulted on every BSMP; NEEPCO on every BSMP whose basin drains to the Tuirial reservoir or to a reach below its dam, and the State's power department for Serlui B; EF&CC on every BSMP whose basin includes a riverine reserve or a wetland; MPCB on every BSMP that proposes works on a lui or drain that carries sewage, among them the Chite, Tuikual and Lawibual streams; the Village or Local Water Resources Committee

on every BSMP whose basin holds a tuikhur or other identified water source; the landholders, or the Village Council, on every BSMP that needs private land or land held under a land pass for a corridor or storage, which is reserved in the master plan or secured by agreement; and, for a basin whose outfall lies on a river that flows on to the Barak plain, such as the Tlawng, the Tuirial or the Tuivai, the water resources department of the adjoining State, through IWRD.

The Irrigation and Water Resources Department (IWRD) 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, dil, 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, lui, rivers, dils and reservoirs	The datum of every level named; on valley-floor land, outfall invert levels against the high flood level of the receiving river at the nearest CWC level-monitoring site where there is one (Turial on the Tuirial, 149.0 m on 17 June 1995, the only one published; no site in the State has a warning or danger level; CWC levels as transcribed by SANDRP, as reported, with the datum not stated), and elsewhere against surveyed flood marks, with any local gauge kept as a separate series; for the free outfalls of the ridge towns, the Chite lui and the Ser lui in Aizawl among them, the bed and bank profile of the receiving lui to the next confluence, its debris and garbage lines and the 1% AEP flood level with its sediment, debris and garbage; for outfalls to the Tuirial reservoir or to the reaches below the Tuirial and Serlui B dams, NEEPCO's full reservoir level (90.5 m) and minimum drawdown level (68.0 m), the maximum water level and the spillway and release data, and the levels of Serlui B from the State's power department [TBC], naming which is used; dils at their surveyed spill levels; the landslide hazard zones of the Aizawl Municipal Corporation's Landslide Hazard Maps and MIRSAC's zonation, slopes above 60°, quarries active and disused, the Hunthar Veng sinking area and the debris paths below cut slopes, fills and retaining walls; and the flap gates, debris racks, sediment traps, debris basins, check dams and any pumping stations on the outfalls, with their capacities and operating rules

Data	Minimum requirement
Rainfall and levels	All available rain gauges (IMD, including the ordinary gauges of its Meteorological Centre Aizawl and at Lengpui, neither of which is in IMD's *Extremes*, and its automatic weather stations at Mizoram University, Kolasib, Champhai, Khawzawl, Serchhip, Hnahthial, Saiha and Chawnhu (record lengths [TBC]); the automatic rain gauges and weather stations listed under Mz-SWIC, about 30 sites (the operator's name is not expanded in the source; start years and logging intervals [TBC]); the State Meteorological Centre of the Directorate of Science and Technology, whose series runs from the 1980s to 2021 (gauge list not seen [TBC]); the ordinary gauges of the Agriculture Department at Serchhip, North Vanlaiphai, Lunglei, Haulawng and Tlabung; the rain gauges of CWC, among them Bairabi, Dapchhuah, Mat-1, Tlabung, Tuichawng, Tuipui D and Shitlangpui, and its level-monitoring sites at Sairang and Turial; the reservoir records of NEEPCO at the Tuirial dam [TBC]; and any gauges or sensors kept by the Aizawl Municipal Corporation, MSDMA or IWRD [TBC]) and water-level records, including those for the 28 May 2024 (Cyclone Remal: the collapse at about 6 a.m. of a disused stone quarry between Melthum and Hlimen and other slides in Aizawl, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen, or 34 in seven Aizawl areas, and 27–29 for the State, all as reported; the rainfall at Aizawl on 27–28 May 2024 was not found, and the 20 mm at Mizoram University in IMD's release of 28 May is for an unclear window), 24 May–3 June 2025 (598 landslides, five dead, 171 houses damaged and 257 road blockages, with Champhai 209, Serchhip 116, Khawzawl 75, Lunglei 61 and Aizawl 21, DM&R figures as reported; Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm on one day whose date is not fixed, as reported; no IMD series for the storm was found), June 2018 (148 mm at Aizawl in one day, probably 12 June, and 677 mm in Serchhip district in 1–13 June, ten dead in landslides on 5 June, houses flooded at Tiperabagh, Serhuan and Tlabung and families stranded at Sairang, all as reported), July 2019 (about 400 houses flooded by the Khawthlangtuipui at Tlabung, 150 of them in the town, and three killed in the State, as reported; no rainfall value was found) and June 2017 (the Khawthlangtuipui flood at Tlabung, with about 350 houses submerged in the sub-division by one count, or 9 fully and more than 60 partly by another, and 8–10 dead, as reported; no rainfall value was found) events
Flood evidence	Surveyed flood marks and mapped flood extents from past events, including public reports
Land use	Existing land use and imperviousness; future land use from the statutory master plan
Soils and groundwater	HSG map (Annex 3A); seasonal high groundwater; aquifer and recharge zones
Sewer interaction	Known sewage cross-connections, dry-weather flow in drains, and solid-waste hotspots

Commentary. The 0.15 m accuracy has no direct precedent; this Manual sets it because on the valley floors and river terraces at Sairang, Bairabi, Vairengte, Chawngte and Tlabung and on the Champhai flats, where the rivers back up over gentle slopes, and on the margins of dils and reservoirs, where a raised road, a dumped fill or a low wall can turn an overflow from one side of a valley floor to the other, 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 28 May 2024 (Cyclone Remal: the collapse at about 6 a.m. of a disused stone quarry between Melthum and Hlimen and other slides in Aizawl, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen, or 34 in seven Aizawl areas, and 27–29 for the State, all as reported; the rainfall at Aizawl on 27–28 May 2024 was not found, and the 20 mm at Mizoram University in IMD's release of 28 May is for an unclear window), 24 May–3 June 2025 (598 landslides, five dead, 171 houses damaged and 257 road blockages, with Champhai 209, Serchhip 116, Khawzawl 75, Lunglei 61 and Aizawl 21, DM&R figures as reported; Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm on one day whose date is not fixed, as reported; no IMD series for the storm was found), June 2018 (148 mm at Aizawl in one day, probably 12 June, and 677 mm in Serchhip district in 1–13 June, ten dead in landslides on 5 June, houses flooded at Tiperabagh, Serhuan and Tlabung and families stranded at Sairang, all as reported), July 2019 (about 400 houses flooded by the Khawthlangtuipui at Tlabung, 150 of them in the town, and three killed in the State, as reported; no rainfall value was found) and June 2017 (the Khawthlangtuipui flood at Tlabung, with about 350 houses submerged in the sub-division by one count, or 9 fully and more than 60 partly by another, and 8–10 dead, as reported; no rainfall value was found) events are the best calibration data Mizoram has, and much of the evidence is held in photographs, news reports and residents' records that should be collected before it is lost.

11.6 Levels of service

11.6.1 Each BSMP shall adopt the following minimum levels of service. A BSMP may adopt stricter levels.

Table 11.2 — Minimum levels of service

Element	Minimum level of service
Minor system	The design AEP of Chapter 6 (Table 6.1)
Habitable buildings	No flooding above floor level in the 1% AEP (100-yr) event
Critical facilities (hospitals, emergency services, substations, water and sewage plants)	No flooding of the facility in the 0.2% AEP (500-yr) event; access road passable in the 1% AEP event
Evacuation routes and arterial roads	Passable (hazard class H2 or better, Chapter 6) in the 1% AEP event
Ponding drain time	Surface water cleared from roads within **6 hours** after rain ends in the 10% AEP (10-yr) event
Tank and dil 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 matters in Mizoram less for tanks than for the few places that hold water: its reservoirs, its few dils, its valley floors and its springs; it has no irrigation tank cascades. The Tuirial reservoir of NEEPCO has a full reservoir level of 90.5 m and a minimum drawdown level of 68.0 m (CERC, Petition No. 125/MP/2021), and the levels of Serlui B were not found [TBC]; no survey of their sedimentation was found [TBC]. The best-known dils are Palak Dil, the Pala Wetland in Siaha district, in the Mara Autonomous District Council's area, Ramsar site No. 2484, designated on 31 August 2021 according to its Ramsar information sheet (as quoted) and announced on 26 July 2022 (as reported), a site of 1,850 ha with a water body of about 135 ha (as quoted); and Tam Dil, 6 km from Saitual, rebuilt as a fishery reservoir by the Fisheries Department (as reported; area not found). The Master Plan for Aizawl: Vision 2030 puts rivers, streams and water bodies at 585 ha, 3.83% of its area, places springs, ponds, lakes and wetlands in its "W" use zone and recommends stopping the dumping and earth filling of water bodies; the Mizoram Water Resources (Management and Regulation) Act, 2024 counts "springs, ponds, lakes, tanks, traditional water harvesting structures, wells" among "community water resources" (s.2(1)(i)), and "tuikhur" is defined in law as "any place wherein water supply is obtained" (Mizoram (Village Councils) Act, 2025, s.2(29)). No State Wetland Authority notification, no notified wetland other than the Ramsar site, no inventory of Aizawl's tuikhur and no survey of the storage of any dil or of any valley floor was found [TBC].

11.7 Modelling and scenarios

11.7.1 **Model.** Each BSMP shall use a coupled 1D–2D hydraulic model of:

- the minor system;
- the major (overland) system;
- rivers, canals and tanks; and
- the outfalls.

Methods shall follow Chapter 3. Tidal and river boundaries shall follow Chapter 5.

11.7.2 **Design storms.** The model shall be run for the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs. Areal reduction shall be applied under Clause 2.7.3.

11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms arrive, and how often heavy rain coincides with a closed outfall. The two-step approach of Clause 3.13.5 may be used: a simplified storage model is run for the whole record, and the coupled 1D–2D model of Clause 11.7.1 is run only for the design storms, starting from the tank levels the continuous run gives. A continuous run of the full 1D–2D model is not required.

11.7.4 **Scenarios.** Each BSMP shall model at least:

- (a) **Existing:** existing land use, network, tanks and outfalls;
- (b) **Future, uncontrolled:** future land use under the statutory master plan, with no site controls;
- (c) **Future, controlled:** future land use with the site controls of Chapter 4;
- (d) **Future, with plan:** scenario (c) plus the works of the CIP; and
- (e) **Climate:** scenarios (a) and (d), with the climate factors of Clause 2.8, used unchanged: no projection of heavy rainfall for Mizoram has been adopted with a design factor; the Agriculture Department's project report for NAFCC (2016), citing a "State remote sensing center report", projects "nearly 25% increase in rainfall" in some districts and a rise of "about 26%" in the number of yearly extreme rainfall events, which is a statement of frequency, not of intensity, and is not used as a factor; the State Action Plan on Climate Change itself was not read [TBC]; and in every sub-area the 72-hour storm of Clause 2.3.6(e) and the hazard screening of Clause 11.3.3 are run in every scenario, because the State's landslide storms last for days.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the 28 May 2024 (Cyclone Remal: the collapse at about 6 a.m. of a disused stone quarry between Melthum and Hlimen and other slides in Aizawl, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen, or 34 in seven Aizawl areas, and 27–29 for the State, all as reported; the rainfall at Aizawl on 27–28 May 2024 was not found, and the 20 mm at Mizoram University in IMD's release of 28 May is for an unclear window), 24 May–3 June 2025 (598 landslides, five dead, 171 houses damaged and 257 road blockages, with Champhai 209, Serchhip 116, Khawzawl 75, Lunglei 61 and Aizawl 21, DM&R figures as reported; Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm on one day whose date is not fixed, as reported; no IMD series for the storm was found), June 2018 (148 mm at Aizawl in one day, probably 12 June, and 677 mm in Serchhip district in 1–13 June, ten dead in landslides on 5 June, houses flooded at Tiperabagh, Serhuan and Tlabung and families stranded at Sairang, all as reported), July 2019 (about 400 houses flooded by the Khawthlangtuipui at Tlabung, 150 of them in the town, and three killed in the State, as reported; no rainfall value was found) and June 2017 (the Khawthlangtuipui flood at Tlabung, with about 350 houses submerged in the sub-division by one count, or 9 fully and more than 60 partly by another, and 8–10 dead, as reported; no rainfall value was found) events where data exist.

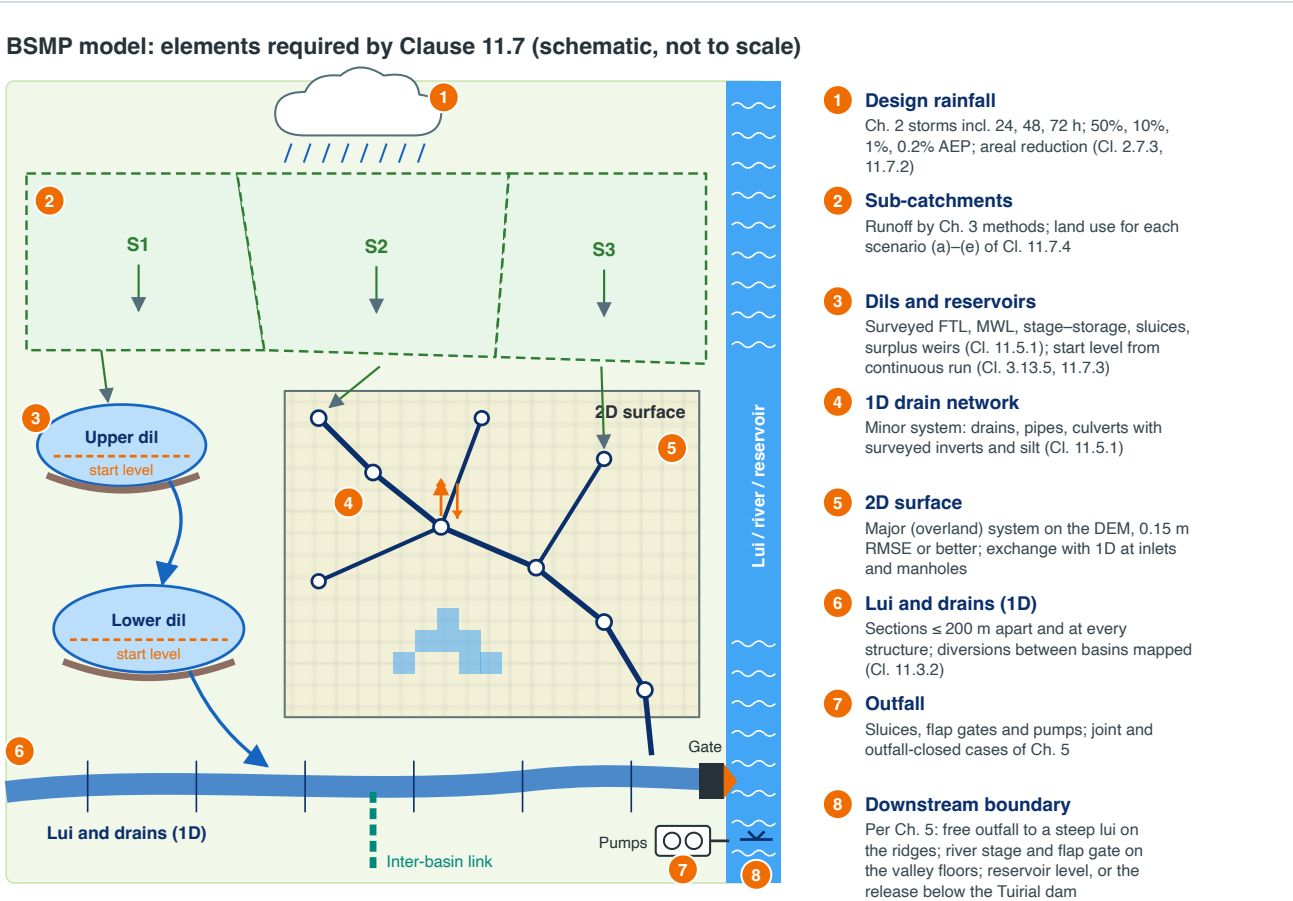

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and dils with starting levels from continuous simulation, and the tidal or river boundary at the outfall (schematic, not to scale). Original drawing for this Manual, 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:** dils, 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:** energy dissipators, stepped chutes, drop structures and protected outfalls wherever a drain or down-drain reaches a lui, so that none discharges onto an unprotected slope, with the receiving lui stabilised to the next confluence where the check of Clause 5.8.5(a) shows it eroding; debris racks, sediment traps and debris basins where lui enter culverts and covered drains, with ramps for the machines that empty them, and the check

dams proposed in the Master Plan for Aizawl: Vision 2030 where a BSMP confirms them; flap gates and penstocks on the outfalls of the valley floors and terraces to the Tlawng at Sairang and Bairabi and to the Khawthlangtuipui at Tlabung, with storage or pumping behind them where a river in flood can close an outfall; the interception and screening of dry-weather flow before the outfalls to the Chite, Tuikual and Lawibual streams and the Tuipui, to any dil and above any tuikhur (Chapter 8, Clause 8.9); and the release rules of the Tuirial and Serlui B dams that set the receiving levels, agreed with NEEPCO and the State's power department;

5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example IMD district rainfall warnings and nowcasts issued by its Meteorological Centre Aizawl, rainfall alarms from the automatic gauges of IMD and Mz-SWIC, level gauges with alarms on the Khawthlangtuipui at Tlabung and on the valley rivers at Sairang and Bairabi, which have none today, warnings from NEEPCO before releases from the Tuirial dam [TBC], the automated landslide monitoring "envisaged in the State Plan since 2015" and not yet set up (CAG), and the District Disaster Management Authorities), 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 the springs (tuikhur) and spring-fed water points that supply the villages and part of the towns, and their catchments above the water points, which this Manual keeps free of paving and of infiltrated road runoff (the spring rule of Chapter 8), the stability of hill slopes, where water put into shale, colluvium, fill or slide debris raises the pore pressure, as SD&SM 2017 warns and the slides of Hlimen and Laipuitlang show, recharge on tested valley alluvium and river terraces, the only ground where it is allowed (Clause 4.11, recharge rule), although groundwater is barely drawn (stage of extraction 3.52% in 2011, CGWB, and 3.95% in 2024, as quoted), and the quality of the springs, lui, rivers, dils and reservoirs that the runoff reaches, several of which carry sewage (Chapter 8, Clause 8.9) (Chapter 8);
- effect on downstream basins and the receiving river, stream (lui), dil or reservoir; and
- who benefits.

11.8.3 **Basin release rates.** Where scenario (c) does not meet the level of service, the BSMP may set a basin-specific **permissible site discharge** ($m^3/s/ha$) stricter than Chapter 4, by AEP and sub-catchment. The rate takes effect under the notification procedure of Clause 4.5.4.

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

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

> Commentary. Storage comes first in Mizoram for a different reason than on the plains: there is little flood storage left to restore on the ridges, but every litre held on a site is a litre that does not run down a cut slope or into a lui already "turbulent with high velocities of currents during the monsoon season" and "very destructive" (Master Plan for Aizawl: Vision 2030), and on the valley floors at Tlabung, Sairang and Bairabi the outfalls are closed while the rivers are high. On hill ground storage means a lined tank or a paved terrace, never a pond that soaks into the

ground (Clause 4.11, hill rule). The storage of at least 25 litres per m² of roof that Clause 4.11 sets, where the AMCBR require "a suitable rain water harvesting facility … in all buildings" (reg. 33) without a volume, is the first of it, and it also serves supply: 27.16% of households in the Aizawl Urban Area use rain water (the same plan), and PHED's supply was reported at 44 litres per head per day, with 35% unaccounted for (as reported; date not fixed). The master plan's eight proposed check dams, below Zuangtui, Sakawrtuichhun, Government Complex, Mission Vengthlang, Tlangnuam, Saikhamakawn, Melthum and Hlimen, would hold sediment and debris as well as water, and are confirmed or replaced by the BSMP. Concrete channels alone will not serve on a lui that carries garbage, boulders, slide debris and sewage. The storms are large for drains with no stated design basis: 148 mm fell at Aizawl in one day, probably 12 June 2018, and 677 mm in Serchhip district in 1–13 June 2018 (as reported), and the 50-year 72-hour depth of NIH-DHAARA's Aizawl cell is 318.9 mm. Conveyance upgrades on their own move water faster to a steep lui whose bed and banks erode and slide with the debris and garbage it carries, to an outfall on a valley floor that the Tlawng, the Khawthlangtuipui or another river in flood may close, or to a reach below the Tuirial or Serlui B dam whose level the releases set. Groundwater in Mizoram calls for storage and the protection of springs, not recharge. The stage of groundwater extraction was 3.52% in 2011, with "Areas Notified for Regulation of ground water development: NIL" (CGWB, State profile), and 3.95% in 2024, with all 26 assessed units safe (CGWB, as quoted); in Lunglei district "Ground water is used for drinking purpose only" and no water-level trend is available "due to lack of ground water abstraction" (CGWB). Little rain enters the ground: the shale, siltstone and sandstone ridges of the Surma group are "characterized by low permeability and infiltration" and act as a "run off zone" (CGWB, Lunglei). The towns' water comes from rivers, roofs and springs: "the main source of water supply for Aizawl is from Tlawng River", 27.16% of households in the Aizawl Urban Area use rain water and 1.01% spring water (Master Plan for Aizawl: Vision 2030, Table 8.2), and "Mizoram is an abode of springs" (CGWB), whose yields of "3,000 to 20,000 liters per day" in January to March sustain the dry season (CGWB, Lunglei). The springs are under strain: "Urbanisation has led to drying up of traditional water sources, like tuikhur" (as reported), and spring-shed work is reported under a GIZ-supported study of 20 springs, with the Forest Department as nodal agency for a pilot of 100 springs, and by NEIDA and the Tata Trusts in Serchhip and Lunglei districts (all as reported); no count of Aizawl's tuikhur was found [TBC]. Water put into the ground on the hills does harm: SD&SM 2017 names "increasing the amount of groundwater penetrating into slopes" among the causes of slope instability, and the Roadmap to Stability (2014) asked for the elimination of "all septic tanks, leach fields and soak pits within Aizawl City". No State groundwater Act was found; the Mizoram Ground Water (Control and Regulation) Bill, 2023 is known by its title page only. The Mizoram Water Resources (Management and Regulation) Act, 2024 has IWRD "promote rain water harvesting to augment ground water recharge" (s.14(1)(b)(viii)); on hill ground this Manual reads that duty as storage and reuse, not recharge (Clause 4.11). This is why springs and their catchments, slope stability, recharge on the only ground that can take it, and the quality of the water the runoff reaches are all assessment criteria. This Manual ranks projects by risk reduction per rupee so that limited budgets go first where most people are protected.

11.9 Integration with land-use planning

11.9.1 An approved BSMP shall be incorporated into the statutory land-use plan: the Master Plan for Aizawl: Vision 2030, against which OBPAS checks every proposal (its approval notification was not found [TBC]), and the zonal and ward development plans that are to follow it, whose regulations were sent to the Government on 17 May 2023 and had not been approved by September 2023 (CAG), with the AMCBR and SD&SM; the master plans of other urban areas and notified towns that UD&PA prepares, among them any plan for the Lunglei Development Planning Area, known by the title of its notification [TBC]; in the Autonomous District Council areas, any plan or regulation of the District Council, if the District Council adopts the Manual; and the layouts and buildings permitted under them. In particular:

- (a) regional facility sites, restored tank flood storage, and major flow paths shall be reserved in the plan;
- (b) the 1% AEP hazard map shall be shown, and Chapter 7 setbacks applied to it;
- (c) land in hazard classes H5–H6 in the 1% AEP event shall not be zoned for new habitable development; and

- (d) the open space of layouts within a basin should be located, where possible, to form part of the major flow paths or regional storage shown in the BSMP.

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

> Commentary. Mizoram's water lines are drawn by plan, by regulation and by court, and none of them is a statutory stream setback. The Master Plan for Aizawl: Vision 2030 recommends "a 15 meters wide green buffer on both sides" of the major drainage channels, which is a recommendation of the plan, and keeps an 800 m green belt on either side of the Tlawng "as per the Mizo District (Forest) Act, 1955, section 14 read with section 21"; the legal basis of that belt, the Riverine Reserved Forest notification of 1965, was quashed by the Gauhati High Court on 27 January 2021, and a notification of April 2021 reported to set an 800 m restricted zone was not read (as reported), so this Manual never treats 800 m as statutory and does not use it. SD&SM 2017 requires that "the riverine reserve shall be maintained" for plots beside natural streams (reg. 28), without defining it, keeps excavated material off "drainage courses or riverine reserves" (reg. 29), and asks site plans to show "flood hazard areas as designated and defined by Aizawl Municipal Corporation" (reg. 6), but no such area has been designated. River Conservation Zones under the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed, would bar construction and the obstruction or diversion of a watercourse without the State Authority's approval, but none has been notified. The AMCBR keep septic tanks and soak pits 15 m from "a water source" (reg. 33), and the slope lines are firmer than the stream lines: no site development permit above 60° (SD&SM reg. 14), engineered site development in Moderate, High and Very High hazard zones and from 24° where unmapped, and the master plan's "SL" zone of slopes above 36° and "areas adjacent to major drainage lines", with its "W" zone for rivers, streams, springs, ponds, lakes, wetlands and water catchment areas; the plan leaves detailed hazard zoning, "no development zone" included, to the zonal development plans, which were not yet approved in September 2023 (CAG). The State told the National Green Tribunal that "Mizoram being a hilly state, there is no flood plain zone in the catchment area" (MPCB, in O.A. No. 593 of 2017 and O.A. No. 673 of 2018), yet the Khawthlangtuipui flooded Tlabung in 2017, 2019 and 2023, families were stranded at Sairang in 2018, and Bairabi on the Tlawng and Champhai on the Tiau are reported among the lowland flood towns (all as reported), so the statement does not hold on those valley floors; no flood plain zoning law was found. Where a notified line or a master-plan line governs, it applies; elsewhere the corridor of Chapter 7 applies as this Manual's proposal, stricter than any statute: a Zone 1 of not less than 15 m from the top of bank of every channel draining 8 ha or more, measured on an incised lui whose bank is a slope steeper than 10° from the crest of that slope, and a Zone 2 to the 1% AEP extent plus 10 m, whichever is wider, for new development and redevelopment approved under the Manual, with Zone 1 land that is private or held under a land pass reserved in the master plan or secured by agreement, not taken, and in an Autonomous District Council area only through the District Council [TBC]. A BSMP gives the master plan, the zonal plans and UD&PA the 1% AEP map of valley-floor land and the lui corridors, with the debris paths and landslide hazard zones beside them, that they need. Using open space land as storage or flow path has no direct precedent; this Manual adopts it because the AMCBR require a suitable rainwater harvesting facility in every building (regs. 5(6)(ix) and 33) and, since 2025, offer incentives for rainwater harvesting and the "Reduction of Hardscape" on plots above 100 m², SD&SM 2017 makes every site developed downhill of another carry the uphill site's drainage "in a safe manner to the nearest practicable drainage way" (reg. 27), and the Master Plan for Aizawl: Vision 2030 keeps "Around 52% of total urban area" under non-urban uses, among them water bodies and undevelopable sloping land, but no rule sets a detention or peak-runoff limit; storage placed in a layout's open space builds on these duties, and because that land still serves as open space, the storage must stay usable as one, and on hill ground it is a lined tank or a shallow paved terrace that drains to a lined drain, never an infiltration basin (Clause 4.11, hill rule). Placing it on the flow path costs the developer nothing extra and gives the basin storage it would otherwise have to buy.

11.10 Consultation and publication

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

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

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

They shall also be shown on a public map viewer.

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

11.11 Approval, review and reporting

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

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

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

11.11.3 **Annual report.** The Lead Authority shall publish an annual implementation report before each monsoon (by 31 March). The report shall show:

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

11.12 Interim arrangements

11.12.1 Until a BSMP is approved for a basin:

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

References (chapter)

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- Department of Irrigation and Drainage Malaysia (2012). *Urban Stormwater Management Manual for Malaysia (MSMA)*, 2nd ed.
- Government of Mizoram, Urban Development and Poverty Alleviation Department. *Aizawl Municipal Corporation Building Regulations, 2012* (as amended to 2025), regs. 5(6)(ix) and 33; and *Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017*, regs. 1, 6, 14 and 27–29.
- *The Mizoram Municipalities Act, 2007* (Act No. 6 of 2007), s.289; *The Mizoram Water Resources (Management and Regulation) Act, 2024* (Act No. 1 of 2024), ss.2(1)(i) and 14; *The Mizoram (Village Councils) Act, 2025* (Act No. 7 of 2025), ss.1(2), 2(29) and 15(1); and the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed.
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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 Mizoram 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 Aizawl Municipal Corporation and of the Aizawl Development Plan Area of the Master Plan for Aizawl: Vision 2030

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

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

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

Item	Tier A authority	Clause
(a)	The Aizawl Municipal Corporation, for its whole area	1.6.1(a)
—	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 boundary of the Aizawl Municipal Corporation and of its wards and localities, and of the Aizawl Development Plan Area of the Master Plan for Aizawl: Vision 2030, with its ten planning zones, as a map and as a GIS layer, and the date from which each body is Tier A. It needs the notified limits of the Corporation and the boundaries of its Local Council areas (the Corporation, UD&PA); the boundary of the Aizawl Development Plan Area and of the Aizawl Urban Area constituted in 2005 (UD&PA); the limits of the Lunglei Municipal Council and of the notified towns that have no urban local body (UD&PA), whose boundaries were not obtained for this Manual [TBC]; and the district and sub-division boundaries (Land Revenue and Settlement Department, Survey of India). The Lunglei Municipal Council is Tier B (Clause 1.6.2) until it opts in or is notified under Clause 1.6.4. 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 / Village Council / Autonomous District Council / other)	District	Basis (Clause 1.6.1(a), (b), (c) or 1.6.4)	Tier A from (date)	Notification or resolution reference
1						
2						
3						

1A.3 The Aizawl Municipal Corporation and Aizawl Development Plan Area boundary map shall be published as open data in a machine-readable format (Clause 10.17.4), with the date of the notification it shows.

Annex 1B — Maps of flood-sensitive catchments

Supports Clauses 1.4, 1.6.5 and 1.10.3(d) of Chapter 1, and Clauses 4.5.3 and 4.5.4 of Chapter 4.

1B.1 The flood-sensitive catchments are listed in Clause 4.5.3.2. Table 1B.1 repeats that list. The maps of this annex and the boundaries of Annex 4A are the same data set and shall be issued together.

Table 1B.1 — Flood-sensitive catchments listed in Clause 4.5.3.2

Item	Catchment	Extent as described in Chapter 4
(a)	Aizawl east: the Chite lui	The catchment of the Chite lui to the Tuirial, which takes "more than two-third of eastern portion" of Aizawl, with its tributaries, the Chanmari, Ramthar, Mirawng, Tlak, Bangla, Taite, Bethlehem veng, Lawibual, Hmawngkawn, Zemabawktuikhur, Zuangtui and Kawmthlang lui (Master Plan for Aizawl: Vision 2030). The Chite, Chanmari, Bethlehem, Mirawng and Bangla lui are "turbulent with high velocities of currents during the monsoon season and they are very destructive" (master plan). The Chite stream from the sewage treatment plant of SIPMIU to Armed Veng is a Priority II polluted stretch (BOD 29 mg/L; CPCB, 2025)
(b)	Aizawl west: the Ser lui	The catchment of the Ser lui to the Tlawng, with the Ramri, Tuikal, Vai and Zawngkawt lui and the Khatla, Tuikual, Vaivakawn and Chanmari west lui, "the worst destructive streams and nullahs" (Master Plan for Aizawl: Vision 2030); the master plan's Aizawl W-I, a third of whose area is waterlogged "for several days or for hours". CPCB lists a Tuikual stream at Reiek Kai as a Priority II stretch (CPCB, 2025); whether it is this lui is a NEER reading to be confirmed [TBC]
(c)	The Hlimen–Melthum quarry belt	The slopes and quarries of Hlimen and Melthum on Aizawl's southern edge: the South Hlimen quarry collapse of 9 August 1992 ("almost 100" dead, MIRSAC, 2013, citing earlier work) and the collapse of the disused quarry between Melthum and Hlimen in Cyclone Remal on 28 May 2024 (as reported; tolls conflict, Commentary to Clause 1.1); the master plan proposes check dams below Melthum and Hlimen
(d)	Hunthar Veng and the NH-6 corridor	The land of Hunthar Veng, Aizawl, a sinking area whose soil was tested in 2017 (CAG), and the cut slopes of NH-6 at Hunthar, which "blocks in most storms" (2018 and 2024, as reported)
(e)	Durtlang and the Bawngkawn–Durtlang road	The land of Durtlang, where three blocks of a BSUP housing complex collapsed on 2 July 2019 (CAG), and the slopes on either side of the Bawngkawn–Durtlang (Leitan) road, on which the High Court froze new construction in July 2024 (as reported)
(f)	Sairang on the Tlawng	The valley-floor land of Sairang on the Tlawng, where families were stranded in June 2018 (as reported); CWC monitors the Tlawng at Sairang, with no highest level printed (CWC data as transcribed by SANDRP)
(g)	Bairabi and Vairengte	Sub-area MZ-A1 (Northern valley floors) of Annex 2A, the river terraces and valley floors at Bairabi and Vairengte, "the lowest-lying towns in the State" in the research for this Manual, where the Barak-valley floors of Clause 2.3.6(c)(ii) apply; a landslide at Vairengte killed a boy in September 2026 (as reported)
(h)	Tlabung on the Khawthlangtuipui	Sub-area MZ-D1 (Tlabung valley floor), the floodplain of the Khawthlangtuipui (Karnaphuli) at Tlabung, a river-flood town: about 350 houses (or 9 fully and more than 60 partly) submerged in June 2017, 30 houses in June 2018, about 400 houses in July 2019 and 40 families evacuated in August 2023 (as reported)

Item	Catchment	Extent as described in Chapter 4
(i)	Lunglei town	The land of Lunglei town, the State's second municipal area, on ridges of shale, siltstone and sandstone of the Surma group that CGWB calls a "run off zone" (CGWB, Lunglei)
(j)	Serchhip town	The land of Serchhip town, 89% of whose area is steeper than 30° (MIRSAC, 2013; NEER arithmetic), and for which MIRSAC has prepared a landslide hazard zonation; Serchhip district received 677 mm in 1–13 June 2018 (SANDRP, as reported)
(k)	Champhai town and the Champhai flats	The land of Champhai town and sub-area MZ-C1 (Champhai flats), the paddy flats of the Champhai valley floor; Champhai district had 209 of the 598 landslides of 24 May–3 June 2025 (DM&R figures, as reported), and Champhai floods from the Tiau (as reported)
(l)	Siaha and Lawngtlai	The land of Siaha and Lawngtlai, the headquarters of the Mara and Lai Autonomous District Councils, which this Manual reaches only through the District Councils (Commentary to Clause 1.3)
(m)	The release reach below the Tuirial dam	The land that drains to the Tuirial below NEEPCO's dam (full reservoir level 90.5 m, CERC), for which a dam-break study routed a peak of 3,035.34 m³/s "near the confluence" (as reported)
(n)	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 Aizawl Municipal Corporation, the Lunglei Municipal Council, the PWD for the roadside drains, the Village Councils and District Councils for the other towns, Survey of India); the drain register of Table 1.5, with each reach's owner, the lui it reaches, its class on the landslide hazard map and its outfall; the Corporation's Landslide Hazard Maps at 1:5,000 and MIRSAC's atlas of Aizawl and selected towns and its zonation of Serchhip (the Corporation, MIRSAC); the landslide inventories of MSDMA, DM&R and the Directorate of Geology and Mineral Resources [TBC]; the levels of CWC's sites at Sairang and Turial with their gauge zeros and datums (CWC), and surveyed flood marks at Tlabung, Sairang, Bairabi, Vairengte and Champhai (the IWRD, the Deputy Commissioners); and the release records and dam-break inundation map of the Tuirial dam (NEEPCO) [TBC]. Kolasib, Mamit, Khawzawl, Saitual, Hnahthial and Chawngte are candidates for notification under Clause 4.5.4 once their catchment boundaries and records are documented [TBC]. The corridors of Chapter 7 are governed by Chapter 7 and by the instruments that bind there rather than by this list. Until it is published, the Authority decides at the pre-application stage whether a site lies in a listed catchment, from the best boundary available, and the decision and its basis are recorded on Form 1-1 and in the drainage report (Clauses 1.5.9 and 1.11.5).

Table 1B.2 — Attributes of the flood-sensitive catchment layer (layout)

Field	Content	Unit or format
catchment_id	Unique identifier	text
name	Catchment name	text
basis	Clause 4.5.3.2 item (a) to (m), 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 Mizoram Stormwater Design Manual (the Manual) named in each alternative. An alternative applies within the area of an Approving Authority (the Authority) only from the date on which the Authority adopts it under P1.3.

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

P1.3 **Adoption.**

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

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

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

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

Part 2 — The alternatives

S-1 — Design-aid route for storage

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

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

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

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

S-2 — Permissible site discharge (PSD)

S-2.1 *Replaces:* the release rate Q_post(T) ≤ 0.9 × Q_pre(T) computed for the site (Clause 2.11.2).

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

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

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

S-3 — Fixed-width waterbody setback

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

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

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

S-3.4 *Conditions:* no setback under this alternative is less than the Zone 1 minimum of Clause 7.4.7 (15 m from top of bank, or from the crest of the bank slope where an incised lui's bank is steeper than 10°) (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, MSDMA, the Disaster Management and Rehabilitation Department (DM&R), the IWRD or the Village Council (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 dil 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 / Village Council / Autonomous District Council), dated _____

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

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

- (i) the Mizoram 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.

Chairman / President: _____ Municipal Commissioner / chief officer of the Council: _____ Date: _____

Annex 1D — Model AMCBR/SD&SM 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 at which the new rule and the conditions would be inserted, and the enabling sections of the Mizoram Urban and Regional Development Act, 1990 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017

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

- (1) These rules may be called the Aizawl Municipal Corporation Building and Site Development (Stormwater Management) (Amendment) Regulations, _____.
- (2) They shall come into force on the date six months after their publication in the Mizoram Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building and site-development regulations that the Board of Councillors of the Aizawl Municipal Corporation makes under section 371 of the Mizoram Municipalities Act, 2007 and the Urban Development and Poverty Alleviation Department notifies, the following rule shall be inserted:

Rule [_____]. Stormwater management.

(1) *Definitions.* In this rule, "the Manual" means the Mizoram 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 Mizoram 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 — Mizoram 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 — 1.5.1(a): Yes / No	_____
B2	Public work by a ULB, State department, board or State undertaking — 1.5.1(b): Yes / No	_____
B3	Work by a Central agency needing the Authority's approval or no-objection — 1.5.1(c): Yes / No	_____
	C. Areas over the common plan of development (Clauses 1.4, 1.5.5)	
C1	Phases, plots and sub-divisions included (one layout approval or one ownership)	_____
C2	Total site area (ha)	_____
C3	Land disturbance (ha)	_____
C4	Existing impervious area (m²)	_____
C5	New impervious area (m²)	_____
C6	Replaced impervious area, removed to subgrade and rebuilt (m²)	_____
C7	New plus replaced impervious area, C5 + C6 (m²)	_____
C8	Plot area for the RWH mandate (m²) (Clause 1.5.3)	_____
	D. Thresholds and exemptions	
D1	Land disturbance 0.1 ha or more — 1.5.2(a): Yes / No	_____
D2	New or replaced impervious area 500 m² or more — 1.5.2(b): Yes / No	_____
D3	Redevelopment (existing impervious cover on the site) — 1.5.6: Yes / No	_____
D4	Constrained redevelopment route of Clause 4.5.6 proposed: Yes / No	_____

No.	Item (clause)	Entry
D5	Linear public work: added impervious area per drainage catchment crossed given in Table 1F.2 — 1.5.7: Yes / No / not applicable	_____
D6	Exemption claimed — 1.5.8(a) single dwelling below the thresholds / 1.5.8(b) resurfacing with no added impervious area / none	_____
D7	RWH mandate applies (AMCBR regs. 33 and 5(6)(ix): every building in the area of the Aizawl Municipal Corporation; AMCBR Chapter VIIIA (2025): incentives only, plots above 100 m²; elsewhere in the State: no rule found) — 1.5.3: Yes / No	_____
	E. Site conditions	
E1	Site in a flood-sensitive catchment (Annex 1B; Clause 4.5.3): No / Yes — name	_____
E2	Source of the catchment boundary used	_____
E3	1% AEP level mapped or determinable for the site (Clause 1.5.4(b)): Yes / No; source	_____
E4	Waterbody on or adjoining the site (Clause 1.5.4(c); Chapter 7): No / Yes — name	_____
E5	Natural drainage path or major-system flow path crossing the site (Clause 1.5.4(d)): No / Yes	_____
E6	Site drains to a tidal outfall (Clause 10.3.2(d)): Yes / No	_____
E7	Variance, waiver, regional facility or fee-in-lieu proposed (Clause 10.3.2(c)): No / Yes — Form 1-2 attached	_____
	F. Determination	
F1	Result: (i) Chapters 4 and 5 apply, with Clause 1.5.4 and the RWH mandate; (ii) Clause 1.5.4 and the RWH mandate only (below thresholds); (iii) exempt under 1.5.8, Clause 1.5.4 and the RWH mandate still apply	_____
F2	Stage 0 mandatory under Clause 10.3.2: Yes (state item (a) to (d)) / No	_____
F3	Storage method: hydrograph method (Chapter 3) / design-aid route S-1 (Clause 1.7, where adopted and eligible)	_____
F4	Other Policy Supplement alternatives relied on (S-2 to S-5), with the adopting resolution	_____
F5	Tier B phased start applies (Clause 1.11.3): Yes / No	_____
	G. Declaration	
G1	I declare that the information above is correct and covers the whole common plan of development. Applicant: name, signature, date	_____
G2	Prepared by (registered professional, Clause 1.4): name, registration number, signature, date	_____
	H. For the Authority (Clause 1.5.9)	
H1	Determination confirmed / corrected	_____
H2	Corrections and reasons	_____
H3	Officer: name, designation, signature, date	_____

Table 1F.2 — Form 1-1: added impervious area by drainage catchment, linear works (Clause 1.5.7)

Drainage catchment crossed	Chainage from – to	Added impervious area (m²)	500 m² or more (Yes / No)	Storage location: right of way / regional facility

Form 1-2 — Variance / Waiver Request

Supports Clause 1.10 of Chapter 1.

Draft form — Mizoram 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 (15 m from top of bank, or from the crest of an incised lui's bank slope steeper than 10°), 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)	_____
E3	Or: shortfall made up by fee-in-lieu or off-site works in the same catchment — volume (m^3), works or fee	_____

No.	Item (clause)	Entry
	F. Waiver of detention: grounds (Clause 1.10.2)	
F1	Site discharges directly to the sea / to a tidal reach with no flood-prone property downstream	_____
F2	Analysis showing that undetained flow does not worsen the outfall-closed condition of Chapter 5 — reference	_____
F3	Retention still provided in full: Yes	_____
	G. Attachments (Clause 1.10.4(a))	
G1	Report certified under Clause 10.6	_____
G2	Preliminary drainage report	_____
	H. Certification and declaration	
H1	Certified by (registered professional; empanelled professional where Clause 10.6.1 applies): name, registration or empanelment number, signature, date	_____
H2	Applicant: name, signature, date	_____
	I. For the Authority (Clause 1.10.4)	
I1	Referred to the State Stormwater Technical Committee (Tier B, site 1 ha or more): Yes / No; date	_____
I2	Decision: granted / granted with conditions / refused	_____
I3	Reasons and conditions	_____
I4	Entry number in the public register (Clause 10.17)	_____
I5	Note: a variance runs with the approval and lapses if the approval lapses (Clause 1.10.4(d))	—
I6	Officer: name, designation, signature, date	_____

ANNEXES TO CHAPTER 2

Design Rainfall and Design Storms

These annexes support Chapter 2. Annexes 2A to 2E will hold the statewide rainfall tables that Chapter 2 refers to: the benchmark checks and zone map, sub-daily ratios, grid-to-point factors, temporal patterns and retention depths. Each needs analysis of NIH-DHAARA and IMD records that has not yet been done for this Manual, so each is marked "To be prepared" and gives its intended layout and the rule to use until it is published (Clause 1.11.5). Form 2-1 is a draft form for the Design Rainfall Sheet that every hydrologic submittal must include (Clause 2.13). The Manual is a draft; it is not adopted by any government or agency.

Annex 2A — NIH-DHAARA vs IMD station and IMD gridded checks at benchmark points; zone map

Supports Clauses 2.3.1 to 2.3.5 of Chapter 2.

To be prepared. This annex will compare, at benchmark points across the State, the NIH-DHAARA design depths with frequency analyses of long IMD daily station records and of IMD gridded daily data (converted to point values with Annex 2C), for 24 hours and longer and for the AEPs of Table 2.1. It will also contain the map of rainfall zones used by Annexes 2B, 2C and 2E and by the Tier B tables of Chapter 4. It needs NIH-DHAARA values at the benchmark coordinates (NIH), IMD daily and recording-gauge station records and IMD gridded rainfall (IMD), State rain-gauge records (the gauges on the daily rainfall list of IMD's Meteorological Centre Aizawl, among them about 30 automatic rain gauges and weather stations of the Mz-SWIC network (operator name not expanded in the source [U]), the ordinary rain gauges of the Agriculture Department at Serchhip, North Vanlaiphai, Lunglei, Haulawng and Tlabung, and the rain gauges of CWC at Bairabi, Dapchhuah, Mat-1, Tlabung, Tuichawng, Tuipui D, Shitlangpui and other sites, and the series of the State Meteorological Centre of the Directorate of Science and Technology (DST), whose types, start years and record lengths are to be confirmed [TBC]), and district and basin boundaries (Survey of India, IWRD). 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
MZ-Z1 Northern hills	The Barak-facing north of the State, in Kolasib district and the west of Mamit district: the Tlawng, Tuirial, Serlui and Langkaih basins and the Tuivai towards the Barak; in CWC subzone 2(c), for which no report exists (Clause 2.3.6(b)); catchments that cross a zone line take the higher zone value	No IMD station; IMD's automatic weather station at Kolasib; CWC rain gauges at Bairabi and Dapchhuah; Mz-SWIC gauges at Buhchangphai, North Hlimen, Kawnpui and Chemphai and at West Phaileng [TBC: record lengths]	24-h depth at each AEP the higher of the NIH-DHAARA cell and the Mizoram interim floor (Clause 2.3.6(c)(i)), and not less than 130 / 190 / 230 / 285 / 320 / 360 mm at 50% / 20% / 10% / 4% / 2% / 1% AEP, the table that carries the floors of the adjoining Barak-valley rule (Clause 2.3.6(c)(ii)); Mizoram interim ratios, 1-h ratio 0.33 (Clause 2.3.6(f)); 72-h depth = 24-h × 1.70 (Clause 2.3.6(e)). NIH-DHAARA 50-yr 24-h 303–338 mm, 1-h 88–89 mm. The plain downstream is governed by the adjoining edition. Hill rule of Clause 4.11
MZ-Z1 Northern hills: MZ-A Northern hills (Kolasib–Kawnpui–Bilkhawthlir)	Also the hills of western Mamit district (Dapchhuah, West Phaileng) and the hill slopes above Bairabi and Vairengte; outfalls to the Tlawng, the Tuirial, the Serlui and the Langkaih; the Tuirial reservoir of NEEPCO (full reservoir level 90.5 m, CERC) and the Serlui B dam; boundaries [TBC]	IMD automatic weather station at Kolasib; Kolasib ordinary gauge (AMFU); Mz-SWIC gauges [TBC]	Barak-valley table of Clause 2.3.6(c)(ii) governs at Kolasib at every AEP (cell 120.8 / 218.0 / 303.3 / 339.3 mm at 2 / 10 / 50 / 100 years); about 106 mm in 1 hour at 50 years. Railway and NH-306 cut slopes. Release reaches below the Tuirial and Serlui B dams (Clause 2.3.6(i)). AMC III from 1 May to 31 October, and at all times where the outfall is a reservoir or a release reach (Clause 2.11.4)
MZ-Z1 Northern hills: MZ-A1 Northern valley floors (Bairabi–Vairengte)	The river terraces and valley floors at Bairabi and Vairengte, "the lowest-lying towns in the State" in the research for this Manual, and the Tlawng valley floor below Sairang; valley-floor land below the 1% AEP flood level; boundaries [TBC]	CWC rain gauge at Bairabi; no IMD station [TBC]	Barak-valley table governs at Bairabi (cell 315.0 mm at 50 years); at Vairengte the cell governs (241.5 / 337.9 / 378.7 mm at 10 / 50 / 100 years; 1-h about 112 mm at 50 years). Record check: no record qualifies; the IMD records of the Barak plain lie downstream, more than 25 km away (Clause 2.3.6(h)). River tailwater of Clause 5.8.5(c); recharge rule of Clause 4.11 on tested terraces above the 1% AEP level; AMC III from 1 April to 31 October on valley-floor land
MZ-Z2 Central ridges	The ridges between the Tlawng and the Tuirial and southwards to the Mat, in Aizawl, Serchhip, Hnahthial and east Mamit districts; in subzone 2(c) (Clause 2.3.6(b))	IMD's Meteorological Centre Aizawl (ORG) and Lengpui (ORG), not in IMD's *Extremes* (Aizawl 42726, Aizawl-Lengpui 42727, city-weather IDs); IMD automatic weather stations at Mizoram University, Serchhip and Hnahthial; Agriculture Department gauges at Serchhip and North Vanlaiphai; CWC's Mat-1 and Tuipui D; Mz-SWIC gauges [TBC]	24-h depth the higher of the cell and the Mizoram interim floor 85 / 130 / 160 / 195 / 225 / 250 mm (Clause 2.3.6(c)(i)); Mizoram interim ratios; 72-h = 24-h × 1.70. NIH-DHAARA 50-yr 24-h 211–260 mm, 1-h 55–68 mm. Middle Bhuban shale and sandstone; Serchhip town 89% steeper than 30° (MIRSAC; NEER arithmetic): hill rule of Clause 4.11. Landslide governs (Clause 2.3.6(i))

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
MZ-Z2 Central ridges: MZ-B Central ridges (Aizawl–Sairang–Serchhip–Thenzawl–Hnahthial–Mamit)	Also Aibawk, Sialsuk, Darlawn and North Vanlaiphai; the Aizawl ridges between the Tlawng and Tuirial valleys, drained east by the Chite lui to the Tuirial and west by the Ser lui to the Tlawng; Sairang on the Tlawng is in MZ-B for rainfall and is valley-floor land under Chapters 4 and 5; boundaries [TBC]	As for the zone	Floor governs at Aizawl (cell 84.8 / 156.9 / 220.1 / 246.8 mm), Mamit and Serchhip (except at 2 years at Serchhip, cell 85.4 mm); cells govern at Thenzawl (260 mm at 50 years) and Hnahthial (244 mm). About 74 mm in 1 hour at 50 years at Aizawl (cell 62.6 mm). Flags: Aizawl 148 mm in one day (probably 12 June 2018, as reported) and 97.4 mm (2025, as reported); Serchhip district 677 mm in 1–13 June 2018 (as reported). CWC level site at Sairang (no highest level printed). Hazard-first sites of Clause 2.3.6(i): the Corporation's Landslide Hazard Maps, Hlimen–Melthum, Hunthar Veng, the Bawngkawn–Durtlang road
MZ-Z3 Eastern uplands	The east of the State, towards the Tiau and the headwaters of the Tuipui and the Tuivai, in Champhai, Khawzawl and Saitual districts; in subzone 2(c) (Clause 2.3.6(b)); the Tiau joins the Manipur river system in Myanmar	IMD automatic weather stations at Champhai and Khawzawl; IMD gauge at Neindawn; Mz-SWIC gauges at Saitual, Phullen, Teikhang, Ngopa, Hnahlan, Vaphai and Khawhai [TBC]	The Mizoram interim floor of Clause 2.3.6(c)(i) governs at every AEP (Clause 2.3.6(c)(iii)); Mizoram interim ratios; 72-h = 24-h × 1.70. NIH-DHAARA 50-yr 24-h 157–181 mm, the lowest in the State, 1-h 52–57 mm, 1-h ratios 0.31–0.33. Khawzawl 248.3 mm in three days and Champhai 1,084 mm in January–July 2025 (as reported); Champhai district 209 landslides in 24 May–3 June 2025 (DM&R figures, as reported)
MZ-Z3 Eastern uplands: MZ-C Eastern uplands (Champhai–Khawzawl–Saitual–Ngopa–Zokhawthar)	Also Khawbung; the uplands and slopes of the zone outside the Champhai flats; Zokhawthar on the Tiau; boundaries [TBC]	As for the zone	Floor 85 / 130 / 160 / 195 / 225 / 250 mm (cells: Saitual 180.7, Champhai 174.4, Khawzawl 156.7 mm at 50 years); probably conservative, until the Champhai and Khawzawl records are fitted (Clause 2.3.6(a)). Hill rule of Clause 4.11. Transboundary outfalls to the Tiau, with no downstream level (Clause 5.8.5(f))
MZ-Z3 Eastern uplands: MZ-C1 Champhai flats	The paddy flats of the Champhai valley floor; valley-floor land below the 1% AEP flood level; boundaries [TBC]	IMD automatic weather station at Champhai [TBC]	Floor as MZ-C. River tailwater of Clause 5.8.5(c); recharge rule of Clause 4.11 on tested alluvium above the 1% AEP level; AMC III from 1 April to 31 October on valley-floor land. Champhai floods from the Tiau (as reported); whether the flat floor ponds is not documented [TBC]
MZ-Z4 Southern hills	The south of the State, towards the Karnaphuli (the Khawthlangtuipui) and the Kaladan (the Chhimtuipui), in Lunglei, Lawngtlai and Siaha districts, with the areas of the Lai, Mara and Chakma Autonomous District Councils; in subzone 2(c) (Clause 2.3.6(b)); the Karnaphuli flows to Bangladesh and the Kaladan to Myanmar	IMD automatic weather stations at Saiha and Chawnhu and gauge at Chawngte; Agriculture Department gauges at Lunglei, Haulawng and Tlabung; CWC gauges at Tlabung, Tuichawng, Tuichang, Shitlangpui and others; Mz-SWIC gauges [TBC]	24-h depth the higher of the cell and the Mizoram interim floor (Clause 2.3.6(c)(i)); the cells govern at the towns queried; Mizoram interim ratios; 72-h = 24-h × 1.70. NIH-DHAARA 50-yr 24-h 271–305 mm, 1-h 71–80 mm. Flag: Chawngte 130 mm in a day in October 2025 (as reported). This Manual reaches the District Council areas only through the District Councils (Chapter 1)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
MZ-Z4 Southern hills: MZ-D Southern hills (Lunglei–Lawngtlai–Siaha–Chawngte–Tuipang)	The hills of the zone outside Tlabung, with the areas of the Lai, Mara and Chakma Autonomous District Councils; Chawngte on the Kau and the Tuichawng is valley-floor land below the 1% AEP level; boundaries [TBC]	As for the zone	Cells govern: Lunglei 107.5 / 207.3 / 294.9 / 331.9 mm, Siaha 304.5 mm and Lawngtlai 270.6 mm at 50 years; about 97 mm in 1 hour at 50 years at Lunglei (cell 73.1 mm). Surma-group shale, siltstone and sandstone, a "run off zone" (CGWB, Lunglei): hill rule of Clause 4.11. Pala Wetland (Palak Dil) in the Mara District Council's area (Chapter 7)
MZ-Z4 Southern hills: MZ-D1 Tlabung valley floor (Tlabung)	The floodplain of the Khawthlangtuipui at Tlabung; valley-floor land below the 1% AEP flood level; boundaries [TBC]	Agriculture Department and CWC gauges at Tlabung [TBC]	Cell governs (113.4 / 210.2 / 295.0 / 330.9 mm at 2 / 10 / 50 / 100 years). A river-flood town: about 350 houses (or 9 fully and more than 60 partly) in June 2017, about 400 houses in July 2019 and 40 families in August 2023 (as reported). River at flood level with flap gates, no downstream Indian control (Clause 5.8.5(d)); recharge rule of Clause 4.11 on tested terraces above the 1% AEP level; AMC III from 1 April to 31 October

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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 Mizoram are the Mizoram interim ratios of Clause 2.3.6(f), the same in every sub-area of Table 2B.1, with no depth below NIH-DHAARA's own depth for that duration at the site, applied to the 24-hour depth of Clause 2.3.6(c) or (d) before the record check of Clause 2.3.6(h); no absolute short-storm floor applies (Clause 2.3.6(g)) (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

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
Every sub-area (MZ-A, MZ-A1, MZ-B, MZ-C, MZ-C1, MZ-D, MZ-D1)	Mizoram interim ratios (interim design ratios, Clause 2.3.6(f), set by this Manual): the same set as the adjoining Barak-headwater edition's, the upper envelope, rounded up to 0.01, of the 50-yr ratios of eleven IMDAA cells across the north-eastern boundary of the State and of the CWC FER 2(a) ratios; no depth below NIH-DHAARA's own depth for the duration at the site; also 0.81 at 9 h, 0.89 at 15 h and 0.94 at 18 h	0.33	0.51	0.59	0.74	0.85	1.00
Every sub-area, every AEP	24-hour depths to which the ratios apply, set by this Manual (Clause 2.3.6(c)), in mm at 50% / 20% / 10% / 4% / 2% / 1% AEP: every sub-area, the higher of the NIH-DHAARA cell and the Mizoram interim floor 85 / 130 / 160 / 195 / 225 / 250 (the Aizawl cell, 5- and 25-yr values on the Gumbel variate, rounded up to 5 mm); MZ-A and MZ-A1 also not less than 130 / 190 / 230 / 285 / 320 / 360 (the table that carries the Barak-valley floors of 320 and 351 mm at 2% and 1%); MZ-C and MZ-C1 the floor; no absolute short-storm floor (Clause 2.3.6(g)); 72-h depth = 24-h × 1.70 (Clause 2.3.6(e))						
Every sub-area (reference)	CWC FER 2(a), NB/18/1991, §3.1.2, p. 24 and Fig. 10, 50-yr basis, 12 IMD recording gauges (lower bound of the Mizoram ratios; not used alone, because its 1-h ratio lies below the eastern and Mamit cells)	0.260	0.370	0.457	0.615	0.805	1.000
Not used in Mizoram (reference)	CWC FER 2(b), Table 4.1, 10-yr basis, six recording gauges (no part of the State lies in 2(b); 1-h ratio 1.45 times the highest Mizoram cell)	0.48		0.62	0.74	0.87	1.00
MZ-Z1: Kolasib, Bairabi and Vairengte cells	NIH-DHAARA, IMDAA, 50-yr (queried 14 Nov 2026; 2–18 h not queried [TBC]; design source under Clause 2.3.6(c))	0.29 / 0.28 / 0.26					1.00
MZ-Z2: Aizawl, Mamit, Serchhip, Thenzawl and Hnahthial cells	NIH-DHAARA, IMDAA, 50-yr (as above)	0.28 / 0.32 / 0.25 / 0.25 / 0.26					1.00
MZ-Z3: Champhai, Khawzawl and Saitual cells	NIH-DHAARA, IMDAA, 50-yr (as above; Khawzawl 0.334 unrounded)	0.32 / 0.33 / 0.31					1.00
MZ-Z4: Lunglei, Tlabung, Lawngtlai and Siaha cells	NIH-DHAARA, IMDAA, 50-yr (as above)	0.25 / 0.24 / 0.28 / 0.26					1.00

2B.2 Depths from fixed observation windows are converted to true-interval depths with the factors of Clause 2.6.3, repeated in Table 2B.2. They are the standard WMO (Hershfield) values and are not provisional.

Table 2B.2 — Fixed-interval adjustment factors (Clause 2.6.3)

Number of fixed observation intervals in the duration	Factor
1	1.13
2	1.04
3–4	1.02

Annex 2C — Grid-to-point factors

Supports Clauses 2.7.1 and 2.7.4 of Chapter 2.

To be prepared. This annex will give the factors that convert grid-average design depths (for example from 0.25° cells) to point depths, by zone, duration and AEP. It needs paired frequency analyses of IMD gridded rainfall and of the IMD and State gauges inside each cell (IMD, the State Meteorological Centre of the Directorate of Science and Technology (DST), the ordinary rain gauges of the Agriculture Department, the Mz-SWIC network (operator name not expanded in the source [U]) and the rain gauges of CWC, whose record lengths are to be confirmed [TBC]), the benchmark points of Annex 2A, and a stated method for deriving the factors. Until it is published, design depths are taken as point values from NIH-DHAARA or an approved station IDF (Clauses 2.3.1 and 2.3.2). Grid-average values are not used as design depths unless a conversion agreed with the Authority is recorded on Form 2-1 (Clause 1.11.5).

2C.1 The commentary to Clause 2.7 shows why the factors matter. In Mizoram NIH-DHAARA was queried at 15 points for this Manual, and all returned data; its reanalysis cells, of about 12 km, give 50-year 24-hour depths from 157 mm at Khawzawl to 338 mm at Vairengte (NIH-DHAARA, queried 14 Nov 2026), and no gauge in the State has been fitted to show whether a cell runs above or below the point rainfall beneath it: in the valley towns of the adjoining editions of this series the platform ran about 1.3 to 1.5 times the station fits, and in another North-East edition low against extremes. Values of this kind are grid- or area-average values and need these factors before any use as point depths. Under Clause 2.3.6 they are nevertheless used as design depths in Mizoram, because no other source exists, with the floors of Clause 2.3.6(c)(i) and (c)(ii) beneath them, 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 — Mizoram 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 Mizoram 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, the automatic weather stations of the Meteorological Centre Aizawl in the State, among them those at Mizoram University, Kolasib, Champhai, Khawzawl, Serchhip, Hnahthial, Saiha and Chawnhu, and the automatic rain gauges and weather stations of the Mz-SWIC network (operator name not expanded in the source [U]), whose start years and logging intervals are to be confirmed [TBC]), separated into independent storms by a stated rule, and the storms of 28 May 2024 (Cyclone Remal), 24 May–3 June 2025, June 2018, July 2019 and June 2017, the last two behind the river floods at Tlabung, for none of which a recording-gauge hyetograph or an IMD rainfall series was found for this Manual [TBC] among them. Until it is published, design storms use the alternating-block pattern of Clause 2.9.1 and the 48- and 72-hour pattern of Clause 2.9.2; for catchments of 25–5,000 km², the CWC Flood Estimation Report curves may be used with a sensitivity run under Clause 2.9.1 (Clause 2.9.4). SCS Type distributions are not used (Clause 2.9.3). For the disaggregation of daily records in continuous simulation (Clause 11.7.3), the method is agreed with the Authority and recorded (Clause 1.11.5).

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

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

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

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

Annex 2E — Retention percentile depths by zone

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

To be prepared. This annex will give, for each zone of Annex 2A, the retention design depth P_R: the 24-hour rainfall depth not exceeded on 90% of days with rain (≥ 2.5 mm) in the long-term record (Clause 2.10.1). It needs long daily records at stations in each zone (IMD, the State Meteorological Centre of the Directorate of Science and Technology (DST), the ordinary rain gauges of the Agriculture Department, the Mz-SWIC network (operator name not expanded in the source [U]) and the rain gauges of CWC, whose record lengths are to be confirmed [TBC]) and IMD gridded data with the factors of Annex 2C where stations are sparse. Until it is published, P_R is computed by the definition of Clause 2.10.1 from the long-term daily record of a station agreed with the Authority, by the steps in 2E.1, and recorded on Form 2-1 (Clause 1.11.5).

2E.1 **Computing P_R from a daily record.**

1. Take the daily (24-hour) rainfall series of the station for its full record.
2. Keep only the days with rain of 2.5 mm or more (wet days).

3. Rank the wet-day depths and take the depth not exceeded on 90% of them (the 90th percentile).
4. Do not apply the climate factor (Clause 2.8.3) or the fixed-interval factor; P_R is a statistic of everyday rainfall, not an AEP design depth.
5. Record the station, the period of record, the number of wet days and P_R on Form 2-1.

Table 2E.1 — Retention depth P_R by zone (layout)

Zone	Stations or grid cells used	Period of record	Number of wet days (≥ 2.5 mm)	P_R, 90th percentile (mm)	Issued on
MZ-Z1 Northern hills					
MZ-Z2 Central ridges					
MZ-Z3 Eastern uplands					
MZ-Z4 Southern hills					

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

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

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

No.	Item (clause)	Entry
E2	CWC subzone 2(c) (no report; enter "none") 24-hour point value, catchments of 25–5,000 km²: subzone used	_____
E3	CWC floor governs for any AEP: No / Yes — AEPs	_____
	F. Retention depth (Clause 2.10)	
F1	P_R (mm) and source: Annex 2E zone value / computed under Annex 2E, 2E.1 — station and period	_____
F2	No climate factor applied to P_R (Clause 2.8.3): confirmed	_____
	G. Design storms (Clauses 2.9, 2.11, 2.12; items 5 and 6)	
G1	Storms up to 24 h: alternating block, peak at 50%; time step (≤ Tc/3 and ≤ 15 min)	_____
G2	48 and 72 h storms: built under Clause 2.9.2 (Table 2F.3)	_____
G3	Other pattern used: none / Annex 2D / CWC FER with sensitivity run (Clauses 2.9.3, 2.9.4)	_____
G4	Hyetographs attached as a table and a plot for each design storm: reference	_____
G5	AMC: III for every design storm of 1 May–31 October in every sub-area, whatever its duration; III for every design storm of 1 April–31 October on valley-floor land below the 1% AEP flood level and on dil margins; III at any time in catchments draining to the Tuirial or Serlui B reservoir, its backwater or a release reach below either dam; 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 — Mizoram 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 Mizoram to its hydrologic soil group (HSG), in both the drained and the undrained state, and (b) a map of the depth to the seasonal high groundwater table in the monsoon season (April–October). It needs NBSS&LUP and State soil survey (agency to be confirmed [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 IWRD, supplemented by piezometers in the valley floors and river terraces at Sairang, Bairabi and Vairengte, at Tlabung on the Khawthlangtuipui and at Chawngte on the Kau, and the Champhai flats, where the water table may stand within 2 m of ground (in small valley ponds of Lunglei district water stands "within 2.0 m below ground level", CGWB), the margins of the dils and of the Tuirial and Serlui B reservoirs, and hill sites with perched water, springs (tuikhur) or seepage below a cut slope or retaining wall. Until it is published, use the interim rules of Chapter 3: assign HSG from measured saturated hydraulic conductivity and depth to an impermeable layer or water table by the criteria of NEH Part 630, Ch. 7 (Clause 3.7.2); verify it by site infiltration tests wherever retention relies on infiltration (Clause 3.7.3); take the seasonal high water table from site piezometers, trial pits or the nearest observation well (Clause 3.10.2); and assign HSG D wherever that level is within 0.6 m of the ground surface (Clause 3.10.1).

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

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

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

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

Annex 3B — Mizoram CN calibration and supplementary land covers (hill forest and scrub, shifting-cultivation land, landslide scars and slide debris, hill-road and railway cuts and fills, terraced cut and fill slopes, stone-quarry faces and spoil, the paddy flats of Champhai, and dil and reservoir margins)

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 Mizoram catchments, compared with the TR-55 values of Table 3.5, and (b) curve numbers for land covers that Table 3.5 does not list: the forest and scrub of the hills, on thin soil over shale, siltstone and sandstone; the shifting-cultivation land that the preamble of the Mizoram Water Resources (Management and Regulation) Act, 2024 names among the causes of the "depletion and scarcity of water resources" in the catchments of the rivers, with the year of clearing recorded; the fresh scars and debris of landslides, such as those of the 598 landslides of 24 May–3 June 2025 (DM&R figures, as reported); the cuts and fills of hill roads and of the Bairabi–Sairang railway, such as the NH-6 cuts at Hunthar in Aizawl; the terraced cut and fill slopes, terrace swales and building pads of regulation 27 of the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017; the faces and spoil of stone quarries, active and disused, such as the Hlimen–Melthum quarries on Aizawl's southern edge; the paddy flats of the Champhai valley floor, with their bunds; and the margins of the dils and of the Tuirial reservoir, which NEEPCO operates between a full reservoir level of 90.5 m and a minimum drawdown level of 68.0 m (CERC order in Petition 125/MP/2021), exposed or drawn down at the start of a storm. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from IWRD 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)
Hill forest or scrub on thin soil over shale, siltstone or sandstone, with the depth of soil recorded; shifting-cultivation land, with the year of clearing recorded						
Fresh landslide scar or slide debris; hill-road or railway cut slope or fill						
Terraced cut or fill slope with lined terrace swales and building pads (Site Development and Slope Modification Regulations, 2017, regulation 27)						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Stone-quarry face or spoil, active or disused						
Paddy flats of the Champhai valley floor, with the bunds recorded						
Margin of a dil or of a reservoir (Tuirial, Serlui B) exposed or drawn down 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 Mizoram.** Mizoram is landlocked and almost all of it is steep hill, 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 valley floors and terraces at Bairabi, Vairengte, Sairang, Tlabung and Chawngte and the Champhai flats are flat in places but are not coastal plain; their slower response is represented by storage and river tailwater (Clauses 3.10.4 and 3.12.4) and by the outfall-closed check of Chapter 5, not by a lower peak rate factor, while the ridges respond within minutes. 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 2(b), applied as a check in subzone 2(c), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzone 2(b) (South Brahmaputra), whose report this Manual applies in place of the unpublished report for subzone 2(c) (Barak and others), the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs a CWC Flood Estimation Report for subzone 2(c) (Barak and others), which covers the whole of Mizoram: the northern hills, which drain through the Tlawng, the Tuirial, the Serlui and the Tuivai to the Barak, the south-east, which drains through the Chhimtuipui (the Kaladan, "Kalden" in CWC's subzone list), and the south-west, which drains through the Khawthlangtuipui (the Karnaphuli), a river the list does not name and which falls under "others" (NEER's reading), and which CWC has never published, with written confirmation from CWC that none exists or is in preparation, and of the subzone of the Khawthlangtuipui and the Tiau [TBC]; until then, from the South Brahmaputra subzone 2(b) report (Revised; Design Office Report No. SB-2(b)/R-4/44/99, March 2000), in which no part of Mizoram lies (its southern limit is about 25°15' N and Mizoram's northern limit 24°35' N; NEER's arithmetic), the areal reduction curves of its Figs 12(a) and 12(b), whose values were not read on the copy used [TBC], and its unit-hydrograph relationships, which this Manual uses only as a check (see the References of Chapter 3); and the level and discharge records of the seven CWC level-monitoring sites in the State (Sairang on the Tlawng, Turial on the Tuirial, Bailley Bridge Tuipui, Sihthangpui on the Chhimtuipui, Keitum on the Tlawng, Tuichang and Tuichawng; five reported inactive in 2018, as reported), NEEPCO's inflow and level records for the Tuirial reservoir, and the bridge-catchment data of the Bairabi–Sairang railway, none of which was obtained [TBC], transcribed and checked against the published reports, and a catchment with physiographic parameters measured from survey or a DEM. Until it is published, take all SUH inputs directly from the applicable Flood Estimation Report (Clause 3.11.4(a)), apply the 24-hour design rainfall of Clauses 2.3.3(b) and 2.7.3 with the climate factor of Clause 2.8 (Clause 3.11.4(b)), report the SUH result alongside the HEC-HMS or SWMM result for the existing natural condition (Clause 3.11.4(c)), and, where the hydrograph model gives a lower 1% AEP peak, either justify it by calibration under Clause 3.15 or adopt the SUH peak (Clause 3.11.4(d)).

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

Parameter	Symbol	Unit	Subzone 2(b) (South Brahmaputra) relationship, applied in Mizoram as a check only
Peak discharge of the 1-hour unit hydrograph	Qp	m³/s	Qp = 0.905 A^0.758 (Eq. 3.4.3.2); the peak depends on the catchment area alone
Peak discharge per unit area	qp	m³/s per km²	qp = Qp / A
Time from centre of unit rainfall to peak	tp	h	tp = 2.87 qp^−0.839
Width of UH at 50% of peak	W50	h	W50 = 2.304 qp^−1.035
Width of UH at 75% of peak	W75	h	W75 = 1.339 qp^−0.978
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.814 qp^−1.018

Parameter	Symbol	Unit	Subzone 2(b) (South Brahmaputra) relationship, applied in Mizoram as a check only
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.494 qp^−0.966
Base width of UH	TB	h	TB = 2.447 tp^1.157
Time to peak from start of rise	Tm	h	Tm = tp + tr/2
Unit duration	tr	h	1
Design storm duration	TD	h	TD = 1.1 tp
Design loss rate	—	mm/h	3.5 (printed "0.35 cm/hr", the modal value of 100 flood events); for the 2(b) SUH check run only, never to assign an HSG or in an urban model (Clause 3.7); likely too high for the Surma shale of Mizoram, which the CGWB describes as of "very low permeability and infiltration" (NEER's reading)
Design base flow	—	m³/s per km²	0.05 (68 of 100 events in the range 0.01–0.09)
Ratio of t-hour to 24-hour rainfall	—	—	10-yr, partial duration, mean of the six self-recording gauges of the report: 1 h 0.48; 3 h 0.62; 6 h 0.74; 9 h 0.81; 12 h 0.87; 15 h 0.91; 18 h 0.95; 24 h 1.00 (Table 4.1). **Not used in Mizoram**, which is not in subzone 2(b): the Mizoram interim ratios of Clause 2.3.6(f) apply in every sub-area
Time distribution of rainfall	—	cumulative fraction by hour	Fig. 11 and Annex 4.4 not read [TBC]
Conversion of 1-day to 24-hour rainfall	—	factor	1.15 (§4.3.1); not used in Mizoram, where the 24-hour design depths come from Clause 2.3.6
Areal reduction factor	ARF	% of point rainfall	Figs 12(a) (1, 3 and 6 h) and 12(b) (12 and 24 h); curve values not read [TBC]. Used in Mizoram for catchments of 25–5,000 km² in place of the unpublished 2(c) report (Clause 2.7.3)
50-yr 24-hour point rainfall at Mizoram towns	—	mm	None: the plates of the report stop at its southern boundary, about 25°15' N, some 40' of latitude north of Mizoram's northern limit at 24°35' N (NEER's arithmetic); no Mizoram town is on them
Gauged catchments that drain Mizoram	—	—	None of the 14 used
Catchment area for which the relationships apply	A	km²	more than 50 to 1,500; up to 5,000 "judiciously"
Report reference	—	—	Annexure 1.1, §§3.4–3.7, Table 3.3, Table 4.1, §4.3, worked example

Note: relationships as printed in the CWC subzone 2(b) report (References of Chapter 3), read from a scanned copy and with Table 3.3 checked against its page images for the earlier North-East editions of this series. A is the catchment area in km². **Coverage.** The report's subzone list gives subzone 2(c), "Barak and others", as covering the "Barak, Kalden and Manipur rivers" (Annexure 1.1). "Kalden" is the Kaladan, which in Mizoram is the Chhimtuipui (NEER's reading). Mizoram's rivers are therefore all in subzone 2(c): the northern hills drain to the Barak through the Tlawng (the Dhaleswari), the Tuirial (the Sonai), the Serlui, the Langkaih and the Tuivai; the south-east drains to the Kaladan through the Chhimtuipui; the south-west drains through the Khawthlangtuipui (the Karnaphuli) to Bangladesh, a river the list does not name, which falls under "others" by elimination; and the Tiau on the eastern border joins the Manipur river system in Myanmar (all NEER's reading, to be confirmed on CWC's subzone map [TBC]). No part of the State lies in subzone 2(b), whose southern limit is about 25°15' N, while Mizoram's northern limit is 24°35' N (NEER's arithmetic). CWC has published no report for subzone 2(c): the 2(b) report's list of the 21 reports published by 2000 has none, and neither has CWC's download page of 2024; written confirmation from CWC is still wanted [TBC]. **Basis.** The unit hydrograph rests on 14 catchments gauged at railway and national-highway bridges outside Mizoram, 100 bridge-years

of record in all; none drains Mizoram, and none is a steep ridge catchment of Surma shale. The 50-yr peaks the report reproduces err by "+ 40.72% − 57.84%", and "very small catchments have larger variation". **Area only.** The 2(b) peak depends on A alone: slope enters nowhere, so the SUH gives the same unit hydrograph to a catchment of the same area whether it falls through gorges at 30°–45° or crosses a plain. **Worked example.** The report's example is railway bridge 160, outside Mizoram (470 km², L 56.35 km, Lc 31.40 km, S 2.02 m/km): Qp = 96.00 m³/s, qp = 0.20 m³/s per km², tp = 11.07 h, adjusted to 11.50 h, W50 = 12.19 h, W75 = 6.46 h, WR50 = 4.19 h, WR75 = 2.34 h and TB = 41.00 h, with a loss of 0.35 cm/h and a base flow of 0.05 × 470 = 23.50 m³/s. **Use in the State.** The 2(b) SUH is used in Mizoram only as the check of Clause 3.11.4, for rural catchments of more than 50 km² on the Tlawng, the Tuirial, the Serlui, the Tuichang, the Tuichawng, the Khawthlangtuipui and their tributaries; the design model is a site study, SCS-CN or a Clark or Snyder unit hydrograph in HEC-HMS, calibrated under Clause 3.15 to the CWC level-monitoring sites (Sairang on the Tlawng, which has an active hydrograph; Turial on the Tuirial; Sihthangpui on the Chhimtuipui; Tuichang and Tuichawng), to the CWC rain gauges at Bairabi, Dapchhuah, Tlabung and elsewhere, to NEEPCO's records for the Tuirial reservoir or to State gauges, wherever any exist (Commentary to Clause 3.7). No discharge record, stage–discharge curve, catchment area at a gauge or unit hydrograph for any Mizoram river was found [TBC]. Where a calibrated model gives a lower 1% AEP peak than the 2(b) SUH, Clause 3.11.4(d) applies as written. Below the Tuirial and Serlui B dams the flood is set by releases (Clause 5.8.5(e)), and on the valley floors by the river level at the outfall (Clause 5.8.5(c) and (d)), not by any unit hydrograph. The urban catchments of Aizawl, Lunglei, Serchhip, Champhai and the other towns are far smaller than 50 km² and are designed by the Rational Method or SWMM under Clause 3.4. Every cross-drainage structure and outfall with a catchment of more than 1 km² needs a site-specific hydrology study with the design rainfall of Clause 2.3.6. The design loss rate of 3.5 mm/h is a φ-index fitted to the floods of rural catchments on the plains and foothills of subzone 2(b); it is not a soil infiltration capacity and is not used to assign HSG (Clause 3.7), in urban SCS-CN or SWMM models, or to size infiltration practices (Chapter 4).

Table 3E.2 — Worked example outline (layout)

Step	Content	Clause
1	Catchment area, main stream length, length to centroid and equivalent slope, from survey or DEM	3.11.4(a)
2	SUH parameters from Table 3E.1 and the plotted unit hydrograph	3.11.4(a)
3	Design storm duration, point and areal 24-hour rainfall with climate factor, time distribution	3.11.4(a), (b)
4	Effective rainfall after the design loss rate; convolution with the SUH; base flow added	3.11.4(a)
5	1% AEP peak compared with the HEC-HMS or SWMM peak for the existing natural condition	3.11.4(c), (d)

Form 3-1 — Hydrologic Calculation Summary

Supports Clauses 3.4, 3.6, 3.7, 3.8, 3.10–3.13, 3.15–3.17 of Chapter 3.

Draft form — Mizoram 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 Mizoram 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 — Mizoram Stormwater Design Manual, Draft v1.0. One form for each point of comparison (POC). Flows in m³/s, volumes in m³.

A. Point of comparison (Clause 3.14.2)

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

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

B. Peak flows (Clauses 3.14.7–3.14.10)

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

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

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

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

C. Volumes and storage (Clauses 3.14.8–3.14.10)

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

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

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

D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

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

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

E. Associated checks (Clause 3.14.12)

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

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

F. Statement by the responsible engineer

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

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

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Mizoram 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 valley floors and river terraces at Sairang, Bairabi and Vairengte, at Tlabung on the Khawthlangtuipui and at Chawngte on the Kau, the Champhai flats, the margins of the dils and of the Tuirial and Serlui B reservoirs, and hill sites with perched water, springs (tuikhur) or seepage, and any area where the groundwater table lies within 3 m of the surface at any time of year (Clause 4.12.1).

To be prepared. This annex will contain (a) the boundaries of the flood-sensitive catchments as a GIS layer and as maps at a scale fit for deciding whether a plot lies inside them, and (b) a map of the shallow-groundwater zone of Clause 4.12.1, with the seasonal high groundwater depth during and after the monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (IWRD, NRSC, Survey of India), the flood works and gauges of IWRD, with their levels and their datum [TBC], the CWC level-monitoring sites (Sairang, Turial, Bailley Bridge Tuipui, Sihthangpui, Keitum, Tuichang and Tuichawng, of which only Turial has a printed highest flood level, 149.0 m on 17 June 1995, as transcribed by SANDRP, with no datum stated [TBC]), the levels and release records of the Tuirial reservoir from NEEPCO and of the Serlui B reservoir [TBC], the Landslide Hazard Maps of the Aizawl Municipal Corporation at 1:5,000 and MIRSAC's *Atlas of Micro-level Landslide Hazard Zonation of Aizawl City and Selected Towns*, the "flood hazard areas" that regulation 6 of the Site Development and Slope Modification Regulations, 2017 asks site plans to show (none found designated), any River Conservation Zone under the Mizoram (Protection of Rivers) Ordinance, 2023 (Ordinance No. 1 of 2023) and Bill, 2023, whose enactment was not confirmed (none found notified), the riverine reserves and wetlands of the EF&CC Department, the flood marks of the Tlabung floods of 2017, 2019 and 2023 [TBC], and any inventory of springs (tuikhur) and their catchments [TBC], town boundaries (UD&PA for the master plans of urban areas and notified towns, the Aizawl Municipal Corporation for the Aizawl Development Plan Area of the Master Plan for Aizawl: Vision 2030, the Lunglei Municipal Council, the Village Councils of the notified towns that have no urban local body, the Land Revenue and Settlement Department for land records, and the Lai, Mara and Chakma Autonomous District Councils for their areas [TBC]), flood maps held by MSDMA, observation-well records of the CGWB and the IWRD, and the extent of the shale, siltstone and mudstone of the Surma group, the Bhuban and Barail sandstones, the colluvium of the slopes, the valley alluvium and river terraces of the Champhai flats, Tlabung, Bairabi, Vairengte and the Tlawng, and urban fill and cut-spoil, with the slopes of more than 10°, and the Surma-group shale at any slope, to which the hill rule of Clause 4.11 applies, and the tested valley alluvium and terraces to which its recharge rule may apply from soil survey maps (NBSS&LUP, the State soil survey (agency to be confirmed [TBC])). Until it is published: (a) the catchments named in Clause 4.5.3.2 apply, and whether a site lies in one is decided and recorded as set out in Annex 1B; and (b) every site to which Clause 4.12.1 may apply establishes its design groundwater level from site piezometer readings over one April–November season or, failing that, from the nearest CGWB or State observation well plus 0.5 m and the design flood level of any adjacent river, stream (lui), dil or reservoir (Clause 4.12.1(b)). For the flotation check in the valley floors and river terraces of the Tlawng, Tuirial and Khawthlangtuipui (at Sairang, Bairabi, Vairengte and Tlabung), the Champhai flats, the margins of dils and reservoirs, and the seepage zones below springs (tuikhur) on slopes 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	valley floor or river terrace (Sairang, Bairabi, Vairengte, Tlabung, Chawngte or other); Champhai flats; dil margin (Tam Dil, Palak Dil or other); reservoir margin or backwater (Tuirial, Serlui B or other); perched water, spring (tuikhur) or seepage on a hill slope; other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, monsoon season	m
shgw_basis	Wells or piezometers used, and period of record	text
tidal_influence	Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b))	yes / no
source	Source agency and date of the data	text
geometry	Zone boundary	polygon

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

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

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

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

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

4B.2 PSD and SSR (Table 4.3)

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

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

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m^3/ha), standard	SSR (m^3/ha), flood-sensitive
MZ-Z1 Northern hills: MZ-A Northern hills (Kolasib–Kawnpui–Bilkhawthlir), at the depths of Clause 2.3.6(c)(ii); where the site's NIH-DHAARA cell is higher, Clause 4.6 applies	C / D	50% / 70% / 90%	—	—	—	—	—
MZ-Z1 Northern hills: MZ-A1 Northern valley floors (Bairabi–Vairengte), at the depths of Clause 2.3.6(c)(ii); where the site's NIH-DHAARA cell is higher, as at Vairengte, Clause 4.6 applies	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
MZ-Z2 Central ridges: MZ-B Central ridges (Aizawl–Sairang–Serchhip–Thenzawl–Hnahthial–Mamit), at the floor of Clause 2.3.6(c)(i); where the site's NIH-DHAARA cell is higher, as at Thenzawl and Hnahthial, Clause 4.6 applies	C / D	50% / 70% / 90%	—	—	—	—	—
MZ-Z3 Eastern uplands: MZ-C Eastern uplands (Champhai–Khawzawl–Saitual–Ngopa–Zokhawthar), at the floor of Clause 2.3.6(c)(i) and (c)(iii)	C / D	50% / 70% / 90%	—	—	—	—	—
MZ-Z3 Eastern uplands: MZ-C1 Champhai flats, at the floor of Clause 2.3.6(c)(i) and (c)(iii)	B / C / D	50% / 70% / 90%	—	—	—	—	—
MZ-Z4 Southern hills: MZ-D Southern hills (Lunglei–Lawngtlai–Siaha–Chawngte–Tuipang)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(i))	—	—	—	—
MZ-Z4 Southern hills: MZ-D1 Tlabung valley floor (Tlabung)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(i))	—	—	—	—

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 hillside colony in Lunglei town draining to a hill stream (lui); 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 hill stream (lui) from a hillside colony in Lunglei town is in Annex 5C.

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

4C.1 **Inputs.**

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

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

Item	Value	Basis
Trial outlet	Stage 1: 120 mm orifice at the floor. Stage 2: 470 mm orifice, invert 0.533 m above the floor. No Stage 3	Trial for this annex; Part 2 revises it
Outfall	Free outfall to a receiving drain whose level stays below the outlet invert	Illustrative input

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

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

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

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

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

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

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

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

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

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

Duration (h)	AMC	2-yr pre	2-yr post	10-yr pre	10-yr post	100-yr post
1	II	0.7	20.1	8.2	41.3	79.2
2	II	2.8	28.2	16.9	57.2	108.5
3	II	5.1	34.2	24.5	69.0	130.2

Duration (h)	AMC	2-yr pre	2-yr post	10-yr pre	10-yr post	100-yr post
6	II	11.4	47.5	42.9	94.7	177.1
12	III	45.0	70.5	106.6	137.2	249.9
24	III	68.4	96.4	152.6	185.1	334.2
48	III	93.5	123.3	201.0	234.7	421.5
72	III	108.9	139.6	230.3	264.5	473.9

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

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

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

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

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

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

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

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

Stage h (m)	Storage (m³)	Stage 1, 120 mm (L/s)	Stage 2, 470 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
0.06	150	3.7	0.0	3.7
0.12	300	7.4	0.0	7.4
0.20	500	11.2	0.0	11.2
0.30	750	14.7	0.0	14.7
0.40	1,000	17.5	0.0	17.5
0.50	1,250	19.9	0.0	19.9
0.60	1,500	22.1	0.0	22.1
0.70	1,750	24.0	0.0	24.0

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

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

4C.8 **Routing.** Each storm is routed by level-pool continuity (Clause 4.6.1): over each 5-minute step, the change in storage equals inflow volume minus outflow volume. The computation used six 50-second sub-steps per 5-minute step. Each row of Table 4C.7 can be checked by hand as $\Delta S \approx (I - \bar{O}) \times 300$ s, where I is the mean inflow over the 5-minute step ending at the time shown and $\bar{O}$ is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: ΔS = 2,853.0 − 2,613.3 = 239.7 m³, and (1.0891 − (0.2655 + 0.3069)/2) × 300 = 240.9 m³.

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

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

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

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

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
12	35.0	14	8	0.130	325

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Findings:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Item	Value
Storage	2,500 m² plan area; 2,913 m³ at the 1% AEP maximum level of 1.17 m
Stage 1	170 mm orifice at the floor, with trash rack and anti-vortex plate
Stage 2	460 mm orifice, invert 0.53 m
Spillway	Crest 1.35 m, length 4.0 m, maximum level 1.65 m
Top of walls	≥ 1.95 m above the floor
100-yr peak release	343 L/s (cap 356 L/s)

Item	Value
2-yr peak release	34 L/s (cap 180 L/s)
10-yr drawdown, 50% blocked	45.3 h (limit 48 h)
Retention	RRV 552 m³ provided in addition; credit 7 m³
Still to be checked	Outfall-closed check on an outfall to a hill stream (lui) from a hillside colony in Lunglei town (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 — Mizoram 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 Mizoram 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 — Mizoram 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 — Mizoram Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for Tier B sites using Clause 4.14.2. It can be used only after Table 4.3 is published in Annex 4B; until then, Tier B sites use Clause 4.6 or, for sites of 1 ha or less, the fixed-coefficient route (Clauses 4.14.1 and 4.14.3).

A. Eligibility (Clause 4.14.1)

Table 4F.12 — Form 4-2: eligibility

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

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

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

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

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

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

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

Line	Quantity	Computation	Value
C7	Q_PSD,100 (L/s)	B5 × A	

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

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

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

E. Statement

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

Table 4F.16 — Form 4-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Mizoram 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 — Mizoram 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 — Mizoram 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 Mizoram. Mizoram has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Mizoram 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 an outfall to a lui, row F10 records the study, the flood marks, the bed survey and the check of the lui to the next confluence of Clause 5.8.5(a) or (b), and for an outfall to the Tuirial or Serlui B reservoir, the operator's levels and their datum, or the interim level, of Clause 5.8.5(e).

Table 5A.2 — Tidal datums, surge and still-water levels by coastal segment (layout)

Coastal segment	Reference port and tide-table edition	MSL (m CD)	MHWS (m CD)	HAT (m CD)	CD to Survey of India datum (m)	10% AEP surge (m)	1% AEP still-water level (m CD)	Wave set-up (m), open-sea outfalls	Sources

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Annex 5B — Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map

Supports Clauses 5.2, 5.3, 5.8 and 5.13 of Chapter 5.

5B.1 Table 5B.1 lists the water bodies that Chapter 5 already names. It is not complete: the annex will add the extents of each reach, the other rivers, canals and mouths of the State, and a map.

Table 5B.1 — Water bodies named in Chapter 5

Water body	Region	Listed as	Clause
Lui of the ridge towns: Lunglei, Serchhip, Champhai, Kolasib, Siaha, Lawngtlai, Mamit, Khawzawl, Saitual, Hnahthial and others	Statewide	Major drains; ungauged, no published flood level [TBC]; free outfall with energy dissipation; 1% AEP study with bulking and blockage and surveyed flood marks; check of the lui to the next confluence; outfall at least 0.5 m above the highest surveyed bed level; lock (where the invert is below the design level) the storm plus recession, not less than 24 hours; no outfall within 15 m of a tuikhur or onto a quarry face	5.2, 5.8.1, 5.8.5
Chite lui (with its tributaries, and the Muthi and Tuipawl lui) to the Tuirial; Ser lui (with the Ramri, Tuikal, Vai and Zawngkawt lui) to the Tlawng	Aizawl	Major drains and city lui; ungauged, no published flood level [TBC]; item (a) rule with the MZ-B rainfall; the Chite and Tuikual streams CPCB Priority II and the Lawibual stream Priority III (Clause 8.9); eight check dams proposed in the master plan, not to raise any outfall level	5.2, 5.8.1, 5.8.5
Tlawng (Dhaleswari) at Sairang, Bairabi and the CWC site at Keitum	Aizawl, Kolasib, Lunglei districts	Riverine outfall reach; CWC level sites at Sairang (active hydrograph) and Keitum, no highest level printed [TBC]; no warning or danger level; modelled 1% AEP level and surveyed flood marks (June 2018 and later); valley-floor outfalls flap-gated, lock the whole 72-hour storm, not less than 72 hours; runs north to the Barak plain, where the adjoining edition governs	5.8.1, 5.8.5
Tiau at Champhai and Zokhawthar; the Champhai flats	Champhai district; Myanmar border	Riverine outfall reach and valley-floor land; no CWC level site; modelled level and flood marks (June 2025 and later); lock not less than 72 hours; no level across the border	5.8.1, 5.8.5
Kau (Tuichawng) at Chawngte; Tuichang and Tuichawng at their CWC sites; Tuipui at Bailley Bridge	Lawngtlai and Lunglei districts; Champhai district	Riverine outfall reaches; CWC level sites with no highest level printed [TBC]; modelled level and flood marks; lock not less than 72 hours on valley-floor land	5.8.1, 5.8.5
Khawthlangtuipui (Karnaphuli) at Tlabung	Lunglei district (MZ-D1)	Riverine outfall reach; river-flood town (June 2017, June 2018, July 2019, August 2023, as reported); no CWC level site listed; design for the river at flood level from a model and surveyed flood marks; flap gates; lock not less than 72 hours, longer where flood marks show it; runs into Bangladesh, no level across the border	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Tuirial (Sonai) reservoir of NEEPCO and the Tuirial below the dam	Kolasib district	Reservoir outfalls and release reach; FRL 90.5 m, MDDL 68.0 m, normal tailwater 30.7 m (CERC); tailwater 91.0 m (FRL + 0.5 m) until NEEPCO gives the MWL, datum [TBC]; CWC Turial gauge HFL 149.0 m (17 June 1995), not to be related to the reservoir levels [TBC]; release: largest recorded, else spillway capacity, else unattenuated 1% AEP inflow [TBC]; dam-break peak 3,035.34 m³/s (as reported) recorded, not a design release; NEEPCO's consent	5.8.1, 5.8.3, 5.8.5
Serlui B reservoir and the Serlui below the dam	Kolasib district	Reservoir outfalls and release reach; FRL and MWL not found [TBC]; operator's levels in writing, or the surveyed shore line or spillway crest + 0.5 m; release as for the Tuirial; the State power department's consent	5.8.1, 5.8.3, 5.8.5
Chhimtuipui (Kaladan) at the CWC's Sihthangpui site	Lawngtlai district; to Myanmar	Riverine outfall reach; no highest level printed [TBC]; no level across the border; model boundary far downstream with a sensitivity run	5.8.1, 5.8.5
Tuivai and the northern rivers where they leave the State	Northern border	Riverine outfall reaches; the adjoining Barak-valley edition governs the reaches downstream; its levels bound the model's downstream boundary only	5.8.1, 5.8.5
Palak Dil (Pala wetland) and Tam Dil	Siaha district (Mara Autonomous District Council area); near Saitual	Dil outfalls; no level found [TBC]; spill level plus head; custodian's consent (and the District Council's in its area); debris, waste and sediment traps; no sewage; no dil used as a detention pond; Palak Dil a Ramsar site (designated 31 August 2021 per its RIS; announced 26 July 2022, as reported)	5.8.5
Drains of the Aizawl Municipal Corporation, the Lunglei Municipal Council, Village Councils, PWD, PHED and the national-highway agencies 1.0 m wide or more; village drains and lui in the Autonomous District Council areas	Mizoram	Major drains; owner's consent (the Chairman's written permission, s.295, and the municipality's consent, s.296, of the Municipalities Act within municipal areas; PWD and the Corporation both on State roads in the Corporation's area), design water level and flap gate	5.2, 5.8.5
Tuirial and Serlui B dams	Tuirial, Serlui	Releases and gate operation to be included in river levels (release records and operating rules [TBC]); releases, not notices	5.8.3, 5.8.5
River mouths subject to sand-bar closure	None in Mizoram	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 IWRD mouth-maintenance programme. It needs IWRD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (IWRD), the drain inventories of the Aizawl Municipal Corporation 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, IWRD canal, the Chite lui and its tributary lui through eastern Aizawl and the Ser lui and its streamlets through western Aizawl, the lui of Lunglei and the other ridge towns, every drain that discharges through a flap gate on the valley floors of Sairang, Bairabi, Vairengte, Tlabung, Chawngte or the Champhai flats, any drain built or held by the Aizawl Municipal Corporation, the Lunglei Municipal Council, a Village Council, a District Council, PWD, PHED or a national-highway agency with an internal width of 1.0 m or more, and every lui or other natural channel that drains 8 ha or more and every tidal creek is a major drain (Clause 5.2); the water bodies of Table 5B.1 are riverine outfall reaches (Clause 5.8.1); and the mouths of the coastal States' rivers (there is none in Mizoram) are assumed closed at the start of the monsoon unless the IWRD certifies otherwise (Clause 5.13.2).

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

Field	Content	Unit or format
feature_id	Unique identifier	text
name	Name of the drain, river, canal, creek or mouth	text
category	Major drain; riverine outfall reach; mouth subject to sand-bar closure	text
clause	Clause of Chapter 5 under which it is listed	text
reach_limits	Upstream and downstream limits of the reach	text
design_flood_level_source	IWRD 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	IWRD 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 hillside colony in Lunglei town draining to a hill stream (lui)

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, a hillside colony in Lunglei town (flood-sensitive catchment (i) of Clause 4.5.3.2). It discharges through its own outlet chamber and a flap gate to a public storm drain that runs down a lined chute to a hill stream (lui), whose level rises over the drain's outlet when the lui runs full in a storm and stays up while the storm and its recession last, 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 Mizoram an outfall to a lui whose invert is below its design level is closed for the design storm and the lui's recession, and for not less than 24 hours, and for the whole storm where the 48- and 72-hour storms are run; an outfall on valley-floor land below the design level of its river is closed for the whole 72-hour storm and not less than 72 hours; an outfall at Tlabung is closed for not less than 72 hours, and longer where flood marks show the Khawthlangtuipui held up for longer; an outfall to a release reach below the Tuirial or Serlui B dam is closed for not less than 72 hours; and an outfall below the design level of either reservoir is closed for the whole storm, under Clause 5.8.5. In each of those cases that lasts longer than the windows used here, the facility must store or pump the volume of the longer closure, up to the whole storm volume (Clause 5.9.4); that needs more storage, or pumping, than this example shows. The routing, the volume balance of Clause 5.10.4 and the assessment are the same. The public drain's own outfall to the lui would also need the energy dissipator, the check of the lui to the next confluence and the invert above the range of bed movement of Clause 5.8.5(a), and the debris rack and the bulking factor of Clause 6.3.6; and on Lunglei's slopes, on natural ground steeper than 10° or on Surma-group shale at any slope, the facility itself would be a lined tank, not an infiltrating basin, and its overflow would go to a lined drain, never onto the slope (Clause 4.11 (hill rule)).

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

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

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

Lock windows (Clause 5.10.3)

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

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

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

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

Results

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

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

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

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

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

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

Check for window 1: V_{inflow} = 3,634 m³ ≤ $V_{storage\ available} + V_{pumped} + V_{gravity}$ = (5,238 − 1,604) + 0 + 0 = 3,634 m³. The facility therefore needs **5,238 m³** of storage, which the routing confirms.

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

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
24	20	Open	18	0.18	445
28	39	Open	24	0.25	621
32	59	Open	32	0.36	906
34	85	Open	37	0.47	1,166
36	286	Closed	0	0.78	1,944
38	106	Closed	0	1.73	4,321
40	66	Closed	0	1.96	4,904
42	51	Open	529	1.79	4,472
44	42	Open	204	0.87	2,181
46	37	Open	49	0.74	1,854
48	33	Open	47	0.70	1,756
50	0	Closed	0	0.71	1,784
54	0	Closed	0	0.71	1,784
56	0	Open	43	0.58	1,459
60	0	Open	32	0.37	921
66	0	Open	16	0.16	397
72	0	Open	7	0.06	162

Assessment

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

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

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

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

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

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

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 31 March each year and after every event in which it closed against a storm flow (Clause 5.11.5).
- The deeper facility is checked for flotation with groundwater at the design groundwater level; in the valley floors and river terraces of the Tlawng, Tuirial and Khawthlangtuipui (at Sairang, Bairabi, Vairengte and Tlabung), the Champhai flats, the margins of dils and reservoirs, and the seepage zones below springs (tuikhur) on slopes 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 — Mizoram 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 dil, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or dil: 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. Lui, valley-floor rivers, Tlabung, reservoirs and release reaches, dils, transboundary rivers, and drains of other bodies: for a lui (Clause 5.8.5(a) and (b)), the 1% AEP study with the rainfall of Clause 2.3.6 for the sub-area (MZ-B for Aizawl), AMC, the bulking and blockage of Clause 6.3.6, the channel as surveyed net of encroachment, silt, slide debris and waste, the surveyed flood marks and their sources, the energy dissipator and the lined path to the lui, the check of the lui to the next confluence (capacity with bulking, velocity, bank stability) and its result, the landslide-hazard-map class of the outfall and of the reach, the bed survey and range of bed movement, the invert at least 0.5 m above the highest surveyed bed level, the scour depth of the foundation, confirmation that no outfall lies within 15 m of a tuikhur, on its protected catchment or on a quarry face, any check dam or trap included in the model, and the lock where the invert is below the design level (storm plus recession, not less than 24 hours); for valley-floor land (Clause 5.8.5(c)), the 1% AEP river level from a model with a site study calibrated to CWC, NEEPCO or State gauges where they exist, any level obtained from CWC for the nearest gauge (Sairang, Keitum, Turial 149.0 m, Bailley Bridge Tuipui, Tuichang, Tuichawng, Sihthangpui) transferred to the outfall, the surveyed flood marks and their sources, every level with its datum and its tie to the named gauge and a Survey of India benchmark; 10% AEP river level (no warning or danger level exists: the design river level until a frequency analysis is accepted); the flap gate, its owner from the drain register, sill and closing level; drain behind the gate routed with its whole catchment, hill catchments included, and present storage, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the design river level; single lock of the whole 72-hour storm, not less than 72 hours, or longer from the model or a stage record, and its source; gate jammed open checked; for Tlabung (Clause 5.8.5(d)), the model of the Khawthlangtuipui, the flood marks of June 2017, July 2019, August 2023 or later and residents' records, the downstream boundary and its sensitivity run, and the lock (not less than 72 hours, longer where the flood marks show it); for the Tuirial or Serlui B reservoir (Clause 5.8.5(e)), the operator's consent, its MWL or FRL plus design-flood surcharge in writing with its datum, or the interim level (Tuirial 91.0 m, FRL 90.5 m + 0.5 m; Serlui B the surveyed shore line or spillway crest + 0.5 m), the Turial gauge level recorded but not related to the reservoir levels, the outfall below the tailwater treated as closed for the whole of the 72-hour storm, the reservoir starting at FRL, and no gate operation, drawdown, release notice or reservoir attenuation credited; for a release reach, the design storm and the 72-hour storm with the largest recorded release, or the spillway capacity, or the unattenuated 1% AEP inflow until the operator gives either, placed before, during and after the storm, and the reported dam-break peak of 3,035.34 m³/s below the Tuirial dam and whether the outfall lies in its inundation extent; for a dil, the custodian's consent (and the District Council's in its area), the surveyed spill level plus head, and the debris, waste and sediment traps before it; for a river that leaves the State (Clause 5.8.5(f)), the model boundary and its sensitivity run, and for the northern rivers the adjoining edition's level used only as the model's downstream boundary; owner's consent (the Chairman's written permission under s.295 and the municipality's consent under s.296 of the Municipalities Act; PWD and the Corporation both on a State road in the Corporation's area; the national-highway agency; the Village Council; the District Council in its area), permitted rate, design water level or computed channel level, and flap gate; and the lines checked (SD&SM reg. 28 riverine reserve; riverine reserves under the Mizo District (Forest) Act, 1955 and any restriction of April 2021 confirmed with EF&CC; the master plan's 15 m buffer; any River Conservation Zone, only if the Rivers law is in force and a zone notified; AMCBR reg. 33's 15 m) (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				

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
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 (m³/s) at the static head for the J2 tailwater; standby capacity (Clause 5.12.2)	
J3. Effect on the receiving water level (Clause 5.12.3)	
J4. Power supply: two independent supplies, or standby generation with 72 h of fuel; automatic changeover (Clause 5.12.4)	
J5. Level of electrical panels, controls, generators and fuel, against the higher of the 1% AEP flood level + 0.5 m and HAT + surge + SLA + 0.5 m (Clause 5.12.5)	
J6. Discharge arrangement (Clause 5.12.6); controls, alarms and logging (Clause 5.12.7); screens (Clause 5.12.8)	

K. Sand bar (Clause 5.13; Clause 5.14, item 10)

Table 5F.13 — Form 5-1: sand-bar assumption

Field	Entry
K1. River mouth or creek inlet concerned	
K2. Mouth assumed closed, or open with IWRD certification attached (Clause 5.13.2)	
K3. Bar crest level from the most recent pre-monsoon survey (m) and the closed-mouth tailwater (Clause 5.13.3)	
K4. Extension of the lock duration, where required (Clause 5.13.5)	

L. Inspection and maintenance (Clause 5.14, item 11)

Table 5F.14 — Form 5-1: inspection and maintenance

Field	Entry
L1. Gate and valve inspection before 31 March and after closure events (Clause 5.11.5)	
L2. Pump test runs before 31 March (Clause 5.12.9)	
L3. Other requirements for the maintenance plan (Chapter 10)	

M. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 5 of the Mizoram 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	

Field	Entry
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — Mizoram Stormwater Design Manual, Draft v1.0.

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — Mizoram 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, the Aizawl Municipal Corporation, MSDMA, IWRD (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 — Mizoram 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 Mizoram 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 Mizoram streets (kerb-opening, grate and combination inlets, including the road-level wall opening into a covered drain) and, for each type, capacity curves on grade and in a sag. It needs a fixed set of standard inlet geometries agreed with the road-owning agencies, and rating tests of those geometries (laboratory or full-scale), or HEC-22 calculations for each geometry checked against tests (data and likely sources: Public Works Department (PWD), the national-highway agencies and Aizawl Municipal Corporation standard details, NIT Mizoram and Mizoram University, where no rainfall-frequency (IDF) study for the State's towns was found and whose hydraulic testing capability was not confirmed during research [TBC], or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

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

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

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 Mizoram, by land use and drain type, for sizing the silt traps of Clause 6.13.3, and a calibration of the sediment allowance of Clause 6.7.8 against measured silt depths. It needs desilting records (volume or mass removed per drain length and per catchment area, with dates), silt-depth surveys before and after the monsoon season, and catchment land-use and soil data (data and likely sources: desilting records of Aizawl Municipal Corporation and other urban local bodies, IWRD records for channels, land cover from NRSC, soils from the Mizoram 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.

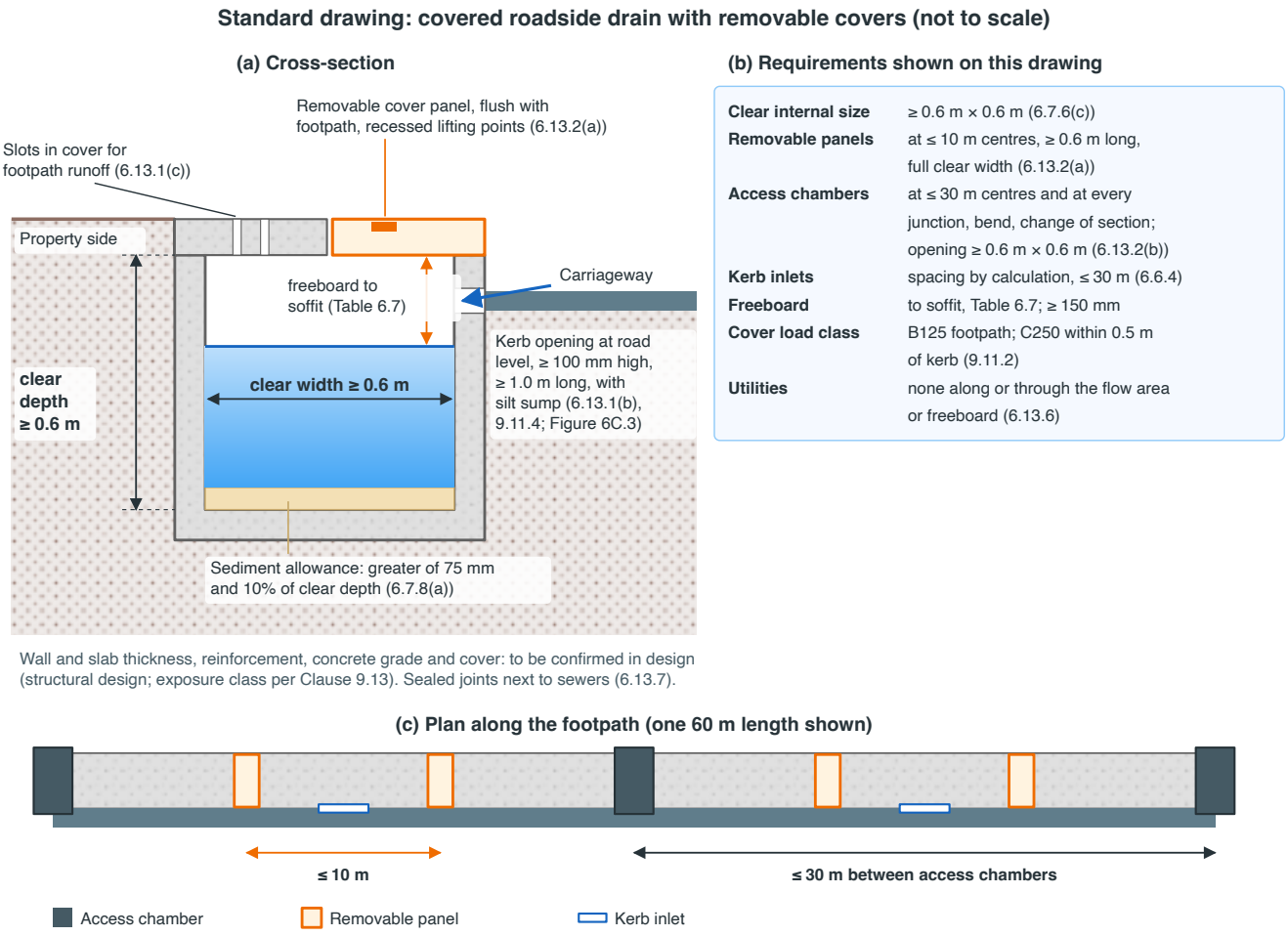


Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

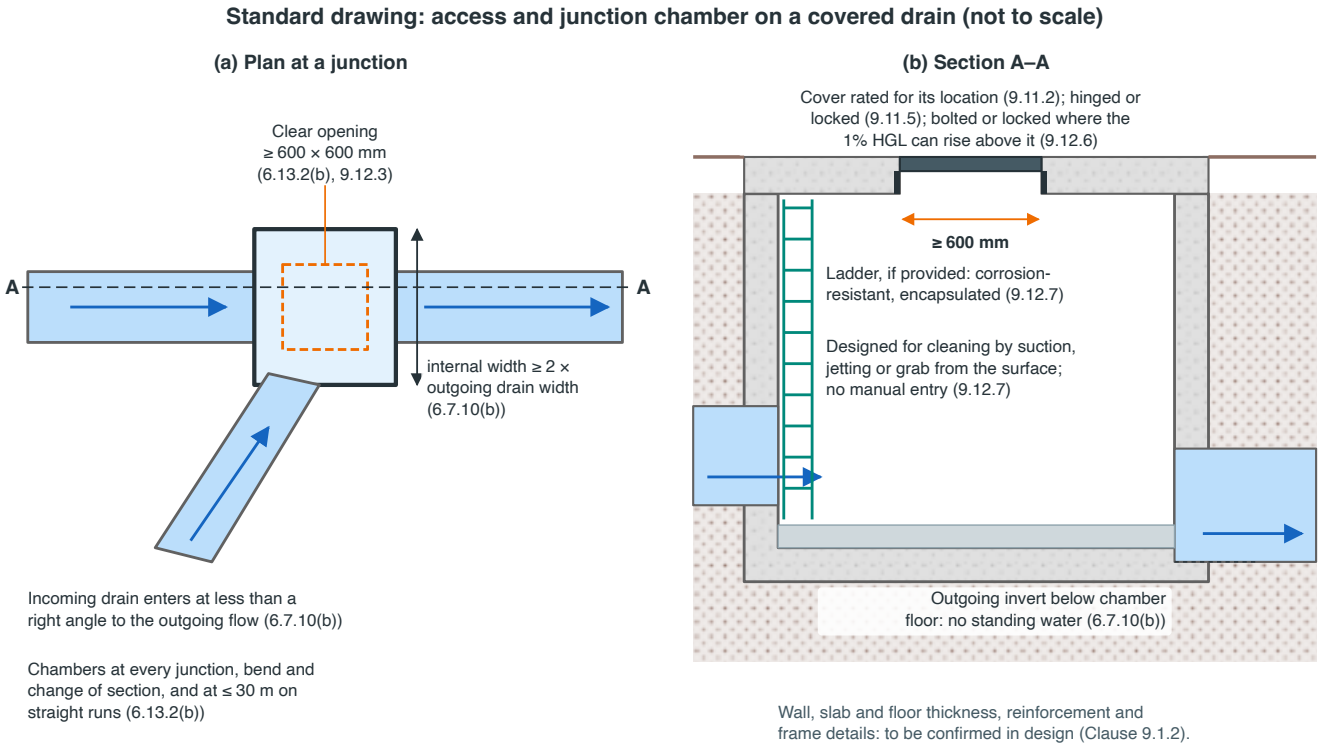


Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

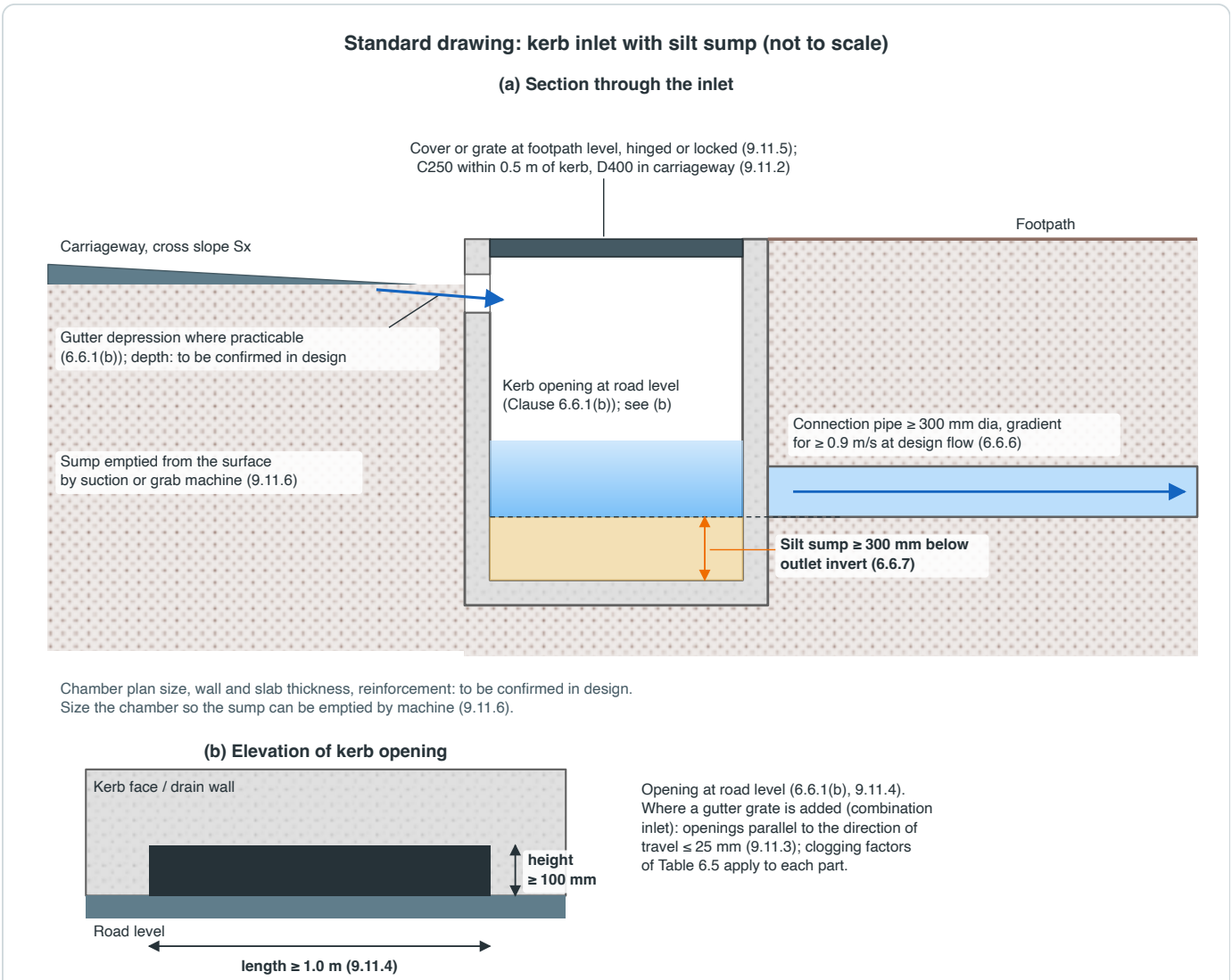


Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th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

ANNEXES TO CHAPTER 7

Waterbodies, Dils (Lakes and 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 Mizo waterbody terms, and the three forms that Clause 7.15 requires. Where an annex cannot yet be completed it says so and gives the rule to use in the meantime. The forms are draft forms; the template and model text are for consideration by a competent authority and are not in force.

Annex 7A — Statewide waterbody GIS layer and inventory fields

Supports Clauses 7.3.1, 7.3.3 and 7.3.5 of Chapter 7.

To be prepared. This annex will contain the statewide GIS layer of waterbodies required by Clause 7.3.1, prepared by each Authority with the IWRD and the Land Revenue and Settlement Department. It needs the land records and maps of the Land Revenue and Settlement Department, which keeps the land records and still administers land use inside the Aizawl Municipal Corporation's area (CAG, 2025), with the land passes and settlement records it issues (none of them was read for this Manual [TBC]); the allotments of house sites and other land made by Village Councils under the Mizoram (Village Councils) Act, 2025; in the Lai, Mara and Chakma Autonomous District Council areas, the land records of the District Councils, which hold and settle the land there (the Lai Autonomous District Council (Land Holding and Settlement) Act, 2002 is known only from a snippet, and none of these records was read [TBC]); the public tanks, streams, reservoirs, wells and drains that vest in the Aizawl Municipal Corporation under sections 80 and 289 of the Mizoram Municipalities Act, 2007; the land use maps of the Master Plan for Aizawl: Vision 2030, with its "W" use zone of rivers, streams, springs, ponds, lakes, wetland and water catchment area, its streams, which the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations, 2017 take as the definition of a "Stream", and its map of drains and catchments (Map 8.3, not extracted for this Manual [TBC]); the Corporation's Landslide Hazard Maps and MIRSAC's landslide hazard zonation atlas for Aizawl and selected towns; the water-resources mapping that the Mizoram Water Resources (Management and Regulation) Act, 2024 requires within five years (s.17), when it is done; NEEPCO's records of the Tuirial reservoir's levels and land; any inventory of springs (tuikhur), of which none was found for Aizawl [TBC]; and each town's drain register (Chapter 6); the NEEPCO and Village Council 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 NEEPCO records, with local name	7.3.1(a)
WB_NAME_LUS	Text	Mizo script	Yes	Name in Mizo	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, sub-division 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	NEEPCO 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 NEEPCO 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 stream (lui; lui-pui); drain or ditch (tui luankawr, tui-hawr); dil (lake or pond, natural or dug; dil té); reservoir (with its drawdown zone); check-dam pool; spring or spring-fed water point (tuikhur; hna, tuihna) and its protected catchment; wetland, marsh or seepage ground; supply channel; surplus course	7.2
CUSTODIAN	Aizawl Municipal Corporation (Municipalities Act, 2007, ss.80 and 289); Lunglei Municipal Council; PWD or national-highway agency (road drains and culverts); IWRD (rivers, minor irrigation, flood works); PHED (water-supply source or intake); NEEPCO (Tuirial reservoir and release reach); State power department (Serlui B reservoir and release reach [TBC]); Fisheries Department (Tam Dil); EF&CC (forest land, riverine reserve, wetland); Land Revenue and Settlement Department (land records, land passes); Village Council, with its Village or Local Water Resources Committee; District Council (Lai, Mara or Chakma) with its Village Council [TBC]; private owner or land-pass holder; developer (until handed over); State Wetlands Authority (none found); 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)

Field	Type	Unit	Content	Clause
GATED	Code	Yes / No	Controllable outlet (needed for a flood cushion, Clause 7.8.2(a))	7.8.2
CONDITION	Code	Serviceable / defective	Result of the latest pre-monsoon inspection, with date	7.7.1(d), 7.14.4

Annex 7B — Fixed-width setback table (alternative S-3, with Annex 1C)

Supports Clauses 7.3.4, 7.4.3, 7.4.6 and 7.4.7 of Chapter 7, and alternative S-3 of the Policy Supplement (Annex 1C).

7B.1 When the table may be used

The fixed-width setback may be used only where all of the following apply:

- (a) the Authority has not adopted a 1% AEP flood extent map for the waterbody (Clause 7.3.4);
- (b) Clause 7.3.4 does not require the Applicant to determine the 1% AEP extent by a hydraulic study: the site is not in a flood-sensitive catchment, is not a site of 1 ha or more adjoining a waterbody, and the Authority has not asked for a study; and
- (c) the waterbody is one to which setbacks apply (Clause 7.4.1): any recorded or found waterbody, and any natural channel draining 8 ha or more at the site.

Where an Authority adopts alternative S-3 under Clause 1.7, the table below is the S-3 table. Clause 1.7.3(e) provides for the S-3 table to be issued by the State Stormwater Technical Committee. Until it is issued, the values are those of Clause 7.4.6, repeated here without change.

Table 7B.1 — Fixed-width setback by waterbody class (alternative S-3)

Waterbody class	Drainage area at the site	Total setback (Zone 1 + Zone 2)	Of which Zone 1	Measured from
Channel, small	8 ha to 65 ha	25 m	15 m	Top of bank (Clause 7.4.3)
Channel, medium	65 ha to 20 km²	40 m	15 m	Top of bank
Channel, large, and rivers	More than 20 km²	50 m	20 m	Top of bank
Tank, lake or pond	Any	MWL contour + 25 m	To the MWL contour, and not less than 15 m from FTL	FTL contour (Zone 1); MWL contour (total)
Marsh, estuary or backwater	Any	As notified by the Authority, and not less than 50 m	15 m	The waterbody boundary of Clause 7.13.1

Values from Clause 7.4.6 (Table 7.1). Zone 2 is the total setback less Zone 1.

7B.2 Rules of application

- (a) **Measurement.** Measure horizontally on plan, outward from the boundary of Clause 7.13.1: the larger of the Revenue record boundary and the surveyed FTL (or top of bank). Where FTL and top of bank both apply, use whichever gives the wider zone (Clause 7.4.3).
- (b) **Drainage area.** For a channel, use the drainage area at the downstream end of the reach that adjoins the site. Where a reach crosses a class limit within the site, apply the wider setback to the whole reach within the site.
- (c) **Both banks.** The setback applies on each bank of a channel and all round a tank, lake, pond or marsh.
- (d) **Minimum set by this Manual.** Zone 1 is never less than 15 m (Clause 7.4.7). A wider statutory or approval setback governs for the uses it restricts (Clause 7.4.5).

- (e) **Stricter of the two.** Where a hydraulic study is made voluntarily, the setback is the wider of Table 7B.1 and Clauses 7.4.3 and 7.4.4.
- (f) **Record.** The basis of the setback (fixed width) shall be stated on the Waterbody Sheet (Form 7-1) and in the approval (Clause 7.4, Disclosure).
- (g) **Review.** The table shall be reviewed within 2 years of the Authority adopting 1% AEP flood maps (Clause 7.16.1).

7B.3 Source of the channel widths

The channel widths were set by this Manual with reference to the 2006 Kansas City APWA default stream buffers, rounded up and floored at the 15 m minimum (Clause 7.4.6, commentary). The source values, as cited in the chapter, are:

Table 7B.2 — Source buffers cited in Clause 7.4.6 (KC APWA 5600, 2006, §5605.3)

Drainage area (source, acres)	Approximate SI equivalent	Source buffer
Less than 40 ac	Less than 16 ha	40 ft (12 m)
40–160 ac	16–65 ha	60 ft (18 m)
160–5,000 ac	65 ha – 20 km²	100 ft (30 m)
More than 5,000 ac	More than 20 km²	120 ft (37 m)

The 65 ha and 20 km² class limits in Table 7B.1 are the SI equivalents of 160 ac and 5,000 ac. The 8 ha lower limit is the 20-acre trigger of APWA 2025.01 (Clause 7.4.1(b)).

Annex 7C — Template tank operating rule, with flood cushion

Supports Clauses 7.7.1(c), 7.7.3, 7.8 and 7.14.4 of Chapter 7.

Model text for consideration by a competent authority. Not in force. For tanks under NEEPCO control, the operating rule is NEEPCO'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, sub-division, district].
2. Custodian: [NEEPCO division / ULB / Village Council / other].
3. Cascade position: upstream tank(s) [ ]; downstream tank, river or drain [ ].
4. Datum: [ ]. Surveyed levels (Clause 7.7.1(a)), date of survey [ ]: FTL [ ] m; MWL [ ] m; TBL (lowest point) [ ] m; surplus weir crest [ ] m, length [ ] m; sluice sills [ ] m.
5. Stage–storage curve (Clause 7.7.1(b)): survey date [ ]; attached as Schedule 1.
6. Controllable outlets (Clause 7.8.2(a)): [gated sluice / regulator / none]; capacity at FTL [ ] m³/s.

7C.2 Purposes and priority

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

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

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

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

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

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

7C.4 Flood cushion (Clause 7.8.2)

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

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

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

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

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

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

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

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

Trigger	Source	Action	By whom
IMD district heavy-rainfall warning for the catchment	IMD	Read gauges [ ] hourly; check outlets are free; confirm the tank is at or below its rule level	[ ]
IMD or MSDMA red alert	IMD, MSDMA	Begin releases needed to reach the rule level, within the maximum release rate; notify downstream bodies (paragraph 21)	[ ]
City forecast system warning, where available	[ ]	[ ]	[ ]
Tank level reaches FTL	Gauge	Record outflow hourly; inspect bund and weir	[ ]
Tank level reaches [MWL − [ ] m]	Gauge	Emergency procedure; warning to the breach area of any emergency action plan (Clause 7.14.3(c))	[ ]

7C.7 Records and review (Clause 7.8.1(g))

22. During the monsoon (1 April to 31 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the monsoon, records shall be kept [weekly].
23. Records shall be kept with the O&M plan (Chapter 10) and given to the Authority on request.
24. The tank shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Clause 7.14.4).
25. This rule shall be reviewed after any event in which the tank surplused at a level above [ ] m, after any change to the weir, sluices or bund (Clause 7.7.6), and in any case with the review of the Manual.

Schedules: 1 stage–storage curve; 2 continuous simulation report; 3 yield and compensation; 4 downstream check of the maximum release; 5 communication list.

Annex 7D — Desilting and restoration specification

Supports Clauses 7.7.1(b), 7.9 and 7.14.4 of Chapter 7.

This specification applies to every desilting, restoration or deepening of a tank, pond or other waterbody under Clause 7.9. Values are those of Chapter 7. Where the chapter does not set a value, it is marked "to be confirmed in design" and shall be stated in the works design.

7D.1 Pre-works survey (Clause 7.9.1)

- (a) **Topographic and bathymetric survey** of the waterspread, foreshore (to the MWL contour), bund, surplus weir and sluices, levelled to the datum of Clause 7.3.5. Survey grid and point density: to be confirmed in design.
- (b) **Original bed level** found by test pits or augering on a grid (grid spacing to be confirmed in design), and from historical records where available. Each pit log shall show the silt thickness, the level of the original bed, and any clay or silt layer below it.

- (c) **Silt testing** where the tank receives urban runoff or sewage: samples from the pits of (b), tested for heavy metals and other contaminants before disposal is planned. The parameters and limits shall be those the Mizoram Pollution Control Board (MPCB) 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 Mizoram Pollution Control Board (MPCB) directs.
- (c) Haul routes and temporary stockpiles shall meet the construction erosion and sediment control rules of Clause 8.12, including stockpiles outside Zone 1.

7D.6 Inlets (Clause 7.9.7)

Every inlet that brings urban runoff shall have a sediment forebay, a constructed wetland inlet zone or a gross pollutant trap, designed under Chapter 8 (Annex 8D).

7D.7 Timing (Clause 7.9.8)

Desilting shall be complete, and the waterbody made safe, by **31 March**. No excavation shall be left open, and no sluice or weir left dismantled, during the monsoon.

7D.8 Completion records

- (a) As-built survey and revised stage–storage curve. The curve is the one that Clause 7.7.1(b) requires "after the last desilting".
- (b) Volume removed, its disposal site, and the silt test results.
- (c) Photographs of the bund, weir, sluices and inlet works.
- (d) Update of the inventory record (Annex 7A: SSC_DATE, LEVEL_DATE, CONDITION).

Table 7D.1 — Hold points for desilting and restoration works

Hold point	Check	Clause
1. Before excavation	Pre-works survey, pit logs, silt tests, and hydrogeological report if deepening	7.9.1, 7.9.3
2. Original bed reached	Levels checked against pit logs; no excavation below the original bed unless approved	7.9.2
3. Edges formed	Side slopes or safety bench as 7D.3	7.9.4
4. Inlet works	Forebay, wetland inlet zone or GPT built	7.9.7
5. Completion (by 31 March)	As-built survey, stage–storage curve, silt disposal record	7.9.8, 7.7.1(b)

Annex 7E — Glossary of Mizo waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Mizo words for waterbodies, springs, channels, floods and land in Mizoram. Mizo is written in the Roman script, and many of the words appear in the names of streams, lakes and places (Chite lui, Ser lui, Palak Dil, Tam Dil, Zemabawktuikhur lui, Tuikhurhlu lui). **In the inventory of Annex 7A, the field WB_NAME_LUS holds the waterbody's name in Mizo, and "Mizo script" in Table 7A.1 means Mizo in its standard Roman spelling** (LUS is the ISO 639-2 and 639-3 code for Mizo, *lus*, written in capitals as in the other field names). The name used in the Revenue, municipal, Village Council, District Council or NEEPCO record for each waterbody, and the name the village uses, should be recorded in the inventory alongside the Manual's term. A meaning is given below only where it was found in one of two dictionaries, read as Internet Archive copies of their scanned text: J. Herbert Lorrain and Fred W. Savidge, *A Grammar and Dictionary of the Lushai Language (Dulien Dialect)* (1898), cited as "L&S 1898"; and Lalropara Pachuau, *English–Mizo Dictionary* (Saitual, 1997), cited by headword only, as its page numbers were not captured. **Three cautions apply.** The page numbers given for L&S 1898 are inferred from the running heads of the scanned text (an entry between the heads of pages 213 and 215 is given as "pp. 213–215") and are to be checked on the page images before this annex is relied on; Lorrain's later *Dictionary of the Lushai Language* (1940) and J. F. Laldailova's dictionary were not read; and the spellings are the dictionaries' own, while modern Mizo writes most compounds closed (tuikhur, tuihawr). Meanings are the dictionaries' English glosses, and modern usage may be narrower or wider. The terms of the Lai, Mara and Chakma languages, spoken in the Autonomous District Council areas, were not researched for this Manual [TBC]. The list is to be extended by the State Stormwater Technical Committee, with a Mizo editor and with modern Revenue, municipal and Village Council usage.

The Manual's term for a lake or pond in Mizoram is **dil**, written on first use as "**dil (Mizo: a lake or pond; *dil té*, a small pond or tank; plural dils)**". Both dictionaries give it for lake and pond, so it covers natural and dug standing water, and the State's best-known lakes carry it (Palak Dil, Tam Dil). Mizo marks plurals with *-te*, which would be confused with *té*, "small", in *dil té*; the English plural **dils** is therefore a convention of this Manual, to be confirmed by a Mizo editor before print. **tuikhur is not a tank word**: it is a well, a waterhole or a spring, and in law "any place wherein water supply is obtained" (Mizoram (Village Councils) Act, 2025, s.2(29)); it is written on first use as "**tuikhur (Mizo: a spring or water point)**" and is used in this Manual only for springs and the water points built on them. An engineered detention basin is never called a dil or a tuikhur: it is a detention pond. A natural lake keeps its own name, such as Palak Dil, and a tuikhur is protected from stormwater and never used as storage.

Table 7E.1 — Waterbodies and springs

Term	Meaning (source)	Manual term (Clause 7.2)
dil	"(s.) a lake" (L&S 1898, pp. 81–83); "Lake, (s.) dil" (L&S 1898, English–Lushai part, page not captured); "lake: dil"; "pond: dil, tui tling reng" (Pachuau 1997)	Dil (lake or pond), see the definitions after Clause 7.2; in names, as Palak Dil and Tam Dil
dil té	"(s.) a pond, a tank" (L&S 1898, pp. 83–85); "Pond, (s.) dil-té" (L&S 1898, English–Lushai part, pp. 307–309)	A small pond or tank; a dil for this chapter
tuikhur (tui-khur)	"(s.) a well, a waterhole" (L&S 1898, pp. 213–215); "Well, (s.) tui khur, tui-chhun-chhuah" (L&S 1898, English–Lushai part); "fountain: tuikhur"; "fount: tui khur" (Pachuau 1997); "any place wherein water supply is obtained" (Mizoram (Village Councils) Act, 2025, s.2(29)); "street hydrant" is rendered *vantlang tuikhur* in the Mizo text of the Ward Committee and Local Council Rules, 2010	Tuikhur (spring or water point), see the definitions after Clause 7.2; never a detention pond or storage
hna; tuihna	"Hna, (s.) the source (of a stream), a spring" (L&S 1898, pp. 99–103); "spring (n) tuihna" (Pachuau 1997)	The source of a stream; a spring, treated as a tuikhur where water is drawn from it

Table 7E.2 — Streams, drains and floods

Term	Meaning (source)	Manual term (Clause 7.2)
lui	"(s.) a stream, a river" (L&S 1898, pp. 137–139); "stream: lui te" (Pachuau 1997)	Stream (lui), see the definitions after Clause 7.2; in names, as Chite lui and Ser lui
lui-pui	"(s.) a river" (L&S 1898, pp. 137–139)	River
tui luankawr	"drain: tui luankawr"; "ditch: tui luankawr (laihchawp)" (Pachuau 1997)	Drain or ditch, built or eroded
tui-hawr	"(s.) a gutter, a ditch" (L&S 1898, pp. 213–215); "Ditch, (s.) tui-hawr"; "Gutter, (s.) tui-hawr, kawm" (L&S 1898, English–Lushai part)	Drain or ditch, as along a road; written *tuihawr* in modern spelling
kawm	"(s.) a gutter cut in the ground under the eaves" (L&S 1898, pp. 115–119)	Eaves drip trench; local only
tui lian	"flood: tui lian; luangliam" (Pachuau 1997)	Flood (modern usage)
tui lét	"(s.) a flood, (v.) to be a flood" (L&S 1898, pp. 215–217); "Flood, (s.) tui lét" (L&S 1898, English–Lushai part)	Flood (older usage)

Table 7E.3 — Land and works

Term	Meaning (source)	Use in this Manual
lei min	"Landslip, (s.) lei min" (L&S 1898, English–Lushai part, pp. 289–291)	Landslide or landslip
kor	"Ravine, (s.) kor, kor-dung" (L&S 1898, English–Lushai part, pp. 313–315)	A ravine; a natural channel under Clause 7.4.1(b) where it drains 8 ha or more
tui-khuah	"(s.) a dam, (v.) to dam up water" (L&S 1898, pp. 213–215; the scanned headword is partly illegible)	A dam or check dam; spelling to be confirmed (Table 7E.4)

Table 7E.4 — Terms and forms not yet verified

These terms, forms or senses were not confirmed during research for this Manual. They shall not be used in a record or a drawing as defined terms until verified.

Term or form	Reported meaning or use	Status
tui-khuah	A dam	The scanned headword is partly illegible; spelling to be confirmed on the page image and with a Mizo editor
dils	This Manual's English plural of *dil*	A convention of this Manual (Mizo *-te* would be confused with *té*, "small"); to be confirmed by a Mizo editor
Closed modern spellings (tuikhur, tuihawr)	The dictionaries print most compounds open or hyphenated	Modern spelling to be confirmed by a Mizo editor before print
Page numbers of L&S 1898	As cited in Tables 7E.1 to 7E.3	Inferred from the running heads of the scanned text; to be checked on the page images
Page numbers of Pachuau 1997	Cited by headword	Not captured
Lai, Mara and Chakma terms	Words for waterbodies and springs in the Autonomous District Council areas	Not researched for this Manual [TBC]

The Manual uses the terms in the last column of Tables 7E.1 to 7E.3 and the Mizoram terms defined after Clause 7.2.

Form 7-1 — Waterbody Sheet

Supports Clauses 7.3.2, 7.4 and 7.15(1) of Chapter 7.

Draft form — Mizoram 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 Mizo) 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): Land Revenue and Settlement records and land passes, Village Council allotments, District Council land records, Municipal Corporation (ss.80 and 289) records, Master Plan for Aizawl maps, Landslide Hazard Maps, NEEPCO records, spring inventories, drain register □; NEEPCO / Village Council 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 NEEPCO 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 (NEEPCO record or 1% AEP computed)	_____	7.2
B3	TBL, lowest point (tanks), m	_____	7.3.1(d)
B4	1% AEP flood level, m, and source (adopted map / hydraulic study / not available)	_____	7.3.4
B5	Drainage area at the site (channels), ha	_____	7.4.1(b)
B6	Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no)	_____	7.3.2
B7	Known encroachments, with date recorded	_____	7.3.1(g)

Table 7F.3 — Form 7-1, Section C: Setback

No.	Field	Entry	Clause
C1	Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B)	_____	7.15(1)
C2	Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)?	_____	7.3.4
C3	Floodway outer edge, m from FTL or top of bank, and how delineated	_____	7.6.1
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3

No.	Field	Entry	Clause
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider statutory, plan or approval line: the riverine reserve of SD&SM reg. 28 where the Aizawl Municipal Corporation fixes its width for the site (the regulation does not define it); the 15 m between a septic tank or soak pit and a water source (AMCBR reg. 33); the master plan's 15 m green buffer along a major drainage channel (a recommendation) or its "SL" zone; a restricted zone from mid-river under the executive notification reported to have been issued in April 2021, if it applies to the site (text not read [TBC]; never a statutory buffer); a River Conservation Zone, only if the Rivers law is in force and a zone is notified (neither confirmed); a slope line of SD&SM regs. 4, 14 or 26; the boundary of a notified wetland, reserve forest or forest land; a court or Tribunal line; a NEEPCO, power department or IWRD line; a District Council 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 — Mizoram Stormwater Design Manual, Draft v1.0. One sheet per tank whose storage is counted. Storage that fails any item in Section B shall not be counted (Clause 7.7.1).

Table 7F.5 — Form 7-2, Section A: Tank and scheme

No.	Field	Entry	Clause
A1	Tank name and inventory ID (Annex 7A); custodian	_____	7.3.1
A2	Scheme in which storage is counted: basin plan / regional facility / fee-in-lieu (S-5)	_____	7.7.1, 7.11
A3	Cascade modelled: uppermost tank _____ to outfall _____	_____	7.7.2
A4	Datum	_____	7.3.5

Table 7F.6 — Form 7-2, Section B: Conditions for counting storage

No.	Condition	Date / reference	Met (yes / no)	Clause
B1	FTL, MWL, TBL, weir crest and length, sluice sills surveyed within the previous 5 years	_____	_____	7.7.1(a)
B2	Stage–storage curve from a bathymetric and topographic survey within 5 years or after the last desilting, whichever is later	_____	_____	7.7.1(b)
B3	Documented operating rule agreed with the custodian (Annex 7C)	_____	_____	7.7.1(c), 7.8
B4	Weir, sluices and bund under an O&M plan; latest pre-monsoon inspection found them serviceable	_____	_____	7.7.1(d), 7.14.4
B5	Custodian's written concurrence	_____	_____	7.7.1(e)

Table 7F.7 — Form 7-2, Section C: Levels and creditable volume

No.	Item	Value	Clause
C1	Starting level: FTL, or cushion level under a rule meeting Clause 7.8.2, m	_____	7.7.3
C2	If a cushion is used: controllable outlet (type) and drawdown time, h	_____	7.8.2(a)
C3	If a cushion is used: reliability from continuous simulation, % of monsoon seasons (≥ 90%)	_____	7.8.2(c)
C4	Computed maximum level, 1% AEP inflow with climate factor routed through the cascade, m	_____	7.7.4
C5	MWL, m; is C4 ≤ MWL?	_____	7.7.4(a)
C6	Freeboard C4 to TBL, m; NEEPCO 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 — Mizoram 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 Mizoram 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 Mizoram 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 — Mizoram 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 Mizoram, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several monsoon seasons, with laboratory analysis to the CPCB methods, and the outfall monitoring of Clause 8.13.1 published under Clause 10.17. Until it is published, the Value Ratings of Table 8.3 (MARC/APWA 2012) apply, and a proprietary device earns a VR only from verified test data (Table 8.3).

The layouts below set the minimum records the programme shall keep, so that results from different authorities can be pooled.

Table 8C.1 — Monitoring site register (layout)

Site ID	BMP type (Table 8.3)	Location and authority	Catchment area (ha)	Impervious (%)	Soil and groundwater setting	Date commissioned	Pretreatment
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.2 — Event record (layout; parameters of Clause 8.13.2)

Site ID	Event date	Rainfall (mm)	Inflow volume (m^3)	Outflow volume (m^3)	TSS in / out (mg/L)	BOD in / out (mg/L)	COD in / out (mg/L)	Faecal coliform in / out (MPN/100 mL)	TN in / out (mg/L)	TP in / out (mg/L)	Oil and grease in / out (mg/L)	Heavy metals (industrial catchments)
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.3 — Performance summary and proposed VR (layout)

BMP type	Sites	Events	Volume reduction (%)	Median effluent TSS (mg/L)	Other findings	VR in Table 8.3	Proposed VR
_____	_____	_____	_____	_____	_____	_____	_____

Annex 8D — BMP design sheets, media specification, plant lists

Supports Clauses 8.5, 8.7, 8.8 and 8.11 of Chapter 8.

Each design sheet collects the requirements of Chapter 8 for one BMP. Values marked "recommended starting value" in Clause 8.7.1 may be departed from with justification. Values that the Manual does not set are marked "to be confirmed in design"; the designer shall state and justify them. Every BMP also needs: sizing for the WQv or Q_wq (Clause 8.6.4(a)), pretreatment (Clause 8.5.3), a safe bypass for flows above Q_wq (Clause 8.4.6) and maintenance access (Chapter 10).

8D.1 Design sheets

Table 8D.1 — Pretreatment (all BMPs)

Item	Requirement	Clause
Where needed	Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland, at each concentrated inflow	8.5.3
Types	Sediment forebay, grass filter strip, silt trap or proprietary device	8.5.3
Size	Holds at least 10% of the WQv of its contributing area; or sized for Q_wq (flow-through devices)	8.5.3
Access	Cleanable without entering or disturbing the main BMP	8.5.4
Silt traps and catch pits	At every inlet receiving runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody; sump at least 300 mm below the outlet invert; earn no VR	8.7.12

Table 8D.2 — Bioretention and rain gardens (Figure 8.2)

Item	Requirement	Clause
Ponding depth	≤ 300 mm above the mulch, with an overflow at maximum ponding level	8.7.2(a)
Ponding drawdown	Within 48 h	8.7.2(b)
Filter media	600–900 mm engineered sandy loam, low fines, low phosphorus (Table 8D.12)	8.7.2(c)
Mulch	50–75 mm	8.7.2(c)
Transition (choker) and gravel drainage layers	Required; thickness and grading to be confirmed in design	8.7.2(d)
Underdrain	Perforated; required where the design infiltration rate cannot meet the 48 h drawdown, or where lined; diameter to be confirmed in design	8.7.2(e)
Lining	Required where Clause 8.8 cannot be met, and at hotspots	8.7.2(f)
Plants	Native or naturalised, tolerant of waterlogging and long dry spells (Tables 8D.13 and 8D.14)	8.7.2(g)
VR	8.5 (rain garden / infiltration 9.0)	Table 8.3

Table 8D.3 — Vegetated swales

Item	Requirement	Clause
Section	Trapezoidal or parabolic; side slopes no steeper than 1V:3H	8.7.3(a)
Longitudinal slope	0.5% to 4%; check dams where steeper	8.7.3(b)
Flow at Q_wq	Depth not more than grass height; velocity ≤ 0.3 m/s	8.7.3(c)
1% AEP or bypass flow	No erosion (Chapter 9 permissible velocities)	8.7.3(d)
Underdrained ("dry") swale	Where slope < 1% or subsoil is poorly drained; filter media as Table 8D.12	8.7.3(e)
VR	4.0 (native vegetation swale)	Table 8.3

Table 8D.4 — Vegetated filter strips

Item	Requirement	Clause
Inflow	Sheet flow only; level spreader where flow arrives concentrated	8.7.4(a)
Length in flow direction	≥ 5 m	8.7.4(b)
Slope	1% to 8%	8.7.4(b)
Use	Mainly pretreatment for bioretention, infiltration and swales	8.7.4(c)
VR	5.0	Table 8.3

Table 8D.5 — Permeable pavement

Item	Requirement	Clause
Run-on	Impervious run-on area ≤ 2 × permeable area; none from unpaved or eroding areas	8.7.5(a)
Base reservoir	Clean open-graded aggregate holding its share of the WQv in its voids; void ratio confirmed by test	8.7.5(b)
Open (infiltrating) base	Only where Clause 8.8 is met; otherwise lined with underdrain and counted as filtration only	8.7.5(c)

Item	Requirement	Clause
Structure	Designed for traffic loading to the road authority's standards	8.7.5(d)
Exclusions	Not at hotspots; not where it will be resurfaced with impermeable material	8.7.5(e)
VR	7.5	Table 8.3

Table 8D.6 — Infiltration trenches and basins (Figure 8.3)

Item	Requirement	Clause
Pretreatment	Always (Table 8D.1)	8.7.6(a)
Fill	Clean washed aggregate, void ratio confirmed by test; geotextile on sides and top; sand base	8.7.6(b)
Observation well	To the base of each trench	8.7.6(c)
Storage	WQv (or Chapter 4 retention volume, if greater) held in the voids	8.7.6(d)
Drawdown	Empty within 72 h at the design infiltration rate	8.7.6(d), 8.8.7
Overflow	At grade, to the minor or major system	8.7.6(e)
Commissioning	Not in service until the contributing area is stabilised	8.7.6(f)
Criteria	All of Clause 8.8 (Table 8D.11)	8.8

Table 8D.7 — Wet ponds (extended wet detention)

Item	Requirement	Clause
Permanent pool	≥ WQv	8.7.7(a)
Extended detention	WQv above the pool, released over 24–48 h	8.7.7(a), 8.4.7
Forebay	At each inlet	8.7.7(b)
Flow path	Length-to-width ≥ 3:1; no short-circuiting	8.7.7(c)
Pool depth	1.0–2.5 m, with safety bench (Clause 7.9.4)	8.7.7(d)
Water balance	Monthly balance with IMD rainfall and pan evaporation: ≥ 50% of pool volume kept through the driest year in 10; no top-up with groundwater, potable water or sewage	8.7.8
Flood detention	Chapter 4 detention may sit above the extended detention level	8.7.7(f)
VR	5.0	Table 8.3

Table 8D.8 — Constructed wetlands

Item	Requirement	Clause
Layout	Inlet sedimentation pond (forebay), then shallow macrophyte zone	8.7.9(a)
Extended detention	WQv above normal water level, released over 24–48 h; depth ≤ 0.5 m	8.7.9(b)
Flow path	Length-to-width ≥ 3:1; deep zones across the flow path	8.7.9(c)
Bypass	High-flow bypass so that floods do not scour the macrophyte zone	8.7.9(d)
At a tank inlet	Within the tank's setback, outside its waterspread; not counted as tank storage	8.7.9(e)
Water balance	As wet ponds (minimum wetland depth kept)	8.7.8

Item	Requirement	Clause
VR	7.0 (extended detention wetland)	Table 8.3

Table 8D.9 — Gross pollutant traps and outfall screens

Item	Requirement	Clause
Treatment flow	Q_wq; all flows up to 1% AEP pass without washing out captured material	8.7.10(a)
Capture size	Down to about 5 mm	8.7.10(b)
Head loss	In the drain HGL (Chapter 9), screen 50% blocked	8.7.10(c), 8.10.3(a)
Storage	For the O&M cleaning interval; not less than 3-monthly cleaning	8.7.10(d)
Access	Vehicle access for suction or grab cleaning; safe cleaning platform	8.7.10(e), 8.10.3(d)
Blocked screen	Overflow or bypass path so that a fully blocked screen does not flood property	8.10.3(b)
Bar spacing	Chosen for the hazard: closer for litter capture, wider where blockage would cause flooding; to be confirmed in design	8.10.3(c)

Table 8D.10 — Oil-grit separators

Item	Requirement	Clause
Where	Fuel stations; vehicle workshops and washing bays; bus and truck depots; parking areas of more than 50 spaces	8.7.11(a)
Sizing	Q_wq, with high-flow bypass	8.7.11(b)
Not alone	Followed by a filtering BMP where the site needs a VR above 5; lined filtering BMP before any infiltration at hotspots	8.7.11(c), 8.8.8

Table 8D.11 — Infiltration and recharge criteria (all infiltrating BMPs)

Item	Requirement	Clause
Groundwater separation	Seasonal high groundwater ≥ 1.0 m below base (roof-only runoff in notified coastal sand: ≥ 0.5 m with mounding check, mound ≥ 0.3 m below base)	8.8.1, 8.8.9(d)
Bedrock or impermeable layer	Base ≥ 1.0 m above, unless designed for rock-aquifer recharge under Clause 8.8.10	8.8.2
Tests	Double-ring (ASTM D3385) for basins, bioretention, permeable pavement; falling-head borehole or trial-pit soakage (e.g. BRE Digest 365) for trenches, soakaways, pits, wells; ≥ 2 per facility and ≥ 1 per 100 m² of base or per 50 m of trench; Form 8-2	8.8.3
Design rate	Measured rate ÷ 2.0 (tests meet 8.8.3(c) and vary by no more than a factor of 2), otherwise ÷ 3.0	8.8.4
Minimum rates	≥ 13 mm/h full infiltration; 3–13 mm/h partial, with underdrain, credit only for volume infiltrated within 72 h; < 3 mm/h no credit	8.8.5
Setbacks (runoff from paved surfaces)	Foundations 3 m, basements 5 m; property boundary 1.5 m; drinking-water well or borewell 30 m; septic tank or soak pit 15 m; crest of slope steeper than 1V:3H 6 m	8.8.6
Expansive soils	Foundation setback doubled	8.8.11(b)

Item	Requirement	Clause
Drawdown	Empty within 72 h at design rate; tested after construction	8.8.7
Hotspots	No infiltration without treatment; none at all for waste sites and contaminated land	8.8.8
Road runoff	Never led directly into a well, borewell or recharge shaft	8.11.3(b)

8D.2 Bioretention drawdown check

The 48-hour ponding drawdown (Clause 8.7.2(b)) and the minimum rates of Clause 8.8.5 together decide whether a cell needs an underdrain.

- Rate needed to drain the maximum ponding depth in 48 h = 300 mm / 48 h = 6.25 mm/h.
- Design rate ≥ 13 mm/h: full infiltration, no underdrain, provided Clause 8.8 is met.
- Design rate from 6.25 mm/h to 13 mm/h: the ponding drains in time, but Clause 8.8.5(b) applies, so an underdrain is required.
- Design rate below 6.25 mm/h: the ponding cannot drain in 48 h by infiltration; an underdrain is required (Clause 8.7.2(e)), and below 3 mm/h no infiltration credit is given.

Illustrative — not design values. Two tests at the base of a proposed cell give 30 mm/h and 22 mm/h. The two results differ by a factor of 30 / 22 = 1.36, which is not more than 2, and the number of tests meets Clause 8.8.3(c), so the safety factor is 2.0. Taking the lower result, the design rate = 22 / 2.0 = 11 mm/h. This is above 6.25 mm/h, so the ponding drains in 300 / 11 = 27 h, within 48 h. It is below 13 mm/h, so the cell is a partial-infiltration design with an underdrain (Clause 8.8.5(b)).

8D.3 Filter media specification

Table 8D.12 — Bioretention filter media and layers

Layer	Requirement from Chapter 8	Values to be confirmed in design
Mulch	50–75 mm (Clause 8.7.2(c)); shredded hardwood or similar organic mulch that does not float away at the ponding depth	Material and source
Filter media	600–900 mm engineered sandy loam with low fines and low phosphorus content (Clause 8.7.2(c))	Particle size grading; fines (silt + clay) limit; organic matter content; phosphorus limit; saturated hydraulic conductivity of the compacted media; source and test certificate for each batch
Transition (choker) layer	Between media and gravel, to stop media washing into the gravel (Clause 8.7.2(d))	Thickness and grading, matched to the media and gravel
Gravel drainage layer	Below the transition layer, surrounding the underdrain (Clause 8.7.2(d))	Thickness, grading, washed
Underdrain	Perforated pipe where Clause 8.7.2(e) applies, with cleanouts	Diameter, slope, perforation, outlet level
Liner	Where Clause 8.7.2(f) applies (cannot meet Clause 8.8; hotspots)	Liner type and protection

Media shall be tested before placing, and placed in lifts without heavy compaction. The State Stormwater Technical Committee should set numeric limits for grading, fines, organic matter and phosphorus, with local sources of sand and compost, when it reviews this annex.

8D.4 Plant lists

No Mizoram 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 Mizoram, and gives no Mizo 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 EF&CC for the site's sub-area of Annex 2A, its altitude, its soil and its water table, under the following rules (set by this Manual):

- (a) **Native or long naturalised species only**, as EF&CC confirms for the site; no species named in Table 8D.15 or otherwise known to be invasive in the State.
- (b) **Wet and dry ground.** Species that stand saturated ground through the season of 1 April to 31 October and survive the dry months of December to March without irrigation once established.
- (c) **Slopes.** On the ridges and their slopes, species chosen first to bind soil on terraces, banks, cut slopes and the margins of lui; bioretention on a slope is lined (Clause 8.8.1).
- (d) **Not in the waterway.** No planting in the bed or on the banks of a lui, or on an embankment, without the consent of its custodian (the Aizawl Municipal Corporation, the IWRD, EF&CC, the Village Council or the District Council, as the case may be), and none that would obstruct the flow of a channel, a terrace swale, an interceptor drain or the outlet of a dil.
- (e) **Not in the waterbodies or their catchments.** No planting under this annex in a dil, a tuikhur or its protected catchment, or Palak Dil, whose vegetation is managed by its custodian under Chapter 7.

Table 8D.13 — Indicative plants for bioretention, swales and filter strips

Use	Botanical name	Local name	Notes
All BMPs of Clause 8.7	None listed for Mizoram in this draft	—	Chosen under rules (a) to (e) above and recorded on the BMP design sheet (Annex 8D)

Table 8D.14 — Indicative plants for constructed wetlands and wet ponds

Zone	Botanical name	Local name	Notes
All zones	None listed for Mizoram in this draft	—	Chosen under rules (a) to (e) above; constructed wetlands are built outside the waterspread of any natural waterbody (Clause 8.7.9(e))

Table 8D.15 — Species not to be planted

Botanical name	Local name	Reason
Any species EF&CC lists as invasive in Mizoram	—	No list of invasive species for Mizoram was read for this Manual [TBC]

Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

Table 8E.1 — Selection of measures (Clause 8.12.3)

Situation	Measure	Detail
Sheet flow leaving a disturbed area, along its downslope edge	Silt fence	Figure 8E.1
Concentrated flow from a disturbed area of up to 2 ha	Sediment trap	Figure 8E.2
Disturbed area of more than 2 ha	Sediment basin with surface dewatering outlet	Figure 8E.2
Existing drain inlet receiving site runoff	Inlet protection	Figure 8E.4
Vehicle exit to a public road	Stabilised construction exit, with wheel washing	Figure 8E.3
Stockpiles	Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the monsoon	Notes to Figure 8E.1
Dewatering	Through a sediment basin, settling tank or filter bag; never pumped directly to a drain or waterbody	Notes to Figure 8E.2
Concrete washout	Lined pit; never into a drain	Notes to Figure 8E.3

8E.1 Silt fence

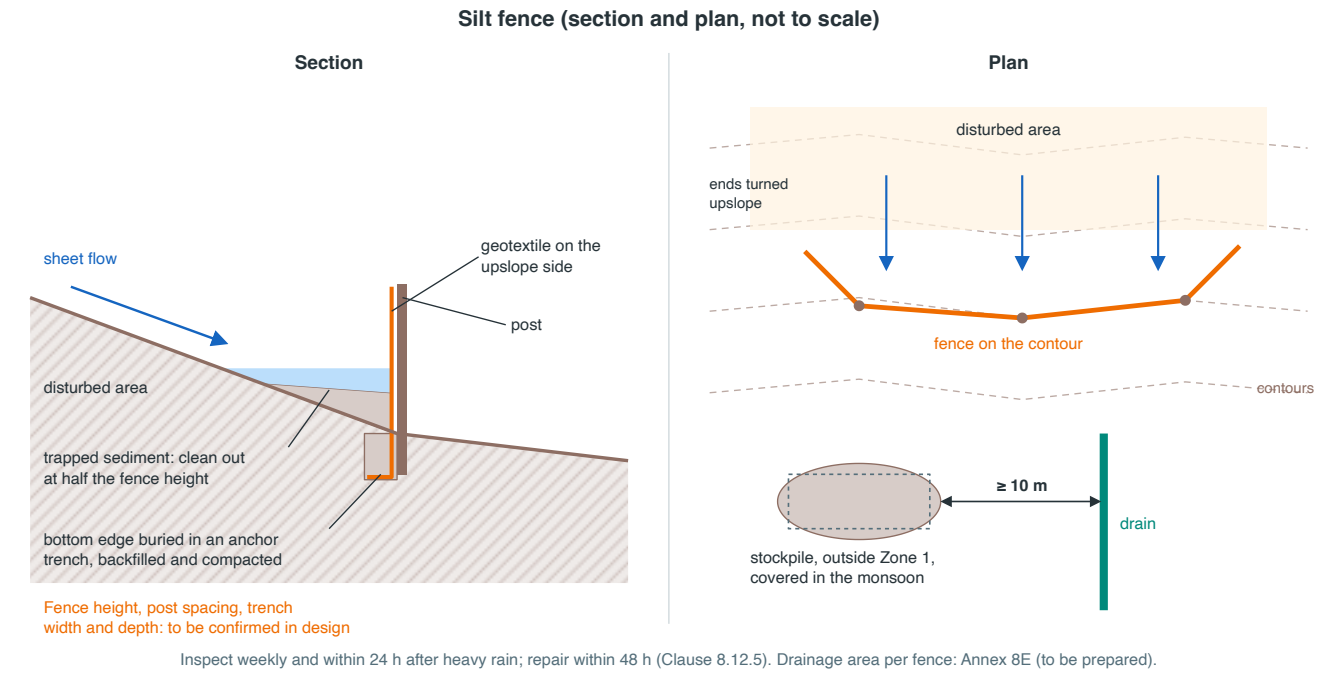


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

To be prepared. Clause 8.12.3(a) refers to this annex for the limit on the area draining to each silt fence. That limit, and the maximum slope length above a fence, need to be set by the State Stormwater Technical Committee for Mizoram rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

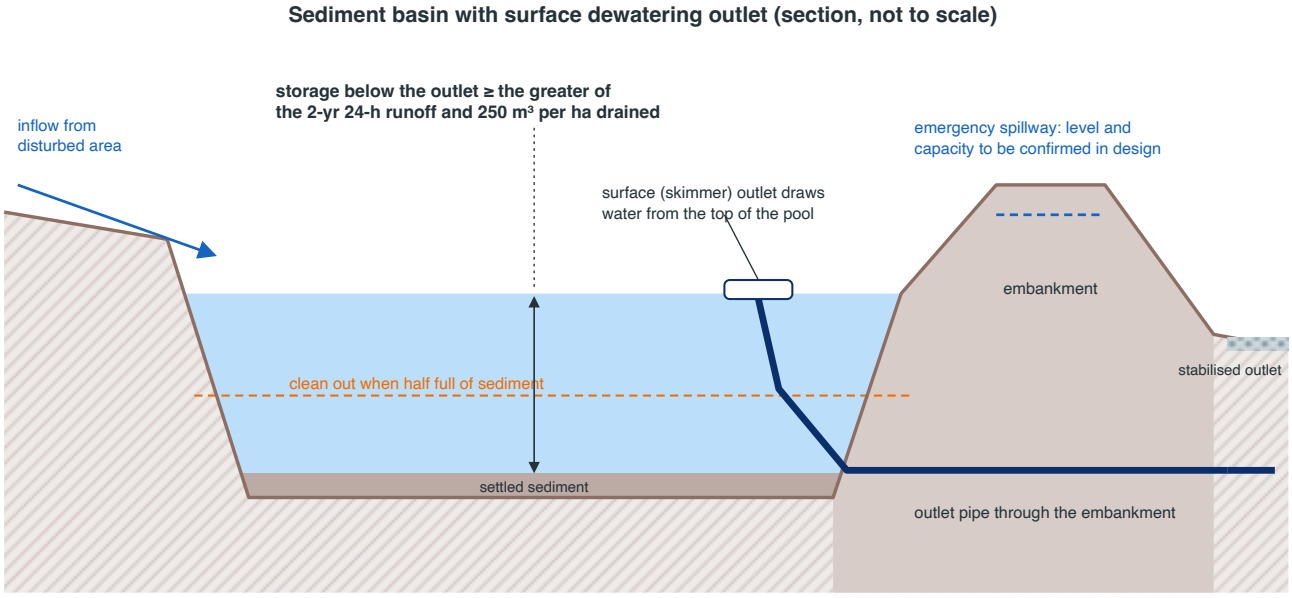
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used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

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

Notes:

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

8E.2 Sediment trap and sediment basin



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

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

Notes:

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

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

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

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

8E.3 Stabilised construction exit and concrete washout

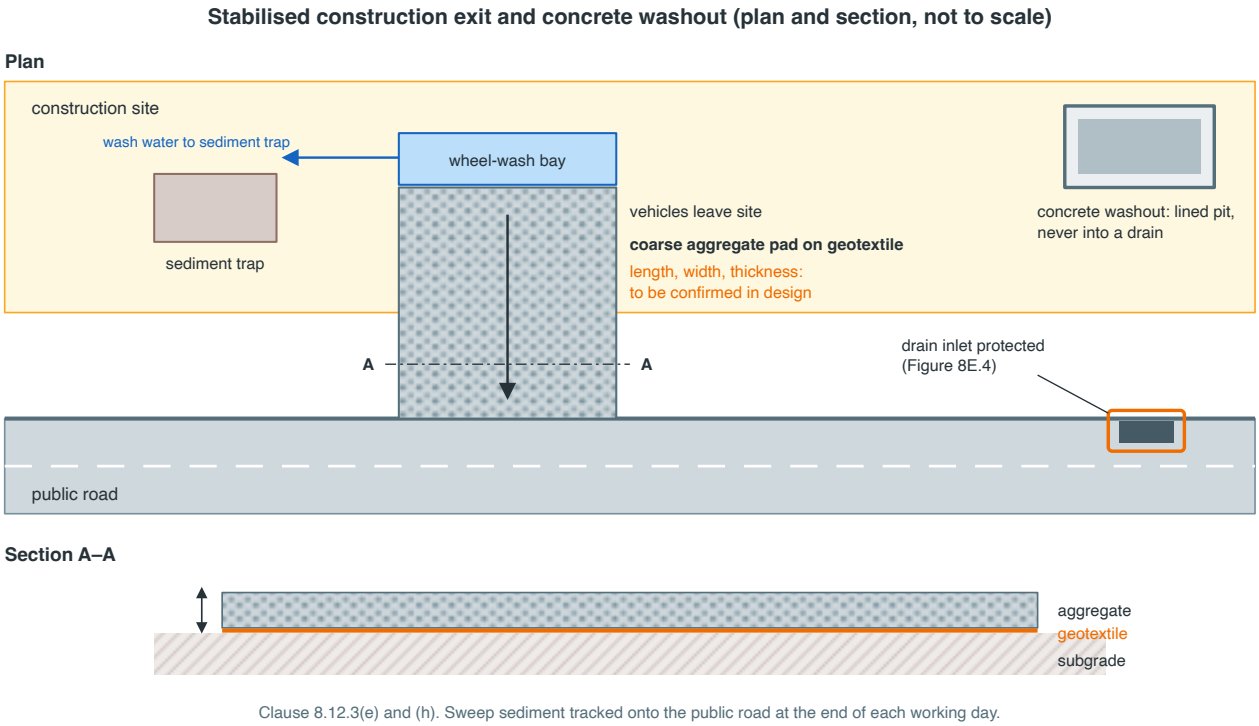


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing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

Notes:

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

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

8E.4 Inlet protection

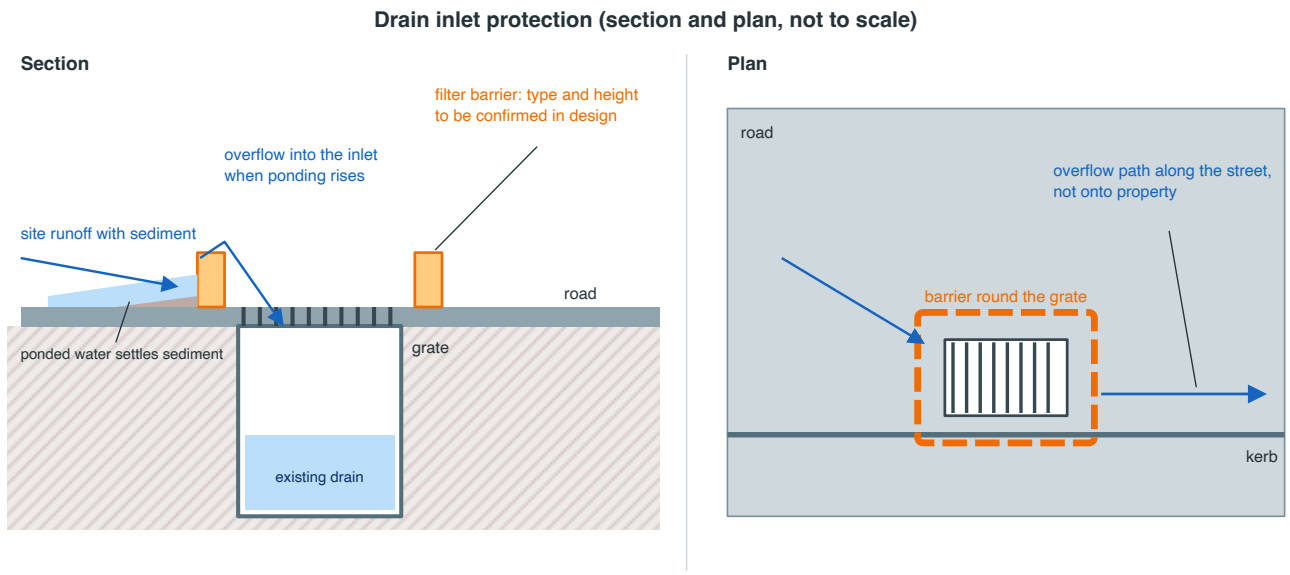


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual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

Notes:

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

8E.5 Timing and inspection

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

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

Form 8-1 — Water Quality Sheet

Supports Clauses 8.4, 8.6 and 8.14 of Chapter 8.

Draft form — Mizoram 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 — Mizoram 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.

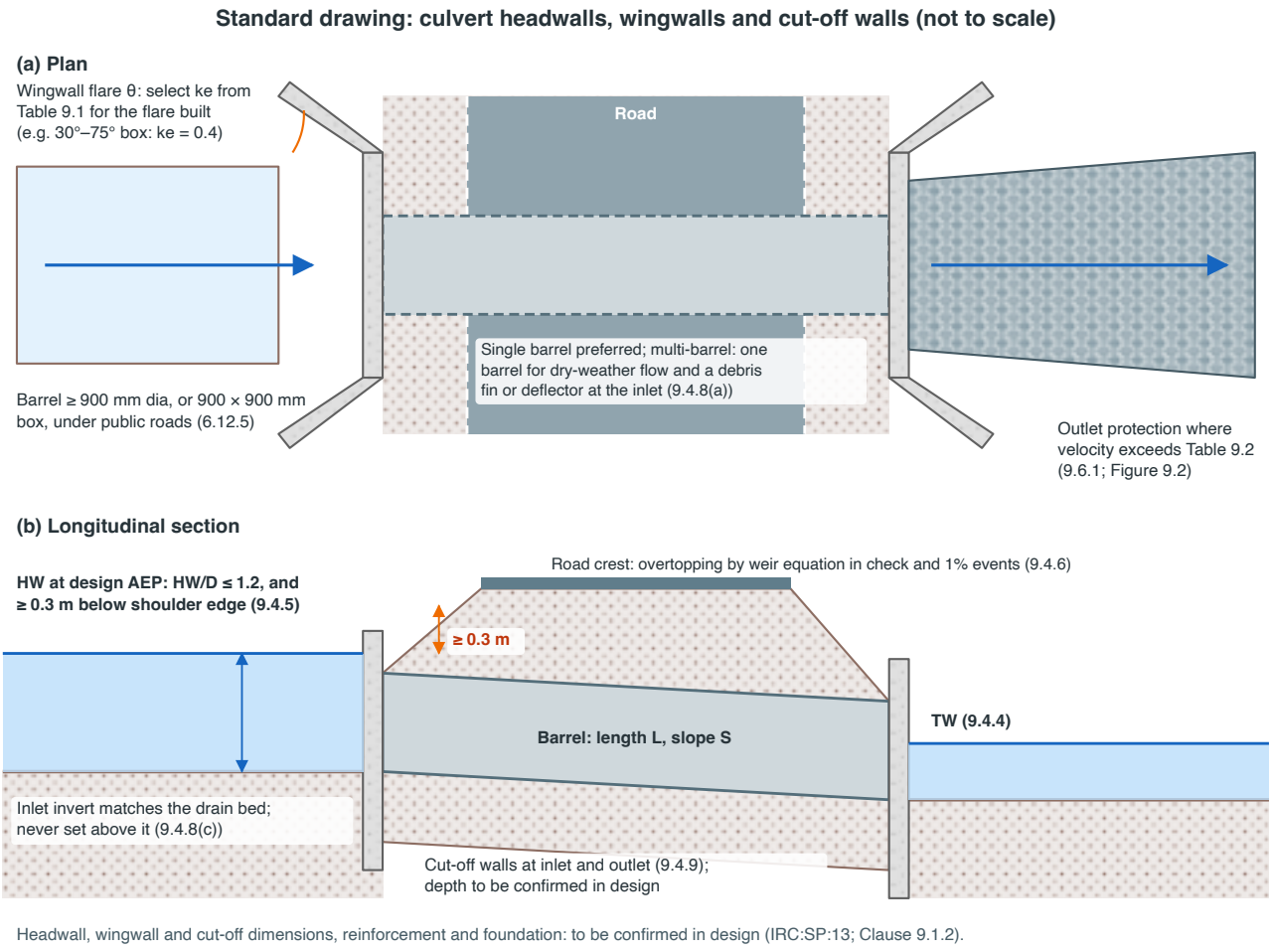


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

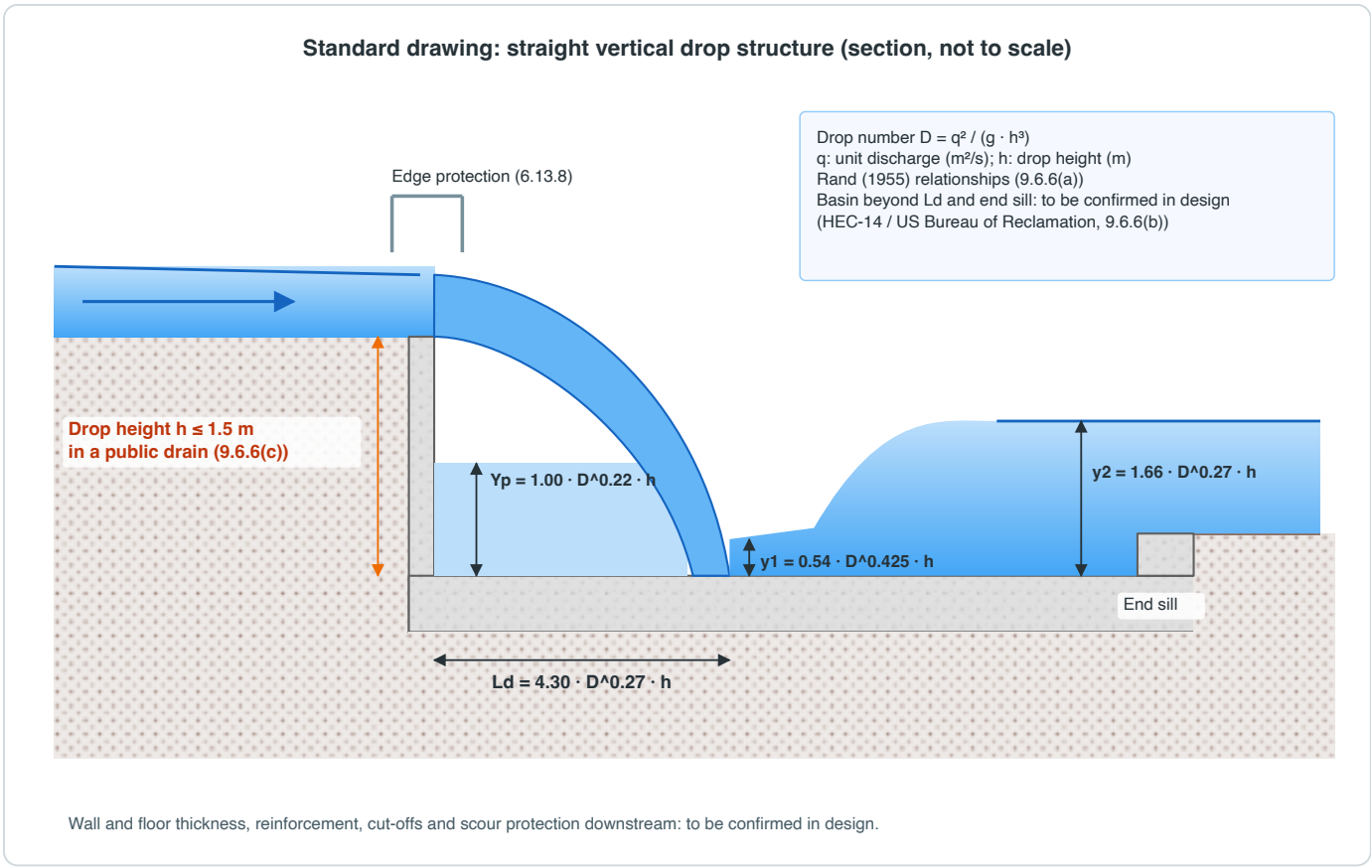


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

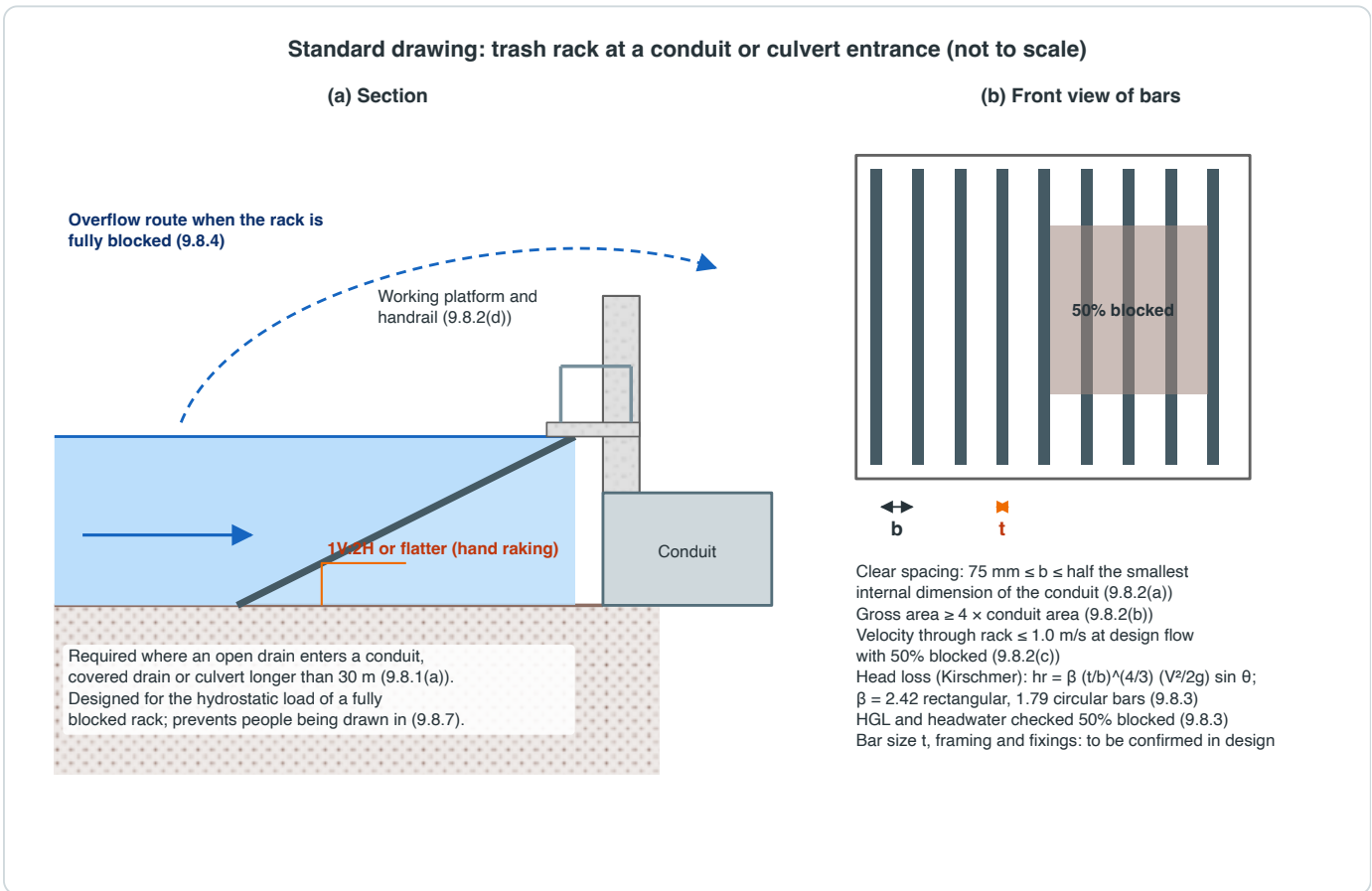


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

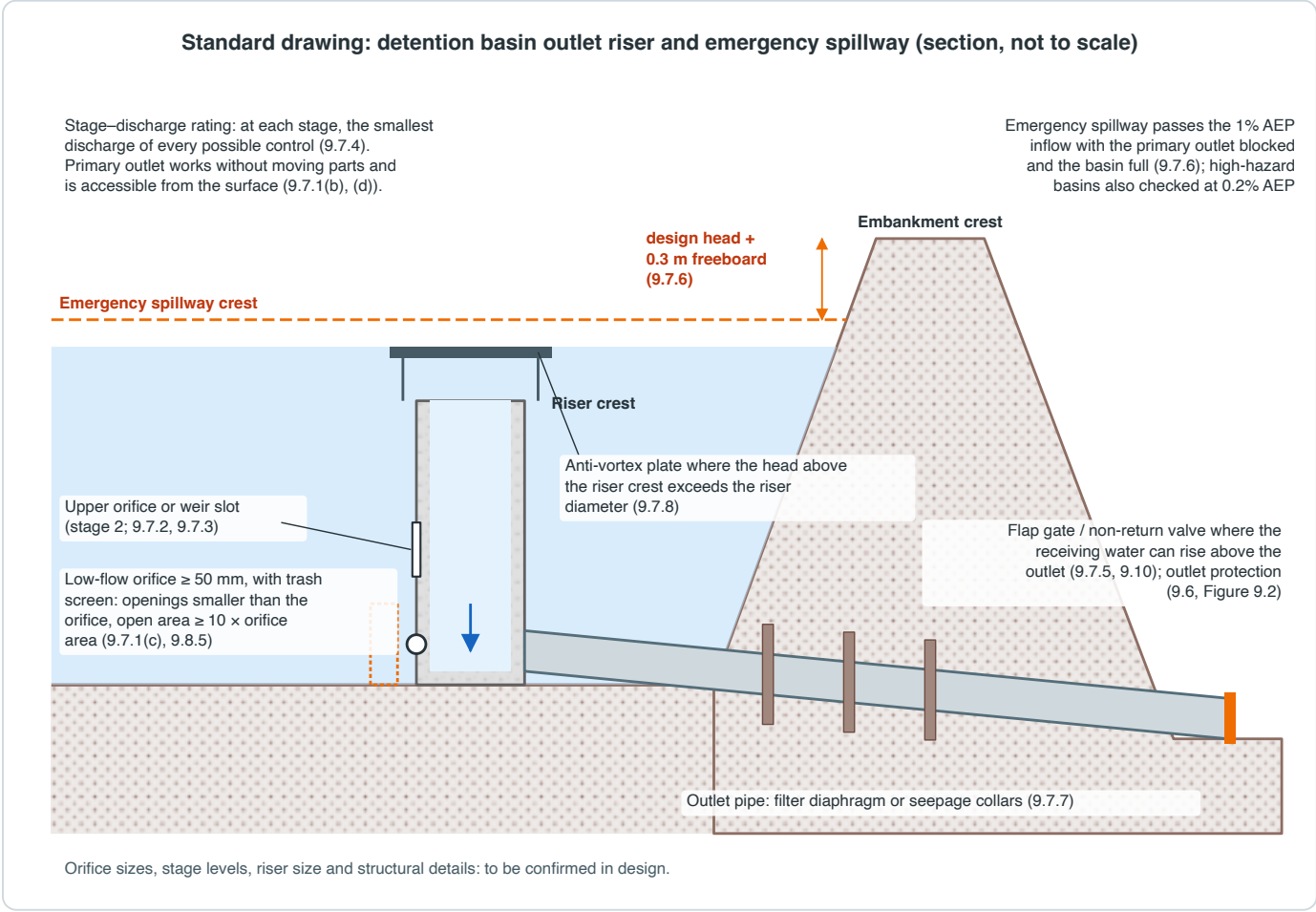


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — Mizoram 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 — Mizoram 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 under regs. 5(6)(ix) and 33 of the AMCBR to every building in the Aizawl Municipal Corporation's area, as storage of at least 25 litres per m² of roof (Clause 4.11, set by this Manual, since neither regulation sets a volume and the 2025 green-building chapter makes rainwater harvesting only an incentive, for plots above 100 m²), credited as retention only through reuse and never as detention; recharge is credited only where Clause 4.11 (recharge rule) allows it, which is on tested valley alluvium and river terraces, on flat ground away from slopes and above the 1% AEP flood level, never on hill ground (Clause 4.11, hill rule) and never within 15 m of a tuikhur (the spring rule of Chapter 8).	1.5.2–1.5.8

Step	Calculation	Clause
C2	**Process flags.** Stage 0 mandatory (≥ 2 ha, flood-sensitive, variance or regional route, tidal outfall or waterbody); Stages 1 and 2 may be combined (< 1 ha, not flood-sensitive); empanelled signatory required; independent check required.	10.3.2, 10.3.3, 10.6.1, 10.6.4
C3	**Route eligibility.** Tier B simplified method: ≤ 2 ha, or ≤ 0.5 ha in a flood-sensitive catchment, and only once Table 4.3 is published. Fixed-coefficient route: ≤ 1 ha and none of the exclusions of Clause 4.14.3. Constrained redevelopment: existing ≥ 60% impervious and ≤ 1 ha. Regional detention or fee-in-lieu: only in a basin with an approved BSMP.	4.5.6.1, 4.13.1, 4.14.1, 4.14.3, 11.12.1(b)
C4	**Retention volume.** RRV = 10 × Q_R × A, with Q_R the SCS-CN runoff from P_R for each sub-area at AMC II, summed over sub-areas. The larger of the Ia = 0.2S and Ia = 0.05S results governs. The Rv form (RRV = 10 × P_R × Rv × A, Rv = 0.05 + 0.009 × I) is offered only for sites < 0.5 ha and the Tier B method. No climate factor.	4.4.2, 3.8.5(c), 2.8.3
C5	**Preservation credit.** Preserved areas are modelled at their pre-development CN in the post-development condition.	4.4.7
C6	**Retention checks.** Design infiltration rate ≤ half the measured rate; groundwater ≥ 1.0 m below the base; drawdown of the retained volume within 72 h at the design rate (or by the stated reuse demand). A practice that fails any check gets no credit; any shortfall is reported and treated as WQv.	4.4.3–4.4.5, 4.4.6.4
C7	**Water quality volume.** P_wq = max(P_ret, P_3m); WQv = 10 × Q_wq × A by SCS-CN, or (P_wq / 1000) × Rv × A (A in m²) for sites < 0.5 ha and the Tier B method. The retained volume counts toward the WQv in full. No climate factor.	8.4.1–8.4.4, 3.8.5(c)
C8	**Retention credit.** Tier A: the credit found by routing is entered (I16); the calculator does not compute it. Tier B: V_credit = C_R × RRV provided, with C_R = 0 until Annex 4B is published.	4.4.6
C9	**Design-aid route (S-1).** V = SSR × A − V_credit; Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages, from Table 4.3. Shown as "not available" until Table 4.3 is published.	1.7.2, 4.14.2
C10	**Permissible site discharge (S-2).** Q = PSD (m³/s/ha) × A for each AEP, from the S-2 tables. Shown as "not available" until they are issued.	1.7.2, 1.7.3(e)
C11	**Fixed-coefficient route.** Q_cap,10 = 2.78 × C_10 × i_10 × A and Q_cap,2 = 2.78 × C_2 × i_2 × A (L/s); V_100 and V_2 = max over d of [10 × C_v × P(d) × A − 1.8 × Q_cap × d] for d = 1 to 72 h, with pervious C ≥ 0.50 for d ≥ 12 h; V = max(V_100, V_2); retention added without credit. Coefficients from Table 4.3A (provisional).	4.14.4–4.14.7
C12	**Release-rate screen (full method).** For each AEP and duration: Q_post ≤ 0.9 × Q_pre (standard), or the two mixed-frequency caps (flood-sensitive). Report the governing duration and margin.	4.5.2, 4.5.3
C13	**Constrained redevelopment.** Q_post ≤ 0.5 × Q_existing for 2-, 10- and 100-yr at each duration; shortfall volume = greenfield storage − storage provided; fee = shortfall × unit rate.	4.5.6.2, 4.5.6.3
C14	**Minimum orifice.** Flag any orifice < 50 mm. Where a cap is below the discharge of a 50 mm orifice at the corresponding stage, report "50 mm orifice deemed to comply".	4.5.5.1, 4.8.2
C15	**Drawdown.** Report the detention drawdown (90% of the 10-yr stored volume within 48 h), the WQv release time (24–48 h) and the retention emptying time (≤ 72 h).	4.7
C16	**Fee-in-lieu.** Fee = detention volume required on site × notified unit rate.	4.13.3
C17	**Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide.	10.5.2(c)
C18	**As-built re-run.** At Stage 4, repeat C4 to C17 with the as-built values and report each change from Stage 2.	10.9.1(b), 10.9.2

10A.4 Outputs

The calculator produces:

- (a) **Form 10-2**, filled in, with the calculator version and release date on every page;
- (b) a machine-readable export of every input and result of Tables 10A.1 and 10A.2; and

- (c) a list of the flags raised (C1 to C3, C6, C14, C17), each with the clause on which it is based (Clause 10.7.7).

10A.5 Testing before release

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

10A.6 Outline of the user guide

The user guide shall contain at least:

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

Annex 10B — GIS data specification and attribute schema

Supports Clauses 10.4.4, 10.14.1(d), 10.14.3 and 10.17 of Chapter 10.

10B.1 Format and reference systems

- (a) **Format.** One OGC GeoPackage (.gpkg) per submittal is preferred. Shapefiles are accepted, one per layer, zipped with all component files. Field names shall be as in Tables 10B.2 to 10B.6; shapefile names are limited to 10 characters, and the names below meet that limit.
- (b) **Horizontal reference.** WGS 84 geographic (EPSG:4326), or WGS 84 / UTM zone 46N (EPSG:32646), for the whole State, whichever contains the site (Clause 10.4.4(c)). One system shall be used for all layers.
- (c) **Vertical reference.** All levels shall be in metres relative to a named vertical datum, stated in the metadata. The metadata shall also state the relationship between that datum and the river datums of the CWC level-monitoring sites on the receiving rivers (not stated in any source found), of the reservoir levels of the Tuirial dam published by NEEPCO in metres (datum not stated) and of Serlui B (not found), and of the flood marks surveyed on ungauged lui, rivers and dils 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 `AIZ–BP–2026–0123_S2_20261015.gpkg`.
- (f) **Identifiers.** Every feature has an identifier unique within the submittal (FAC_ID, OUT_ID, CAT_ID, FLP_ID). The Authority replaces them with register identifiers on acceptance and returns the mapping to the Applicant.

10B.2 Layers

Table 10B.1 — Layers

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

10B.3 Attribute schema

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

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

Field	Type	Unit	Req.	Content	Source
FAC_ID	T	—	Yes	Facility identifier	10B.1(f)
FAC_TYPE	T	—	Yes	Code from Table 10B.7	Clause 4.10, Table 10.3
FAC_NAME	T	—		Name on the drawings	—
OWNER_TYP	T	—	Yes	PRIVATE / ASSOC / DEVELOPER / ULB / DEPT	Clauses 10.10, 10.14
OWNER_NM	T	—	Yes	Name of a corporate owner or association only; for an individual, "private individual" (Clause 10.17.3)	Clause 10.17.3
CTRL_AREA	R	ha	Yes	Area draining to the facility	Clause 4.5.1.3
V_RET	R	m³		Retention volume provided	Clause 4.4
V_WQ	R	m³		Water quality volume provided	Clause 8.4
V_DET	R	m³		Detention volume at the top design level	Clause 4.6
Q_2	R	L/s		Release at the 50% AEP (2-yr) design level	Clause 4.5
Q_10	R	L/s		Release at the 10% AEP (10-yr) design level	Clause 4.5
Q_100	R	L/s		Release at the 1% AEP (100-yr) design level	Clause 4.5
ORIF_MM	R	mm		Low-flow orifice diameter or least slot dimension	Clause 4.8.2
INV_OUT	R	m		Outlet invert level	Clause 10.9.1(a)
TWL_DES	R	m		Top design water level	Clause 10.9.2(a)
SPILL_LV	R	m		Spillway or overflow crest level	Clause 4.9

Field	Type	Unit	Req.	Content	Source
PUMPED	T	—	Yes	Y / N	Clause 10.10.3
REGIONAL	T	—	Yes	Y / N	Clause 4.13
EMPANEL	T	—	Yes	Y / N: facility under Clause 10.6.1(c) or (d)	Clause 10.6.1
STATUS	T	—	Yes	Code from Table 10B.8	Clause 10.17.1(a)
APPR_DATE	D	—		Date of Stage 2 approval	Clause 10.3
ASB_DATE	D	—		Date the as-built certificate was accepted	Clause 10.9
DECL_REF	T	—		Registration reference of the Maintenance Declaration (Form 10-6)	Clause 10.10.1(e)
HAND_DATE	D	—		Date of the Asset Handover Certificate (Form 10-8)	Clause 10.14
LAST_INSP	D	—		Date of the latest inspection	Clause 10.12
INSP_RES	T	—		Code from Table 10B.9	Clause 10.17.1(a)
OUT_ID	T	—	Yes	Outfall to which the facility discharges	—

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

Field	Type	Unit	Req.	Content	Source
OUT_ID	T	—	Yes	Outfall identifier	10B.1(f)
RECEIVER	T	—	Yes	Receiving drain, channel, waterbody or sea, by name	Clause 4.5.1.3
RECV_TYPE	T	—	Yes	PUBLIC_DRAIN / CANAL / RIVER / TANK / SEA / OTHER	Chapter 5
INV_LEVEL	R	m	Yes	Outfall invert level	Clause 10.9.1(a)
SIZE_MM	R	mm	Yes	Diameter, or width × height written in the drawing	Chapter 6
TIDAL	T	—	Yes	Y / N	Chapter 5
GATE_TYPE	T	—		NONE / FLAP / TIDE / DUCKBILL / PENSTOCK / NRV	Clauses 5.11, 9.10
GATE_REQ	T	—	Yes	Y / N: invert below the 1% AEP still-water level	Clause 5.11.1
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1
Q_100	R	L/s		Design 1% AEP discharge	Chapter 5

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

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

Field	Type	Unit	Req.	Content	Source
NOTES	T	—		Free text	—

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

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

Table 10B.6 — Metadata (SW_META)

Field	Content
FILE_NO	Authority file number
STAGE	1, 2, 4 or HANDOVER
H_CRS	EPSG code of the horizontal reference system
V_DATUM	Name of the vertical datum
TIDE_REL	Relationship of the vertical datum to the Chapter 5 river datums of the CWC level-monitoring sites on the receiving rivers (not stated in any source found), of the reservoir levels of the Tuirial dam published by NEEPCO in metres (datum not stated) and of Serlui B (not found), and of the flood marks surveyed on ungauged lui, rivers and dils (for example, MSL = x.xx m on the site datum)
SURVEYOR	Name and licence number of the surveyor
SURV_DATE	Date of the survey
PREP_BY	Name and registration number of the certifying professional
CALC_VER	Compliance calculator version (Annex 10A), or "not issued"
DATE	Date the file was prepared

10B.4 Code lists

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

Code	Facility	Inspection row of Table 10.3
RET_SOAK	Soakaway, recharge pit or shaft	Retention / infiltration
RET_TRENCH	Infiltration trench or basin	Retention / infiltration

Code	Facility	Inspection row of Table 10.3
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
Outfall gates	Stop-log slot or penstock upstream on outfalls larger than 600 mm (Chapter 5) and on outfalls of 900 mm or more or serving a pumped or storage system (Chapter 9); the gate chamber accessible at all tides, with its access above HAT + surge + sea-level allowance	5.11.3(d), (e); 9.10.3
Pump stations	Maintenance vehicle access usable in the 1% AEP event; hard standing and a quick-coupling connection for mobile pumps; clear space between adjacent pumps or motors of 0.6 m (small and medium units) or 1.0 m (large units)	9.9.6, 9.9.10, 9.9.12
Pretreatment devices	Cleanable without entering or disturbing the main BMP	8.5.4
Screens at outfalls, culvert inlets and pump sumps	Cleanable from a safe platform, with vehicle access	8.10.3(d)

Element	Requirement	Clause
Infiltration trenches	Observation well to the base of each trench	8.7.6(c)
Publicly accessible storage	Side slopes no steeper than 4H:1V, with at least a quarter of the perimeter at 6H:1V or flatter	4.15.1(c)
Wet basins	Safety bench at least 3 m wide, no more than 0.3 m below normal water level	4.15.2
Fencing	At least 1.2 m high, non-climbable, with a lockable gate, where Clause 4.15.3 requires it	4.15.3

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

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

> **Commentary.** APWA 5600 (2006, §5608) required a maintenance access strip of 15 ft (about 4.5 m) for detention facilities. The Manual did not adopt a fixed width for private sites, because plot sizes in Mizoram towns vary widely (Clause 10.13, Commentary). The State Stormwater Technical Committee may add standard values to Table 10C.2 when it issues the standard drawings of Annexes 6C and 9B.

Annex 10D — Model O&M plans by facility type

Supports Clauses 10.11, 10.12 and 10.13 of Chapter 10.

The model plans below are starting points. The designer adapts them to each facility and completes the items marked "_____". Inspection frequencies are the minimum frequencies of Table 10.3; a plan may set more frequent inspection, never less. Where this annex leaves a value to the designer, the Manual does not set it.

10D.1 Contents of every O&M plan

Every plan shall contain the items of Clause 10.11.1:

Table 10D.1 — Contents of an O&M plan

Item	Content	Clause
1	Inventory and plan drawing of each facility, with design levels, volumes and outlet details (from SW_FAC, Annex 10B)	10.11.1(a)
2	Routine tasks and their frequency (Tables 10D.2 to 10D.8)	10.11.1(b)
3	Trigger for sediment removal, as a depth (mm) or a percentage of design volume: _____	10.11.1(c)
4	Inspection checklist matching Form 10-7	10.11.1(d)
5	For pumps, gates and valves: operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning	10.11.1(e)
6	Actions against standing water and mosquito breeding, consistent with the drawdown times of Clause 4.7	10.11.1(f)
7	Safety: confined spaces, deep water, public access	10.11.1(g)
8	Access routes and equipment (Annex 10C)	10.11.1(h)
9	Annual cost estimate (₹ _____ per year) and who pays it	10.11.1(i)
10	Records to be kept, and for how long: _____ years (pump records at least 5 years, Clause 9.9.8(c))	10.11.1(j)

10D.2 Model plans

Table 10D.2 — Retention and infiltration (soakaways, trenches, bioretention, permeable paving)

Task	Frequency	Standard or trigger	Clause
Inspect surface, inlets, pretreatment and overflow	Every 6 months; before 31 March; after each heavy-rainfall day	No blockage; overflow clear	Table 10.3
Check drawdown at the observation well or surface	At each inspection after rain	Empties within 72 h of the end of rain; if not, investigate clogging	4.4.5, 8.7.6(c)
Clean pretreatment (forebay, filter strip, silt trap)	When the sediment trigger (item 3) is reached	Pretreatment cleaned without disturbing the main BMP	8.5.3, 8.5.4
Bioretention: mulch, plants, ponding	Every 6 months	Ponding drains within 48 h; dead plants replaced; mulch 50–75 mm	8.7.2
Permeable paving: surface	Every 6 months	Sweep or vacuum; no resurfacing with impermeable material	8.7.5(e)
Keep the contributing area stable	Each inspection	Bare soil stabilised; no sediment washing in	10.8.3(b)
Keep the facility in place and in use	Each inspection	Not filled, covered, paved or built over without approval	10.10.1(d)

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

Task	Frequency	Standard or trigger	Clause
Inspect inlets, outlet, orifice, trash rack and spillway	Every 6 months; before 31 March; after each heavy-rainfall day	Orifice and rack clear; spillway unobstructed	Table 10.3, 4.8, 4.9
Remove debris and sediment	When the sediment trigger is reached, and after events	Design volume restored	10.11.1(c)
Check that the basin drains	After rain	No low point ponds for more than 72 h	4.15.7
Vegetation	As set in the plan	Grass cut; no woody growth on embankments or in the outlet zone	10.11.1(b)

Task	Frequency	Standard or trigger	Clause
Safety features	Every 6 months	Signs in Mizo and English and a depth marker in place; fences and gates sound where required	4.15.3, 4.15.5
Embankment (if any)	Every 6 months and after events	No cracks, slips, seepage or animal burrows	4.9.6

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

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

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

Task	Frequency	Standard or trigger	Clause
Test run of each pump, duty and standby	Monthly	Each pump starts on level control; roles alternate	Table 10.3, 9.9.4(c)
Full duty test	Before 31 March	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 31 March	Automatic changeover works; fuel for at least 72 h of all duty pumps on site	9.9.9
Level sensors, float back-up, alarms, telemetry	Monthly	High-level and fault alarms reach the control room	9.9.8
Screens and silt trap	Every 3 months and after events	Clean	9.9.7
Records	Continuous	Sump levels, run hours and power status logged; kept at least 5 years	9.9.8(c)
Warning actions	On an IMD heavy-rainfall or cyclone warning	Actions written in the plan: _____ (for example staff on site, fuel topped up, mobile pump connection checked)	10.11.1(e), 9.9.12

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

Task	Frequency	Standard or trigger	Clause
Inspect and operate	Every 3 months; after each heavy-rainfall day	Opens at a small head; no debris, sand or growth holding it	Table 10.3, 9.10.4

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

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

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

Table 10D.8 — Private drains and inlets

Task	Frequency	Standard or trigger	Clause
Inspect and clean drains, inlets and silt sumps	Every 6 months; before 31 March	Free of silt and debris	Table 10.3
Check for sewage connections	Each inspection	None; any cross-connection removed	1.5.4, 8.9
Overland flow paths	Each inspection	Not obstructed by walls, fill or stored material	6.9.2, 10.15.1(g)

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

Supports Clauses 10.6, 10.7.4 and 11.4.3 of Chapter 10.

> *Model text for consideration by a competent authority. Not in force.* Clause 10.6.2 assigns the issue of empanelment criteria to UD&PA. 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 Aizawl Municipal Corporation Building Regulations 2012 and the Aizawl Municipal Corporation (Site Development and Slope Modification) Regulations 2017 (Clause 1.4);
    - (c) have at least [ ] years of experience in drainage design after graduation, shown by a list of at least [ ] projects with the applicant's role in each (Clause 10.6.2); and
    - (d) have completed a training course on this Manual, with an assessment, within the [ ] years before application (Clause 10.6.2).
3. **Eligibility for list (b).** As for list (a), with at least [ ] years of experience, of which at least [ ] years in the design or review of drainage under this Manual or an equivalent standard.
4. **Basin modelling endorsement (c).** A Stormwater Design Professional who shows experience in basin-scale 1D–2D modelling, including calibration, on at least [ ] studies (Clause 11.4.3).
5. **Independence of a checker.** A checker under Clause 10.6.4 shall not be employed by, or a partner of, the designer's firm or the Applicant, and shall not have worked on the design.
6. **Conflict of interest of a reviewer.** An Empanelled Reviewer shall not review a site on which the reviewer, or the reviewer's firm, has worked in any capacity (Clause 10.7.4), and shall declare any other interest before accepting a review. The Authority remains the decision-maker (Clause 10.7.4).
7. **Application.** The application shall include proof of degree and registration, the project list with references, the training certificate, and a signed declaration that the information is true.
8. **Term and renewal.** Empanelment is valid for [ ] years. Renewal requires evidence of continuing practice and of any refresher training issued after a revision of the Manual (Clause 1.12).
9. **Suspension and removal.** The competent authority may suspend or remove an empanelled person after a false or negligent certificate (Clause 10.6.5), on a report under step 6 of Table 10.4, or on loss of registration. The person shall be given notice and an opportunity to be heard. Every suspension and removal shall be published on the list.
10. **Publication.** The lists shall be published and kept current, with each person's name, registration number, list, endorsement and validity date.

Form 10-1 — Drainage Report Checklist

Supports Clauses 10.4.1 to 10.4.4 and 10.7.1 of Chapter 10.

Draft form — Mizoram Stormwater Design Manual, Draft v1.0. Lodge with every Stage 1 and Stage 2 submittal. For each item give the page or sheet where it is addressed, or the reason it does not apply. The Authority does not start technical review without a completed Form 10-1 (Clause 10.4.3).

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

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

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

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

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

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

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

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

No.	Item	Clause	Provided (yes / no)	Detail
D1	Reports and drawings as searchable PDF	10.4.4(a)	_____	_____
D2	Models in native, runnable format; software name and version	10.4.4(b)	_____	_____
D3	GIS data to Annex 10B; horizontal reference system (EPSG code)	10.4.4(c)	_____	_____
D4	Vertical datum named; relationship to the Chapter 5 river datums of the CWC level-monitoring sites on the receiving rivers (not stated in any source found), of the reservoir levels of the Tuirial dam published by NEEPCO in metres (datum not stated) and of Serlui B (not found), and of the flood marks surveyed on ungauged lui, rivers and dils	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 — Mizoram 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 — Mizoram 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, AMCBR/SD&SM 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 Mizoram 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 — Mizoram 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 — Mizoram 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 — Mizoram 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, sub-division, district; extent	_____
A4	Approval reference (file number, Stage 2 approval date)	_____
A5	For multi-owner developments: the association or body that takes over after the developer (Clause 10.10.2)	_____

Table 10F.22 — Form 10-6, Section B: Schedule of facilities

Facility (FAC_ID)	Type	Location on the attached plan	Design volume (m³)	Outlet	O&M plan reference
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Model declaration. I/We, the owner named in Section A, declare and undertake, for myself/ourselves and for every successor in title to the land:

1. to operate, inspect and maintain each facility in Section B under the approved O&M plan, and to make the inspections of Clause 10.12 (Clause 10.10.1(b));
2. to give the Authority, its officers and its contractors a right of entry to inspect each facility and the access route shown on the plan, and to carry out works in default under Clause 10.15, with the cost recoverable from the owner (Clause 10.10.1(c));
3. not to remove, fill, cover, reduce or change the use of any facility, or obstruct its access route, without the Authority's written approval (Clauses 10.10.1(d), 10.13.5);
4. where Clause 10.10.3 applies, to lodge an Annual Maintenance Declaration and Inspection Report (Form 10-7) by 31 March each year;
5. for underground tanks, to follow the confined-space entry procedure stated here: _____ (Clause 4.15.6);
6. on sale or transfer of the land or any part of it, to disclose this declaration and the latest Form 10-7 to the purchaser, who takes on these obligations from the date of transfer (Clause 10.10.4); and
7. for a multi-owner development, that the developer remains responsible until the body named at A5 is legally constituted and has accepted this declaration in writing (Clause 10.10.2).

Table 10F.23 — Form 10-6, Section C: Execution and registration

Field	Entry
Owner: signature, name, date	_____
Witness 1: signature, name, address	_____
Witness 2: signature, name, address	_____
Acceptance by the association or body at A5 (when constituted): signature, date	_____
Registration: office, document number, date	_____
For the Authority: received and recorded in the facility register; officer, date	_____

Form 10-7 — Annual Maintenance Declaration and Inspection Report

Supports Clauses 10.10.3, 10.11.1(d) and 10.12 of Chapter 10.

Draft form — Mizoram Stormwater Design Manual, Draft v1.0. Due by **31 March** each year from every owner of a facility in a Tier A area, and from every owner of a pumped facility, tide gate or regional facility anywhere (Clause 10.10.3). See Figure 10.3.

Table 10F.24 — Form 10-7, Section A: Owner and facilities

No.	Field	Entry
A1	Reporting year (1 April to 31 March)	_____
A2	Owner or association; Maintenance Declaration registration reference	_____
A3	Facilities covered (FAC_ID and type)	_____
A4	Any facility under Clause 10.6.1(c) or (d) (yes / no). If yes, Section E is required	_____

Table 10F.25 — Form 10-7, Section B: Inspections made during the year (Table 10.3)

Facility	Routine inspections (dates)	Pre-monsoon inspection (date)	After heavy-rainfall events (dates)	Monthly pump test runs (number)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Table 10F.26 — Form 10-7, Section C: Pre-monsoon checklist (one per facility)

No.	Item	Condition (OK / defect)	Defect and date corrected
C1	Inlets, pretreatment and silt traps clear	_____	_____
C2	Orifice, trash screen and outlet clear; orifice size unchanged	_____	_____
C3	Sediment below the trigger in the O&M plan	_____	_____
C4	Storage volume not reduced; no filling, covering or change of use	_____	_____
C5	Overflow and spillway route clear	_____	_____
C6	Retention drains within 72 h (observation well or surface)	_____	_____
C7	Pumps: full duty test; standby pump and standby power tested; fuel for 72 h on site	_____	_____
C8	Alarms and telemetry tested	_____	_____
C9	Flap or tide gates and non-return valves: operated and seal tested	_____	_____
C10	Safety: covers locked, fences, signs and depth markers in place	_____	_____
C11	Access routes clear and not used for parking	_____	_____

Table 10F.27 — Form 10-7, Section D: Declaration of the owner

Field	Entry
I/We declare that the pre-monsoon inspection of Clause 10.12 has been made, that the defects found have been corrected as listed in Section C, and that the facilities are maintained under the approved O&M plan. Owner: name, signature, date	_____

Table 10F.28 — Form 10-7, Section E: Empanelled professional (facilities under Clause 10.6.1(c) and (d))

Field	Entry
I have inspected the facilities listed and confirm Section C. Name, empanelment number, signature, date	_____

Table 10F.29 — Form 10-7, Section F: For the Authority

Field	Entry
Date received; on time (by 31 March) yes / no	_____
Entered in the facility register (Clause 10.17), date	_____
Follow-up action, if any (Clause 10.15)	_____

Form 10-8 — Asset Handover Certificate

Supports Clause 10.14 of Chapter 10.

Draft form — Mizoram Stormwater Design Manual, Draft v1.0. Signed by the developer and the ULB when drains, open space facilities, regional facilities or other stormwater assets built by a developer are handed over.

Table 10F.30 — Form 10-8, Section A: Asset and parties

No.	Field	Entry
A1	Developer: name and address	_____
A2	ULB	_____
A3	Layout or project, approval reference	_____
A4	Assets handed over (FAC_ID, type, length or volume), with a plan	_____

Table 10F.31 — Form 10-8, Section B: Conditions of handover (Clause 10.14.1)

No.	Condition	Met (yes / no)	Reference or date
B1	As-built certificate (Form 10-5) accepted	_____	_____
B2	Facility cleaned; pipes and culverts inspected internally (CCTV or manual entry), record handed over	_____	_____
B3	Land, or an easement over it, transferred to the ULB	_____	_____
B4	O&M plan, drawings, GIS data (Annex 10B) and warranties handed over	_____	_____

Table 10F.32 — Form 10-8, Section C: Defects liability and register

No.	Field	Entry	Clause
C1	Defects liability period: from _____ to _____ (includes at least one full monsoon season, from 1 April to 31 October, after handover)	_____	10.14.2
C2	Developer responsible during the period for defects and routine maintenance	_____	10.14.2
C3	Security deposit held by the ULB, ₹, and release date	_____	10.14.2
C4	Entered in the ULB GIS drainage asset register and the facility register: date	_____	10.14.3

Table 10F.33 — Form 10-8, Section D: Signatures

Party	Name and designation	Signature	Date
Developer	_____	_____	_____
Certifying professional	_____	_____	_____
ULB	_____	_____	_____

ANNEXES TO CHAPTER 11

Basin and City Stormwater Master Plans

These annexes support Chapter 11. They give a terms of reference template for a Basin Stormwater Master Plan (BSMP), the layout of the basin list and boundary layer, the layout and method for depth–damage curves, the standard for publishing BSMP data and models, and the annual implementation report form. Annexes 11B and 11C need data that are not yet available; they say so and give the rule to use in the meantime. The template and the form are a model and a draft form for consideration by a competent authority, and are not in force.

Annex 11A — BSMP terms of reference template

Supports Clauses 11.1 to 11.12 of Chapter 11.

> *Model text for consideration by a competent authority. Not in force.* The Lead Authority adapts this template for each basin. Items in "[ ]" are for the Lead Authority to complete. Clause references are to this Manual, which the consultant shall follow in full.

11A.1 Background and purpose

1. The [Lead Authority] intends to prepare a Basin Stormwater Master Plan for the [name] basin under Chapter 11 of the Mizoram 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, dil 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:** IWRD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, a planning authority or UD&PA, MSDMA] (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, stream (lui), dil or reservoir 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, dil, 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, lui, rivers, dils and reservoirs: outfall invert levels on valley-floor land, on a named datum, against the high flood level of the receiving river at the nearest CWC level-monitoring site (none in the State has a warning or danger level) or surveyed flood marks, with any local gauge kept as a separate series and any conflict between published values stated; for the free outfalls of the ridge towns, the bed and bank profile of the receiving lui to the next confluence and the 1% AEP level with its sediment, debris and garbage; for outfalls to the Tuirial reservoir or the reaches below the Tuirial and Serlui B dams, the full, minimum and maximum reservoir levels and the spillway and release data from NEEPCO and the State's power department, and dils at their surveyed spill levels; the landslide hazard zones, slopes above 60°, quarries, sinking areas and debris paths above the basin; and flap gates, debris racks, sediment traps, debris basins, check dams and pumping stations on the outfalls, with their capacities and operating rules;
- (f) rainfall and water levels: all available records (IMD, including the ordinary gauges of its Meteorological Centre Aizawl and at Lengpui, neither of which is in IMD's *Extremes*, and its automatic weather stations at Mizoram University, Kolasib, Champhai, Khawzawl, Serchhip, Hnahthial, Saiha and Chawnhu (record lengths [TBC]); the automatic rain gauges and weather stations listed under Mz-SWIC, about 30 sites (the operator's name is not expanded in the source; start years and logging intervals [TBC]); the State Meteorological Centre of the Directorate of Science and Technology, whose series runs from the 1980s to 2021 (gauge list not seen [TBC]); the ordinary gauges of the Agriculture Department at Serchhip, North Vanlaiphai, Lunglei, Haulawng and Tlabung; the rain gauges of CWC, among them Bairabi, Dapchhuah, Mat-1, Tlabung, Tuichawng, Tuipui D and Shitlangpui, and its level-monitoring sites at Sairang and Turial; the reservoir records of NEEPCO at the Tuirial dam [TBC]; and any gauges or sensors kept by the Aizawl Municipal Corporation, MSDMA or IWRD [TBC]), including the 28 May 2024 (Cyclone Remal: the collapse at about 6 a.m. of a disused stone quarry between Melthum and Hlimen and other slides in Aizawl, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen, or 34 in seven Aizawl areas, and 27–29 for the State, all as reported; the rainfall at Aizawl on 27–28 May 2024 was not found, and the 20 mm at Mizoram University in IMD's release of 28 May is for an unclear window), 24 May–3 June 2025 (598 landslides, five dead, 171 houses damaged and 257 road blockages, with Champhai 209, Serchhip 116, Khawzawl 75, Lunglei 61 and Aizawl 21, DM&R figures as

reported; Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm on one day whose date is not fixed, as reported; no IMD series for the storm was found), June 2018 (148 mm at Aizawl in one day, probably 12 June, and 677 mm in Serchhip district in 1–13 June, ten dead in landslides on 5 June, houses flooded at Tiperabagh, Serhuan and Tlabung and families stranded at Sairang, all as reported), July 2019 (about 400 houses flooded by the Khawthlangtuipui at Tlabung, 150 of them in the town, and three killed in the State, as reported; no rainfall value was found) and June 2017 (the Khawthlangtuipui flood at Tlabung, with about 350 houses submerged in the sub-division by one count, or 9 fully and more than 60 partly by another, and 8–10 dead, as reported; no rainfall value was found) events;

- (g) flood evidence: surveyed flood marks and mapped extents of past events, including public reports, photographs and residents' records;
- (h) land use: existing land use and imperviousness; future land use from the statutory master plan;
- (i) soils and groundwater: HSG map (Annex 3A or Clause 3.7.2), seasonal high groundwater, aquifer and recharge zones; and
- (j) sewer interaction: known cross-connections, dry-weather flow in drains, solid-waste hotspots.

Confirm the basin boundary and the inter-basin diversions (Clause 11.3.2). Deliver the data report and the data in the formats of Annex 11D.

Task 3 — Model build. Build a coupled 1D–2D hydraulic model of the minor system, the major (overland) system, rivers, canals and tanks, and the outfalls (Clause 11.7.1; Figure 11.2). Use the methods of Chapter 3 and the tidal and river boundaries of Chapter 5. Run the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs, with areal reduction under Clause 2.7.3 (Clause 11.7.2). Where the basin has tank cascades, run continuous simulation under Clause 3.13 with the full IMD gridded daily record where available, and at least 30 years, disaggregated by the temporal patterns of Annex 2D. The two-step approach of Clause 3.13.5 may be used: starting tank levels and antecedent conditions from the continuous run are passed to the design-storm runs (Clause 11.7.3).

Task 4 — Calibration and validation. Calibrate and validate the model under Clause 3.15, using at least two of the 28 May 2024 (Cyclone Remal: the collapse at about 6 a.m. of a disused stone quarry between Melthum and Hlimen and other slides in Aizawl, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen, or 34 in seven Aizawl areas, and 27–29 for the State, all as reported; the rainfall at Aizawl on 27–28 May 2024 was not found, and the 20 mm at Mizoram University in IMD's release of 28 May is for an unclear window), 24 May–3 June 2025 (598 landslides, five dead, 171 houses damaged and 257 road blockages, with Champhai 209, Serchhip 116, Khawzawl 75, Lunglei 61 and Aizawl 21, DM&R figures as reported; Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm on one day whose date is not fixed, as reported; no IMD series for the storm was found), June 2018 (148 mm at Aizawl in one day, probably 12 June, and 677 mm in Serchhip district in 1–13 June, ten dead in landslides on 5 June, houses flooded at Tiperabagh, Serhuan and Tlabung and families stranded at Sairang, all as reported), July 2019 (about 400 houses flooded by the Khawthlangtuipui at Tlabung, 150 of them in the town, and three killed in the State, as reported; no rainfall value was found) and June 2017 (the Khawthlangtuipui flood at Tlabung, with about 350 houses submerged in the sub-division by one count, or 9 fully and more than 60 partly by another, and 8–10 dead, as reported; no rainfall value was found) events where data exist (Clause 11.7.5). Report the performance measures of Clause 3.15.4 and the reasonableness check of Clause 3.15.6.

Task 5 — Scenarios and hazard maps. Model the scenarios of Clause 11.7.4: (a) existing; (b) future, uncontrolled; (c) future, controlled; (d) future, with plan; and (e) climate, applied to (a) and (d). Produce flood hazard maps of extent, depth, velocity and hazard class (H1–H6, Chapter 6) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan (Clause 11.8.4(a)).

Task 6 — Level-of-service assessment. Compare scenarios (a), (c) and (d) with the levels of service of Table 11.2 and any stricter levels the client adopts (Clause 11.6.1). Map every shortfall.

Task 7 — Options. Develop options in the order of Clause 11.8.1: protect and restore storage; regional retention and detention, sited by modelling; conveyance; outfall works; property-level protection; non-structural measures. Assess each option for the criteria of Clause 11.8.2: reduction in flood risk (buildings and people flooded, and expected annual

damage using Annex 11C); capital and 30-year maintenance cost; land required; effect on the springs (tuikhur) and spring-fed water points that supply the villages and part of the towns, and their catchments above the water points, which this Manual keeps free of paving and of infiltrated road runoff (the spring rule of Chapter 8), the stability of hill slopes, where water put into shale, colluvium, fill or slide debris raises the pore pressure, as SD&SM 2017 warns and the slides of Hlimen and Laipuitlang show, recharge on tested valley alluvium and river terraces, the only ground where it is allowed (Clause 4.11, recharge rule), although groundwater is barely drawn (stage of extraction 3.52% in 2011, CGWB, and 3.95% in 2024, as quoted), and the quality of the springs, lui, rivers, dils and reservoirs that the runoff reaches, several of which carry sewage (Chapter 8, Clause 8.9); effect on downstream basins and the receiving river, stream (lui), dil or reservoir; and who benefits.

Task 8 — Basin inputs for site design. Where scenario (c) does not meet the level of service, propose basin release rates (m³/s/ha) by AEP and sub-catchment (Clause 11.8.3). Recommend catchments for notification as flood-sensitive, with the evidence of Clause 4.5.4.1. Identify regional facility sites, with storage volumes, land needs and the sites they serve, and compute the fee-in-lieu unit rate, including land, construction and 10 years of maintenance (Clauses 4.13.3, 11.8.4(c), (d)).

Task 9 — Capital Improvement Programme. Rank the works by risk reduction per rupee, with cost, phasing and responsible agency (Clause 11.8.4(e)).

Task 10 — Maintenance and monitoring. Prepare the pre-monsoon maintenance programme: desilting, gate and pump testing, and tank operating rules (Clause 11.8.4(f); Chapters 7 and 10). Specify monitoring needs: new rain gauges, level sensors and flood-mark survey points (Clause 11.8.4(g); Clause 10.16.1).

Task 11 — Land-use integration. Prepare the material for the statutory land-use plan required by Clause 11.9.1: sites to be reserved; the 1% AEP hazard map with the Chapter 7 setbacks; land in hazard classes H5–H6 in the 1% AEP event; and open space locations that can form part of flow paths or regional storage.

Task 12 — Consultation. Publish the draft BSMP for public comment for at least 60 days, with public meetings in each affected local body (Clause 11.10.1). Keep a log of comments and responses.

Task 13 — Final BSMP and publication. Revise the BSMP after consultation. Prepare the package for approval by the State Stormwater Technical Committee, including the model for review (Clause 11.11.1). Publish the data, models, maps and CIP under Annex 11D (Clause 11.10.2).

11A.5 Deliverables

Table 11A.1 — Deliverables

No.	Deliverable	Task	Due (months from start)
D1	Inception report, data inventory and survey plan	1	[ ]
D2	Data report and data sets (Annex 11D)	2	[ ]
D3	Model build report and model files	3	[ ]
D4	Calibration and validation report	4	[ ]
D5	Scenario results, hazard maps and level-of-service assessment	5, 6	[ ]
D6	Options report, with basin inputs for site design	7, 8	[ ]
D7	Draft BSMP with draft CIP, for consultation	9–12	[ ]
D8	Final BSMP, consultation log, approval package and open-data release	13	[ ]

11A.6 Ownership and publication

All data, models, maps and reports produced under these terms are owned by the Lead Authority and shall be published under Annex 11D. The consultant shall not use any software licence, data licence or format that prevents publication, or that prevents a third party from re-running the model with the stated software version.

Annex 11B — Basin lists and boundaries for Tier A bodies

Supports Clauses 11.3 and 11.4 of Chapter 11.

To be prepared. This annex will contain the list of basins for every Tier A body, with a GIS layer of basin boundaries delineated under Clause 11.3.2. It needs the list of Tier A bodies (Annex 1A), a DEM of the accuracy of Clause 11.5.1, flown again over the valley floors and the slide-prone slopes after any large flood or landslide, the drain network of every drain-owning body (the Aizawl Municipal Corporation and its Local Councils, the Lunglei Municipal Council, PWD, the national-highway agencies, PHED and SIPMIU, and the Village Councils for the village drains), a drain register giving every reach its owner, the lui it reaches, its class on the landslide hazard maps and its outfall, the drains and catchments proposed on Map 8.3 of the Master Plan for Aizawl: Vision 2030 (not yet extracted [TBC]), the rivers and flood works of IWRD, the Tuirial and Serlui B reservoirs with their levels, spillways, gates and release rules on a stated datum, the dils with their spill levels, the springs (tuikhur) and their catchments above the water points, the quarries, active and disused, and the sinking areas, and the landslide hazard zones of the Corporation's Landslide Hazard Maps and MIRSAC's atlas (other likely sources: Survey of India, CWC, CGWB, NIH, MIRSAC, UD&PA's master-plan maps and the land records of the Land Revenue and Settlement Department). No basin map of any Mizoram town was found. Until the annex is published, the basins of Aizawl (the Chite lui to the Tuirial; the Ser lui to the Tlawng), with the hazard areas of Hlimen–Melthum, Hunthar Veng and Durtlang, and those of Sairang, Bairabi and Vairengte, Tlabung, Lunglei, Serchhip, Champhai and the Champhai flats, Siaha and Lawngtlai and the Tuirial release reach named in Clause 11.3.3 are at least those named there; other towns and bodies define their basins in their first BSMP (Clause 11.3.3); in every basin the hazard screening of Clause 11.3.3 comes first; and the interim arrangements of Clause 11.12 apply in every basin without an approved BSMP. For Annex 11C, the damage assessments of landslides and floods in Mizoram fall to the Disaster Management and Rehabilitation Department (DM&R), which "is responsible for prevention, preparedness, mitigation, response, relief and rehabilitation" (CAG) and whose counts the press reports, as for 24 May–3 June 2025, beside the land records of the Land Revenue and Settlement Department (this Manual's reading); DM&R's final counts for the calibration events were not obtained [TBC].

Table 11B.1 — Basins named in Clause 11.3.3 (provisional)

Tier A body or area	Basin	Note from Chapter 11
Aizawl Development Plan Area (the Aizawl Municipal Corporation, UD&PA)	Catchment of the Chite lui to the Tuirial, with its tributaries and the Muthi and Tuipawl lui	Free outfalls to steep lui (Clause 5.8.5(a) and (b)); Chite sewage treatment plant and Priority II stretch in the 1D network; surveyed flood marks and 1% AEP level with debris and garbage as boundary
Aizawl Development Plan Area (as above)	Catchment of the Ser lui to the Tlawng, with its streamlets and the Khatla, Tuikual, Vaivakawn and Chanmari west lui	As above
Aizawl Development Plan Area (as above)	Hazard areas within these basins: the Hlimen–Melthum quarry belt, Hunthar Veng and the NH-6 cuts, Durtlang and the Bawngkawn–Durtlang road	Hazard screening first; debris paths mapped; basin assignment [TBC]

Tier A body or area	Basin	Note from Chapter 11
Sairang	Catchments draining to the Tlawng	CWC Sairang site (no high flood level) and surveyed flood marks as boundary; outfall-closed case a design case (Clause 5.8.5(c))
Bairabi and Vairengte (sub-area MZ-A1)	Catchments of the two towns	Surveyed flood marks for at least the 72-hour storm; the adjoining Barak-valley rule downstream
Tlabung (sub-area MZ-D1)	Catchments draining to the Khawthlangtuipui	River at surveyed flood level for not less than 72 hours (Clause 5.8.5(d)); June 2017 and July 2019 as calibration evidence
Lunglei (Lunglei Municipal Council, a Tier B body)	Catchments of the town and their receiving lui	Names and outfalls [TBC]
Serchhip	Catchments of the town draining towards the Mat	Hazard screening first; receiving lui [TBC]
Champhai town and the Champhai flats (sub-area MZ-C1)	Catchments draining towards the Tiau	Surveyed flood marks as boundary; no downstream gauge in Myanmar
Siaha and Lawngtlai	Catchments of the two towns	Through the District Councils only, if they adopt the Manual
Tuirial release reach	Catchments draining to the Tuirial below the NEEPCO dam	Largest recorded release, or the spillway capacity until NEEPCO gives one, as boundary (Clause 5.8.5(e))
Other towns and bodies	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_LUS	Text	Basin name in English and Mizo
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 IWRD 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 Mizoram 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 Mizoram towns, 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 28 May 2024 (Cyclone Remal: the collapse at about 6 a.m. of a disused stone quarry between Melthum and Hlimen and other slides in Aizawl, with tolls reported rising to 29 dead in Aizawl district, with 7 missing, by 29 May, and given later as 15 at the quarry and 5 at Hlimen, or 34 in seven Aizawl areas, and 27–29 for the State, all as reported; the rainfall at Aizawl on 27–28 May 2024 was not found, and the 20 mm at Mizoram University in IMD's release of 28 May is for an unclear window), 24 May–3 June 2025 (598 landslides, five dead, 171 houses damaged and 257 road blockages, with Champhai 209, Serchhip 116, Khawzawl 75, Lunglei 61 and Aizawl 21, DM&R figures as reported; Serchhip 104.6 mm, Kolasib 98.3 mm and Aizawl 97.4 mm on one day whose date is not fixed, as reported; no IMD series for the storm was found), June 2018 (148 mm at Aizawl in one day, probably 12 June, and 677 mm in Serchhip district in 1–13 June, ten dead in landslides on 5 June, houses flooded at Tiperabagh, Serhuan and Tlabung and families stranded at Sairang, all as reported), July 2019 (about 400 houses flooded by the Khawthlangtuipui at Tlabung, 150 of them in the town, and three killed in the State, as reported; no rainfall value was found) and June 2017 (the Khawthlangtuipui flood at Tlabung, with about 350 houses submerged in the sub-division by one count, or 9 fully and more than 60 partly by another, and 8–10 dead, as reported; no rainfall value was found) floods (Land Revenue and Settlement Department and MSDMA damage assessments, insurers), and replacement costs (Public Works Department schedules of rates). Until it is published, each BSMP shall state the depth–damage relations it uses and their source, and shall report the reduction in buildings and people flooded for every option (Clause 11.8.2), which does not depend on the curves.

Table 11C.1 — Depth–damage curve (layout, one table per building type)

Depth of water above floor level (m)	0	0.25	0.5	1.0	1.5	2.0	3.0
Structure damage (% of replacement cost)	_____	_____	_____	_____	_____	_____	_____
Contents damage (% of contents value)	_____	_____	_____	_____	_____	_____	_____
Building type, source and year of costs	_____						

11C.1 Use in option assessment

Expected annual damage (EAD) is computed for each scenario from the damages at the modelled AEPs. With damages D_1, D_2, … at annual exceedance probabilities P_1 > P_2 > …, using at least the 50%, 10%, 1% and 0.2% AEP results of Clause 11.7.2:

> EAD ≈ Σ ½ × (D_i + D_(i+1)) × (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, reservoir and dil levels, receiving-lui profiles, landslide, debris and garbage hazards and outfall structures, rainfall and levels, flood evidence, land use, soils and groundwater, sewer interaction)	GeoTIFF (terrain); GeoPackage (features); CSV (tables and time series)	Summary	Yes, except security-sensitive asset details
Model files: native, runnable, with all boundary-condition, rainfall and control files, the software name and version, and a run log	Native format, zipped	No	Yes
Calibration and validation report	Searchable PDF	Yes	Yes
Consultation log of comments and responses	PDF or CSV	—	Yes

11D.2 Formats and references

- (a) Raster data shall be GeoTIFF, preferably cloud-optimised, with the cell size stated. Vector data shall be GeoPackage. Tables and time series shall be CSV in UTF-8, with a header row and units in the column names.
- (b) Horizontal and vertical references shall be as in Annex 10B.1(b) and (c). The vertical datum and its relationship to the Chapter 5 river datums of the CWC level-monitoring sites on the receiving rivers (not stated in any source found), of the reservoir levels of the Tuirial dam published by NEEPCO in metres (datum not stated) and of Serlui B (not found), and of the flood marks surveyed on ungauged lui, rivers and dils 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 `chite-lui_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 — Mizoram Stormwater Design Manual, Draft v1.0. Published by the Lead Authority for each basin with an approved BSMP before each monsoon season, by **31 March** (Clause 11.11.3).

Table 11F.1 — Form 11-1, Section A: Basin and plan

No.	Field	Entry
A1	Basin; Lead Authority; partners	_____
A2	BSMP version and date of approval	_____
A3	Reporting year (1 April to 31 March)	_____
A4	Date of publication (by 31 March) and web address	_____

Table 11F.2 — Form 11-1, Section B: CIP progress

CIP rank	Work	Agency	Cost in CIP (₹)	Spent this year (₹)	Spent to date (₹)	Status	Expected completion
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 11F.3 — Form 11-1, Section C: Fee-in-lieu ledger (Clauses 4.5.6.3(c) and 4.13.4)

Regional facility or tank	Volume credited to sites (m³)	Volume delivered (m³)	Fees received (₹)	Fees spent (₹)	Fees held, with year received
_____	_____	_____	_____	_____	_____
Basin total: volume owed and delivered	_____	_____	_____	_____	_____

Table 11F.4 — Form 11-1, Section D: Maintenance completed (Clause 11.8.4(f))

No.	Item	Planned	Done	Date completed
D1	Desilting of drains and canals (length, km; volume, m³)	_____	_____	_____
D2	Tank and dil 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	_____