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~~***(REVISED MAY 2020)***~~

SECTION 7 – STORMWATER MANAGEMENT DESIGN CRITERIA

7.01 INTRODUCTION

.1 Scope:

(a) Stormwater management is the term traditionally used when referring to managing rainfall runoff based on using design storms and sizing drainage facilities. Rainwater management refers to rainfall runoff source control ~~under~~ for frequently occurring events. In this section, the term stormwater management is used and is intended to include the scope of rainwater management. ~~***(REVISED MAY 2020)***~~ ***(REVISE? TBD 2025)***

(b) For Defined Terms refer to Section 2.01 []. ***(REVISE? TBD 2025)***

.2 Objectives:

(a) Overall – To provide flood protection, drainage, and minimize impacts on the ~~aquatic~~ environment. Achieve a balance between protecting property from flood hazards and protecting the ~~aquatic~~ environment in terms of both water quality and quantity. ***(REVISE? TBD 2025)***

(b) Major System – To safely convey the 1:100 ~~year~~ Annual Exceedance Probability (AEP) or (1% AEP) storm event runoff with overland flow path and piped flow to suitable receiving bodies. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020***~~

(c) Minor System – To safely contain the 1:5 ~~year~~ AEP (20% AEP) storm runoff within the minor system. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

(d) Rainwater Management Best Management Practices (BMP) – To ~~emulate~~ mimic the ~~natural~~ conditions of a naturalized undeveloped land by reducing impervious area, retaining trees and tree canopy, and infiltrating frequent rain events~~capturing or retaining small rainwater events and infiltrating the water into the ground~~. ***(REVISE? TBD 2025)***

(e) Downstream Environmental Protection – To ensure that the quality and quantity of flows do not adversely affect the groundwater or receiving waters (streams, creeks, ditches, lakes, wetlands, ocean). ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

(f) Protection of Environmentally Sensitive Areas (ESAs) – To protect ESAs, including leave strip areas from development impacts. Prioritize avoidance of negative impacts, restoration, and enhancement of Environmentally Sensitive Areas. ***(REVISE? TBD 2025)***

(g) Consideration for the Blue and Green Network of parks, watercourse, water bodies, greenways, and urban tree canopy to enhance habitat connectivity and ecosystem. ***(REVISE? TBD 2025)***

(h) Natural Asset Management – To incorporate natural asset management into stormwater management plans, ensuring long-term sustainability and level of service. Recognize the value of natural assets and their ecosystem services in providing community services. ***(REVISE? TBD 2025)***

.3 City Authority and Bylaws: ***(REVISE? TBD 2025)***

(a) This manual should be used in accordance with the most recent version of other City policies and bylaws including, but not limited to those listed below: ***(REVISE? TBD 2025)***

~~(a) Stormwater Management in Nanaimo~~

~~(b) Official Community Plan~~

~~(c) Other bylaws pertaining to stormwater as listed in Section 3.01(c) City Bylaws~~

(i) *Subdivision and Development Standards Bylaw* ***(REVISE? TBD 2025)***

(ii) *City Plan* *Official Community Plan* *(OCP Bylaw 6600)* ***(REVISE? TBD 2025)***

(iii) *Development* Approval *Information Bylaw No. 7346* ***(REVISE? TBD 2025)***

(iv) *Storm Sewer Regulation and Fee Bylaw No. 7351****(REVISE? TBD 2025)***

(v) Flood Prevention Bylaw No. 5105 ***(REVISE? TBD 2025)***

(vi) *Management and Protection of Trees Bylaw No. 7126* ***(REVISE? TBD 2025)***

(vii) Stormwater Management. Council Policy. ***(REVISE? TBD 2025)***

(viii) Ditch/Swale. Council Policy. ***(REVISE? TBD 2025)***

.4 Other Applicable Government Initiatives:

(a) In addition, this manual should be used in accordance with other commonly applicable government acts, regulations, policies, guidelines and documents~~,~~. including, but not necessarily limited to the following: ***(REVISE? TBD 2025)***

(i) ~~(a)~~ Federal *Fisheries Act*

(ii) ~~(b) Provincial Fish Protection Act~~ *Riparian Areas Protection Act* and *Riparian Areas Protection Regulation* ***(REVISE? TBD 2025)***

(iii) *Water Sustainability Act* and *Water Sustainability Regulation* ***(REVISE? TBD 2025)***

(iv) ~~(c)~~ ***Fish-Stream Crossing Guidebook***, ~~Revised Edition,~~ Ministry of Forests, Lands and Natural Resource Operations, Ministry of Environment ***(REVISE? TBD 2025)***

~~(d) Stormwater Source Control Guidelines 2012 – Metro Vancouver~~

(v) ~~(e)~~ ***Stormwater Planning: A Guidebook for British Columbia***, Ministry of Water, Land and Air Protection ***(REVISE? TBD 2025)***

(vi) ***Requirements and Best Management Practices for Making Changes in and About a Stream in British Columbia***, Government of British Columbia. ***(REVISE? TBD 2025)***

.5 ~~Previous~~ Design Criteria Interpretations: ***(REVISE? TBD 2025)***

(a) The City's ~~of Nanaimo~~ utility systems have been constructed over many years using design criteria and practices that were in place at the time. ***(REVISE? TBD 2025)***

(b) ~~¶The~~ Use the current criteria ~~is to be used~~ when designing all new infrastructure and when assessing the adequacy of existing systems. ***(REVISE? TBD 2025)***

(c) ¶When ~~replacing~~ evaluating existing infrastructure and watercourses, ~~should~~ where the existing system does not meet current criteria, the ~~Design Engineer~~Professional of Record will provide a risk assessment and professional recommendations for consideration by the City Engineer. ~~will be responsible to ensure the design is appropriate and founded on solid engineering principles and practices. Existing systems which do not meet current design criteria~~ These will be evaluated on a case-by-case basis and upgraded as resources permit or by the developer if triggered by the proposed development. ***(REVISE? TBD 2025)***

(d) Pre-development is defined as a natural state: ***(REVISE? TBD 2025_redesignated)***

(i) Structures, parking areas, and manmade surfaces are not considered to be pre-development. ***(REVISE? TBD 2025)***

(ii) A forested area should be assumed. ***(REVISE? TBD 2025)***

(iii) However, if there is evidence that the lands natural state was something other than forested, such as a meadow or rock outcrop, the Qualified Registered Professional is responsible to document such evidence and submit to the City Engineer for approval.

(e) Post-development is the proposed development. ***(REVISE? TBD 2025)***

.6 Development Requirements (Responsibilities and Reporting): ***(REVISE? TBD 2025)***

~~(a) Responsibilities:~~

(a) Applicants and their agent, a Professional of Record, are ~~Development proponents shall be~~ responsible for designing stormwater systems ~~which consider watershed management, flood protection, drainage, conveyance, riparian preservationleave strip, and watercourse protection.~~ that align with the objectives in Section 7.01.2 [→]. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

(b) Drainage works design must comply with Section 7.02 [→] - Summary of Stormwater and Environmental Protection Design Criteria and associated sections in this Manual.

~~¶Post-development runoff release rates must be designed to consider the capacity of the downstream drainage system and the protection of any downstream watercourses from erosion. The design must ensure that the frequency and magnitude of erosion events do not increase when compared to the pre-development conditions. These requirements are further detailed in Section 7.03.7 – Peak Flow and Runoff Volume Control. ***(REVISED MAY 2020)***~~

~~¶For new developments and re-developments that drain to watercourses, frequently occurring post-development runoff volumes and rates must be designed to emulate pre-development conditions. These requirements are further detailed in Section 7.03.7 – Peak Flow and Runoff Volume Control. ***(REVISED MAY 2020)***~~

~~¶For developments and re-developments that do not drain into a creek, river or wetland system, but discharge directly into the ocean through pipes, ditches or overland flow paths, rainfall volume and runoff rate control may not be required as for discharge to watercourses. These requirements are further detailed in Section 7.03.7 – Peak Flow and Runoff Volume Control. *(REVISED MAY 2020)*~~

~~¶The stormwater system must be designed in a manner which prevents pollutants and sediment from entering watercourses and ocean from the development both during and after construction. These requirements are further detailed in Section 7.14 - Water Quality.~~

(c) Construction activities must ~~be managed to~~ manage and minimize the impact to ~~adjacent~~ connected watercourses as set out in the ~~"Storm Sewer Regulation and Charge Bylaw No. 3808" and Erosion and Sediment Control Guideline~~ *Storm Sewer Regulation and Fee Bylaw No. 7351* .

(d) ~~It is the Design Engineer's~~ The Professional of Record is ~~responsibility to ensure that~~ responsible for ensuring all applicable guidelines, standards, bylaws, and other regulations and policies are ~~strictly followed~~ met.

~~(b) Reporting:~~

(e) ~~Development shall prepare a Stormwater Management Plan for developments of more than three single or duplex residential lots and for all multi-family, commercial, industrial, and institutional developments, or at the discretion of the City Engineer.~~ Prepare a Stormwater Management Plan for subdivision, multi-unit residential, commercial, industrial, and institutional developments, or as otherwise required by *Development* Approval *Information Bylaw No. 7346*. ~~The Stormwater Management Plans shall be presented in~~Submit as a report ~~which~~ that includes: ***(REVISE? TBD 2025)*** ~~(*REVISED MAY 2020)~~

(i) A watershed location plan(s) showing: ***(NEW? TBD 2025)***

1. The watershed boundary and major system components, including labeled watercourses and Environmentally Sensitive Area (ESA) leave strips. Road network with key road names. ***(NEW? TBD 2025)***
2. Topography with low points marked, overland flow paths, and drainage routes. ***(NEW? TBD 2025)***
3. Identify outlet boundary conditions for the proposed development. Indicate the water level elevations at the outlet for the 20% AEP and the 1% AEP to establish the starting elevation of the downstream Hydraulic Grade Line (HGL). In some cases, the downstream water level elevation may be set by flood plain elevations typically associated with the 1:200 AEP (0.5% AEP) or an ocean tide level. ***(NEW? TBD 2025)***
4. At key junctions in the watershed, show the cumulative tributary areas, and if available the 1% AEP peak discharge. ***(NEW? TBD 2025)***
5. Prepare scaled plans using the City Geographical Information System (GIS) resources and the coordinate system in Section 1.42 []. List additional resources used for the base plan. ***(NEW? TBD 2025)***

~~(i)~~(ii) A tributary catchment area plan(s) based on boundary conditions from the watershed location plan, with the these additional details:~~outlining all areas included in the stormwater calculations, tributary to for the rainwater management measures and the associated minor and major systems.~~ *(REVISE? TBD 2025)* ***(REVISED MAY 2020)***

1. Drainage works for minor system and major system, with references to City GIS pipe and manhole ID numbers. *(REVISE? TBD 2025)*
2. Existing topography and proposed grading contours for post-development, when available. *(REVISE? TBD 2025)*
3. Street names and lot numbers; *(REVISE? TBD 2025)*
4. A summary table of pipe and open channel analysis. *(REVISE? TBD 2025)*

~~(ii)~~(iii) A detailed plan of the proposed development, based on base plan from the tributary area, that includes: *(REVISE? TBD 2025)* ~~An overall plan showing major and minor systems and rainwater management measures (quantity and/or quality control as required). The plan shall, at minimum, include reference to street names and the legal addresses of adjacent lots; it is encouraged to include references to City of Nanaimo GIS pipe and manhole ID numbers for existing infrastructure. The design flows in pipes and open channels shall be presented in a tabular format.~~

1. Pre-development and post-development topography. ***(REVISE? TBD 2025)*** *(REVISE? TBD 2025)*
2. Sub-catchment areas to proposed drainage works. *(REVISE? TBD 2025)*
3. Mitigative measures (retention, detention, water quality). *(REVISE? TBD 2025)*
4. Label proposed areas, manholes, pipes and appurtenances in a logical way. *(REVISE? TBD 2025)*
5. Overland flow routes identified. *(REVISE? TBD 2025)*
6. A summary table of pipe and open channel analysis. *(REVISE? TBD 2025)*

~~(iii) Detailed design drawings for the proposed minor and major systems and rainwater management measures. The drawings should show the routing of flows and hydraulic grade lines under both the 5 year and 100 year design conditions.~~ ***(REVISED MAY 2020)***

~~(iv) A plan showing the pre and post-development topography that adequately describes the terrain.~~

~~(v)~~(iv) ~~A rationale explaining which method is chosen and why the method is chosen for hydrological analysis.~~ Methodology for analysis explaining the chosen hydrological and hydraulic and associated report presentation requirements, as per Section 7.03 Stormwater Runoff [→]. *(REVISE? TBD 2025)* ***(REVISED MAY 2020)***

~~(vi)~~(v) Summary tables for the plans ~~that~~ provides the following key design information: *(REVISE? TBD 2025)*

1. ~~(a)~~ Total and sub catchment areas. ***(REVISED MAY 2020)***

2. ~~(b)~~ Percent imperviousness values of the catchments ~~under both pre and post development conditions.~~ ***~~(REVISED MAY 2020)~~*** *(REVISE? TBD 2025)*

3. ~~(c)~~ Summary of the methodology and key parameters and assumptions. ~~Hydrological parameters (e.g. runoff coefficients, time of concentration values, infiltration parameters etc.) used for flow and HGL calculation.~~ ***~~(REVISED MAY 2020)~~*** *(REVISE? TBD 2025)*

~~(vii) Design calculations, including:~~

~~(a) Where applicable as described in Section 7.03.7 – Peak Flow and Runoff Volume Control features and the infrastructure to convey the runoff from the proposed development site and associated contribution catchments, to the nearest trunk storm sewer or ocean. Where it is found that the discharge from the development alters the flows entering the downstream pipe to a point where the pipes no longer have sufficient capacity, the report shall include specific recommendations on downstream improvements to be made to accommodate the additional drainage.~~ ***~~(REVISED MAY 2020)~~***

4. ~~(b)~~ Hydraulic and Hydrologic design calculations for the pipe network, using either the Rational Method and Manning's Equation or computer modeling, to the plan limit boundary conditions. *(REVISE? TBD 2025)*

5. Clearly identify non-conforming conditions. These include, but are not limited to, minor system drainage works that exceed capacity during the 20% AEP event, as per Section 7.04 [→], and surcharge of the HGL in the major system and flooding as per Section 7.05 [→]. *(REVISE? TBD 2025)*

(vi) Water Quality - ~~(viii) The report shall include details regarding the~~ details on provisions ~~included to~~ address water quality leaving the ~~suite~~ site and entering the ~~minor~~ drainage system as per Section 7.14 [→], using the criteria in Section 7.02 [→]. *(REVISE? TBD 2025)*

(vii) Capture with Retention - details on provisions to address volume control as per Section 7.02 [→], through Rainwater Best Management Practices (BMP) as outlined in Section 7.13 [→]. ~~(vii) (d) Design calculations for rainwater management best practices including the design volume and facility size.~~ ***~~(REVISED MAY 2020)~~*** *(REVISE? TBD 2025)*

(viii) Runoff Rate Control - details for peak discharge control as per Section 7.03.6 [→] and including design ~~(vii) (c) Design~~ calculations for storage facilities including the required storage volume, design size and flow control considerations as per as per Section 7.12 [→]. ~~***(REVISED MAY 2020)***~~ *(REVISE? TBD 2025)*

~~(vii) (e) Time of concentration design calculations including a rationale explaining which method was chosen and why that method was chosen.~~

(ix) Non-conforming conditions require approval by the City Engineer, as per Section 7.01.5(c) [→]. *(NEW? TBD 2025)*

(x) ~~(ix)~~ For systems which include works or facilities which require ongoing maintenance, a~~n~~ detailed operation and maintenance plan is required. ~~shall be provided detailing the inspection and maintenance, an operation and maintenance plan shall be provided detailing the inspection and maintenance requirements.~~ *(REVISE? TBD 2025)*

(xi) ~~(iii)~~ Detailed design drawings, as per Section 1.05 [], for the proposed minor and major systems and rainwater management measures. The drawings should show the routing of flows and hydraulic grade lines under both the ~~5 year~~ 1:5 AEP (20% AEP) and ~~100 year~~ 1:100 AEP (1% AEP) design conditions. *(REVISE? TBD 2025)* ~~***(REVISED MAY 2020)***~~

(xii) ~~(x)~~ All Stormwater Management Plans, reports and drawings that are relied upon are to be ~~signed and sealed~~ authenticated by a Qualified Registered Professional ~~Engineer~~ licensed in British Columbia. *(REVISE? TBD 2025)*

7.02 SUMMARY OF STORMWATER AND ENVIRONMENTAL PROTECTION DESIGN ~~AREA~~ CRITERIA *(REVISE? TBD 2025)*

.1 This section provides a summary of the design criteria to be used for the planning and design of stormwater management infrastructure. The planning and design for stormwater management infrastructure must meet the following criteria: ~~***(REVISED MAY 2020)***~~

(a) A minor system conveyance capacity ~~up to~~ using the 1:5 AEP (20% AEP) rainfall event in Section 7.03.3 [→] ~~year return period to minimize inconvenience nuisance of frequent surface runoff~~ and identified in Section 7.04 [→]. ~~***(REVISED MAY 2020)***~~*(REVISE? TBD 2025)*

(b) A major system conveyance capacity ~~up to~~ using the 1:100 AEP (1% AEP) rainfall event in Section 7.03.3 [→] ~~year return period to provide safe conveyance of flows to minimize damage to life and property.~~ ~~***(REVISED MAY 2020)***~~ and identified in Section 7.05 [→]. *(REVISE? TBD 2025)*

(c) For areas draining to watercourses, ~~: Provide volume reduction, detention,~~ provide capture with retention and water quality treatment. This ~~to~~ minimizes erosion, protects aquatic habitat and water quality. Depending on the habitat conditions, such as fish and wildlife, there may be other authorities having jurisdiction. Runoff rate control may be required to protect downstream infrastructure and natural assets. *(REVISE? TBD 2025)*

(d) For areas draining directly to the ocean, capture with retention ~~volume reduction is~~ may not be required. ~~;~~ H~~h~~owever, runoff rate control ~~detention for the protection of~~ may be required to protect downstream infrastructure. ~~may be required and water quality treatment.~~ ~~***(REVISED MAY 2020)***~~ *(REVISE? TBD 2025)*

(e) ~~Volume reduction: Retain, infiltrate, or reuse the 6 month, 24 hour (50% of the 2 year, 24 hour) post development runoff volume. For Nanaimo, this equates to approximately 31mm of rainfall depth.~~Capture with retention through Rainwater Best Management Practices (BMPs) to provide volume reduction and opportunities for infiltration, evaporation, reuse, or other approved method, as outlined in Section 7.13 [→]. ***(REVISE? TBD 2025)***

(i) The target is to capture 31 mm of rainfall depth from impervious areas. In Nanaimo, 31 mm of rainfall represents the 85th percentile for rainfall events less than 24 hours duration. ***(REVISE? TBD 2025)***

(ii) This captured water should drawdown from the BMP and recover within 12 to 36 hours to restore storage capacity.***(NEW? TBD 2025)***

(iii) If the site conditions do not permit infiltration or a constrained system is needed, then the maximum release rate permitted is 0.25 L/s/ha. ***(REVISE? TBD 2025_moved)***

(f) ~~(g)~~ Provide water quality treatment for 36 mm of rainfall, which is 90% of the average annual ~~runoff (the 6 month, 24 hour storm or 50% of the 2 year, 24 hour storm)~~ rainfall onto~~, for~~ impervious surfaces exposed to vehicle traffic as described in Section 7.14 – Water Quality [→]. The treatment performance is to remove ~~Remove~~ 80% of Total Suspended Solids over ~~50µm~~ 50 µm particle size. ***(REVISE? TBD 2025)***

(g) Control ~~R~~runoff rate ~~control use~~using strategies like detention in storage facilities as per Section 7.12 [→], with the calculations for storage as per Section 7.03.6 [→]. ~~(f) Detention: Detain post-development flows to pre-development levels for the 6 month, 24 hour (50% of the 2 year, 24 hour) event for areas draining to watercourses to minimize erosion. If downstream drainage system cannot accommodate the 5 year post-development flows, detain them to pre-development levels.~~***(REVISE? TBD 2025)***

(h) Protect the ~~If the~~ downstream receiving watercourse from erosion. If the watercourse is located in an environmentally sensitive area (ESA) or is vulnerable to erosion, the City Engineer may require additional investigation to assess both the immediate connection point and potential downstream impacts, as per Section 7.01.5(c) [→]. ***(REVISE? TBD 2025)***

(i) ~~(h)~~ Account for climate change in stormwater management designs as described in Section 7.15 - Climate Change [→].

7.03 STORMWATER RUNOFF

.1 Scope:

This section describes the rationale, methodology and parameters for determining the hydrologic variables such as stormwater runoff volume and rates in the design of drainage flow conveyance and storage facilities. ***~~(REVISED MAY 2020)~~***

.2 Catchment ~~Areas~~ and Impervious Areas: ***(REVISE? TBD 2025)***

(a) Drainage catchments are governed by topography of the land and drainage works or watercourses that intercepts and conveys runoff. Drainage areas can refer to nested hydrologic units: ***(NEW? TBD 2025)***

(i) Watersheds are the largest units, ranging from short creeks draining to the ocean, to systems of creeks, lakes, wetlands, and rivers. Watershed boundaries can be obtained from City GIS; however, the Professional of Record should verify boundaries. ***(NEW? TBD 2025)***

(ii) Tributary catchment areas are upstream areas draining into a junction or confluence of drainage works or watercourses. ***(NEW? TBD 2025)***

(iii) The drainage area for a proposed development may be within one or more tributary areas or even watersheds. Post-development design may alter drainage boundaries, and these changes should be considered in the design and analysis. ***(NEW? TBD 2025)***

(iv) During extreme events such as flooding, drainage catchment boundaries may shift. ***(NEW? TBD 2025)***

(b) The impervious area is a key driver in stormwater runoff. Depending on the calculation method, it may be embedded within another parameter, such as the runoff coefficient in the Rational Method; or represented explicitly as in most hydrograph models. For larger drainage catchments, impervious area is often approximated using land use designations. ***(NEW? TBD 2025)***

(i) Analysis of the existing storm system typically considers current impervious surfaces such as buildings, roads, and parking areas. These can be estimated using recent orthophotos. ***(NEW? TBD 2025)***

(ii) Analysis for replacement will generally use ultimate land use and references the current Official Community Plan Bylaw No. 6500 and applicable Regional District Community Plans for areas outside the City. ***(REVISED? TBD 2025)***

(iii) Post- development site analysis uses the impervious area specified in the design, rather than zoning-based approximations. Pre- development conditions are assumed to reflect very low impervious conditions (treed), even if the development site is currently developed, as per Section 7.01.5(d) [→].***(NEW? TBD 2025)***

~~(a) Ultimate land use for the purpose of stormwater calculations shall be determined by referring to will reference the current "*Official Community Plan" Bylaw No. 6500* and the current Official Regional District Community Plans for the area outside the City. ***(REVISE? TBD 2025)***~~

~~(b) The contributing catchment area shall be governed by the natural contours of the land and any changes to the topography caused by the development. The catchment shall alsoconsider any contributing catchment areas which have been established by the City of Nanaimo. ***(REVISE? TBD 2025(REVISED MAY 2020)***~~

.3 Rainfall Data:

(a) IDF Curves:
Intensity~~/~~ Duration~~/~~ Frequency data has been compiled into the IDF Curves shown on Standard Drawing No. SW-25 [] for the applicable design ~~year return period~~ annual exceedance probability (AEP) rainfall. The updated IDF curve takes climate change into account~~,~~ to planning horizon Year 2100~~. see Standard Drawing No. SW-25~~. *(REVISE? TBD 2025)* ***~~(REVISED MAY 2020)~~***

(b) Rainfall Gauges:
The City ~~of Nanaimo~~ has several rainfall gauges with historical rainfall data. This rainfall data is available for reference if desired and can be provided by the City ~~staff~~; however, it is up to the ~~individual engineer~~ Qualified Registered Professionals to verify the quality of the data and use the data for hydrological calculation. *(REVISE? TBD 2025)* ***~~(REVISED MAY 2020)~~***

(c) Design Storms:
The City has used various design storm hyetographs in hydrograph-based watershed studies. For consistency, it may be advisable to use the same design storm applied in the watershed study if seeking comparable values. However, any selected option should reflect the Intensity-Duration-Frequency (IDF) curves that include climate change projections to the Year 2100. Alternatively, AES design storms for durations of 1-hour, 2-hour, 6-hour, 12-hour, and 24-hour are suitable options. *(NEW? TBD 2025)*

.4 Time of Concentration:

(a) Time of Concentration
is the time required for stormwater runoff to travel from the most remote point of the drainage ~~basin~~ catchment area to the point of interest and having the greatest impact on downstream flows. *(REVISE? TBD 2025)*

(b) Method:
There are several methods available to calculate time of concentration such as the Upland Method, Kinematic Wave Equation, Kirby Equation, Kirpich Equation, and others. The ~~Design Engineer shall~~ Qualified Registered Professional~~s~~ is responsible to determine and document the most appropriate method of calculating the time of concentration. Overland flow path times in undeveloped areas may be estimated using the Upland Method of Estimating Time of Concentration as shown on Standard Drawing No. SW-26 [] if the slope and land use of the area is known. *(REVISE? TBD 2025)*

(c) Minimum and Maximum Time of Concentration:
The minimum time of concentration for all calculations ~~shall be~~ is 5 minutes. The maximum time of concentration ~~shall be~~ is 10 minutes for the overland flow component into the stormwater system in fully developed areas. Time of concentration with large areas of land which will remain undeveloped ~~shall be~~ is determined by one of the above mentioned methods. *(REVISE? TBD 2025)*

.5 Rational Method:

(a) Application:

The use of the Rational Method for final design calculations is to be limited to the design of minor or major systems where detention storage and/or other runoff controls do not exist or are not required, and where the catchment is not larger than 20 hectares.

(b) Formula:

$$Q = C\ I\ A\ X\ 2.78$$

Where:
Q = storm runoff flow in litres/second
C = the coefficient to runoff
I = the rainfall intensity in mm per hour
A = contributing catchment area in hectares

(c) Coefficient of Runoff (C):

The choice of coefficient of runoff "C" ~~shall be~~ is based on ground slope, type of ground or surface cover, soil conditions, size of drainage area and the ~~expected ultimate~~ land use of the properties within the drainage catchment areas. The following table provides a range of coefficient for land use conditions: ~~Selection of the runoff coefficient for existing areas shall include a review of the orthographic photo to determine the impervious area.~~ ***(REVISE? TBD 2025)***

~~The choice of the coefficient shall be guided by the expected characteristics of the proposed development and fall within the following ranges for new development:~~

TYPE OF DEVELOPMENT	COEFFICIENT OF RUNOFF
Industrial	0.80 to 1.00
Commercial Business Areas, Multi-~~Family~~ Unit Residential ***(REVISE? TBD 2025)***	0.65 to 0.90
Single ~~Family~~ Residential and Low Density Multi-~~Family~~ Unit Residential ***(REVISE? TBD 2025)***	0.50 to 0.80
Rural Areas, Parks, Golf Courses	0.25 to 0.55
Dense Forest (see Note 1) ***(REVISE? TBD 2025)***	0.05 to 0.15
Light Forest (see Note 1) ***(REVISE? TBD 2025)***	0.15 to 0.25
Note 1. Department of Fisheries and Oceans and the Ministry of Environment, Land Development. (1993). Guidelines for the Protection of Aquatic Habitat. Table 8-1 ***(REVISE? TBD 2025)***	

(d) Presentation:
Where the rational formula is used~~, two copies of~~ for the storm sewer design calculations, in a format in accordance with Appendix H2, Stormwater Management Flow Analysis – Calculation Sheet ~~shall be~~ must submitted. ***(REVISE? TBD 2025)***

.6 Computer Simulation Methodology – Hydrograph-Based: ***(REVISE? TBD 2025)***

(a) Application:
For all stormwater calculations which include detention storage or other runoff controls and/or catchment greater than 20 hectares, a computer simulation model ~~shall~~ must be used. The model results should be calibrated and must be used for design and sizing of all pipes and storage facilities. ***(REVISE? TBD 2025)***

(b) Stormwater Modeling Software:
The City ~~of Nanaimo~~ supports the use of any interface that supports the SWMM modeling engine for the creation of hydrologic and hydraulic computer models. The use of the other types of software requires the prior approval of the City Engineer. ***(REVISE? TBD 2025)***

(c) Hydrology Methods:
There are several hydrology methods available in modeling software. Infiltration methods such as Green Ampt or Horton's are encouraged for modeling urban watersheds; however, these methods require site specific information regarding the geotechnical conditions.

(d) Storage Analysis:
Comprehensive analysis of the storage should be completed by the ~~Design Engineer~~ Qualified Registered Professional including a review of all storm durations up to the 24 hour event to determine the governing storm duration. In the future, the City may require continuous modeling be completed for storage analysis. ***(REVISE? TBD 2025)***

(e) Procedure:
An analysis of the post-development conditions is to be done at key points of the major and minor system for various durations of the design return period storms. This process will identify the most critical event to be used when designing the system. It should be noted that the storm duration which generates a critical event for the conveyance system may be different than the storm duration which generates a critical event for the storage facility.

(f) Presentation:
A report is required to document the design rationale used to develop the model. The report is to be included in the Stormwater Management Plan. At a minimum, the report ~~shall include~~ includes the following: ***(REVISE? TBD 2025)***

(i) An executive summary.

(ii) Type and version of the modeling software used.

(iii) All hydraulic and hydrologic parameters and assumptions.

(iv) Design storms used and/or continuous modeling data used.

(v) Summary of peak flows for each element of the system for both the major system and minor ~~storm~~ system in a table. ***(REVISE? TBD 2025)***

(vi) ~~Summary hydrograph(s) of any~~ At storage or flow control facilities, the summary incoming and outgoing hydrographs and the stage discharge curve. ***(REVISE? TBD 2025)***

(vii) Post- development hydrograph at the point where the flows leave the system being modeled and ~~at the point~~ where the flows leave the proposed development.

(viii) Pre- development major system and minor ~~storm~~ system calculations. ***(REVISE? TBD 2025)***

(ix) Comparison of pre- and post- development flows and hydrographs at the point where the flows leave the proposed development.

(x) Recommendations.

(xi) Tables showing existing and future pipe information.

(xii) Drawings showing hydraulic grade line (HGL) for design scenarios. ***(REVISE? TBD 2025)***

(xiii) A digital copy of the model files.

.7 Runoff Rate Control ~~Peak Flow and Runoff Volume Control~~: ***(REVISE? TBD 2025)***

(a) Design Rainfall Events (AEPs) Inputs: ***(NEW? TBD 2025)***

(i) 1:2 AEP (50%) and 1:5 AEP (20%) for flow control device design (Section 7.03.3 [→]) ***(NEW? TBD 2025)***

(ii) 1:100 AEP (1%) for overflow sizing ***(NEW? TBD 2025)***

(b) Methodology is to compare pre-development and post-development hydrographs to evaluate: ***(NEW? TBD 2025)***

(i) Peak flow rate ***(NEW? TBD 2025)***

(ii) Duration of peak flow ***(NEW? TBD 2025)***

(iii) Additional runoff volume ***(NEW? TBD 2025)***

(c) Criteria ***(NEW? TBD 2025)***

(i) Post-development peak flow must not exceed pre-development peak flow ***(NEW? TBD 2025)***

(ii) Peak flow duration must be representative of pre-development conditions ***(NEW? TBD 2025)***

(iii) Additional runoff volume (difference between hydrographs) must be managed ***(NEW? TBD 2025)***

(d) Outputs / Solutions ***(NEW? TBD 2025)***

(i) Storage facilities (Section 7.12 [→]) ***(NEW? TBD 2025)***

(ii) Rainwater BMPs (Section 7.13 [→]) ***(NEW? TBD 2025)***

(a) Developments Not Upstream of a Creek, River or Wetland:

For new developments and re-developments that do not drain into a creek, river or wetland system, but discharge directly via pipes, ditches, or overland flow paths into the ocean, storm water management facilities may not be required for runoff volume controls. However, the Developer will be responsible for any downstream upgrades to the major or minor system extending to the nearest trunk sewer or outlet which is required as a result of the increased runoff from the development. Alternatively, the Developer may install hydraulic controls and provide storage which ensure the peak flow from the development site is maintained to pre-development conditions for the minor and major systems. ***(REVISED MAY 2020)***

(b) Developments Upstream of a Creek, River, or Wetland:

For new developments and re-developments that eventually discharge into a creek, river or wetland system, runoff volume controls are required to prevent erosion and shall recognize both peak flow rates and the duration of the peak flows. The objective is to limit both the magnitude and duration of post-development peak flows to that of the pre-development conditions, as much as possible. ***(REVISED MAY 2020)***

Post-Development Peak Flow and Runoff Volumes Shall be Controlled in Two Ways:

(i) Post-development 2 year and 5 year peak flows shall be controlled to 2 year and 5 year pre-development levels such that the post-development hydrographs shall emulate the pre-development hydrographs for both the 2 year and 5 year return periods. It is understood that it can be challenging to emulate existing conditions; at a minimum, the post-development hydrograph shall show that:

(a) The peak flow does not exceed the pre-development peak flow.
(b) The duration of the peak flow does not exceed the duration of the pre-development peak flow.

(i) 6 month, 24 hour Storm Retained or Infiltrated Onsite:

Approximately 90% of all rainfall in BC are small rainfall events which, on most undeveloped sites, are primarily infiltrated into the soil. By incorporating rainwater best management practices, including rainwater best management practices, the majority of this rainfall can be infiltrated into the ground or retained for slow release. The

~~rainwater management target is 6 month, 24 hour post-development runoff volume. Research has indicated that this is consistent with 50% of the 2 year, 24 hour rainfall event volume. For Nanaimo, this equates to approximately 31 mm of rainfall depth.~~

~~(ii) Care should be taken to ensure that watercourse base flows are not adversely affected by stormwater runoff volume and rate controls, or other hydrologic changes.~~ ~~***(REVISED MAY 2020)***~~

~~(c) Pre-development is defined as a natural state; in most cases, a forested area should be assumed. However, if it can be shown that the land's natural state was something other than forested, such as a meadow or rocky outcrop, it will be acceptable. Structures, parking areas, and manmade surfaces are not considered to be pre-development.~~

~~(d) The above requirements for development, to ensure runoff emulates the existing natural conditions, are necessary for watershed health protections. However, the City does recognize that these targets may be challenging to achieve on some sites. Subject to the approval of the City Engineer, the City may accept Stormwater Management Plans which do not meet the targets outlined above, if the Design Engineer is able to provide evidence that:~~ ~~***(REVISED MAY 2020)***~~

~~(i) The development site has characteristics which make it challenging to meet the targets outlined above.~~
~~(ii) The intent of the above requirements has been achieved.~~

~~.8 Water Quality Treatment Event:~~

~~(a) The Water Quality Design The Water Quality Design Storm is considered the 6 month, 24 hour (50% of the 2 year, 24 hour) event. This event captures approximately 90% of the average annual runoff. Larger events should be bypassed around water quality treatment facilities to minimize suspension and washing through sediments.~~

7.04 MINOR SYSTEM

.1 ~~Definition~~ Components and Conveyance: ***(REVISE? TBD 2025)***

(a) The minor system ~~shall~~ must be designed to convey the runoff from the 1:5 AEP (20% AEP) rainfall, as per Section 7.03.3 [→]~~1:5 year design storm~~. The minor system includes all drainage works that convey, detain, divert, and intercept the ~~minor design~~ runoff including pipes, catch basins, manholes, swales, ditches, driveway culverts ~~etc.,~~ and other appurtenances ~~designed to ultimately discharge into a major system~~. ***(REVISE? TBD 2025)***

.2 Location:

(a) The minor system ~~shall~~ is ~~normally be~~ typically located in road right-of-way ~~for ease of access to repair or maintain the system~~. ***(REVISE? TBD 2025)***

(b) Where the minor system is located in private property, the ~~flow route~~ utility corridor ~~shall~~ must be preserved by statutory right-of-way and/or restrictive covenants ~~and/or statutory right-of-way~~ for ease of access to repair or maintain the system. ***(REVISE? TBD 2025)***

~~.3 Trunk Storm Sewers:~~

~~Storm sewers 600 mm in diameter or larger, or servicing an urban drainage basin in excess of 20 hectares, will be considered trunk sewers.~~

.3 Surcharge and Hydraulic Grade Line (HGL): ***(NEW? TBD 2025)***

(a) Storm sewer pipes must be designed so that hydraulic grade line (HGL) is within the pipe during a 20% AEP rainfall event. The design must account for the HGL elevation at the connection into the existing storm system. ***(REVISE? TBD 2025)*** ***(NEW? TBD 2025)***

(b) Driveway culverts are designed initially assuming inlet control and sized with the headwater below the crown of the pipe and otherwise meet the criteria in Section 7.07 [→]. ***(NEW? TBD 2025)***

(c) Ditches may function as part of both the minor and major drainage systems and must be evaluated under both rainfall runoff conditions. A key design constraint is ensuring proper hydraulic interaction with culverts and service connections. Design for the 20% AEP rainfall does not permit surcharge in these connected systems. Ditches are designed as open channels and meet the design parameters in Section 7.08 [→]. The hydraulic grade line (HGL) corresponds to the water surface elevation during the design storm and should be contained within the channel. Design must also account for clogging risk by providing adequate inlet capacity, maintenance access, and, where applicable, redundancy to prevent localized flooding. ***(NEW? TBD 2025)***

(d) Swales may function as part of both the minor and major drainage systems and be evaluated under both rainfall runoff conditions. A primary performance target is containing and directing overland flow paths. Swales are designed as open channels and meet the minimum design parameters in Section 7.09 [→]. The hydraulic grade line (HGL) corresponding to the water surface elevation which should be contained within the channel. ***(NEW? TBD 2025)***

(e) Surcharging of storm sewer pipes and driveway culverts is permitted during a rainfall event greater than 20% to 1% AEP rainfall event, provided that the design complies with the performance requirements of the major system outlined in Section 7.05 [→]. ***(NEW? TBD 2025)***

(f) Non-conformance requires an assessment and approval by the City Engineer, as per Section 7.01.5(c) [→]. ***(NEW? TBD 2025)***

7.05 MAJOR SYSTEM

.1 ~~Definition~~ Components and Conveyance: ***(REVISE? TBD 2025)***

(a) The major system ~~shall~~ must be designed to safely convey the runoff from the 1:100 AEP (1% AEP) rainfall, as per Section 7.03.3 [→] ~~1:100 year design storm~~. Sources of runoff include outflows from the minor system, overland flows, storage facilities, lakes, wetlands and watercourses. The major system includes all drainage work~~s that convey, detain, divert and intercept the major design runoff~~ , but is not limited to ~~including piping, manholes,~~ road crossing culverts, swales, ditches, roadways, overland flow paths, and watercourses ~~etc., and other appurtenances designed to ultimately discharge into a natural watercourse~~. ***(REVISE? TBD 2025)***

.2 Location of Overland Flow Paths: ***(REVISE? TBD 2025)***

(a) Generally, the major system ~~shall be~~ overland flow paths ~~where the design flow can be~~ are conveyed in public road right-of-way and adequate watercourses. Where adequate overland ~~major system~~ flow paths cannot be established, pipes~~,~~ and ditch culverts of the minor system may be ~~enlarged to accommodate~~ increased to convey the major flows, subject to approval of the City Engineer. If the runoff from major flows is conveyed in a piped system, an alternate overland flow path must be provided to ensure redundancy in the case of blockages or rainfall events that exceed the system capacity. ***(REVISE? TBD 2025)***

(b) When the major flow ~~is~~ may be conveyed ~~accommodated~~ by a public ~~street~~ roadway, the street ~~shall~~ must be designed to provide sufficient hydraulic capacity to handle the major flow. Planning ~~the~~ for ~~major drainage system shall be done simultaneously with~~ street layout, ~~and~~ roadway ~~gradient~~ grades and the drainage system must be coordinated to ensure the street functions as part of the major ~~planning to define the function of the streets as a part of the storm~~ drainage system. ***(REVISE? TBD 2025)***

(c) When ~~major flow is~~ an overland flow path crosses ~~through~~ private property, the flow route ~~shall~~ must be protected and preserved by restrictive covenants and/or statutory right-of-way ~~for ease of~~ to ensure access to repair or maintain the system. ***(REVISE? TBD 2025)***

(d) Overland flow paths through private property ~~shall~~ must be designed to minimize property damage and endangerment to public safety and have a suitable erosion protection. ***(REVISE? TBD 2025)***

(e) If no safe overland flow path exists, the Professional of Record must notify the City Engineer and provide a risk assessment and recommendations as per Section 7.01.5(c) [→]. ***(REVISE? TBD 2025)*** ~~the storm sewer system must be designed to be the major system and sized to convey the major design storm to the outlet~~.

(f) Where surcharge from the minor system results in major system flow on the roadway, ~~the major flow is accommodated through the storm sewer system,~~ additional catch basins may be required to ensure the flow can be recaptured by the minor system, as per Section 7.06.12 [→]. ~~The capability of the catch basins to accept the major flow is to be reviewed and confirmed .~~ ***(REVISE? TBD 2025)***

.3 Discharge to Existing Watercourses:

(a) The discharge to an existing watercourse ~~shall~~ must be designed in a way that protects the watercourse from erosion, as per Section 7.02 [→]. Typically, ~~F~~flow velocities exceeding 1.5 m/s require an energy dissipater to reduce flow velocity to an acceptable rate. For design refer to Section 7.11 [→], and for specifications refer to Section 7.33 [→]. ***(REVISE? TBD 2025)***

~~(b) When improvements are required to a natural watercourse, design concepts which preserve and enhance the natural characteristics of the watercourse shall be employed.~~

.4 Flooding:

(a) The major system routing may allow ~~for~~ minor inconvenience, such as localized flooding of streets and green spaces (parks, boulevard, landscaped areas, naturally vegetated areas, etc.). However, ~~but no~~ major damage, such as damage to dwellings, significant erosion ~~or~~ of private property, or damage to public facilities ~~shall~~ must not occur as a result ~~from~~ of the major storm. The Professional of Record must document non-conforming conditions as per Section 7.01.5(c) [→]. ***(REVISE? TBD 2025)*** ~~Any allowances for minor inconvenience flooding shall be mentioned in the Stormwater Management Plan and shall be approved by the City Engineer.~~

(b) Full width cross-sections ~~shall~~ are to be provided showing the depth of the major flow along public streets, private property, ditches, and watercourses at typical and critical areas of the overland flow path. ***(REVISE? TBD 2025)***

(c) The major system ~~shall~~ must be designed such that all habitable portions of buildings including basements are a minimum 0.3 m above the major flow hydraulic grade line. If buildings or service connections are found to be non-conforming, the Professional of Record must notify the City Engineer and may be required to provide a risk assessment and recommendations as per Section 7.01.5(c) [→]. ~~No building shall have the bottom of its foundation less than 0.3 m above the maximum high water elevation of any storm water stormwater storage facility. In circumstances where lower building elevations are desired, the minor system may be enlarged to accommodate the major flow.~~ ***(REVISE? TBD 2025)***

(d) Existing buildings constructed to a previous standard may not have this protection from the major system. As a result, if a lot is redeveloped, the new minimum habitable floor elevation on that lot may not be the same as previous minimum habitable floor elevation.

(e) The grading for new developments ~~shall~~ must ensure that the slope of the ground around structures has positive drainage away from structures.

.5 Roadway:

(a) Where the ~~road~~ roadway functions as part of the major system, ~~is used to accommodate major flow,~~ the following criteria must be considered: ***(REVISE? TBD 2025)***

(i) For local streets, the maximum depth at the crown of the ~~road~~ roadway is to be ~~50mm.~~50 mm. ***(REVISE? TBD 2025)***

(ii) For mobility arterial, mobility collector, urban arterial and urban collector streets, ~~neighborhood collectors, minor collectors, major collectors and arterial roads ,~~ a minimum of 3.0 m width of the ~~road shall~~ roadway must be free from flooding. ***(REVISE? TBD 2025)***

(iii) Care should be taken when designing intersections of ~~roads~~ streets which are used to convey the major storm so that flows can pass over the cross street. ***(REVISE? TBD 2025)***

(iv) Care should be taken when designing the grading at ~~road~~ roadway curves and at locations where major flow path turns at intersections or at tee intersections. ***(REVISE? TBD 2025)***

(v) Cul-de-sacs which are down slope from the street will not be accepted as part of the major system, unless approved by the City Engineer.

(vi) Care should be taken when designing driveways which are down~~hill~~ slope from streets which form part of the major system. ~~Type 2 driveway letdowns shall be avoided as shown in Standard Drawing No. CS-5A.~~ ***(REVISE? TBD 2025)***

~~(b) When the street forms part of the major system, it shall be crowned and have curb and gutter capable of handling the major flows.~~

~~(c)~~(b) The hydraulic capacity of a street section to convey water ~~shall~~ can be calculated by the Manning Equation, subject to the above conditions for major flows in a roadway. ***(REVISE? TBD 2025)***

.6 Surcharge and 1:100 AEP Hydraulic Grade Line ($HGL_{~~100~~}$): ***(NEW? TBD 2025)***

(a) Road crossing culverts are to be designed and sized so that the headwater remains below the road elevation for runoff from a 1:100 AEP (1% AEP) rainfall event. Where the headwater exceeds the diameter of the pipe, the surcharged condition must meet the criteria in Section 7.05.4. Culverts must also meet the criteria in Section 7.07 [→]. ***(NEW? TBD 2025)***

(b) Ditches function as part of the major drainage systems. A key design constraint is ensuring proper hydraulic interaction with culverts and service connections under major system flow conditions. Ditches are designed as open channels and must meet the design parameters in Section 7.08 [→]. The HGL will likely submerge minor system components such as driveway culverts; this is acceptable provided major system criteria are satisfied. Maintain a freeboard of 0.3 m for structures described in Section 7.05.5. Non-conformance with the design criteria must be reported to the City Engineer in accordance with Section 7.01.5(c) [→]. ***(NEW? TBD 2025)***

(c) Where stormwater storage facilities, culverts, or ditches are hydraulically connected to building service connections or other sensitive infrastructure, the risk assessment and professional recommendations, as per Section 7.01.5(c) [→], may include backwater prevention measures, such as backwater valves, which are subject to approval by the City Engineer. ***(NEW? TBD 2025)***

(d) Swales function as part of the major drainage systems. A primary performance target is containing and directing overland flow paths. Swales are designed as open channels and meet the minimum design parameters in Section 7.09 [→]. The hydraulic grade line (HGL) corresponding to the water surface elevation should be contained within the channel. Swales typically are not hydraulically connected to service connections; however, this must be verified by the Professional of Record. ***(NEW? TBD 2025)***

(e) Where the roadway functions as part of the major system and conveys major flows, the hydraulic grade line (HGL) must be evaluated against roadway criteria in Section 7.05.5 [→] to ensure compliance with allowable depths and widths. ***(NEW? TBD 2025)***

(f) Surcharging of storm sewer pipes and driveway culverts is permitted during a rainfall event where the hydraulic grade line (HGL) exceeds the minor system capacity for events greater than the 20% AEP up to the 1% AEP rainfall event. ***(NEW? TBD 2025)***

(g) Non-conformance requires an assessment and approval by the City Engineer, as per Section 7.01.5(c) [→]. ***(NEW? TBD 2025)***

7.06 PIPE DESIGN DETAILS

.1 Grades and Velocity of Stormwater in Pipes and Service Connections:

(a) The minimum design velocity for pipes ~~shall~~ must be 1.0 m/s. ***(REVISE? TBD 2025)***

(b) Where the pipe discharge velocity ~~of the design flow~~ exceeds 1.5 m/s into an open ditch or watercourse, provision ~~shall~~ must be made for the installation of an energy dissipater to reduce flow velocity to the acceptable rate. For specifications, refer to Section 7.33 [→]. ***(REVISE? TBD 2025)***

(c) There are no maximum allowable velocities; however, where velocity exceeds 3.0 m/s or grades exceed 10%, the need for scour protection ~~shall~~ must be examined and anchor blocks ~~shall be~~ are required as per Standard Drawing No. T-8 [] ~~.~~and Standard Drawing No. T-8A []. ***(REVISE? TBD 2025)***

(d) All ~~100mm~~ 100 mm diameter service connections ~~shall~~ are to have a minimum grade of 2%.

.2 Pipe and Service Connection Sizes:

(a) Minimum pipe diameters ~~shall~~ must be 250 mm. In residential areas, 200 mm diameter pipe may be approved by the City Engineer ~~in~~ for the final section of a lateral sewer ~~providing the pipe has~~ provided it meets the required capacity and future extension is not possible is due to ~~in the future is precluded by~~ physical barriers or there is an existing alternate drainage connection for ~~pick-up of drainage from~~ adjacent areas.~~(REVISE? TBD 2025)~~

(b) Unless otherwise approved by the City Engineer, downstream pipe diameter ~~shall~~ are to be greater than or equal to upstream pipe diameter. ***(REVISE? TBD 2025)***

(c) Residential service connections ~~shall be a minimum~~ are a 100 mm diameter, or larger as required by site conditions. ~~except service connections servicing lawn basins shall be are a minimum 150 mm diameter.~~ ***(REVISE? TBD 2025)***

(d) Commercial and Industrial service connections ~~shall be a minimum~~ are a 150 mm diameter, or larger as required by site conditions. ***(REVISE? TBD 2025)***

(e) Service connections servicing lawn basins are a150 mm diameter, or larger as required by site conditions. ***(REVISE? TBD 2025)***

.3 Selection of Pipe Material and Class:

(a) The ~~Design Engineer~~ Professional of Record ~~shall~~ will consider earth and live loading, soil conditions, and design life of the installation for determining pipe material and class. Pipe materials and brands ~~shall~~ must be per the City's ~~of Nanaimo's~~ Approved Products List []. ***(REVISE? TBD 2025)***

.4 Pipe Friction Factors:

(a) Storm sewers ~~shall~~ are to be designed using the Manning Formula. The minimum 'n' value ~~shall be~~ is 0.013 for all approved pipes. ***(REVISE? TBD 2025)***

.5 Pipe and Service Connection Depths:

(a) Minimum Cover:

(i) Storm sewers are to ~~shall~~ have 1.5 m of cover in ~~road~~ right-of-way. ***(REVISE? TBD 2025)***

(ii) Storm sewers are to ~~shall~~ have 1.0 m of cover in untravelled areas.

(iii) Service connections are to ~~shall~~ have 0.75 m of cover.

(iv) Where minimum cover cannot be provided, an explanation of the reasons and pipe loading calculations ~~shall~~ must be submitted with the proposed method of pipe protection to the City Engineer for approval. ***(REVISE? TBD 2025)***

(b) Where practical, service connections ~~shall~~ must be deep enough for ~~to accommodate by~~ gravity flow from the lowest elevation of each lot serviced. Where it is not practical, or where servicing the low elevation of the lots would require utilities in private lands, the development ~~shall~~ must be graded ~~in such a way which~~ to prevent~~s~~ overland flow from impacting neighboring structures. ***(REVISE? TBD 2025)***

(c) ~~In addition, all~~All existing foundation drains ~~shall~~ must be ~~accommodated are to be~~ connected. For vacant lots, service connections ~~shall also~~ must be deep enough to ~~accommodate by~~ allow gravity flow from foundation drains for future building(s) constructed to the minimum basement floor elevation, as determined by the ~~Design Engineer~~ Professional of Record. ***(REVISE? TBD 2025)***

(d) Storm ~~Sewer~~ sewers ~~mains shall~~ must be deep enough so that ~~all~~ service connections ~~accommodating~~ for surface and foundation drainage from all lots in the upstream drainage ~~basin~~ catchment can ~~be drained~~ drain to the storm sewer system by gravity. ***(REVISE? TBD 2025)***

.6 Curved Pipes:

(a) Horizontal curves on sewers require approval from the City Engineer. ~~***(REVISED MAY 2020)***~~

(b) Horizontal curves will be considered where the configuration of the property lines requires curvature for a constant offset and where the design velocity exceeds 1 m/s. ~~***(REVISED MAY 2020)***~~

(c) Vertical curves may be approved by the City Engineer where excessive depths or rock cuts are to be avoided or where energy dissipation is required.

(d) Curvature will be achieved through joint deflection only, bending of the pipe barrel will not be permitted. Joint deflections ~~shall~~ must not exceed 50% of the manufacturer's maximum recommended joint deflection. Radius of curvature ~~shall~~ must be uniform throughout the curves. ~~***(REVISED MAY 2020)***~~

(e) Only one vertical or horizontal curve is permitted between manholes.

.7 Location of Storm Sewer Mains and Service Connections:

(a) Storm sewer mains offsets from all watermains must be in accordance with Section 5.10.3 or apply protective measures as per Section 5.10.4 and Standard Drawing T-5 []. ~~shall be located not less than 3.0 m horizontally and 0.45 m vertically from all watermains unless otherwise approved by the Provincial Department of Health. Normal~~ Typical storm sewer main offsets are shown in the standard drawings for roadways in Section 8.0. ***(REVISE? TBD 2025)***

(b) If there is a significant elevation difference between the lots on opposite sides of the street, if possible, storm sewers ~~shall~~ are to be located on the low side of the street where both sides are served by the sewer. If only the high side of the street is serviced by the storm sewer, storm sewers ~~shall~~ are to be located on the high side of the street.

(c) All lots ~~shall~~ must be provided with a storm sewer service connection, unless otherwise approved by the City Engineer. Service connections ~~shall~~ are to be located to the offsets as shown on Standard Drawing No. T-7 [].

(d) Storm sewer mains may be installed in a common trench with sanitary sewers provided the minimum outside pipe separation is 300 mm.

.8 Utilities in Private Lands:

(a) The following ~~shall~~ must be considered in the design of utilities crossing private lands:

(i) ~~(a)~~ The design of utilities ~~shall~~ must avoid crossing private lands. Utilities in private lands ~~shall~~ require the approval of the City Engineer. Approval will only be granted where it is shown that all other options have been exhausted.

(ii) ~~(b)~~ Utilities following property boundaries across private lands ~~shall~~ must ~~generally~~ be offset a minimum 2.0 m from the property boundary. ***(REVISE? TBD 2025)***

(iii) ~~(c)~~ Appurtenances such as manholes, valves, etc., ~~shall~~ must be located entirely on one property, they ~~shall~~ cannot be located on property boundaries.

(iv) ~~(d)~~ Utilities ~~shall~~ cannot cross private parcels in such a manner that they render the property unusable. Special consideration must be given to ensure the location of the utility crossing minimizes the limitations on the future use of the property.

(b) ~~(e)~~ For a sample statutory right-of-way condition sheet, refer to Appendix C, Standard Drawing No. RW-2.

(c) ~~(f)~~ For an Easement Release and Inspection Form Following the Construction of the Utility, refer to Appendix C.

(d) ~~(g)~~ For ~~a~~ minimum widths of statutory right-of-way and working widths, refer to Appendix D.

.9 Service Connection Lengths:

(a) The maximum length of a storm sewer service connection measured horizontally between the storm sewer and the property line ~~shall be~~ is ~~30~~ 15 m. Storm sewer services longer than ~~30~~ 15 m ~~shall~~ require approval by the City Engineer. The service alignment will be perpendicular to the main. All inspection assemblies required for service connections in excess of ~~30~~ 15 m in length ~~shall~~ must be shown on the design drawings. ***(REVISE? TBD 2025)***

(b) For industrial, commercial, and multi-~~family~~ unit residential servicing, and/or where oil interceptors are required, manholes ~~shall~~ must be provided where the service connects with the main or at the property line regardless of the size of the service. *(REVISE? TBD 2025)*

(c) All services 250 mm in diameter or larger require manholes where the service connects with the main or at the property line. In the case of closely spaced services, ~~ever~~ every other service manhole is to be located on the service line close to the property line. *(REVISE? TBD 2025)*

.10 Number of Service Connections per Lot:

(a) Each lot ~~shall~~ must be serviced by one only service connection for storm drainage. Where the size of the lot or the topography makes one service connection impractical, additional service connections may be allowed subject to the approval of the City Engineer.

.11 Manholes:

(a) Distances between manholes ~~shall~~ must not exceed 120 m unless otherwise approved by the City Engineer. For pipes larger than 600 mm in diameter, manhole spacing may be increased to 180 m.

(b) Manholes ~~shall~~ must be located at grade and alignment changes, at lateral size changes, at the upstream end of all lateral sewers, and either at the junctions of all lateral sewers with the main or at property line for services 250 mm and larger.

(c) Cleanouts may only be used, if approved by the City Engineer, at the upstream end of lateral sewers in a temporary situation during a phased development where the future phase of the development will remove the cleanout.

(d) Outside drops ~~shall~~ must be provided for pipe sizes 375 mm or less where the difference in elevation between incoming and outgoing sewers exceed 600 mm. Drops less than 600 mm in elevation ~~shall~~ must be accommodated by manhole benching. Precast manhole barrels ~~shall~~ must be sized according to normal inside pipe diameter and depth as detailed below:

Minimum		
Pipe Size (Normal)	**Depth of Manhole (Top of Cover to ~~Inv.~~Invert)**	**Barrel Size (Inside Dia.)**
150 – 375 mm	0 – 5.9 m	1050 mm
150 – 375 mm	6.0 – 9.0 m	1200 mm
150 – 600 mm	9.0 m or greater	1500 mm
400 – 600 mm	0.0 – 8.9 m	1200 mm
675 – 750 mm	All Depths	1350 mm
900 – 1050 mm	All Depths	1500 mm

Minimum barrel sizes ~~shall~~ are to be increased for manholes within multiple large pipes.

(e) Where cast in place manholes are proposed, all design and construction details, require approval from ~~shall be submitted to~~ the City Engineer ~~for approval~~. ***(REVISE? TBD 2025)***

(f) Manholes ~~shall~~ must be designed to incorporate a minimum pipe invert elevation difference or at least 25 mm, in addition to the normal grade of the storm sewer, wherever a horizontal deflection exceeding 45 degrees occurs. Smaller pipe sizes ~~shall~~ are to be crown to crown with larger pipe sizes when entering manholes. For super critical flows or large pipes (>600 mm diameter), the hydraulic losses through manholes ~~shall~~ must be calculated and the corresponding drop in inverts across the manhole ~~shall~~ must be included in the design where appropriate.

(g) Manholes ~~shall~~ are to be located to avoid any conflict with curb and gutter or sidewalks.

(h) A watertight manhole frame and cover ~~shall be~~ are required for all sewer manholes where flooding can occur or in areas subject to vandalism (i.e. parks, undeveloped right-of-ways, etc.).

.12 Catch Basins:

(a) Catch basins ~~shall~~ are to be provided at regular intervals along streets, at street intersections, and at all low points in the street.

(b) Catch basins located in streets ~~shall~~ must be spaced to collect a maximum of 450 m² of pavement drainage where grades do not exceed 5%. On grades over 5% the maximum area collected ~~shall~~ can be reduced to 300 m².

(c) Double catch basins are required at all low points in ~~roads~~ roadways and downhill cul-de-sacs except where located along non-mountable curb which provides for installation of a single curb inlet, refer to the curb inlet standard drawing. ~~Location requirements for the different catch basin types shall conform to the following:~~ ***(REVISE? TBD 2025)***

(d) Location requirements for the different catch basin types ~~shall~~ must conform to the following: ***(REVISE? TBD 2025)***

(i) Curb inlet catch basins ~~shall~~are to be used in locations along non-mountable curbed ~~roads~~ streets at all low points or in other areas where additional inlet capacity is required. ***(REVISE? TBD 2025)***

(ii) Boulevard catch basins ~~shall~~ are to be used in boulevards and easements outside of the paved ~~road.~~roadway. ***(REVISE? TBD 2025)***

(iii) Lawn basins ~~shall~~ may be used for locations on private property where~~, at the discretion of the City Engineer,~~ drainage is required to be contained and prevented from flowing onto other properties~~.~~, unless otherwise approved by the City Engineer. ***(REVISE? TBD 2025)***

(iv) Shallow catch basins ~~shall~~ may be used in locations where it is not possible to provide a catch basin with a stump.

(e) Where the street roadway functions as part of the major system, catch basins must be provided in sufficient number and at appropriate locations to ensure that major storm runoff from the overland flow path can enter the storm system. The inlet capacity of the catch basins is to be reviewed by the Professional of Record and approved by the City Engineer. ***(NEW? TBD 2025)***

~~(d)~~(f) Catch Basin Leads:

(i) Single basin leads ~~shall~~ have a minimum diameter of 200 mm.

(ii) Double basin leads ~~shall~~ have a minimum diameter of 250 mm.

(iii) Lawn basin leads ~~shall~~ have a minimum diameter of 150 mm.

(iv) Leads over 30 m ~~shall~~ have a minimum diameter of 250 mm.

(v) Double catch basin leads ~~shall~~ must be ~~are~~ joined using a wye fitting before connecting to the main ~~wyed together. Basin shall not be directly connected.~~ ***(REVISE? TBD 2025)***

(vi) The desired grade for a catch basin leads is 2%. Where it is impractical to obtain 2%, a catch basin lead with a 1% grade is acceptable.

.13 Surcharge and Hydraulic Grade Line (HGL): ***(REVISE? TBD 2025)***

(a) Compliance limits for the Hydraulic Grade Line (HGL) are specified in Section 7.04 – Minor System [→], while HGL, surcharge, and flooding criteria are outlined in Section 7.05 – Major System [→]. ~~In areas of new construction, storm sewer pipes shall be designed so that the minor storm hydraulic grade line is within the pipe, and the hydraulic grade line meets the requirements set out in Section 7.05 – Major System.~~***(REVISE? TBD 2025)***

~~(b) When necessary, and subject to approval by the City Engineer, storm sewers may be permitted to temporarily discharge into existing ditches with submerged outlets, to allow future extension of the sewer at an adequate depth. In these cases, a hydraulic gradient must be calculated and shown on the plan to ensure that no danger of flooding will result.~~

.14 Trench Dams:

(a) Where there is any possibility of groundwater concentration to other utility trenches, storm sewer connections and trench dams ~~shall be provided~~ are as per Section 4.18 – Trench Dams. ***(REVISE? TBD 2025)***

.15 Subsurface Drains:

(a) Subsurface drains will be used where a geotechnical evaluation shows a high groundwater table or an area which significant cuts into the existing ground may create the potential for a saturated condition. Subsurface drains located adjacent to ~~roads~~ roadways will be extended well below the ~~road~~ roadway base. The material for subsurface drains will be clear round drain rock in an envelope of approved filter material. A minimum 150 mm PVC perforated pipe will be placed at the bottom of the trench. ***(REVISE? TBD 2025)***

7.07 CULVERTS

.1 General:

(a) Generally, culverts ~~shall~~ must be sized to suit the drainage area and ~~shall~~ cannot be smaller than upstream culverts without prior approval of the City Engineer.

(b) Inlet and outlet structures ~~shall~~ must be appropriately designed with energy dissipation, scour protection, erosion control and overflow protection as needed. For additional design criteria, Section 7.11 - Inlet and Outlet Structures [→]. For specifications, refer to Section 7.32 [→] and Section 7.33 [→]. ***(REVISE? TBD 2025)***

.2 Road Crossing Culverts: ***(REVISE? TBD 2025)***

(a) Road crossing culverts ~~shall be designed to accommodate the~~ are part of the minor system and major system, refer to Section 7.04 [→] and Section 7.05 [→]. ~~The culvert inlet may surcharge under the major storm. The surcharge at the inlet shall meet the flooding requirements of the major system as specified in Section 7.05 - Major System [→].~~ ***(REVISE? TBD 2025)***

(b) Road crossing culverts ~~shall~~ must be minimum 450 mm diameter regardless of hydraulic capacity. ***(REVISE? TBD 2025)***

(c) Road crossing culverts ~~of~~ for watercourses ~~which are, or could be~~ that are, or may reasonably be expected to become, fish bearing, ~~shall be~~ are designed to provide fish passage. Designs are to incorporate baffles and embedded fish gravel substrate (see Section 9.0) and, where practicable, utilize open-bottom culverts as the preferred option. ~~where possible. Open bottom culverts are preferable~~. ***(REVISE? TBD 2025)***

.3 Driveway Culverts:

(a) Driveway culverts ~~shall be~~ are designed ~~to accommodate the~~ as part of the minor ~~storm~~ system as per Section 7.04 [→]. ~~with the headwater not above the crown of the pipe.~~ ***(REVISE? TBD 2025)***

(b) Driveway culverts ~~shall~~ must be minimum 300 mm diameter regardless of hydraulic capacity. ***(REVISE? TBD 2025)***

7.08 DITCHES (WITHIN ROAD RIGHT-OF-WAY)

.1 Ditches ~~shall be~~ are used in road allowances right-of-way where there is no curb and gutter to direct minor flows as per Section 7.04 [→] and major flows as per Section 7.05 [→] ~~flows towards watercourses or the nearest piped system.~~ ***(REVISE? TBD 2025)***

.2 Ditches ~~shall~~ are to be designed to promote groundwater infiltration. ***(REVISE? TBD 2025)***

.3 Ditches adjacent to travelled roadways ~~shall~~ must not exceed 1.9 m in depth. *(REVISE? TBD 2025)*

.4 Ditches ~~shall~~ are to be trapezoidal in shape having maximum side slopes of ~~1-1/2~~ 1.5H:1V and a minimum bottom width of 450 mm.

.5 The minimum grade of a ditch ~~shall~~ must be 0.5%. *(REVISE? TBD 2025)*

.6 The maximum velocity in an unlined ditch ~~shall be~~ is limited to 1.5 m/s. Higher velocities may be permitted where soil conditions are suitable or where erosion protection has been provided. Excessive velocities should be avoided by using a piped system instead of ditches.

.7 On steep slopes, grade control structures may be required.

7.09 SWALES (WITHIN ROAD RIGHT-OF-WAY) *(REVISE? TBD 2025)*

.1 Swales ~~shall be~~ are to be used in ~~road allowances~~ right-of-way where there is no curb and gutter to direct minor and major flows towards watercourses or the nearest piped system or on private property in conjunction with lot grading to protect properties from overland sheet flow. *(REVISE? TBD 2025)*

.2 Swales ~~shall~~ are to be designed to promote groundwater infiltration. *(REVISE? TBD 2025)*

.3 Swales ~~shall~~ have a minimum depth of 150 mm, and a minimum width of 1.5 m. *(REVISE? TBD 2025)*

.4 The minimum grade of a swale ~~shall~~ must be 1.0%. *(REVISE? TBD 2025)*

.5 Swales ~~shall~~ should not be used where the velocity exceeds 1.5 m/s or on an excessively steep slopes. *(REVISE? TBD 2025)*

7.10 OPEN CHANNELS (WITHIN PRIVATE PROPERTY AND EASEMENTS)

.1 The design of open channels as part of the major system or minor system ~~shall be~~ are restricted to the following maximum velocities: *(REVISE? TBD 2025)*

(a) Unlined channel: 1.5 m/s

(b) Suitably lined channel: 3 m/s

.2 If the mean velocity exceeds that permissible for the particular kind of soil or greater than 1.5 m/s, the channel ~~shall~~ must be suitably lined to protect it from erosion. *(REVISE? TBD 2025)*

.3 The maximum depth of flow ~~shall not~~ cannot exceed 300 mm with a freeboard of 150 mm. *(REVISE? TBD 2025)*

.4 Side slopes on designed channels ~~shall not~~ cannot exceed 3H:1V. ***(REVISE? TBD 2025)***

.5 Open channels ~~shall~~ are to be designed, where possible, to promote infiltration. ***(REVISE? TBD 2025)***

7.11 INLET AND OUTLET STRUCTURES

.1 Inlet and outlet structures ~~shall be~~ are required on all storm sewer pipes and culverts. Headwater requirements as per criteria in Section 7.04 – Minor System [→] and Section 7.05 – Major System [→]~~shall be as per Section 7.07 - Culverts~~. ***(REVISE? TBD 2025)***

.2 A trash rack is required as a part of all inlet structures to storm sewer pipes. Trash racks may be required on culverts ~~as~~ at the discretion of the City Engineer. ***(REVISE? TBD 2025)***

.3 Trash rack hydraulic and structural design ~~shall~~ must allow for passage of design flows with 50% blockage of the trash rack with debris. ***(REVISE? TBD 2025)***

.4 A safety grillage is required as part of an outlet structure from storm sewer pipes greater than 450 mm in diameter or 3.0 m in length. Safety grillages may be required on culverts at the discretion of the City Engineer.

.5 Pipe leaving inlet structures, where the inlet elevation significantly higher than the storm sewer, ~~shall~~ are to have a maximum grade of 5% for minimum 2.0 m. After the 2.0 m, the pipe grade can be adjusted with a vertical curve to attain design depth. ***(REVISE? TBD 2025)***

.6 Cast in place concrete inlet and outlet structures ~~shall~~ must be designed by a structural professional engineer to suit the specific site and soil conditions. Standard drawings ~~shall~~ are to be used as a guide for specific design criteria. Approved prefabricated inlet and outlet structures may be used. The ~~Engineer~~ Professional of Record ~~shall~~ must ensure the structures are designed to suit the existing site and soil conditions. ***(REVISE? TBD 2025)***

.7 Sandbag headwalls ~~shall not~~ cannot be used except for driveway crossings or hydrant access crossing.

.8 Outlets for storm ~~sewers~~ systems where ~~having~~ velocities may cause erosion in the receiving channel ~~in excess of 1.5 m/s shall~~ must ~~incorporate~~ include a method to dissipate the energy, designed by a Professional of Record ~~so that the erosion will not occur in the receiving channel~~. For specifications, refer to Section 7.33 [→]. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

.9 All inlet and outlet structures ~~shall~~ must include provisions for safe maintenance access and ~~shall~~ must conform to WorkSafeBC requirements ***(REVISE? TBD 2025)***

SECTION 7 – STORMWATER MANAGEMENT DESIGN CRITERIA

7.12 STORAGE FACILITIES

.1 General:

(a) The design of permanent storage facilities forming part of the ~~major~~ minor system ~~shall be~~ are an integral part of the overall drainage basin plan. ***(REVISE? TBD 2025)***

(b) The design of permanent storage facilities ~~shall~~ must consider safety and economical maintenance of operations. Storage facilities should also, where possible, be designed as multiuse facilities that include recreational, environmental and aesthetic aspects. ***(REVISE? TBD 2025)***

(c) Storage facilities ~~shall~~ are to accommodate the entire future developed tributary area. ***(REVISE? TBD 2025)***

(d) Depending on the ~~sit~~ site specific characteristics, a combination of storage and other groundwater recharge facilities may be appropriate to effectively reduce the runoff from development sites. ***(REVISE? TBD 2025)***

.2 Ownership:

(a) ~~Single Family and Duplex~~ Residential: ***(REVISE? TBD 2025)***
Large storage facilities servicing ~~single family or duplex~~ residential developments will be owned and maintained by the City. Storage facilities constructed as part of a Bare Land Strata ~~single family or duplex~~ residential development will be owned and operated by the Strata Corporation. ***(REVISE? TBD 2025)***

(b) Multi-~~Family~~ Unit Residential, Commercial, Industrial, and Institutional: ***(REVISE? TBD 2025)***
Storage facilities required as part of a multi-~~family~~ unit, commercial, industrial, or institutional development will be owned and operated privately. Facilities may be underground or above ground including roof top or parking lots. ***(REVISE? TBD 2025)***

.3 Storage Facility Options:

(a) Constructed Wetland:
Constructed wetlands can be incorporated into the drainage system as a means to not only control runoff but to introduce habitat for wildlife and add a bio-filtration element to the facility that improves water quality. The use of constructed wetlands is strongly encouraged.

(b) Wet Pond:
A wet pond is a method where rainwater runoff is collected and stored for a significant amount of time. The water in the active storage portion of the pond is usually released after the storm has ended, while a permanent pool is maintained during dry periods. These may form a recreational or aesthetic facility centered on a permanent pool of water. ***~~(REVISED MAY 2020)~~***

(c) Dry Pond:
Dry ponds are used as temporary water storage after a significant rainfall event. They are typically controlled so that frequent low flows are not detained in the dry pond. As the pond is dry for the majority of the time, dry ponds can be landscaped in a way that they can be used for other purposes.

(d) Underground Storage:
A variety of methods are available for storing rainwater underground to control flows. Underground storage that incorporates other functions is encouraged; storage tank for water re-use (landscape irrigation), groundwater recharge, and infiltration are possible options.

(e) Other Methods:
There are a variety of other ways to store rainwater onsite including rooftop storage, parking lot storage, infiltration swales, rain gardens and many others. The City ~~of Nanaimo~~ is open to innovative ways to store and infiltrate rainwater subject to the approval of the City Engineer. ***(REVISE? TBD 2025)***

.4 General Design Guidelines:

(a) Storage facilities ~~shall be tailored to suit the unique characteristics of the~~ are site specific and ~~shall include~~ require a geotechnical evaluation to address the groundwater table interaction, and the permeability and stability of the existing soils. ***(REVISE? TBD 2025)***

(b) Maximum grade for a dry detention pond ~~shall~~ are to be 4H:1V. ***(REVISE? TBD 2025)***

(c) Maximum grade for a wet detention pond ~~shall~~ are to be 7H:1V from the normal water level to a depth of 0.4 m; steeper side slopes may be considered with a risk assessment and mitigation. ***(REVISE? TBD 2025)*** ~~if the safety risks are minimized such as separating the area from the public or the pond being inaccessible due to vegetation. Slopes of 4H:1V vertical shall be used for 0.4m depth below water level to the bottom of the pond.~~ ~~***(REVISED MAY 2020)***~~

(d) Storage facilities ~~shall~~ must be designed to accommodate the design storage volume. The crest of the surrounding berm must be at least 300 mm higher than the maximum water level expected during the 1% AEP overflow condition. ~~with a freeboard of 300 mm under the 100 year storm conditions~~. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

(e) Where practical, sub-surface drains ~~shall be provided~~ are preferred to ensure that the storage facility can be completely drained. Where subsurface drains cannot be installed, the pond ~~shall~~ must be designed so that mobile pumping equipment may be installed and used to drain the pond. ***(REVISE? TBD 2025)***

(f) All existing and future foundation drains ~~shall~~ must drain by gravity to the storage facility inlet pipe above the design storage level. ***(REVISE? TBD 2025)***

(g) An overflow spillway ~~shall~~ must be provided to handle potential peak runoff from the major storm or a blockage to the outlet. Discharge ~~shall~~ must be to the major system downstream flow path, see Section 7.05 [→]. ***(REVISE? TBD 2025)***

(h) An 8.0 m buffer zone ~~shall~~ is to be provided along the top of wet ponds, dry ponds, and constructed wetlands with a minimum building set-back of 15 m from the top of the storage facility. To be verify with a Qualified Registered Professional, especially when there is connectivity to Environmental Sensitive Areas. ***(REVISE? TBD 2025)***.

(i) An access of at least 3.0 m wide ~~shall~~ is to be provided to all storage facilities for maintenance purposes. The access design must accommodate ~~shall allow the passage of~~ motor vehicles unless otherwise approved by the City Engineer. ***(REVISE? TBD 2025)***

(j) Storage facilities ~~shall~~ are to be appropriately landscaped and protected from erosion. ***(REVISE? TBD 2025)***

~~(k) Inlets for the storage facility shall be a form of surcharging manhole or catch basin inside the facility. Open channels in the storage facility shall not be permitted.~~

~~(l)~~(k) The outlet control for storage facilities ~~shall~~ are to be designed for ~~easy~~ safe access and maintenance ~~and shall be provided~~ with a lock to prevent vandalism. ***(REVISE? TBD 2025)***

~~(m)~~(l) The pond design will include a sediment removal process for control of heavy solids which may be washed to the pond during the construction period associated with the development of the contributing basin. Sediment basins will be provided at all inlet locations for continued use after completion of the subdivision development.

~~(n) Additional design guidelines can be found in the Department of Fisheries and Oceans Land Development Guidelines for the Protection of Aquatic Habitat.~~

.5 Temporary Storage Facilities:

(a) Where land development occurs in advance of completed drainage basin facilities, temporary storage facilities may be utilized on an individual basis as approved by the City Engineer.

(b) The design of temporary storage facilities ~~shall~~ are to consider the following: ***(REVISE? TBD 2025)***

(i) The temporary storage facility meets or exceeds the requirements of this section for permanent storage facilities unless otherwise noted.

(ii) All storm drainage systems discharging to the temporary storage facility can be connected to the permanent drainage works when completed and the temporary facility is abandoned.

.6 Storage Facility Outlets:

(a) The outlet of the storage facility should be designed to control the outflow as calculated ~~in the Stormwater Management Plan~~ based on Runoff Rate Control in Section 7.03.7. ***(REVISE? TBD 2025)***

(b) The outlet structure for a storage pond ~~shall~~ must discharge to a point downstream which has the ability to safely and adequately accommodate the maximum discharge. ***(REVISE? TBD 2025)***

(c) Outlet structures ~~shall~~ must be freeflow and ungated. Controls such as orifices and weirs are the preferred method of controlling the outflow. Manual controls such as gates, valves, or stop logs are discouraged. A valve will be permitted in the drain of a storage pond. ***(REVISE? TBD 2025)***

(d) Outlet structures ~~shall~~ are to conform to Section 7.11 [→]. ***(REVISE? TBD 2025)***

(e) For outlets that are not submerged, a lattice type cover over the inlet end of the outlet is preferred. A limiting velocity of 1.0 m/s is required for the design of the lattice.

(f) Outlets ~~shall~~ must be designed to all appropriate WorkSafeBC requirements for entry and exit. ***(REVISE? TBD 2025)***

(g) Outlet structure ~~shall~~ must be designed to allow ~~easy and~~ safe access for cleaning of the inlet side during peak runoff. ***(REVISE? TBD 2025)***

7.13 RAINWATER BEST MANAGEMENT PRACTICES

.1 Introduction:

The development of previously vegetated land significantly changes the hydrological characteristics of the land by removing vegetation, changing the topography of the land, increasing impervious surfaces, and changing drainage paths. Traditionally, the increases in stormwater runoff~~, which is~~ created by this development~~, has~~ have been mitigated through detention storage to control peak runoff and by increasing the hydraulic capacity of the drainage system. Recently, there has been progress toward considering more than just the hydraulic aspects of rainwater runoff ~~but to~~ and include aspects that can mimic the natural hydrologic process, protect ~~the overall~~ watershed health, and improve water quality. Some of the rainwater best management practices described in this section ~~were developed as~~ are an attempt to mimic the natural characteristics of a watershed. Many of them promote infiltration of rainwater into the ground and provide groundwater recharge benefits in addition to rainwater runoff control. Rainwater best management practices (BMP) may also be called~~:~~ rainwater BMPs, stormwater source controls, low impact development BMPs, or rainwater management methods. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

The use of rainwater best management practices is required wherever technically feasible for new developments and re-developments which outlet into a watercourse ~~creek or river system. For developments and re-developments which outlet into a creek or river system.~~. For developments that do not drain into a ~~creek or river system~~ watercourse, but discharge directly into pipes, ditches, or overland flow

paths which discharge directly into the ocean, rainwater best management practices may not be required for runoff volume control, but for water quality enhancement only. *(REVISE? TBD 2025)* ***~~(REVISED MAY 2020)~~***

.2 Types of Rainwater Best Management Practices:
The following are brief descriptions of various rainwater best management practices which can be applied:

(a) Infiltration Swales:
An infiltration swale is designed to accept flows from small areas of impervious surface and allow it to infiltrate into the soils below. The swale also allows larger flows to be conveyed to the minor or major drainage system and provides water quality treatment. ***~~(REVISED MAY 2020)~~***

(b) Rain Gardens:
Rain gardens are designed to have an aesthetically pleasing appeal in addition to providing water quality treatment and infiltration into the ground. The plantings are carefully selected based on the expected soil moisture conditions. Generally, rain gardens have a drain rock reservoir and a perforated drain system to collect excess water.

(c) Absorbent Landscaping:
The majority of ~~Nanaimo's~~ the City's undeveloped land contains landscapes which soak up the rainfall. Applying absorbent landscaping to development sites is an attempt to mimic this natural landscape. The minimum thickness for absorbent landscaping is 300 mm. *(REVISE? TBD 2025)*

(d) Green Roof:
A green roof includes a layer of growing media which supports vegetation. The application of green roofs can significantly reduce the runoff increase caused by new building construction. Green roofs must be designed with the structural considerations of the building and must comply with the *BC Building Code*.

(e) Infiltration Trenches:
An infiltration trench allows rainwater runoff to soak away into the ground. Infiltration trenches are best suited for runoff which does not require treatment, such as roof runoff. For areas where runoff requires treatment, consider pairing an infiltration trench with a rain garden.

(f) Soak-Away Manholes:
Soak-away manholes are similar to infiltration trenches; they allow the rainwater runoff to infiltrate into the soil through perforations in the manhole. Soak-away manholes are best suited for runoff which does not require treatment. For areas where runoff requires treatment, consider pairing a soak-away manhole with a feature which provides an aspect of treatment, such as a rain garden or infiltration swale.

(g) ~~Previous~~ Pervious Paving:. *(REVISE? TBD 2025)*
~~Previous~~ Pervious paving allows rainfall to penetrate into the underlying soils through the paving. Care should be taken when designing pervious pavers to ensure materials used do not require special maintenance. Pervious paving should generally be restricted to low traffic areas. Where possible, other best management practices, such as rain gardens or infiltration swales are preferred to pervious paving ~~a~~ as less maintenance is required and additional treatment benefits are realized. *(REVISE? TBD 2025)*

(h) Deep Groundwater Recharge:
Deep groundwater recharge involves directly injecting stormwater into underground aquifers. Generally, injected stormwater must be treated to a high level for water quality prior to injection. Design for this practice may be highly complex and require~~d~~ specialist expertise and approval by the City Engineer.

(i) Retention:
Retention of rainwater runoff involves storage and release of rainwater at very low rates, to mimic natural groundwater interflow rates. ~~This is similar to detention, but the release rates is very low, at 0.25 L/s/ha. The water is released through a control orifice to the municipal minor drainage system.~~ *(REVISE? TBD 2025)*

(j) Other Methods:
The BMPs listed above are some of the more common approaches to managing rainwater runoff in ways that mimic natural systems. Other methods may be accepted ~~on~~ with approval by the City Engineer.

.3 Application:

(a) Refer to Section 7.02 for the Summary of Stormwater and Environmental Protection Design Criteria

~~(a)~~(b) ~~Single Family and Duplex:~~ Residential: ~~.~~ *(REVISE? TBD 2025)*
Recent densification of residential zoning increases impervious coverage from roofs and driveways, resulting in higher runoff volumes to the storm system. For residential lots, the most practical rainwater best management practices (BMPs) include absorbent landscaping, pervious driveways and patios, and raingardens for localized infiltration. Where site constraints limit infiltration options, subsurface storage tanks with controlled release may be considered, subject to approval by the City Engineer. ~~Due to a small lot size, limited oversight once developed, and potential for multiple owners and other aspects related residential subdivisions, the application of best management practices for Single Family and Duplex developments is limited to absorbent landscaping and disconnected roof leaders or neighbourhood based solutions. It may not be appropriate to disconnect roof leaders for some development sites such as small lot developments, areas with high ground water tables, or other site specific issues.~~ *(REVISE? TBD 2025)*

~~Best management practices other than absorbent landscaping can be integrated into each lot of the development; however, they will not form part of the calculation for reduction in runoff. Previous driveways and patios are strongly encouraged.~~ *(REVISE? TBD 2025)*

~~(b)~~(c) Multi-~~Family~~ Unit Residential, Commercial, Industrial, and Institutional: . *(REVISE? TBD 2025)*

The use of rainwater best management practices to infiltrate ~~to~~ and retain rainwater is required for multi-~~family~~ unit, commercial, industrial, and institutional developments in order to preserve the natural hydrologic condition as much as possible. *(REVISE? TBD 2025)*

~~(c)~~(d) Steep Slope Development:

Steep slope ~~residential developments (R10 Zoning~~ development, in Development Permit Area (DPA 6) and adjacent to Hazardous Slope (DPA 2) may not be suitable for some rainwater best management practices. Developments in these areas will require specific attention to methods of retention and detention so that post development stormwater management targets can be met. *(REVISE? TBD 2025)* ~~***(REVISED MAY 2020)***~~

~~(d)~~(e) Areas which are underlain by shallow coal mines and Development Permit Area (DPA 4) may not be suitable for some rainwater best management practices. Developments in these areas will require specific attention to methods of retention and detention so that post development stormwater management targets can be met. *(REVISE? TBD 2025)* ~~***(REVISED MAY 2020)***~~

.4 Design:

(a) Detailed methodology for the design of rainwater best management practices can be found in Metro Vancouver's "Stormwater Source Control Design Guidelines ~~2012~~ 2023". An overview of some of the design considerations are listed below.

(b) Sizing Methods:

There are several ways to size and design rainwater best management practices. ~~It can be complex and it is generally recommended that continuous simulation modeling be completed over an extended period of time (at least one year).~~ Programs capable of continuous modeling ~~shall~~ will be in accordance with Section 7.03.6(b) [→]. The Professional of Record (or Qualified Registered Professional) must document the chosen approach and clearly demonstrate that the design meets the performance targets in Section 7.02 [→]. ~~For sites where rainwater management best practices will be used in a series or "chain", continuous simulation for sizing and design is required. Alternatively, for individual facilities, rainwater management best practices can be designed using spreadsheets to calculate the water balance and size of facility, or the equations provided in Metro Vancouver's "Stormwater Source Control Design Guidelines, 2012 " can be used for facility sizing and design to meet the rainwater management target.~~

(c) Soil Hydraulic Conductivity:

Hydraulic Conductivity rates are to be determined by a Qualified Registered Professional and be supported by site soil conductivity testing. ~~For practices that infiltrate water into the ground, the expected rate of infiltration is described by the soil's saturated hydraulic conductivity. For planning purposes, the following hydraulic conductivity rates can be used:~~ ***(REVISE? TBD 2025***

~~Sand~~	~~210.0 mm/hr~~
~~Loamy Sand~~	~~61.0 mm/hr~~
~~Loam~~	~~13.0 mm/hr~~
~~Silt Loam~~	~~6.8 mm/hr~~
~~Sandy Clay Loam~~	~~2.3 mm/hr~~
~~Sandy Clay~~	~~1.5 mm/hr~~
~~Silty Clay~~	~~0.9 mm/hr~~
~~Clay~~	~~0.6 mm/hr~~
~~***(REVISE? TBD 2025)***~~	

~~For detailed design purposes, onsite infiltration testing is required, and the rates must be recommended by a Geotechnical Engineer based on field testing and analysis.~~ ¶ Rainwater infiltration and groundwater recharge facilities are still encouraged on sites with moderate or low soil hydraulic conductivity, even when the facility cannot accommodate the full ~~though the~~ target infiltration volume ~~may not be able to be accommodated by the facility~~. Retention type facilities may be investigated to make up the difference.

(d) Groundwater:

Seasonal groundwater levels are to be assessed when considering ~~R~~rainwater infiltration and groundwater recharge. ~~shall not be placed in areas with unsuitably high are to be assessed for seasonal groundwater level. The seasonally high groundwater table should be at least 600 mm below the bottom of the infiltration facility.~~ ***(REVISE? TBD 2025)***

(e) Bedrock:

Rainwater infiltration and groundwater recharge facilities may not be practical in areas where there is bedrock close to the surface. ~~There shall be a minimum of 600 mm between the bottom of the infiltration facility and bedrock.~~ It should be noted that certain types of bedrock are highly pervious (i.e. fractured sandstone) and suitable for infiltration. ***(REVISE? TBD 2025)***

(f) Drinking Water Wells:

The design of groundwater recharge facilities ~~shall~~ must be separated from drinking water wells ~~and must meet all Ministry of Health guidelines for separation of wells from septic fields~~ and comply with all applicable provincial requirements for groundwater protection and minimum separation distances between wells and sceptic systems. ***(REVISE? TBD 2025)***

(g) Water Quality:
Water infiltrated into the ground ~~shall~~ must be uncontaminated. Sites ~~which~~ that present a high risk of groundwater contamination ~~shall~~ must provide appropriate pre-treatment and spill control~~, if necessary, prior to infiltrating rainwater runoff~~. Examples of these sites include: ***(REVISE? TBD 2025)***

(i) Automobile Service Yards, and

(ii) Industrial Chemical Storage Facilities.

(h) Contaminated Soils:
Sites with contaminated soils ~~shall~~ must be reviewed by a ~~Geotechnical Engineer and/or Hydrogeologist~~ Qualified Registered Professional for suitability for rainwater infiltration into the ground. ***(REVISE? TBD 2025)***

(i) Steep Slopes and Unstable Soils:
Sites containing steep slopes, near steep slopes, or unstable soils ~~shall~~ must be reviewed by a ~~geotechnical engineer Professional of Record~~Qualified Registered Professional for suitability for rainwater infiltration and groundwater recharge facilities, but generally these facilities are prohibited in such conditions as they can saturate soils and can exacerbate slope instability. Designers should refer to the City's Development Permit Areas~~,~~ (DPA), DPA 3 and DPA 5, for areas where there may be concerns for surface water control and/or subsurface infiltration. It is important that infiltrated water does not seep out ~~in~~ of down slope areas, impacting other properties. If there is a reason for concern with the suitability of proposed on-site infiltration facilities, the City Engineer may request a peer review by a Qualified Registered Professional, with specific expertise in hydrogeology~~often a Hydrogeologist or Geotechnical Engineer~~. ***(REVISE? TBD 2025)***

(j) Overflows:
Rainwater best management practices ~~shall~~ must be designed with an overflow into the minor or major drainage system. ***(REVISE? TBD 2025)***

(k) Maintenance:
The design must ~~shall of rainwater best management practices shall be such that~~ minimizes the maintenance required in order for the facilities to properly operate~~ shall be minimized.~~. Regular maintenance which is required ~~shall~~ must be identified in the Stormwater Management Plan. ***(REVISE? TBD 2025)***

(l) Sediment Loads:
All rainwater management best practices, other than green roofs, ~~shall~~ must be designed in such a way that there is a simple procedure for removing sediment which does not require confined entry. Specific attention ~~shall be paid to~~ is needed during the construction period. Infiltration facilities ~~shall~~ are to be designed in a way which prevents sediment from entering the facility and plugging the water-soil interface. ***(REVISE? TBD 2025)***

7.14 WATER QUALITY

.1 Introduction:

(a) All stormwater management systems ~~shall~~ must be designed in a way that prevents harmful materials from entering the natural watercourses. Methods of controlling the water quality ~~shall~~ must be outlined in the Stormwater Management Plan Report. ***(REVISE? TBD 2025)***

.2 Treatment:

(a) High Risk Sites:

Sites which present a high risk of groundwater or receiving water contamination ~~shall~~ must provide appropriate treatment prior to water entering the stormwater system. Examples of these sites include: ***(REVISE? TBD 2025)***

(i) Automobile Service Yards, and

(ii) Industrial Chemical Storage Facilities.

These uses may require covered areas to separate them from stormwater contact, and may require discharge to the sanitary sewer.

(b) Parking Areas:

All uncovered parking areas greater than 100 m² in size ~~shall~~ require treatment to remove oil, total suspended solids (TSS), and other contaminants. Remove 80% TSS over 50 µm particle size. Treatment can be achieved by draining the parking area to rainwater best management practices or by installing a mechanical method ~~or~~ for removing the contaminants. Where possible, treatment using rainwater best management practices is preferred as they provide additional rainwater management benefits at the same time as water quality treatment. ***(REVISE? TBD 2025)***

(c) Design Requirements for Water Quality Treatment:

On sites where water quality treatment is required, including when mechanical treatment is selected (such as an oil water separator), the facilities must be designed to treat 90% of the total volume of stormwater runoff for a typical year ~~or the 6 month, 24 hour post development flow volume~~ which is equivalent to ~~31~~ 36 mm of rainfall per square metre of impervious area. Maintenance manuals ~~shall~~ are to be provided for all mechanical treatment facilities. ***(REVISE? TBD 2025)***

(d) Sediment:

All stormwater management systems ~~shall~~ must be designed to minimize sediment discharges both during ~~construction~~ and after construction. Excess sediment is harmful to both the downstream aquatic environment and the functionality of conveyance and infiltration facilities. The systems must be designed with awareness of possible sediment sources and methods of intercepting and removing sediment before it clogs infrastructure and harms the downstream environment. ***(REVISE? TBD 2025)***

(e) Water Quality:
Treated water ~~shall~~ must meet ~~in~~ ***British Columbia Approved Water Quality Guidelines*** as set out by the ~~Water Protection and Sustainability Branch of the Ministry of Environment~~ British Columbia Ministry of Environment and Climate Change Strategy. ***(REVISE? TBD 2025)***

7.15 CLIMATE CHANGE

.1 Rainfall Patterns:

(a) The City recognizes that climate change is altering historical rainfall patterns in Nanaimo. Rainfall is a key parameter in the design of storm systems. These changes introduce uncertainty in long-term infrastructure and development planning, which is addressed through a risk-based approach. ***(REVISE? TBD 2025)*** ~~(a) The City of Nanaimo recognizes that our climate is changing and the change may impact the rainfall patterns which are historically seen in Nanaimo. It is not fully clear as to what impact climate change will have and requirements to accommodate climate change may be adjusted over time. (a part of) However, to accommodate the expected changes in climate patterns, the design of stormwater management systems shall be conservative in nature and make allowance for climate change.~~

(b) Mitigation of rainfall uncertainty due to climate change is based on guidance from the Association of Professional Engineering and Geoscientists of BC ~~guidance~~[1] and current down scaled climate model projections from the Pacific Climate Impacts Consortium[2] Risk management is implemented through engineering design and stormwater management for frequent (minor rainfall) and extreme (major rainfall) events. There updates are reflected in the Intensity-Duration-Frequency (IDF) curves derived from rain gauge data, which have been updated to account for Climate Change to Year 2100 as shown in Standard Drawing No. SW-25 . Refer to Section 7.03.3.~~(a)~~ [→]. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

~~.2 Sea Level Rise:~~

~~(a) The City of Nanaimo recognizes that our climate is changing, and the change may will impact the sea levels. Development sites which are near the waterfront may be required to review and accommodate sea level rise in their development. ***(REVISE? TBD 2025)***~~

~~Sea level rise is a complex problem and thus requirements will be established confirmed on a site by site basis;. There is uncertainty associated with hazard of sea level rise and other compounding hazards, and this will be presented by the Professional of Record as risk management approach. The requirements to accommodate climate change may also be adjusted from time to time. are subject to updated updates and require approval by the City Engineer. ***(REVISE? TBD 2025)***~~

~~For cases where exact a sea level rise has not been determined, the predicted rise of 1.0 m by the end of the century shall will be used as a minimum.[1] *(REVISE? TBD 2025)*~~

~~[1] APEGBC, Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC, 2012, Section H5, Pg. 127.~~

7.20 SCOPE

.1 This specification refers to gravity sewer pipe and appurtenant fittings for storm sewers. Only those products approved by the City Engineer and listed in the City's ~~of Nanaimo~~ Approved Products List [] will be accepted for installation. ***(REVISE? TBD 2025)***

.2 Refer to Section 4.0 - Excavation, Trenching and Backfill [] for related specifications. ***~~(REVISED MAY 2020)~~***

7.21 MATERIALS TESTING

.1 If, in the opinion of the City Engineer, testing is required, the ~~Engineer~~ Professional of Record will arrange for a testing firm to carry out tests to determine whether the applicable standards and specifications have been met. Where initial testing indicates inadequacies, additional testing may be required by the ~~Engineer~~ Professional of Record. ***(REVISE? TBD 2025)***

.2 The Contractor, as directed by the ~~Engineer~~ Professional of Record, ~~shall~~ must supply specimens or samples for testing. ***(REVISE? TBD 2025)***

.3 The types of tests listed below may be required by the City Engineer unless in the opinion of the City Engineer other testing is required. ***(REVISE? TBD 2025)***

.4 Joints for storm sewer main pipe and fittings and service connection pipe and fittings ~~shall~~ must be capable of meeting the following exfiltration tests. The ~~Engineer~~ Professional of Record may require that these tests be carried out by the Contractor or ~~his~~ their supplier prior to acceptance of pipe on the project. ***(REVISE? TBD 2025)***

(a) Pipes in Proper Alignment:

Not fewer than 3 or more than 5 pipes selected from stock by the ~~Engineer~~ Professional of Record ~~shall~~ are to be assembled according to standard installation instructions issued by the manufacturer. With ends bulkheaded and restrained against internal pressure, the section ~~shall be~~ is subjected to ~~70kPa~~ 70 kPa hydrostatic pressure. Pressure ~~shall~~ must be maintained for a period of 24 hours. There ~~shall~~ must be no leakage at the joints. ***(REVISE? TBD 2025)***

(b) Pipes in Maximum Deflected Position:

At least 2 joints of the assembly ~~shall~~ are to be deflected to the maximum amount recommended by the manufacturer. 35 kPa internal hydrostatic pressure ~~shall~~ is then ~~be~~ applied to the test section and maintained for a period of 24 hours. ~~Joints shall show~~ There ~~will~~ must be no leakage~~.~~ at the joints. ***(REVISE? TBD 2025)***

(c) Pipes in Maximum Lateral Misalignment:

The test section ~~shall~~ is to be supported on blocks or otherwise so that one of the pipes is suspended freely between adjacent pipes and bears only on the jointing material. The suspended pipe ~~shall~~ is then ~~be~~ loaded on the bell or coupling by a load equal to one-third of the ultimate 3-edge bearing strength required by the applicable ASTM specification, except that a pipe with ~~having~~ a laying length of more than 1.2 m ~~shall~~ must be loaded no more than the amount computed for a 1.2 m length. ~~While under this load, stressed joints shall show~~ There must be no leakage at the stressed joint while under this load of ~~under~~ 35 kPa internal hydrostatic pressure. ***(REVISE? TBD 2025)***

7.22A PIPING, FITTINGS AND SERVICES

.1 The size~~s~~ and type~~s~~ of pipe to be used are shown on the drawings.

.2 Concrete Pipe:

(a) Non-reinforced concrete pipe and fittings ~~shall~~ must conform to ASTM C14M Class 3 to a maximum diameter of ~~600mm~~ 600 mm and ~~shall be~~ designed with flexible rubber gaskets joints conforming to ASTM C443M. ***(REVISE? TBD 2025)***

(b) Reinforced circular concrete pipe and fittings ~~shall~~ must conform to ASTM C76M Class III or higher for all pipe greater than ~~600mm~~ 600 mm diameter and ~~shall~~ are to be designed with flexible rubber gasket joints conforming to ASTM C443M. ***(REVISE? TBD 2025)***

(c) Pipe with chips, cracks, porous concrete, or any other defects which impair joint sealing or durability will not be accepted.

.3 Polyvinyl Chloride (PVC) Pipe (Smooth Profile):

(a) Pipe and fittings up to 675 mm diameter ~~shall~~ must be DR35. Pipe and fittings ~~shall~~ must have a minimum pipe stiffness of ~~320kPa~~ 320 kPa at 5.0% deflection when tested in accordance with ASTM D2412. ***(REVISE? TBD 2025)***

(b) Pipe and fittings ~~shall~~ must be manufactured to the following specifications: ***(REVISE? TBD 2025)***
~~100mm~~ 100 mm – 375 mm ~~dia~~ diameter to ASTM D3034 and CSA B182.2
~~450mm~~ 450 mm – 675 mm ~~dia~~ diameter to ASTM F679 and CSA B182.2

(c) Pipe and fittings ~~shall~~ must include integral bell and spigot ends with stiffened wall section and a formed groove for a rubber gasket conforming to ASTM F477. ***(REVISE? TBD 2025)***

(d) All PVC storm pipe ~~shall~~ must be green in colour. ***(REVISE? TBD 2025)***

.4 Ductile Iron Pipe:

(a) Pipe and fittings ~~shall~~ must conform to ASTM A746 or as approved by the City Engineer. ***(REVISE? TBD 2025)***

.5 Polyvinyl Chloride (PVC) Service Pipe:

(a) All storm service inspection assemblies ~~shall~~ must be green in colour. *(REVISE? TBD 2025)*

(b) Storm service connections of 100 mm diameter ~~shall~~ must be DR28 and conform to CSA B182.1. Pipe and fittings ~~shall~~ must have elastomeric seal joints, locked in gasket, and integral bell joint features. *(REVISE? TBD 2025)*

(c) Storm service connections greater than 100 mm diameter ~~shall~~ are to be as specified for PVC (smooth profile) mainline pipe. *(REVISE? TBD 2025)*

.6 High Density Polyethylene (HDPE) Pipe (Smooth Profile):

(a) Pipe ~~shall~~ must conform to AWWA C906. All pipes are to be certified by Canadian Standards Association – CSA B137.1. ~~*(REVISED MAY 2020)*~~ *(REVISE? TBD 2025)*

(b) Minimum acceptable pipe class ~~shall be~~ is DR26 with a hydrostatic design stress rating of ~~10MPa.~~ 10 MPa. *(REVISE? TBD 2025)*

(c) All pipe supplied ~~shall~~ must bear the pipe series designation and manufacturer's name. *(REVISE? TBD 2025)*

(d) Fabricated HDPE mitred fittings ~~shall~~ must conform to AWWA C906 and certified by Canadian Standards Association – CSA B137.1. Mounded HDPE fittings to ASTM D3261 suitable for pressure rating specified and fusion to main pipe. Pipe deflection up to manufacturer's recommended minimum radius may be used in place of fabricated mitre bends and to form the required vertical and horizontal curves. Polyethylene fittings ~~shall~~ must have a pressure rating at least equal to that of the pipe being joined. ~~*(REVISED MAY 2020)*~~*(REVISE? TBD 2025)*

7.22B JOINTS

.1 Storm sewer main pipe and fittings and service connection pipe and fittings ~~shall~~ must be jointed with a rubber gasket or other pre-formed, factory-manufactured gasket or approved material, designed for use with the specified pipe. Solvent connected joints and fittings ~~will~~ are not ~~be~~ permitted. *(REVISE? TBD 2025)*

.2 High Density Polyethylene (HDPE) Pipe (Smooth Profile) Joints:

(a) Joints ~~shall~~ must be by thermal butt-fusion constructed in accordance with the manufacturer's specifications. *(REVISE? TBD 2025)*

(b) Flange joints ~~shall~~ can be used to ~~joint~~ join long sections of butt-jointed pipe or as shown on the construction drawings. *(REVISE? TBD 2025)*

(c) Flanges for polyethylene pipe ~~shall~~ must be slip-on type installed in conjunction with stub ends supplied by the pipe manufacturer. The flanges ~~shall~~ must be Class 150 meeting ANSI B16.5 drilling dimensions. Flanges ~~shall~~ must be carbon steel. *(REVISE? TBD 2025)*

(d) All flanged joints ~~shall~~ must be separated by a neoprene gasket bonded to one of the flange faces. Neoprene for flange gaskets ~~shall~~ are to be ~~3mm~~ 3 mm thick with holes drilled for flange bolts and size equal to flange diameter. *(REVISE? TBD 2025)*

(e) Bolts and nuts for flanges ~~shall~~ must be stainless steel complete with isolation washers. *(REVISE? TBD 2025)*

(f) Refer to Section 7.46 ~~for~~ - Fitting and Joint [→] installation. *(REVISE? TBD 2025)*

7.23 SERVICE JUNCTIONS

.1 Concrete Pipe (non-reinforced and reinforced):

(a) Service connections ~~shall~~ must be manufactured using a sanded PVC male end stub pipe with integral bell. *(REVISE? TBD 2025)*

(b) Stub orientation may be at 45˚ or 90˚ to the centerline of the mainline pipe (either at 9 o'clock to 11 o'clock, or at 10 o'clock to 3 o'clock).

(c) Field break-in and mortar patch joints ~~shall~~ are not ~~be used~~ permitted unless approved by the City Engineer. Refer to Section 7.48 ~~for~~ - Service Connection Junction [→] installation. *(REVISE? TBD 2025)*

.2 PVC Pipe (Smooth Profile):

(a) Service connections to PVC mainline pipe ~~shall~~ must be made with extrusion molded PVC or fabricated PVC fittings manufactured to ASTM D3034, CSA B182.1 and CSA B182.2. *(REVISE? TBD 2025)*

(b) The use of saddles instead of manufactured wye fittings ~~shall require~~ requires approval by the City Engineer. Where pipe saddles have been installed without approval, the City will require removal and reinstatement with an acceptable installation. *(REVISE? TBD 2025)*

(c) Refer to Section 7.48 ~~for~~ - Service Connection Junction [→] installation. *(REVISE? TBD 2025)*

.3 PVC Pipe (Ribbed Profile):

(a) Ribbed pipe ~~shall are~~ is only ~~be used~~ permitted ~~if~~ when repairing an existing ribbed pipe section. *(REVISE? TBD 2025)*

(b) Service connections to PVC mainline pipe ~~shall be~~ must made with extrusion molded or fabricated PVC fittings manufactured to ASTM D3034, CSA B182.1 and CSA B182.2. *(REVISE? TBD 2025)*

(c) For connections more than two pipe sizes smaller than the mainline, prefabricated service saddle connections may be approved.

(d) Refer to Section 7.48 ~~for~~ - Service Connection Junction [→] installation. *(REVISE? TBD 2025)*

.4 High Density Polyethylene (HDPE) Pipe (Smooth Profile):

(a) Service connections to HDPE mainline pipe ~~shall~~ must be made with manufactured fittings, electro-fused or heat-welded to the mainline pipe. Mechanical connections, if used, ~~shall~~ must be water-tight. *(REVISE? TBD 2025)*

(b) Refer to Section 7.48 ~~for~~ - Service Connection Junction [→] installation. *(REVISE? TBD 2025)*

.5 High Density Polyethylene (HDPE) Pipe (Open Profile):

(a) Service connections to HDPE mainline pipe ~~shall~~ must be made with extrusion molded or fabricated fittings manufactured to CSA B182.1, B182.2 and B182.4. *(REVISE? TBD 2025)*

(b) For service connections more than two pipe sizes smaller than the mainline, prefabricated service saddle connections may be approved.

(c) Refer to Section 7.48 ~~for~~ - Service Connection Junction [→] installation. *(REVISE? TBD 2025)*

7.24 PERFORATED DRAINS

.1 The granular material for perforated drains ~~shall~~ must be a clear round drain rock with 100% passing 40 mm and 0% passing ~~10mm~~ 10 mm screens. *(REVISE? TBD 2025)*

.2 Piping ~~shall~~ must be a minimum 150 mm diameter DR28 PVC perforated pipe with ~~.~~ ~~A~~a minimum of 50 perforations 5 mm in diameter per linear metre of pipe ~~shall be required~~ for all pipe sizes. *(REVISE? TBD 2025)*

.3 Perforations ~~shall~~ must be located in the bottom half of the pipe only. *(REVISE? TBD 2025)*

.4 Filter fabric ~~shall~~ must be non-woven polyester fabric conforming to: *(REVISE? TBD 2025)*

Tensile Strength (ASTM 1682)	~~=~~	250	N (minimum)
Bursting Strength (ASTM D-751)	~~=~~	865	kPa (minimum)
Permeability	~~=~~	$2x10^{-2}$	cm/s

7.25A PRECAST MANHOLE SECTIONS

.1 Unless otherwise approved, all manholes sections ~~shall~~ must be precast reinforced concrete conforming to ASTM C478. *(REVISE? TBD 2025)*

.2 All precast sections ~~shall~~ must be complete with ladder rungs. *(REVISE? TBD 2025)*

.3 0-ring rubber gaskets ~~shall~~ must conform to ASTM C443. *(REVISE? TBD 2025)*

.4 Refer to Section 7.51 ~~for~~ - Precast Manhole Sections [→] installation. *(REVISE? TBD 2025)*

7.25B PRECAST MANHOLE BASES

.1 Precast manhole bases ~~shall~~ must be reinforced concrete in accordance with ASTM C478. *(REVISE? TBD 2025)* ***~~(REVISED MAY 2020)~~***

.2 All dimensions, specifications, and installations ~~shall~~ must conform to the requirements for cast in place manhole bases in accordance with Section 7.49 - Cast In Place Manhole Concrete Bases [→], Section 7.52 - Precast Manhole Bases [→] and the Standard Drawings. *(REVISE? TBD 2025)*

.3 Pipe alignment, grade, and invert elevations in the precast manhole bases ~~shall~~ must conform to the construction drawings. *(REVISE? TBD 2025)*

7.25C MANHOLE TOPS

.1 Manhole tops ~~shall~~ must be flat slab, precast concrete. Tops ~~shall~~ must be reinforced to meet CS600 loading requirements. Precast tops ~~shall~~ must conform to ASTM C478 with approved offset opening for frame and cover. *(REVISE? TBD 2025)*

7.25D MANHOLE COVERS AND FRAMES

.1 Covers and frames ~~shall~~ must be cast iron and certified to meet CS600 loading requirements with the bearing faces of the cover to be frame machined for non-rocking fit. *(REVISE? TBD 2025)*

.2 Patterns, dimensions and weights ~~shall~~ are to be in accordance with the Standard Drawings. Covers ~~shall~~ must have “CITY OF NANAIMO STORM DRAIN” permanently embossed on the covers. *(REVISE? TBD 2025)*

.3 Standard manhole frame and cover ~~shall~~ are to conform to Standard Drawing No. SW-16 – Storm Manhole ~~Frame and~~ Cover [].*(REVISE? TBD 2025)*

.4 Utility chamber manhole frame and cover ~~shall~~ are to conform to Standard Drawing No. SW-17 – Utility Chamber Storm Manhole Frame, Ring and Cover [].*(REVISE? TBD 2025)*

.5 A watertight manhole frame and cover, if required, ~~shall~~ are to conform to Standard Drawing No. SW-18 – Watertight Storm Manhole Frame and Cover [].*(REVISE? TBD 2025)*

.6 Covers located in statutory right-of-way ~~shall~~ must be permanently embossed with the additional wording “DO NOT COVER”. *(REVISE? TBD 2025)*

.7 Refer to Section 7.54 ~~for~~ Frame and Cover [→] installation. *(REVISE? TBD 2025)*

7.25E MANHOLE ~~STEPS~~ LADDER RUNGS *(REVISE? TBD 2025)*

.1 ~~Steps~~ Rungs ~~shall~~ must conform to ASTM C478 for concrete manhole ~~steps~~ rungs and ladders and ~~shall~~ must be a ~~19mm~~ 19 mm diameter aluminum alloy conforming to CSA S157. *(REVISE? TBD 2025)*

.2 Refer to Section 7.55 ~~for manhole steps~~ Manhole Ladder Rungs [→] installation. *(REVISE? TBD 2025)*

7.26 CONCRETE

.1 Concrete for cast in place ~~shall~~ are to conform to Section 11.0 - Cast In Place Concrete Works []. *(REVISE? TBD 2025)* ~~*(REVISED MAY 2020)*~~

7.27 PRECAST CONCRETE GRADE RINGS

.1 Precast concrete grade rings must ~~shall conforming to~~conform to ASTM C478 ~~shall be used~~. *(REVISE? TBD 2025)*

.2 For ~~roads~~ streets with steep grades, sloped concrete grade rings are to be used in conjunction with an adjustable manhole frame assembly. *(REVISE? TBD 2025)* ~~*(REVISED MAY 2020)*~~

7.28 TEMPORARY CLEANOUT FRAMES AND COVERS

.1 Temporary cleanout structures may only be used ~~at the discretion of~~ if approved by the City Engineer where there is development phasing. *(REVISE? TBD 2025)*

~~.2 Temporary cleanout frames and covers shall be as specified for storm manhole frames and covers. See Section 7.25D - Manhole Covers and Frames.~~

7.29 PIPE AND FITTINGS FOR DROP MANHOLE STRUCTURES

.1 Pipe and fittings for drop manhole structures ~~shall be as~~ are specified under Section 7.22A - Piping, Fittings and Services [→] and Section 7.22B – Joints [→].*(REVISE? TBD 2025)*

.2 Refer to Section 7.56 for drop manhole structures [→] installation.

7.30 -NOT USED-

7.31A PRECAST CATCH BASIN BARRELS AND LEADS

.1 Catch basins barrels ~~shall~~ must be 600 mm or 750 mm diameter as noted on the standard drawings and ~~shall~~ must be reinforced concrete conforming to ASTM C478, Class III. *(REVISE? TBD 2025)*

.2 Catch basin leads ~~shall~~ are to be of the same material as the main piping and used the same type of joints, gaskets, and fittings. ***(REVISE? TBD 2025)***

.3 Catch basin lead minimum sizes and desired grade as per Section 7.06.12 [→]. ~~Leads shall be 200 mm in diameter (minimum) for single basins and 250 mm in diameter (minimum) for double basins, and shall be connected to sewers with manufactured wyes or tees. Leads over 30 m in length shall be 250 mm in diameter.~~ ***(REVISE? TBD 2025)***

7.31B CATCH BASIN CASTINGS

.1 Catch basin frame and grating ~~shall~~ are to be in accordance with Standard Drawings: ***(REVISE? TBD 2025)***

(a) SW-6 - Catch Basin Frame and Grate []
(b) SW-7 - Adjustable Catch Basin Frame and Hood []
(c) SW-8 - Boulevard Catch Basin Frame and Grate []

7.32 INLET AND OUTLET STRUCTURES

.1 Concrete inlet and outlet structures ~~shall~~ must be precast unless approved by the City Engineer. ***(REVISE? TBD 2025)***

.2 Cast in place concrete ~~shall~~ are to conform to Section 11.0 - Cast In Place Concrete Works []. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

.3 The trash rack ~~shall~~ are to be pre-fabricated to match the pre-fabricated inlet or outlet structure. Custom built trash racks ~~shall~~ must be constructed with 20 mm diameter hot dipped galvanized bar. ***(REVISE? TBD 2025)***

7.33 ENERGY DISSIPATOR OUTLET STRUCTURES

.1 Energy dissipators ~~shall~~ must be ~~constructed of are typically and~~ pre-cast concrete integral to the outlet structure, unless approved by the City Engineer. ~~be designed to~~ The design must reduce runoff velocities to less than 1.5 m/s and ~~dispose~~ disperse runoff evenly. ***(REVISE? TBD 2025)***

7.34 INLET AND OUTLET PROTECTIVE FENCING AND HANDRAILS

.1 Unless otherwise specified, protective fencing, and handrails including posts, pipe rails, and hardware are to be hot dip galvanized steel. Mesh ~~shall~~ must be 50 mm wire mesh, 9 gauge, hot dip galvanized, or plastic coated. ***(REVISE? TBD 2025)***

7.35A CULVERTS

.1 Concrete pipe ~~shall~~ are to conform to Section 7.22A - Piping, Fittings and Services, clause 7.22A.2 [→]. ***(REVISE? TBD 2025)***

.2 PVC pipe ~~shall~~ are to conform to Section 7.22A - Piping, Fittings and Services, clause 7.22A.3 [→]. ***(REVISE? TBD 2025)***

.3 Ribbed PVC pipe ~~shall~~ is permitted only ~~be used~~ for driveway culverts and ~~shall~~ must conform to CSA B1800. ***(REVISE? TBD 2025)***

7.35B CULVERT HEADWALLS

.1 Sacks ~~shall~~ are to be 0.25 kg burlap with approximate inside dimensions of 350 x 900 mm as measured when the sack is laid flat. ***(REVISE? TBD 2025)***

.2 All cast in place concrete ~~shall~~ are to conform to Section 11.0 - Cast In Place Concrete Works []. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

.3 Reinforcing bars ~~shall~~ must be 15M intermediate grade steel conforming to CSA G30.18, Grade 400. ***(REVISE? TBD 2025)***

.4 Composite material headwalls may be used for culvert headwalls at the discretion and on approval of the City Engineer.

7.36 RIPRAP

.1 Riprap ~~shall~~ must be hard, dense, durable quarry stone, free from seams, cracks, or other structural defects, with a specific gravity of not less than 2.65. ***(REVISE? TBD 2025)***

.2 The gradation of rock sizes (mass in kg) for each class of riprap ~~shall~~ is to conform to the following table: ***(REVISE? TBD 2025)***

Class of Riprap (kg)	Nominal Thickness of Riprap (mm)	Rock Gradation (Percentage Larger than given rock mass, kg)			Approximate Average Dimension of Rock (mm)
		85%	50%	15%	
10	350	1.0	10	30	200
25	450	2.5	25	75	300
50	550	5.0	50	150	350
100	700	10	100	300	450
250	1000	25	250	750	600
500	1200	50	500	1500	800
1000	1500	100	1000	3000	1000
2000	2000	200	2000	6000	1200
4000	2500	400	~~400~~4000 ***(REVISE? TBD 2025)***	12000	1500

Example: For Class 50 Riprap

85% of riprap stones are greater than 5.0 kg.
50% of riprap stones are greater than 50 kg.
15% of riprap stones are greater than 150 kg.

Based on Province of British Columbia Ministry of Transportation and Infrastructure. (2020). *Standard specifications for* highway *construction: Volume 1*. Table 205-C: Gradation and Intermediate Dimension of Rock by Class of Riprap ***(REVISE? TBD 2025)***

7.36 MANHOLE AND TEMPORARY CLEANOUT LID MARKERS

.1 Markers are required, where manhole and temporary cleanout lids are not located within developed ~~road~~ right-of-way or residential properties, to indicate the location of the manholes and temporary cleanouts. These markers ~~shall~~ must be constructed of 50 mm galvanized steel pipe painted with a minimum of two coats of yellow exterior duty paint applied in accordance with the manufacturer's recommendations and set in a concrete base. The markers ~~shall~~ are to extend 1.0 m above the ground surface. The markers ~~shall~~ are to be located on site at a location, determined by the City Engineer, opposite the manhole or temporary cleanout lid and the distance to the lid is to be marked in black figures on a flattened upper portion of the marker. See Standard Drawing No. SW-20 – Storm Manhole and Temporary Cleanout Marker []. ***(REVISE? TBD 2025)***

7.37 SERVICE BOXES

.1 Service boxes for single storm sewer services ~~shall~~ are to be 300 mm x 500 mm concrete boxes complete with cast iron traffic cover marked “Storm” and concrete extension sections as required. ***(REVISE? TBD 2025)***

.2 Service boxes for twin storm sewer services ~~shall~~ are to be 425 mm x 750 mm concrete boxes complete with steel traffic cover marked “Storm” and concrete extension sections as required. ***(REVISE? TBD 2025)***

SECTION 7 – STORMWATER MANAGEMENT INSTALLATION

7.40 TRENCH EXCAVATION, BEDDING AND BACKFILL

.1 Refer to Section 4.0 - Excavation, Trenching and Backfill [] for installation requirements. ~~***(REVISED MAY 2020)***~~

7.40A PIPE ALIGNMENT AND GRADE

.1 The pipe ~~shall~~must be laid on the alignment and grade in accordance with the construction drawings. Each pipe ~~shall~~ must be checked for line and grade ~~as it is installed.~~during installation. Methods used to maintain pipe alignment and grade ~~shall~~ must be approved by the ~~Engineer~~ Profession of Record. ***(REVISE? TBD 2025)***

.2 Unless otherwise directed by the Engineer, tolerances for pipe alignment and grade ~~shall~~ must be: ***(REVISE? TBD 2025)***

Alignment	=	± 50 mm
Grade	=	± 10 mm

7.41 PIPE CUTTING

.1 Pipe cutting ~~shall~~ are to be done in the manner recommended by the pipe manufacturer employing tools designed for this purpose. ***(REVISE? TBD 2025)***

7.42 PIPE INSTALLATION

.1 Pipe ~~shall~~ must be installed in strict accordance with the manufacturer's recommended practice. Joint gaskets are required unless stated otherwise by the ~~Engineer~~ Professional of Record. ***(REVISE? TBD 2025)***

.2 Pipe ~~shall~~ must be checked before being lowered into the trench to ensure that no foreign material, manufacturer's defects, or cracks exist that might prevent the proper jointing of the pipe or its operation. ***(REVISE? TBD 2025)***

.3 The open end of the pipe in the trench ~~shall~~ must be suitably covered to prevent entrance of trench water and other material during periods when pipe is not being installed. ***(REVISE? TBD 2025)***

.4 Precautions ~~shall~~ are to be taken to ensure that displacement of the pipe in the trench does not occur through soil displacement or floatation due to the presence of trench water. Pipe that has been displaced ~~shall~~ must be removed from the trench and re-laid. ***(REVISE? TBD 2025)***

.5 Lifting holes in concrete pipe ~~shall~~ are to be plugged with prefabricated plugs in non-shrink grout, or other plugs recommended by the pipe manufacturer. ***(REVISE? TBD 2025)***

.6 ~~The contractor shall will use methods for installing pipe in an auger hole or casing pipe as described in Section 4.0 - Excavation, Trenching and Backfill [].~~ *(REVISE? TBD 2025)* ***(REVISED MAY 2020)***

7.43 JOINTS AT RIGID STRUCTURES

.1 A flexible joint ~~shall~~ must be provided at locations where the pipe is held in a fixed position by a rigid support or structure. The distance from the support or structure ~~shall depend~~ depends on the diameter and type of pipe being installed and ~~shall~~ must be in accordance with the pipe manufacturer's recommended practice. The purpose of the flexible joint is to prevent pipe failure due to uneven support under the pipe. Approved flexible joints include rubber gasket bell and spigot connections and dresser couplings. *(REVISE? TBD 2025)*

7.44 HORIZONTAL AND VERTICAL CURVES

.1 Pipe on horizontal and vertical curves ~~shall~~ must be laid true to the radius of the curve ~~of the radius~~ shown on the drawings. Variations in vertical curves and grades are permitted only within the allowable joint deflection specified in Section 7.06.6 [→], ~~and only where~~ unless approved by the City Engineer. *(REVISE? TBD 2025)* ***(REVISED MAY 2020)***

7.45 DEFLECTION

.1 The amount of pipe deflection at joints and couplings ~~shall~~ must be the limit as specified in Section 7.06.6 [→]. *(REVISE? TBD 2025)*~~.~~ ***(REVISED MAY 2020)***

7.46 FITTINGS AND JOINTS

.1 Fittings ~~shall~~ are to be installed at the locations shown on the construction drawings or as directed by the ~~Engineer~~ Professional of Record. Fittings ~~shall~~ must be installed in accordance with the manufacturer's specifications. *(REVISE? TBD 2025)*

.2 High Density Polyethylene (HDPE) Pipe (Smooth Profile):

(a) Pipes ~~shall~~ must be joined ~~by~~ using the thermal butt fusion method. *(REVISE? TBD 2025)*

(b) The contractor ~~shall~~ must make arrangements to have the pipe jointing ~~to~~ be carried out by the pipe manufacturer or certified personnel~~,~~ familiar with the jointing technique, using equipment and ~~techniques~~ methods specifically designed for the pipe diameter and material ~~being jointed~~. *(REVISE? TBD 2025)*

(c) Where required, flanged joints ~~shall~~ must be used ~~for~~ to connect long pipe sections. *(REVISE? TBD 2025)*

(i) ~~The~~ Each joint ~~shall~~ must consist of a polyethylene stub end ~~butt~~ butt-fused to the end of pipe and a carbon steel slip-on flange. *(REVISE? TBD 2025)*

(ii) Flanged joints and flange bolts ~~shall~~ must be stainless steel~~, complete with~~ and include isolation washers. ***(REVISE? TBD 2025)***

(d) Refer to Section 7.22B [→] for Joint Specifications.

7.47 CONNECTIONS TO EXISTING PIPING AND APPURTENANCES

.1 All connections to existing piping, services, and appurtenances ~~shall be~~ will made by City ~~of Nanaimo~~ forces unless otherwise ~~authorized~~ approved by the City Engineer. ***(REVISE? TBD 2025)***

.2 All connections to existing piping and services ~~shall~~ must utilize a manufactured rubber gasket bell and spigot joint or dresser coupling designed for the types of pipes to be connected. For connections to existing service connections refer to Standard Drawing No. SW-27 – Concrete Encasement for Connections to Existing Storm Services []. ***(REVISE? TBD 2025)***~~. (REVISED MAY 2020)~~

.3 The use of field joints or rubber repair couplings ~~shall~~ require the approval of the City Engineer. ***(REVISE? TBD 2025)***

.4 Rubber repair couplings must have 4 stainless steel clamps complete with stainless steel clamps complete with stainless steel anti shear band. Only those products approved by the City Engineer will be accepted for installation.

.5 Slip couplers ~~shall~~ must be used on PVC pipes. Rubber repair couplings are not ~~to be used~~ permitted on PVC pipes. ***(REVISE? TBD 2025)***

7.48 SERVICE CONNECTION JUNCTIONS

.1 Service connection junctions ~~shall~~ are to be installed at the locations shown on the construction drawings or as directed by the ~~Engineer~~ Professional of Record during construction. ***(REVISE? TBD 2025)***

.2 Where service connections are not installed ~~in conjunction~~ with the main, install fittings ~~shall be installed in the sewerline~~ sewer line to accommodate the future service connections~~,~~ and cap~~s~~ or plug~~s shall be installed in~~ the fittings. Install ~~M~~markers ~~shall be installed as specified in~~ as per Section 7.61 – Service Connection Installation~~, clause 7.61.3 (i)~~ [→]. ***(REVISE? TBD 2025)***

.3 Concrete Pipe (Reinforced and Non-reinforced):

(a) Field break-in and mortar patch joints ~~shall~~ are not be used unless approved by the City Engineer. If approved, the following ~~shall~~ will apply: ***(REVISE? TBD 2025)***

(i) Service connections ~~shall~~ must be manufactured using a sanded PVC male end stub pipe with integral bell. ***(REVISE? TBD 2025)***

(ii) Break into the pipe by ~~corning~~ coring to within ~~40mm~~ 40 mm of the outside diameter of the service stub. All exposed reinforcing steel ~~shall~~ must be removed. ***(REVISE? TBD 2025)***

(iii) Insert the stub into the core ensuring that no portion of the service stub protrudes past the inside of the concrete pipe wall, and the stub length ~~shall~~ is to be equivalent to the thickness of the concrete pipe wall and length of the stub's integral bell. ***(REVISE? TBD 2025)***

(iv) Prepare non-shrink, fast setting cementitious grout with a 3:1 sand/cement mix to a “dry pack” consistency. Pack grout tightly into the void between the stub and the pipe and mound around the stub for lateral support.

(v) Hand finish interior and exterior grout surfaces to a smooth finish.

(vi) In order to prevent damage to the field joint, allow sufficient time for grout to develop strength prior to installation of connecting pipe and backfilling.

(vii) Installation ~~shall~~ must be inspected by the ~~Engineer~~ Professional of Record prior to backfilling. ***(REVISE? TBD 2025)***

(b) Refer to Section 7.23 ~~for~~ - Service Junction [→] specifications. ***(REVISE? TBD 2025)***

.4 PVC Pipe (Smooth Profile):

(a) Service saddle connections ~~shall~~ cannot be used unless approved by the City Engineer. ***(REVISE? TBD 2025)***

(b) If approved, installation of service saddle connections ~~shall~~ must conform to the following: ***(REVISE? TBD 2025)***

(i) Drill hole into main line pipe to the exact outside diameter of the new connection.

(ii) The use of saddles instead of manufactured wye fittings ~~shall require~~ requires approval by the City Engineer. Saddles ~~shall~~ must be rigid PVC material complete with rubber seating gasket. Saddles are to be attached to pipe with stainless steel banding straps. ***(REVISE? TBD 2025)***

(iii) Attach service saddle in accordance to the manufacturer's specifications.

(c) Refer to Section 7.23 ~~for~~ - Service Junction [→] specifications. ***(REVISE? TBD 2025)***

.5 PVC Pipe (Ribbed Profile):

(a) Installation of service saddle connections ~~shall~~ are to conform to Section 7.48.4 [→]. ***(REVISE? TBD 2025)***

(b) Refer to Section 7.23 ~~for~~ - Service Junction [→] specifications.

.6 High Density Polyethylene (HDPE) Pipe (Smooth Profile):

(a) Service connections to mainline pipe using manufactured fittings ~~shall~~ must be in strict accordance with manufacturer's instructions. ***(REVISE? TBD 2025)***

(b) Connection of HDPE service junctions to non-pressurized PVC service pipe ~~shall~~ must be made with flexible couplings. Flexible couplings ~~shall~~ must be manufactured from elastomeric PVC and be held in place with series 300 stainless steel worm gear clamps. ***(REVISE? TBD 2025)***

(c) Refer to Section 7.23 - Service Junction [→] specifications.

.7 High Density Polyethylene (HDPE) Pipe (Open Profile):

(a) Installation of service saddle connections ~~shall~~ are to conform to Section 7.48.4 [→]. ***(REVISE? TBD 2025)***

(b) Refer to 7.23 ~~for~~ - Service Junction [→] specifications.

7.49 CAST IN PLACE MANHOLE CONCRETE BASES

.1 All water ~~shall~~ is to be removed from the excavation prior to placing base concrete. The base ~~shall~~ must be constructed such that the first section of a precast section can be set plumb with uniform bearing throughout its full circumference. ***(REVISE? TBD 2025)***

.2 If material in the bottom of the trench is unsuitable for support, the bottom ~~shall~~ may be overexcavated to firm base as determined by the ~~Engineer~~ Professional of Record and backfilled to the required grade with thoroughly compacted base gravel as specified for trench bottom stabilization under the applicable section included in Section 4.0 - Excavation, Trenching and Backfill []. ***(REVISE? TBD 2025)***~~.~~ ~~***(REVISED MAY 2020)***~~

.3 Where overexcavation and backfill with base gravel is not practical, special structure support ~~shall~~ are to be provided as specified for trench bottom stabilization under the applicable section included in Section 4.0 - Excavation, Trenching and Backfill []. ***(REVISE? TBD 2025)***~~.~~ ~~***(REVISED MAY 2020)***~~

.4 Concrete manhole bases ~~shall~~ must be constructed as shown on the drawings. Pipes and fittings through the manhole ~~shall~~ must be supported on concrete blocks and the concrete base poured around the pipe to a depth of at least 150 mm below the bottom of the pipe and up to the springline of the pipe. Install rubber manhole adaptor rings on all plastic pipe installed in the manhole base. ***(REVISE? TBD 2025)***

.5 Invert elevations of pipes ~~a~~ at the manhole ~~shall~~ must be checked by the Contractor prior to and following placement of base concrete around the pipe to ensure that all pipes are installed at the designed elevation. ***(REVISE? TBD 2025)***

.6 Variations in manhole inverts from established grade or elevations ~~shall~~ must be corrected. ***(REVISE? TBD 2025)***

.7 Manhole channeling ~~shall~~ must be constructed as shown on Standard Drawings or as shown on the construction drawings. Channeling ~~shall~~ must be constructed to have a minimum 0.3 m straight section before the change in direction within the manhole. ***(REVISE? TBD 2025)***

.8 The channels in the base of manholes ~~shall~~ must be shaped and finished to provide smooth passage for the ~~storm water~~ stormwater in order to minimize head losses and deposits at bends and at junctions of channels. ***(REVISE? TBD 2025)***

.9 Channels ~~shall~~ must be accurately formed. The practice of forming channels roughly to shape and finishing with cement mortar will not be permitted. The channels ~~shall~~ are to be steel trowel finished. ***(REVISE? TBD 2025)***

.10 Benching in manholes ~~shall~~ must be sloped to drain. ~~While green, the concrete benching shall be given a broom~~ Broom finish to produce a non-skid surface. ***(REVISE? TBD 2025)***

7.50 -NOT USED-

7.51 PRECAST MANHOLE SECTIONS

.1 Precast manhole barrel sections ~~shall~~ must be placed plumb. ***(REVISE? TBD 2025)***

.2 Joints between the top riser and the cover slab ~~shell~~ must be made watertight with cement mortar. Prior to placing sections, the mating face ~~shall~~ are to be thoroughly soaked with water and a layer of cement mortar ~~shall be~~ spread on the lower face. After sections are placed, excess mortar ~~shall be~~ is removed and the joint made flush inside and out. ***(REVISE? TBD 2025)***

.3 Joints between precast manhole barrels must utilize o-ring gaskets and ~~shall~~ conform to the manufacturer's specifications. The inside surface of the precast barrel at the o-ring joints ~~shall~~ must be filled with cement grout to a smooth finish. ***(REVISE? TBD 2025)***

.4 Damaged o-ring manhole joints require removal and replacement of damaged manhole section. Mortar patching of damaged area, if approved by the ~~Engineer~~ Qualified Registered Professional, ~~shall~~ requires removal of the o-ring gasket and installation as per Section 7.51.2 [→]. ***(REVISE? TBD 2025)***

.5 Refer to Section 7.25A ~~for~~ – Precast Manhole Section [→] specifications. ***(REVISE? TBD 2025)***

7.52 PRECAST MANHOLE BASES

.1 Installation of precast manhole bases ~~shall~~ are to conform to Section 7.49 - Cast In Place Manhole Concrete Bases [→]. ***(REVISE? TBD 2025)***

.2 Precast manhole bases ~~shall~~ must be placed on 150 mm thick base ~~if~~ of 38 mm drain rock. ***(REVISE? TBD 2025)***

.3 Plastic and concrete pipes installed in the precast manhole base ~~shall~~ must utilize rubber manhole adaptor rings to seal the connection. ***(REVISE? TBD 2025)***

.4 Refer to 7.25B ~~for~~ -Precast Manhole Section [→] specifications.

7.53 CONCRETE

.1 Cast in place concrete ~~shall~~ are to conform to Section 11.0 - Cast In Place Concrete Works []. ***(REVISE? TBD 2025)***. ~~***(REVISED MAY 2020)***~~

7.54 FRAMES AND COVERS

.1 Frames ~~shall~~ must be set on precast concrete grade rings to bring the cast iron manhole frame up to grade ~~as shown on the Standard Drawings~~ elevation shown on construction drawings. Contractor to install concrete grade rings to a minimum of 50 mm thick and to a maximum of ~~100mm~~100 mm thick. The concrete grade rings ~~shall~~ must be laid in common bond with racked mortar joints and ~~shall be~~ mortared inside and outside of the manhole. ***(REVISE? TBD 2025)***

(a) Fine grade elevation adjustments of frames ~~shall~~ are to be done with a minimum of 3, steel only, shims equally spaced. ***(REVISE? TBD 2025)***

.2 Manhole covers ~~shall~~ must be installed:

(a) for unpaved areas: Covers ~~shall~~ are to have a 1.5 m x 1.5 m, 50 mm thick asphalt apron. Covers ~~shall~~ must be set flush with the asphalt surround. ***(REVISE? TBD 2025)***

(b) for paved areas: Covers ~~shall~~ must be flush with pavement grade with a maximum allowed variance of 6 mm lower than finished pavement. Covers ~~shall~~ must not protrude above finished pavement. ***(REVISE? TBD 2025)***

(c) covers installed outside of the tolerances listed above require approval by the City Engineer. ***(REVISE? TBD 2025)***

.3 Steel manhole riser rings ~~shall be used~~ are permitted in easements only. ***(REVISE? TBD 2025***

.4 The inside surface of the manhole frame ~~shall~~ are to be painted green with an enamel rust paint in accordance with the manufacturer's specifications. ***(REVISE? TBD 2025***

.5 Refer to Section 7.25D [→] for Manhole Covers and Frames Specifications.

7.55 MANHOLE ~~STEPS~~ LADDER RUNG *(REVISE? TBD 2025)*

.1 Manhole ~~steps shall~~ ladder rungs are to be installed in manhole sections by the manufacturer unless circumstance dictates otherwise in which case approval must be received from the City Engineer. *(REVISE? TBD 2025)*

.2 The distance from the top of the manhole cover to the first manhole ~~step~~ rung, ~~shall~~ must conform to WorkSafeBC requirements. *(REVISE? TBD 2025)*

.3 All ~~steps~~ rungs ~~shall~~ must be complete with approved polyethylene anchor insulating sleeves and installed in 25 mm to 26 mm diameter precast or drilled holes in a manhole section. *(REVISE? TBD 2025)*

.4 Refer to Section 7.25E [→] for manhole ~~steps~~ rungs specifications. *(REVISE? TBD 2025)*

7.56 DROP MANHOLE STRUCTURES

.1 Manhole drop structures ~~shall~~ must be constructed as shown on Standard Drawing No. SW-14 - Storm Drop Manhole []. *(REVISE? TBD 2025)*

7.57 STUBS

.1 Blind stub sections for connection of future sewers and service connections to the manholes ~~shall~~ must be installed where shown on the construction drawings and as directed by the ~~Engineer~~ Professional of Record. Stubs ~~shall~~ are to be as long as the vertical depth from finish grade to the invert of each stub. Each stub ~~shall~~ must be plugged with a removable, watertight plug as shown on the construction drawings. Where stubs are installed, the bottom of the manhole ~~shall~~ must be channelled to the stub entrance. *(REVISE? TBD 2025)*

7.58 ~~TEMPORARY CLEANOUTS~~ – NOT USED- *(REVISE? TBD 2025)*

.1 ~~Temporary cleanouts shall be constructed as shown on the Standard Drawings~~.

7.59 -NOT USED-

7.60 PRECAST CATCH BASIN BARRELS AND LEADS

.1 Catch basins ~~shall~~ must be installed in accordance with the Standard Drawings. *(REVISE? TBD 2025)*

.2 Catch basin leads ~~shall~~ must be installed to allow passage of video cameras and flushing equipment. Installation of mitred may be allowed to avoid pipe conflicts or insufficient bury. Mitre bends ~~shall~~ cannot exceed 45˚ and there ~~shall~~ must be a minimum 1.0 m separation between mitre bend hubs. *(REVISE? TBD 2025)*

.3 Catch basin leads taken into manholes ~~shall~~ must be benched in the same manner as main line piping. ***(REVISE? TBD 2025)***

.4 Catch basin grates are to be set 20 mm below the gutter line. The concrete gutter and ~~blacktop~~ asphalt are to be shaped to form a dish around the inlet. ***(REVISE? TBD 2025)***

.5 Construction and finishing of catch basins ~~shall~~ are to be the same as for manholes as described in Section 7.54 - Frames and Covers [→]. ***(REVISE? TBD 2025)***

.6 Catch basin leads are to protrude ~~50mm~~50 mm into the catch basin barrel and ~~shall~~ must be grouted inside and outside of the barrel in accordance with the Standard Drawings. ***(REVISE? TBD 2025)***

.7 There ~~shall~~ must be a 400 mm minimum clearance between the outside of the catch basin barrel and the trench wall to allow for compaction. ***(REVISE? TBD 2025)***

.8 Curb inlet catch basins are to be installed to be rigid once installed and the inlet hood remain flush with the top of the curb.

7.61 SERVICE CONNECTION INSTALLATION

.1 Location of Service Connections:

(a) Service connections are to be installed at the locations and depths as specified by the ~~Engineer~~ Professional of Record. Where the depth of the service connection exceeds 2.0 m, the service ~~shall~~ must be extended into the property the same distance as the depth of the service, up to a maximum distance of 4.0 m. This ~~shall~~ must be done during the installation of the service connection from the main to the property. ***(REVISE? TBD 2025)***

(b) At no time ~~shall~~ are two or more storm services be coupled into one lead crossing the street or right-of-way. Each service ~~shall~~ must have its own independent connection into the main sewer. ***(REVISE? TBD 2025)***

.2 Grade and Alignment of Service Connections:

(a) Trenches ~~shall~~ must be excavated so the pipe can be installed in a direct line from the service connection fitting at the sewer or from a manhole to the terminus of the service. Service connections ~~shall~~ must be installed at grade of not less than 2% unless otherwise directed by the Engineer. Service pipe ~~shall~~ must be installed at a uniform grade between the terminus at the property line and the junction fitting at the sewer or upper end of a service drop. ***(REVISE? TBD 2025)***

.3 Storm Sewer Service Connection Installation:

(a) Pipe ~~shall~~ must be installed in strict accordance with the manufacturer's recommended practice. ***(REVISE? TBD 2025)***

(b) Pipe ~~shall~~ must be checked before being lowered into the trench to ensure that no foreign material, manufacturer's defects, or cracks exist that might prevent the proper jointing of the pipe or its operation. ***(REVISE? TBD 2025)***

(c) The Contractor ~~shall~~ must use methods for installing pipe in an auger hole or casing pipe as shown on the construction drawings. ***(REVISE? TBD 2025)***

(d) The trench ~~shall~~ must be excavated to provide a minimum cover of 0.75 m over the service connection pipe at property line. ***(REVISE? TBD 2025)***

(e) In rock, the trench is to be extended three 3.0 m into the property to facilitate future extension of the service connection.

(f) The trench bottom ~~shall~~ must be graded to form a continuous support along the service pipe. All rocks or projections which might prove detrimental to the pipe ~~shall~~ must be removed. ***(REVISE? TBD 2025)***

(g) Joints ~~shall~~ must be made using the specified couplings. No ~~Glued~~ glued joints ~~shall not be made~~. ***(REVISE? TBD 2025)***

(h) At the terminus of each sewer service approved watertight caps suitably supported by sandbags ~~shall~~ are to be installed to prevent leakage. ***(REVISE? TBD 2025)***

(i) A 38 mm x 89 mm pressure treated wood marker stake ~~shall~~ must be placed at the service terminus as shown on the drawings to facilitate future location of the service pipe. This stake ~~shall~~ must extend in locations where the extension of the stake above ground surface would prove hazardous, in which case the stake ~~shall~~ must be cut off flush with the ground surface. The stake ~~shall~~ must be marked in an approved manner to show the depth of the service pipe invert below the top of the stake. The stakes ~~shall~~ must be painted green to visually identify the storm sewer service connections. The ~~Engineer~~ Professional of Record will take invert elevations of the service connection assembly prior to placement of the cap by the Contractor. ***(REVISE? TBD 2025)***

(j) Inspection assemblies ~~shall~~ must be installed as shown on the standard drawings. ***(REVISE? TBD 2025)***

(k) The service box ~~shall~~ must be installed plumb with the lid 25 mm above finished grade in unpaved areas and 0 - 6 mm below finished grade in paved areas. ***(REVISE? TBD 2025)***

.4 Riser Service Connections:

(a) Riser service connections ~~shall~~ must be installed as shown on Standard Drawings No. SW-21 - General Storm Service Connection Detail, Riser and Non Riser Types [] or Standard Drawing No. SW-22 - Commercial Areas Storm Service Connection Detail, Riser and Non Riser Types [] in locations shown on the construction drawings. ***(REVISE? TBD 2025)***

SECTION 7 – STORMWATER MANAGEMENT INSTALLATION

7.62 NOTIFICATION TO THE CITY OF NANAIMO

.1 The City ~~of Nanaimo~~ Works Inspector ~~shall~~ must be given 48 hours notice of all tests. ***(REVISE? TBD 2025)***

7.62A CLEANING AND FLUSHING

.1 The pipes ~~shall~~ must be cleaned upon completion of the sewer pipe installation and one month prior to the end of the maintenance period to the satisfaction of the ~~Engineer~~ Professional of Record and the Inspector. Cleaning ~~shall~~ must be completed by power flushing with water to remove all foreign matter. ***(REVISE? TBD 2025)*** ***~~(REVISED MAY 2020)~~***

.2 Ensure that snow chains are installed at the downstream manhole so that no foreign material passes beyond downstream manhole. Flow through the system ~~shall~~ must remain unimpeded at all times while snow chains are installed. ***(REVISE? TBD 2025)***

.3 Begin cleaning from the upstream pipe in the system and proceed downstream. Under no circumstances is the pipe cleaning process to proceed downstream until all contributing upstream pipes have been successfully cleaned and approved by the ~~Engineer~~ Professional of Record, the Inspector, or by the City ~~of Nanaimo~~ CCTV contract administrator. ***(REVISE? TBD 2025)***

.4 Manholes ~~shall~~ must be cleaned after the upstream section of pipe has been successfully cleaned and approved by the ~~Engineer~~ Professional of Record, the Inspector, or by the City ~~of Nanaimo~~ CCTV contract administrator. ***(REVISE? TBD 2025)***

.5 Pipes ~~shall~~ must be cleaned in the direction of flow and ~~shall~~ cannot be flushed in a backflush direction unless approved by the ~~City Engineer~~ Professional of Record, by the Inspector, or by the City ~~of Nanaimo~~ CCTV contract administrator. ***(REVISE? TBD 2025)***

.6 Under no circumstances ~~shall~~ must debris pass beyond the downstream manhole. Active vactoring ~~shall~~ must remove all debris at the snow chains installed at the downstream manhole.

.7 Dispose of the debris at approved dump ~~sire~~ site such as the Regional District of Nanaimo's landfill or by the CCTV contract administrator's approved alternative. ***(REVISE? TBD 2025)***

.8 Decanting of liquid waste accumulated during debris removal is permitted at a controlled release rate, to a maximum of ~~8l/s~~ 8 L/s, at a location approved by the City ~~of Nanaimo~~ CCTV contract administrator. ***(REVISE? TBD 2025)***

.9 Timeframe between cleaning and video inspection of pipeline ~~shall~~ cannot exceed 24 hours unless approved by the City Engineer. ***(REVISE? TBD 2025)***

.10 Ensure all environmental mitigation is in accordance ~~to current BC Ministry of Environment and Department of Fisheries and Oceans Standards~~ Provincial and Federal Regulations. ***(REVISE? TBD 2025)***

7.63 VIDEO INSPECTING MAINS

.1 All pipe video inspection including methods of cleaning, equipment and rates of camera travel, ~~shall~~ are to be in accordance with the UK Water Research Centre's (WRc), Sewage Rehabilitation Manual, most current edition. ***(REVISE? TBD 2025)***

.2 The contractor ~~shall~~ must arrange for a video inspection upon completion of the sewer pipe installation and within one month prior to the end of the maintenance period to the satisfaction of the ~~Engineer~~ Professional of Record and the Inspector. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

.3 For gravity sewers and service connections, the contractor ~~shall~~ must arrange for video inspection to check alignment, grade, and condition of the main sewer pipe including catch basin leads. Where a new sewer pipe crosses an existing sewer pipe, the contractor ~~shall~~ must also arrange for a video inspection of the existing sewer pipe at the location of the crossing. ***(REVISE? TBD 2025)*** ~~***(REVISED MAY 2020)***~~

(a) Illumination depth of field ~~shall~~ must be no less than 3 joints for standard joint and spigot pipe types to allow for pipe deflection assessments (9.0 m). No dark/opaque circle ~~shall~~ are to be visible in the middle of this depth of field viewing area. ***(REVISE? TBD 2025)***

(b) Eliminate steaming and fogging encountered during the inspection survey by introducing forced air flow by means of a fan.

(c) Camera lens to remain free of grease or other deleterious matter to ensure optimal clarity.

(d) Plan and tilt view each service connection (junction) such that the camera looks down the centerline of the service, pause for a minimum of five (5) seconds and note condition of the joint and/or pipe/service interface.

(e) Camera guides (Skids) ~~shall~~ should not be visible at either side of the pipe during normal camera travel or during Pan & Tilt operation. Configuration or camera/guides ~~shall~~ must be altered to alleviate this problem. ***(REVISE? TBD 2025)***

(f) CCTV push camera work ~~shall~~ must be video captured (complete with skids for centering) from the main wye pulling back to entrance point to avoid an invert only view. ***(REVISE? TBD 2025)***

(g) A winch line ~~shall~~ must be provided to support camera travel in steep, slippery, or relined pipe sections. ***(REVISE? TBD 2025)***

(h) Position camera lens centrally in the pipeline with a positioning tolerance of ±10% off the vertical centerline axis of the pipeline. For elliptical pipe the camera to be positioned 2/3 the height of pipe measured from the invert.

(i) Position camera lens looking along the longitudinal axis of pipeline except when viewing service connections or panning defects.

(j) Instantaneous travelling speed of the camera in the pipeline to be as follows:

(i) 0.1 m/s for pipeline of diameter less than 200 mm

(ii) 0.15 m/s for diameters 200 mm and larger but cannot exceeding 310 mm: and

(iii) 0.20 m/s for diameters exceeding 310 mm

.4 The inspection ~~shall~~ must include the preparation of: *(REVISE? TBD 2025)*

(a) an HDSD 32 GB Class 10 regular card. Picture size: NTSC 640X480 pixels, aspect ratio 4:3, 29.97 frames per second @ 8 megabits per second capture rate. Individual MPEG4 video files ~~shall~~ cannot exceed 1.7GB in size. *(REVISE? TBD 2025)* ***~~(REVISED MAY 2020)~~***

(b) a Microsoft Access database CD of the Header and Observation codes as specified by the City ~~Engineer~~. *(REVISE? TBD 2025)*

(c) a pipe condition assessment paper report.

(d) All submitted to the ~~Engineer~~ Professional of Record. *(REVISE? TBD 2025)*

.5 The ~~Engineer~~ Professional of Record must ~~shall~~ review the pipe condition report and provide certification that the condition of the installed pipe is accurately recorded and the pipe installation meets ~~the City of Nanaimo Standards and Specifications.~~ ***~~(REVISED MAY 2020)~~***this manual . *(REVISE? TBD 2025)*

.6 The pipe condition report and certification ~~shall become~~ are the property of the City ~~of Nanaimo~~. *(REVISE? TBD 2025)* ***~~(REVISED MAY 2020)~~***

.7 Variations in line of grade of pipe, from that established by the ~~Engineer~~ Professional of Record prior to installation, and any jointing, pipe cleaning, or other deficiencies discovered during the inspection, ~~shall~~ must be rectified. Re-inspection of the pipe may be required by the ~~Engineer~~ Professional of Record at the Contractor's expense. *(REVISE? TBD 2025)*

.8 During the test, manhole construction and invert elevations ~~shall~~ must be checked and any variations from the established grade, drawing, or specifications, ~~shall~~ must be rectified. *(REVISE? TBD 2025)*

.9 Video inspection and pipe condition coding ~~shall~~ must be undertaken only by personnel with current Canadian certification by a City approved agency. *(REVISE? TBD 2025)*

~~(REVISED MAY 2020)~~

7.63A SMOKE TESTING

.1 The ~~Engineer~~ Professional of Record ~~shall~~ must arrange for smoke testing of all installed storm mains in the presence of the City ~~of Nanaimo Works~~ Inspector. ***(REVISE? TBD 2025)***

.2 The ~~Engineer~~ Professional of Record ~~shall~~ must provide as-built service location information to the City ~~of Nanaimo works~~ Inspector prior to smoke testing. ***(REVISE? TBD 2025)***

.3 Cross-connections noted during the smoke testing ~~shall~~ must be corrected and the ~~as-built~~ record drawing information revised. ***(REVISE? TBD 2025)***

7.64 DRAINAGE DITCH CONSTRUCTION

.1 Drainage ditches ~~shall~~ are to be excavated to the line and grade shown on the construction drawings or as otherwise determined by the ~~Engineer~~ Professional of Record. ***(REVISE? TBD 2025)***

7.65 CULVERT INSTALLATION

.1 Trenches for culvert installation ~~shall~~ must be excavated to the required depth and grade, then backfilled in accordance with the requirements for storm mainlines. ***(REVISE? TBD 2025)***

.2 Concrete Pipe:

(a) Install pipe in accordance with Section 7.42 - Pipe Installation [→].

.3 Polyvinyl Chloride (PVC) Pipe:

(a) Install pipe in accordance with Section 7.42 - Pipe Installation [→].

7.66 CULVERT HEADWALLS

.1 Culvert headwalls ~~shall~~ must be constructed as shown on the Standard Drawings. ***(REVISE? TBD 2025)***

.2 "Wet-mix" Sandbags:

(a) The sandbag sacks ~~shall~~ are to be wetted and filled with wet premixed concrete and folded at the top to retain the concrete at the time of placing.

(b) Immediately after being filled with concrete, sacks ~~shall~~ are to be placed and lightly tamped to conform with the slope, culvert pipe, and adjacent sacks in-place. ***(REVISE? TBD 2025)***

(c) Sacked concrete ~~shall~~ are to be laid in courses such that joints in succeeding courses are staggered. Courses ~~shall~~ are to be a minimum of ten per vertical metre. Dirt and debris ~~shall~~ are to be removed from the top of sacks before the next course is laid thereon. ***(REVISE? TBD 2025)***

(d) Prior to sacked concrete setting, courses of bags ~~shall~~ are to be tied by driving a 15M reinforcing bar vertically from top to bottom through each course so that displacement ~~will~~ cannot occur after the final set of concrete. Top of reinforcing bar ~~shall~~ must be bent over on top. ***(REVISE? TBD 2025)***

.3 Headwalls ~~shall~~ must be protected from heavy rainfall and from contacting water for a period of at least 24 hours after placing. ***(REVISE? TBD 2025)***

.4 Composite culvert headwalls ~~shall~~ must be installed as per manufacturer's recommendations and ~~Engineer~~ Professional of Record approved design drawings. ***(REVISE? TBD 2025)***

7.67 PERFORATED DRAINS

.1 Excavate trench to the lines and grades as shown on the construction drawings.

.2 Place sufficient filter fabric in the trench to provide a minimum 300 mm overlap after the drain rock is placed.

.3 Place a 150 mm thick layer of drain rock and install the perforated pipe. Perforations ~~shall~~ must be installed on the bottom half of the pipe. ***(REVISE? TBD 2025)***

.4 Place drain rock to within 150 mm of finished surface and surround with filter fabric.

.5 Place remaining 150 mm of drain rock or, if specified, ~~top soil~~ topsoil to finish grade. ***(REVISE? TBD 2025)***

.6 Install all manholes as per Section 7.0 - Stormwater Management.

7.68 INLET AND OUTLET STRUCTURES

.1 Inlet and outlet structures ~~shall~~ must be installed in accordance with Standard Drawings. ***(REVISE? TBD 2025)***

.2 Excavate to the lines and grades as shown on the construction drawings. If subgrade is unsuitable for support as determined by the ~~Engineer~~ Professional of Record, the bottom ~~shall~~ must be excavated and backfilled to the required grade with road base gravel compacted to 95% modified proctor or drain rock. ***(REVISE? TBD 2025)***

.3 Structure ~~shall~~ must be placed on a minimum of 100 mm (compacted thickness) of road base gravel compacted to 95% modified proctor. Where groundwater is present, drainrock may be substituted for road base gravel if approved by the ~~Engineer~~ Professional of Record. ***(REVISE? TBD 2025)***

.4 Cast in place concrete ~~shall~~ are to conform to Section 11.0 - Cast In Place Concrete Works []. ***(REVISE? TBD 2025)*** ***~~(REVISED MAY 2020)~~***

7.69 RIPRAP

.1 Areas to receive riprap ~~shall~~ must be trimmed to a uniform surface, to the grades shown on the drawings. Before rock placement commences, loose materials ~~shall~~ must be removed and minor pot holes and hollows filled in with select granular sub-base, well tamped in. *(REVISE? TBD 2025)*

.2 Geotextile material and placement, where required, ~~shall~~ must be as shown on the drawings. *(REVISE? TBD 2025)*

.3 At the toe of sloped riprap, larger rocks ~~shall~~ must be placed regularly enough to form a firm foundation, 50% thicker than the required nominal thickness. *(REVISE? TBD 2025)*

.4 Other large rocks ~~shall~~ are to be regularly spaced. Smaller rocks ~~shall~~ are to be well positioned to form an interlocking, even surface. *(REVISE? TBD 2025)*

7.70 PIPE VIDEO AND MANHOLE CONDITION REPORT FORMAT

.1 Reference plans ~~shall~~ must accompany reports with manholes labeled and inspected sections highlighted. Manhole and pipe numbering ~~shall~~ must conform to the construction drawings, or if available, City ~~of Nanaimo~~ pipe and manhole numbers. Reports ~~shall~~ are to be submitted in both digital and hardcopy formats. *(REVISE? TBD 2025)*

.2 All sewer defects ~~shall~~ must be photographed and included with the report and referenced by numbers accordingly. *(REVISE? TBD 2025)*

.3 The video pipe condition rating report format ~~shall~~ are to be in accordance with the UK Water Research Centre's (WRc), Sewerage Rehabilitation Manual, most current edition. Structural defects ~~shall~~ must be properly weighted with the appropriate scores assigned to them as shown in the following table: *(REVISE? TBD 2025)*

WRc GRADING SYSTEM		
DEFECT CODE NO.	TYPE OF DEFECTS	POINT SCORES
1	Open Joints	1 to 2
2	Displaced Joints	1 to 2
3	Cracks	10 to 40
4	Fracture	40 to 80
5	Broken	80
6	Hole	80 to 165
7	Collapsed	165
8	Spalling	5 to 120
9	Wear	5 to 120
10	Deformation	20 to 165

.4 Every video inspected sewer will be assigned a composite grade based on the sum of its defect point scores as per the following table: ~~*(REVISED MAY 2020)*~~

WRc - SEWER RATING COMPOSITE GRADE ~~*(REVISED MAY 2020)*~~

COMPOSITE GRADE ~~*(REVISED MAY 2020)*~~	PEAK SCORE RANGE (SUM OF THE SCORES FROM THE ABOVE TABLE)	TYPICAL DEFECT DESCRIPTION
1 (least defective)	1 to 9	No observable structural defects
	10 to 39	Circumferential crack. Moderate joint defects, i.e. open joint (medium) or joint displaced (medium), spalling slight and wear slight.
3	40 to 79	Fracture with deformation <5%. Longitudinal cracking or multiple cracking. Minor loss of level. More severe joint defects, i.e. open joint (large) or joint displaced (large). Spalling medium. Wear medium.
4	80 to 164	Broken, deformation up to 10% and broken fracture with deformation 5 - 10%. Multiple fractures. Serious loss of level. Spalling large. Wear large.
5 (most defective)	165+	Already collapsed. Deformation >10% and broken. Extensive areas of fabric missing. Fracture with deformation >10%.

.5 The following additional information ~~shall~~ must be included for each sewer section as the CCTV Title Page: ***(REVISE? TBD 2025)***

(a) Date of survey.
(b) Contractor Project Index No. (i.e. Tape No. V2-1234)
(c) Survey No.
(d) Start MH No.
(e) Finish MH No.
(f) Line ID No.
(g) Direction of Camera Travel.
(h) Street Location (~~Road~~Street Name or RW No.). ***(REVISE? TBD 2025)***
(i) Distance from the manhole rim to pipe invert.
(j) Length of Capture.
(k) Total of Captured CCTV.
(l) Current weather information.

.6 All pipe video inspections ~~shall~~ must include an annotated map with the following information: *(REVISE? TBD 2025)*
(a) Manhole and catch basin locations with labels.
(b) City of Nanaimo drawing numbers.
(c) Manhole I.D. numbers (as per the City ~~of Nanaimo~~ GIS numbering system). *(REVISE? TBD 2025)*
(d) Catch basin I.D. numbers (as per the City ~~of Nanaimo~~ GIS numbering system). *(REVISE? TBD 2025)*

.7 Computer database file to contain identical survey report information as the printed report exclusive of photographs. Index numbers and distance of survey information ~~shall~~ are numerically increase. For an individual survey, whether the information is sorted by index or distance, the result will be in the same order. *(REVISE? TBD 2025)*

.8 All pipe video inspections operators ~~shall~~ must be thoroughly trained with current Canadian certification by a City approved agency. *(REVISE? TBD 2025)*

.9 Manhole video inspection is not required. Manholes ~~shall~~ must be rated as per the following table, and form part of the video inspection report. *(REVISE? TBD 2025)*

MANHOLE RATING SYSTEM *(REVISE? TBD 2025)*

INTERNAL CONDITION GRADE	TYPICAL DEFECT DESCRIPTION
1 (least defective)	-No observable structural defects. -No observable signs of infiltration.
2	-Minor cracks, chips, spalling. -Signs of minor staining, but no infiltration.
3	-Fractures, medium spalling, defective pipe/MH joints. -Some staining, mineral build-up and seeding infiltration. Possible infiltration through manhole cover.
4	-Broken manhole wall, channel or riser assembly, multiple fractures, medium wear. -Moderate staining, mineral build-up and running infiltration. -Infiltration through manhole cover. -Manhole frame and cover cracks or broken.
5 (most defective)	-Failure in manhole wall, channel or riser assembly, multiple fractures with deformation, large wear. -Heavy staining, mineral build-up and gushing infiltration. -Surface ponding and infiltration through manhole cover. -Manhole frame and cover cracks or broken.