# SECTION 7 – STORMWATER MANAGEMENT
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***(REVISED MAY 2020)***

# SECTION 7 – STORMWATER MANAGEMENT DESIGN CRITERIA

7.01 INTRODUCTION

.1 Scope:

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 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)***

.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.
(b) Major System – To safely convey the 1:100 year storm event runoff with overland and piped flow to suitable receiving bodies. ***(REVISED MAY 2020)***
(c) Minor System – To safely contain the 1:5 year storm runoff within the minor system. ***(REVISED MAY 2020)***
(d) Rainwater Best Management Practices – To emulate the natural conditions of undeveloped land by capturing or retaining small rainwater events and infiltrating the water into the ground.
(e) Downstream Environmental Protection – To ensure that the quality and quantity of flows do not adversely affect the receiving waters. ***(REVISED MAY 2020)***

.3 City Bylaws:

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:

(a) Stormwater Management in Nanaimo
(b) Official Community Plan
(c) Other bylaws pertaining to stormwater as listed in Section 3.01(c) City Bylaws

.4 Other Applicable Government Initiatives:

In addition, this manual should be used in accordance with other applicable government policies, guidelines and documents, including, but not necessarily limited to the following:

(a) Federal Fisheries Act
(b) Provincial Fish Protection Act

(c) Fish-Stream Crossing Guidebook, Revised Edition, Ministry of Forests, Lands and Natural Resource Operations, Ministry of Environment
(d) Stormwater Source Control Guidelines 2012 – Metro Vancouver
(e) Stormwater Planning: A Guidebook for British Columbia

.5 Previous Design Criteria:

City of Nanaimo utility systems have been constructed over many years using design criteria and practices that were in place at the time. The current criteria is to be used when designing all new infrastructure and when assessing the adequacy of existing systems. Existing systems which do not meet current design criteria will be evaluated on a case-by-case basis and upgraded as resources permit. When replacing existing infrastructure, should the existing system not meet current criteria, the Design Engineer will be responsible to ensure the design is appropriate and founded on solid engineering principles and practices.

.6 Development Requirements:

(a) Responsibilities:

Development proponents shall be responsible for designing stormwater systems which consider watershed management, flood protection, drainage, conveyance, riparian preservation, and watercourse protection. ***(REVISED MAY 2020)***

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.

Construction activities must be managed to minimize the impact to adjacent watercourses as set out in the "Storm Sewer Regulation and Charge Bylaw No. 3808" and Erosion and Sediment Control Guideline.

It is the Design Engineer's responsibility to ensure that all applicable guidelines, standards, bylaws, and other regulations and policies are strictly followed.

(b) Reporting:

Development proponents 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. The Stormwater Management Plans shall be presented in a report which includes: ***(REVISED MAY 2020)***

(i) A tributary area plan outlining all areas included in the stormwater calculations, tributary to the rainwater management measures and the associated minor and major systems. ***(REVISED MAY 2020)***

(ii) 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. ***(REVISED MAY 2020)***

(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) A rationale explaining which method is chosen and why the method is chosen for hydrological analysis. ***(REVISED MAY 2020)***

(vi) Summary tables that provide the follow key design information:

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

(b) Percent imperviousness values of the catchment under both pre and post development conditions. ***(REVISED MAY 2020)***

(c) Hydrological parameters (e.g. runoff coefficients, time of concentration values, infiltration parameters etc.) used for flow and HGL calculation. ***(REVISED MAY 2020)***

(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)***
(b) Hydraulic and Hydrologic design calculations for the pipe network using either the Rational Method and Manning's Equation or computer modeling.
(c) Design calculations for storage facilities including the required storage volume, design size and flow control considerations. ***(REVISED MAY 2020)***
(d) Design calculations for rainwater management best practices including the design volume and facility size. ***(REVISED MAY 2020)***
(e) Time of concentration design calculations including a rationale explaining which method was chosen and why that method was chosen.

(viii) The report shall include details regarding the provisions included to address water quality leaving the suite and entering the minor system.
(ix) For systems which include works or facilities which require ongoing maintenance, an operation and maintenance plan shall be provided detailing the inspection and maintenance, an operation and maintenance plan shall be provided detailing the inspection and maintenance requirements.
(x) All Stormwater Management Plans are to be signed and sealed by a Professional Engineer licensed in British Columbia.

7.02 SUMMARY OF STORMWATER AND ENVIRONMENTAL PROTECTION DESIGN AREA

.1 This section provides a summary of all 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 the 1:5 year return period to minimize inconvenience of frequent surface runoff. ***(REVISED MAY 2020)***

(b) A major system conveyance capacity up to the 1:100 year return period to provide safe conveyance of flows to minimize damage to life and property. ***(REVISED MAY 2020)***

(c) For areas draining to watercourses: Provide volume reduction, detention, and water quality treatment to minimize erosion and protect aquatic habitat and water quality.

(d) For areas draining directly to the ocean, volume reduction is not required; however, detention for the protection of downstream infrastructure may be required and water quality treatment. ***(REVISED MAY 2020)***

(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.

(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.

(g) Provide water quality treatment for 90% of the average annual runoff (the 6 month, 24 hour storm or 50% of the 2 year, 24 hour storm) for impervious surfaces exposed to vehicle traffic as described in Section 7.14 – Water Quality. Remove 80% of Total Suspended Solids over 50μm particle size.

(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:

Ultimate land use for the purpose of stormwater calculations shall be determined by referring to the current “Official Community Plan” and the current Official Regional District Community Plans for the area outside the City.

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 also consider any contributing catchment areas which have been established by the City of Nanaimo. ***(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 rainfall. The updated IDF curve takes climate change into account, Standard Drawing No. SW-25. ***(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 City staff; however, it is up to the individual engineer to verify the quality of the data and use the data for hydrological calculation. ***(REVISED MAY 2020)***

.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 to the point of interest and having the greatest impact on downstream flows.

(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 determine the most appropriate method of calculating the time of concentration. Overland flow 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.

(c) Minimum and Maximum Time of Concentration:

The minimum time of concentration for all calculations shall be 5 minutes. The maximum time of concentration shall be 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 determined by one of the above mentioned methods.

.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:

$$Q = CIA \times 2.78$$

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 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 areas. Selection of the runoff coefficient for existing areas shall include a review of the orthographic photo to determine the impervious area.

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 | 0.65 to 0.90 |
| Single Family Residential and Low Density Multi-Family | 0.50 to 0.80 |
| Rural Areas, Parks, Golf Courses | 0.25 to 0.55 |

(d) Presentation:

Where the rational formula is used, two copies of the storm sewer design calculations, in a format in accordance with Appendix H2, Stormwater Management Flow Analysis – Calculation Sheet shall be submitted.

.6 Computer Simulation Methodology:

(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 be used. The model results must be used for design and sizing of all pipes and storage facilities.

(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.

(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 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.

(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 the following:

(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 and minor storm in a table.
(vi) Summary hydrograph(s) of any storage or flow control facilities.
(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 and minor storm calculations.
(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 for design scenarios.

(xiii) A digital copy of the model files.

.7 Peak Flow and Runoff Volume Control:

(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.

(ii) 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.

(iii) 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:

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:

The minor system shall be designed to convey the 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, etc., and other appurtenances designed to ultimately discharge into a major system.

.2 Location:

The minor system shall normally be located in road right-of-way for ease of access to repair or maintain the system. Where the minor system is located in private property, the flow route shall be preserved by restrictive covenants and/or statutory right-of-way for ease of access to repair or maintain the system.

.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.

7.05 MAJOR SYSTEM

.1 Definition:

The major system shall be designed to convey the 1:100 year design storm. The major system includes all drainage works that convey, detain, divert and intercept the major design runoff including piping, manholes, swales, ditches, etc., and other appurtenances designed to ultimately discharge into a natural watercourse.

.2 Location:

(a) Generally, the major system shall be overland flow paths where the design flow can be conveyed in public road right-of-way and adequate watercourses. Where adequate overland major system paths cannot be established, pipes, and culverts of the minor system may be enlarged to accommodate the major flow subject to approval of the City Engineer.

(b) When the major flow is accommodated by a public street, the street shall be designed to provide sufficient hydraulic capacity to handle the major flow. Planning the major drainage system shall be done simultaneously with street layout and gradient planning to define the function of the streets as a part of the storm drainage system.

(c) When major flow is overland through private property, the flow route shall be protected and preserved by restrictive covenants and/or statutory right-of-way for ease of access to repair or maintain the system.

(d) Overland flow paths through private property shall be designed to minimize property damage and endangerment to public safety and have a suitable erosion protection.

(e) If no safe overland flow path exists, 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 the major flow is accommodated through the storm sewer system, additional catch basins may be required to ensure the flow can be captured by the minor system. The capability of the catch basins to accept the major flow is to be reviewed and confirmed.

.3 Discharge to Existing Watercourses:

(a) The discharge to an existing watercourse shall be designed in a way that protects the watercourse from erosion. Flow velocities exceeding 1.5 m/s require an energy dissipater to reduce flow velocity to an acceptable rate.

(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.) but no major damage such as damage to dwellings, significant erosion or private property, or damage to public facilities shall result from the major storm. 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 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.

(c) The major system shall be designed such that all habitable portions of buildings including basements are a minimum 0.3 m above the major flow hydraulic grade line. No building shall have the bottom of its foundation less than 0.3 m above the maximum high water elevation of any storm water storage facility. In circumstances where lower building elevations are desired, the minor system may be enlarged to accommodate the major flow.

(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 ensure that the slope of the ground around structures has positive drainage away from structures.

.5 Roadway:

(a) Where the road is used to accommodate major flow, the following criteria must be considered:

(i) For local streets, the maximum depth at the crown of the road is to be 50mm.
(ii) For neighborhood collectors, minor collectors, major collectors and arterial roads, a minimum of 3.0 m width of the road shall be free from flooding.
(iii) Care should be taken when designing intersections of roads which are used to convey the major storm so that flows can pass over the cross street.
(iv) Care should be taken designing the grading at road curves and at locations where major flow path turns at intersections or at tee intersections.
(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 downhill from streets which form part of the major system. Type 2 driveway letdowns shall be avoided as shown in Standard Drawing No. CS-5A.

(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) The hydraulic capacity of a street section to convey water shall be calculated by the Manning Equation subject to the above conditions for major flows in a roadway.

7.06 PIPE DESIGN DETAILS

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

(a) The minimum design velocity for pipes shall be 1.0 m/s.
(b) Where the pipe discharge velocity of the design flow exceeds 1.5 m/s, into an open ditch or watercourse, provision shall be made for the installation of an energy dissipater to reduce flow velocity to the acceptable rate.
(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 be examined and anchor blocks shall be required as per Standard Drawing No. T-8 and Standard Drawing No. T-8A.
(d) All 100mm diameter service connections shall have a minimum grade of 2%.

.2 Pipe and Service Connection Sizes:

(a) Minimum pipe diameters shall be 250 mm. In residential areas, 200 mm diameter may be approved by the City Engineer in the final section of a lateral sewer providing the pipe has the required capacity and extension in the future is precluded by physical barriers or there is existing alternate pick-up of drainage from adjacent areas.

(b) Unless otherwise approved by the City Engineer, downstream pipe diameter shall be greater than or equal to upstream pipe diameter.

(c) Residential service connections shall be a minimum 100 mm diameter, except service connections servicing lawn basins shall be a minimum 150 mm diameter.

(d) Commercial and Industrial service connections shall be a minimum 150 mm diameter.

.3 Selection of Pipe Material and Class:

The Design Engineer shall consider earth and live loading, soil conditions, and design life of the installation for determining pipe material and class. Pipe materials and brands shall be per the City of Nanaimo's Approved Products List.

.4 Pipe Friction Factors:

Storm sewers shall be designed using the Manning Formula. The minimum 'n' value shall be 0.013 for all approved pipes.

.5 Pipe and Service Connection Depths:

(a) Minimum Cover:

(i) Storm sewers shall have 1.5 m of cover in road right-of-way.
(ii) Storm sewers shall have 1.0 m of cover in untraveled areas.
(iii) Service connections shall have 0.75 m of cover.
(iv) Where minimum cover cannot be provided, an explanation of the reasons and pipe loading calculations shall be submitted with the proposed method of pipe protection to the City Engineer for approval.

(b) Where practical, service connections shall be deep enough to accommodate by gravity 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 be graded in such a way which prevents overland flow from impacting neighboring structures.

(c) In addition, all existing foundation drains shall be accommodated. For vacant lots, service connections shall also be deep enough to accommodate by gravity foundation drains for future building(s) constructed to the minimum basement floor elevation as determined by the Design Engineer.

(d) Storm Sewer mains shall be deep enough that all service connections accommodating surface and foundation drainage from all lots in the upstream drainage basin can be drained to the storm sewer system by gravity.

.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 not exceed 50% of the manufacturer's maximum recommended joint deflection. Radius of curvature shall be uniform throughout the curves. ***(REVISED MAY 2020)***
(e) Only one vertical and/or horizontal curve shall be permitted between manholes.

.7 Location of Storm Sewer Mains and Service Connections:

(a) Storm sewer mains shall be located not less than 3.0 m horizontally and 0.45m vertically from all watermains unless otherwise approved by the Provincial Department of Health. Normal storm sewer main offsets are shown in the standard drawings for roadways.
(b) If there is a significant elevation difference between the lots on opposite sides of the street, if possible, storm sewers shall 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 be located on the high side of the street.
(c) All lots shall be provided with a storm sewer service connection, unless otherwise approved by the City Engineer. Service connections shall 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:

The following shall be considered in the design of utilities crossing private lands:

(a) The design of utilities shall 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.
(b) Utilities following property boundaries across private lands shall generally be offset a minimum 2.0 m from the property boundary.
(c) Appurtenances such as manholes, valves, etc., shall be located entirely on one property, they shall not be located on property boundaries.

(d) Utilities shall not 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.

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

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

(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 30 m. Storm sewer services longer than 30 m shall require approval by the City Engineer. All inspection assemblies required for service connections in excess of 30 m in length shall be shown on the design drawings.

(b) For industrial, commercial, and multi-family servicing, and/or where oil interceptors are required, manholes shall be provided where the service connects with the main or at the property line regardless of the size of the service.

(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 other service manhole is to be located on the service line close to the property line.

.10 Number of Service Connections per Lot:

(a) Each lot shall 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 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 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 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 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 be accommodated by manhole benching. Precast manhole barrels shall 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.) | 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 be increased for manholes within multiple large pipes. | | |

(e) Where cast in place manholes are proposed, all design and construction details shall be submitted to the City Engineer for approval.

(f) Manholes shall 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 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 be calculated and the corresponding drop in inverts across the manhole shall be included in the design where appropriate.

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

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

.12 <u>Catch Basins:</u>

(a) Catch basins shall 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 be spaced to collect a maximum of 450 $m^2$ of pavement drainage where grades do not exceed 5%. On grades over 5% the maximum area collected shall be reduced to 300 $m^2$.

(c) Double catch basins are required at all low points in roads 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:

(i) Curb inlet catch basins shall be used in locations along non-mountable curbed roads at all low points or in other areas where additional inlet capacity is required.
(ii) Boulevard catch basins shall be used in boulevards and easements outside of the paved road.
(iii) Lawn basins shall 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.
(iv) Shallow catch basins shall be used in locations where it is not possible to provide a catch basin with a stump.

(d) 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 basin leads shall be wyed together. Basin shall not be directly connected.
(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:

(a) 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.

(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 per Section 4.18 – Trench Dams.

.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 will be extended well below the road 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.

## 7.07 CULVERTS

.1 General:

(a) Generally, culverts shall be sized to suit the drainage area and shall not be smaller than upstream culverts without prior approval of the City Engineer.
(b) Inlet and outlet structures shall be appropriately designed with energy dissipation, scour protection, erosion control and overflow protection as needed.

.2 Road Culverts:

(a) Road culverts shall be designed to accommodate the major system. 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.
(b) Road culverts shall be minimum 450 mm diameter regardless of hydraulic capacity.
(c) Road crossings of watercourses which are, or could be fish bearing, shall be designed to provide fish passage where possible. Open bottom culverts are preferable.

.3 Driveway Culverts:

(a) Driveway culverts shall be designed to accommodate the minor storm with the headwater not above the crown of the pipe.
(b) Driveway culverts shall be minimum 300 mm diameter regardless of hydraulic capacity.

7.08 DITCHES (WITHIN ROAD RIGHT-OF-WAY)

(a) Ditches shall be used in road allowances where there is no curb and gutter to direct minor and major flows towards watercourses or the nearest piped system.
(b) Ditches shall be designed to promote groundwater infiltration.
(c) Ditches adjacent to travelled roadways shall not exceed 1.9 m in depth.
(d) Ditches shall be trapezoidal in shape having maximum side slopes of 1-1/2 H:1V and a minimum bottom width of 450 mm.
(e) The minimum grade of a ditch shall be 0.5%.
(f) The maximum velocity in an unlined ditch shall be 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.
(g) On steep slopes, grade control structures may be required.

7.09 SWALES (WITHIN ROAD RIGHT-OF-WAY)

(a) Swales shall be used in road allowances 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.
(b) Swales shall be designed to promote groundwater infiltration.
(c) Swales shall have a minimum depth of 150 mm, and a minimum width of 1.5 m.
(d) The minimum grade of a swale shall be 1.0%.
(e) Swales shall not be used where the velocity exceeds 1.5 m/s or on an excessively steep slopes.

7.10 OPEN CHANNELS (WITHIN PRIVATE PROPERTY AND EASEMENTS)

(a) The design of open channels as part of the major or minor system shall be restricted to the following maximum velocities:

(i) Unlined channel: 1.5 m/s
(ii) Suitably lined channel: 3 m/s

(b) If the mean velocity exceeds that permissible for the particular kind of soil or greater than 1.5 m/s, the channel shall be suitably lined to protect it from erosion.
(c) The maximum depth of flow shall not exceed 300 mm with a freeboard of 150 mm.
(d) Side slopes on designed channels shall not exceed 3H:1V.
(e) Open channels shall be designed where possible to promote infiltration.

## 7.11 INLET AND OUTLET STRUCTURES

(a) Inlet and outlet structures shall be required on all storm sewer pipes and culverts. Headwater requirements shall be as per Section 7.07 - Culverts.

(b) A trash rack is required as a part of all inlet structures to storm sewer pipes. Trash racks may be required on culverts as the discretion of the City Engineer.

(c) Trash rack hydraulic and structural design shall allow for passage of design flows with 50% blockage of the trash rack with debris.

(d) 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.

(e) Pipe leaving inlet structures, where the inlet elevation significantly higher than the storm sewer, shall have a maximum grade of 5% for minimum 2. 0m. After the 2.0 m, the pipe grade can be adjusted with a vertical curve to attain design depth.

(f) Cast in place inlet and outlet structures shall be designed by a structural engineer to suit the specific site and soil conditions. Standard drawings shall be used as a guide for specific design criteria. Approved prefabricated inlet and outlet structures may be used. The Engineer shall ensure the structures are designed to suit the existing site and soil conditions.

(g) Sandbag headwalls shall not be used except for driveway crossings or hydrant access crossing.

(h) Outlets for storm sewers having velocities in excess of 1.5 m/s shall incorporate a method to dissipate the energy so that the erosion will not occur in the receiving channel. ***(REVISED MAY 2020)***

(i) All inlet and outlet structures shall include provisions for safe maintenance access and shall conform to WorkSafeBC requirements.

## 7.12 STORAGE FACILITIES

### .1 General:

(a) The design of permanent storage facilities forming part of the major system shall be an integral part of the overall drainage basin plan.

(b) The design of permanent storage facilities shall 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.

(c) Storage facilities shall accommodate the entire future developed tributary area.

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

.2 Ownership:

(a) Single Family and Duplex Residential:

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.

(b) Multi-Family Residential, Commercial, Industrial, and Institutional:

Storage facilities required as part of a multi-family, commercial, industrial, or institutional development will be owned and operated privately. Facilities may be underground or above ground including roof top or parking lots.

.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.

.4 General Design Guidelines:

(a) Storage facilities shall be tailored to suit the unique characteristics of the site and shall include a geotechnical evaluation to address the groundwater table interaction, and the permeability and stability of the existing soils.

(b) Maximum grade for a dry detention pond shall be 4H:1V.

(c) Maximum grade for a wet detention pond shall be 7H:1V from the normal water level to a depth of 0.4 m; steeper side slopes may be considered 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 be designed to accommodate the design storage volume with a freeboard of 300 mm under the 100 year storm conditions. ***(REVISED MAY 2020)***

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

(f) All existing and future foundation drains shall drain by gravity to the storage facility inlet pipe above the design storage level.

(g) An overflow spillway shall be provided to handle potential peak runoff from the major storm or a blockage to the outlet. Discharge shall be to the major system downstream flow path.

(h) An 8.0 m buffer zone shall 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.

(i) An access at least 3.0 m wide shall be provided to all storage facilities for maintenance purposes. The access shall allow the passage of motor vehicles unless otherwise approved by the City Engineer.

(j) Storage facilities shall be appropriately landscaped and protected from erosion.

(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) The outlet control for storage facilities shall be designed for easy access and maintenance and shall be provided with a lock to prevent vandalism.

(m) 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 consider the following:

(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.

(b) The outlet structure for a storage pond shall discharge to a point downstream which has the ability to safely and adequately accommodate the maximum discharge.

(c) Outlet structures shall 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.

(d) Outlet structures shall conform to Section 7.11.

(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 m/s is required for the design of the lattice..

(f) Outlets shall be designed to all appropriate WorkSafeBC requirements for entry and exit.

(g) Outlet structure shall be designed to allow easy and safe access for cleaning of the inlet side during peak runoff.

## 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 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 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 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 may also be called: rainwater BMPs, stormwater source controls, low impact development BMPs, or rainwater management methods. ***(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 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, 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. ***(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 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.

(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 Paving:

Previous 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 less maintenance is required and additional treatment benefits are realized.

(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 required 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.

(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 approval by the City Engineer.

.3 Application:

(a) Single Family and Duplex:

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.

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.

(b) Multi-Family Residential, Commercial, Industrial, and Institutional:

The use of rainwater best management practices to infiltrate to retain rainwater is required for multi-family, commercial, industrial, and institutional developments in order to preserve the natural hydrologic condition as much as possible.

(c) Steep Slope Development:

Steep slope residential developments (R10 Zoning) 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. ***(REVISED MAY 2020)***

(d) Areas which are underlain by shallow coal mines 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. ***(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". 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 be in accordance with Section 7.03.6(b). 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:

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:

| | |
|---|---|
| Sand | 210 mm/hr |
| Loamy Sand | 61 mm/hr |
| Loam | 13 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 |

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 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:

Rainwater infiltration and groundwater recharge shall not be placed in areas with unsuitably high groundwater. The seasonally high groundwater table should be at least 600 mm below the bottom of the infiltration facility.

(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.

(f) Drinking Water Wells:

The design of groundwater recharge facilities shall be separated from drinking water wells and must meet all Ministry of Health guidelines for separation of wells from septic fields.

(g) Water Quality:

Water infiltrated into the ground shall be uncontaminated. Sites which present a high risk of groundwater contamination shall provide appropriate pre-treatment and spill control, if necessary, prior to infiltrating rainwater runoff. Examples of these sites include:

(i) Automobile Service Yards, and
(ii) Industrial Chemical Storage Facilities.

(h) Contaminated Soils:

Sites with contaminated soils shall be reviewed by a Geotechnical Engineer and/or Hydrogeologist for suitability for rainwater infiltration into the ground.

(i) Steep Slopes and Unstable Soils:

Sites containing steep slopes, near steep slopes, or unstable soils shall be reviewed by a geotechnical engineer 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 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 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 review by a Hydrogeologist or Geotechnical Engineer.

(j) Overflows:

Rainwater best management practices shall be designed with an overflow into the minor or major drainage system.

(k) Maintenance:

The design of rainwater best management practices shall be such that the maintenance required in order for the facilities to properly operate shall be minimized. Regular maintenance which is required shall be identified in the Stormwater Management Plan.

(l) Sediment Loads:

All rainwater management best practices, other than green roofs, shall 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 the construction period. Infiltration facilities shall be designed in a way which prevents sediment from entering the facility and plugging the water-soil interface.

## 7.14 WATER QUALITY

.1 Introduction:

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

.2 Treatment:

(a) High Risk Sites:

Sites which present a high risk of groundwater or receiving water contamination shall provide appropriate treatment prior to water entering the stormwater system. Examples of these sites include:

(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 $m^2$ in size shall require treatment to remove oil, total suspended solids (TSS), and other contaminants. Treatment can be achieved by draining the parking area to rainwater best management practices or by installing a mechanical method or 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.

(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 mm of rainfall per square metre of impervious area. Maintenance manuals shall be provided for all mechanical treatment facilities.

(d) Sediment:

All stormwater management systems shall 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.

(e) Water Quality:

Treated water shall meet in British Columbia Approved Water Quality Guidelines as set out by the Water Protection and Sustainability Branch of the Ministry of Environment.

## 7.15 CLIMATE CHANGE

.1 Rainfall Patterns:

(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. 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. Based on 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], the IDF curve was updated to account for Climate Change, Standard Drawing No. SW-25. Refer to Section 7.03.3.(a). ***(REVISED MAY 2020)***

[1] APEGBC, Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC, 2012, Section 3.53, Pg. 23 and Section H.3.1., pg. 123.
[2] http://www.pacificclimate.org/analysis-tools/plans2adapt Potential Impacts for Nanaimo in the 2080's.

.2 Sea Level Rise:

(a) The City of Nanaimo recognizes that our climate is changing and the change may impact the sea levels. Development sites which are near the waterfront may be required to review and accommodate sea level rise in their development. Sea level rise is a complex problem and requirements will be established on a site by site basis; requirements to accommodate climate change may also be adjusted from time to time. For cases where exact sea level rise has not been determined, the predicted rise of 1.0 m by the end of the century shall be used as a minimum.[3]

[3] 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 of Nanaimo Approved Products List will be accepted for installation.

.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 Engineer, testing is required, the Engineer 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.

.2 The Contractor, as directed by the Engineer, shall supply specimens or samples for testing.

.3 The types of tests listed below may be required by the Engineer unless in the opinion of the Engineer other testing is required.

.4 Joints for storm sewer main pipe and fittings and service connection pipe and fittings shall be capable of meeting the following exfiltration tests. The Engineer may require that these tests be carried out by the Contractor or his supplier prior to acceptance of pipe on the project.

(a) Pipes in Proper Alignment:

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

(b) Pipes in Maximum Deflected Position:

At least 2 joints of the assembly shall be deflected to the maximum amount recommended by the manufacturer. 35kPa internal hydrostatic pressure shall then be applied to the test section and maintained for a period of 24 hours. Joints shall show no leakage.

(c) Pipes in Maximum Lateral Misalignment:

The test section shall 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 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 pipe having a laying length of more than 1.2 m shall be loaded no more than the amount computed for a 1.2 m length. While under this load, stressed joints shall show no leakage under 35kPa internal hydrostatic pressure.

7.22A PIPING, FITTINGS AND SERVICES

.1 The sizes and types of pipe to be used are shown on the drawings.

.2 Concrete Pipe:

(a) Non-reinforced concrete pipe and fittings shall conform to ASTM C14M Class 3 to a maximum diameter of 600mm and shall be designed with flexible rubber gaskets joints conforming to ASTM C443M.
(b) Reinforced circular concrete pipe and fittings shall conform to ASTM C76M Class III or higher for all pipe greater than 600mm diameter and shall be designed with flexible rubber gasket joints conforming to ASTM C443M.
(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 be DR35. Pipe and fittings shall have a minimum pipe stiffness of 320kPa at 5.0% deflection when tested in accordance with ASTM D2412.
(b) Pipe and fittings shall be manufactured to the following specifications:
100mm – 375 mm dia to ASTM D3034 and CSA B182.2
450mm – 675 mm dia to ASTM F679 and CSA B182.2
(c) Pipe and fittings shall include integral bell and spigot ends with stiffened wall section and a formed groove for a rubber gasket conforming to ASTM F477.
(d) All PVC storm pipe shall be green in colour.

.4 Ductile Iron Pipe:

(a) Pipe and fittings shall conform to ASTM A746 or as approved by the Engineer.

.5 Polyvinyl Chloride (PVC) Service Pipe:

(a) All storm service inspection assemblies shall be green in colour.

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

(c) Storm service connections greater than 100 mm diameter shall be as specified for PVC (smooth profile) mainline pipe.

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

(a) Pipe shall conform to AWWA C906. All pipes to be certified by Canadian Standards Association – CSA B137.1. ***(REVISED MAY 2020)***

(b) Minimum acceptable pipe class shall be DR26 with a hydrostatic design stress rating of 10MPa.

(c) All pipe supplied shall bear the pipe series designation and manufacturer’s name.

(d) Fabricated HDPE mitred fittings shall 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 have a pressure rating at least equal to that of the pipe being joined. ***(REVISED MAY 2020)***

## 7.22 JOINTS

.1 Storm sewer main pipe and fittings and service connection pipe and fittings shall 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 not be permitted.

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

(a) Joints shall be by thermal butt-fusion constructed in accordance with the manufacturer’s specifications.

(b) Flange joints shall be used to joint long sections of butt-jointed pipe or as shown on the construction drawings.

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

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

(e) Bolts and nuts for flanges shall be stainless steel complete with isolation washers.

(f) Refer to Section 7.46 for fitting and joint installation.

7.23 SERVICE JUNCTIONS

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

(a) Service connections shall be manufactured using a sanded PVC male end stub pipe with integral bell.
(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 not be used unless approved by the City Engineer. Refer to Section 7.48 for service connection junction installation.

.2 PVC Pipe (Smooth Profile):

(a) Service connections to PVC mainline pipe shall be made with extrusion molded PVC or fabricated PVC fittings manufactured to ASTM D3034, CSA B182.1 and CSA B182.2.
(b) The use of saddles instead of manufactured wye fittings shall require approval by the City Engineer.
(c) Refer to Section 7.48 for service connection junction installation.

.3 PVC Pipe (Ribbed Profile):

(a) Ribbed pipe shall only be used if repairing an existing ribbed pipe section.
(b) Service connections to PVC mainline pipe shall be made with extrusion molded or fabricated PVC fittings manufactured to ASTM D3034, CSA B182.1 and CSA B182.2.
(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.

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

(a) Service connections to HDPE mainline pipe shall be made with manufactured fittings, electro-fused or heat-welded to the mainline pipe. Mechanical connections, if used, shall be water-tight.
(b) Refer to Section 7.48 for service connection junction installation.

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

(a) Service connections to HDPE mainline pipe shall be made with extrusion molded or fabricated fittings manufactured to CSA B182.1, B182.2 and B182.4.
(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.

7.24 PERFORATED DRAINS

.1 The granular material for perforated drains shall be a clear round drain rock with 100% passing 40 mm and 0% passing 10mm screens.

.2 Piping shall be a minimum 150 mm diameter DR28 PVC perforated pipe. A minimum of 50 perforations 5 mm in diameter per linear metre of pipe shall be required for all pipe sizes.

.3 Perforations shall be located in the bottom half of the pipe only.

.4 Filter fabric shall be non-woven polyester fabric conforming to:

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

7.25A PRECAST MANHOLE SECTIONS

.1 Unless otherwise approved, all manholes sections shall be precast reinforced concrete conforming to ASTM C478.

.2 All precast sections shall be complete with ladder rungs.

.3 0-ring rubber gaskets shall conform to ASTM C443.

.4 Refer to Section 7.51 for precast manhole sections installation.

7.25B PRECAST MANHOLE BASES

.1 Precast manhole bases shall be reinforced concrete in accordance with ASTM C478. ***(REVISED MAY 2020)***

.2 All dimensions, specifications, and installations shall 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.

.3 Pipe alignment, grade, and invert elevations in the precast manhole bases shall conform to the construction drawings.

7.25C MANHOLE TOPS

.1 Manhole tops shall be flat slab, precast concrete. Tops shall be reinforced to meet CS600 loading requirements. Precast tops shall conform to ASTM C478 with approved offset opening for frame and cover.

7.25D MANHOLE COVERS AND FRAMES

.1 Covers and frames shall 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.

.2 Patterns, dimensions and weights shall be in accordance with the Standard Drawings. Covers shall have "CITY OF NANAIMO STORM DRAIN" permanently embossed on the covers.

.3 Standard manhole frame and cover shall conform to Standard Drawing No. SW-16 – Storm Manhole Frame and Cover.

.4 Utility chamber manhole frame and cover shall conform to Standard Drawing No. SW-17 – Utility Chamber Storm Manhole Frame, Ring and Cover.

.5 A watertight manhole frame and cover, if required, shall conform to Standard Drawing No. SW-18 – Watertight Storm Manhole Frame and Cover.

.6 Covers located in statutory right-of-way shall be permanently embossed with the additional wording "DO NOT COVER".

.7 Refer to Section 7.54 for frame and cover installation.

7.25E MANHOLE STEPS

.1 Steps shall conform to ASTM C478 for manhole steps and ladders and shall be a 19mm diameter aluminum alloy conforming to CSA S157.

.2 Refer to Section 7.55 for manhole steps installation.

7.26 CONCRETE

.1 Concrete for cast in place shall conform to Section 11.0 - Cast In Place Concrete Works. ***(REVISED MAY 2020)***

7.27 PRECAST CONCRETE GRADE RINGS

.1 Precast concrete grade rings conforming to ASTM C478 shall be used.

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

7.28 TEMPORARY CLEANOUT FRAMES AND COVERS

.1 Temporary cleanout structures may only be used at the discretion of the City Engineer where there is development phasing.

.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 specified under Section 7.22A - Piping, Fittings and Services and Section 7.22B - Joints.

.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 be 600 mm or 750 mm diameter as noted on the standard drawings and shall be reinforced concrete conforming to ASTM C478, Class III.

.2 Catch basin leads shall be of the same material as the main piping and used the same type of joints, gaskets, and fittings.

.3 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.

7.31B CATCH BASIN CASTINGS

.1 Catch basin frame and grating shall be in accordance with Standard Drawings:

(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 be precast unless approved by the City Engineer.

.2 Cast in place concrete shall conform to Section 11.0 - Cast In Place Concrete Works. ***(REVISED MAY 2020)***

.3 The trash rack shall be pre-fabricated to match the pre-fabricated inlet or outlet structure. Custom built trash racks shall be constructed with 20 mm diameter hot dipped galvanized bar.

7.33 ENERGY DISSIPATOR OUTLET STRUCTURES

.1 Energy dissipators shall be constructed of concrete and be designed to reduce runoff velocities to less than 1.5 m/s and dispose runoff evenly.

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 be 50 mm wire mesh, 9 gauge, hot dip galvanized, or plastic coated.

7.35A CULVERTS

.1 Concrete pipe shall conform to Section 7.22A - Piping, Fittings and Services, clause 7.22A.2.

.2 PVC pipe shall conform to Section 7.22A - Piping, Fittings and Services, clause 7.22A.3.

.3 Ribbed PVC pipe shall only be used for driveway culverts and shall conform to CSA B1800.

7.35B CULVERT HEADWALLS

.1 Sacks shall be 0.25 kg burlap with approximate inside dimensions of 350 x 900 mm as measured when the sack is laid flat.

.2 All cast in place concrete shall conform to Section 11.0 - Cast In Place Concrete Works. ***(REVISED MAY 2020)***

.3 Reinforcing bars shall be 15M intermediate grade steel conforming to CSA G30.18, Grade 400.

.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 be hard, dense, durable quarry stone, free from seams, cracks, or other structural defects, with a specific gravity of not less than 2.65.

.2 The gradation of rock sizes (mass in kg) for each class of riprap shall conform to the following table:

| 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 | 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.

## 7.37 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 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 extend 1.0 m above the ground surface. The markers shall be located on site at a location, determined by the 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.

## 7.38 SERVICE BOXES

.1 Service boxes for single storm sewer services shall be 300 mm x 500 mm concrete boxes complete with cast iron traffic cover marked "Storm" and concrete extension sections as required.

.2 Service boxes for twin storm sewer services shall be 425 mm x 750 mm concrete boxes complete with steel traffic cover marked "Storm" and concrete extension sections as required.

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 be laid on the alignment and grade in accordance with the construction drawings. Each pipe shall be checked for line and grade as it is installed. Methods used to maintain pipe alignment and grade shall be approved by the Engineer.

.2 Unless otherwise directed by the Engineer, tolerances for pipe alignment and grade shall be:

| | | | |
|---|---|---|---|
| Alignment | = | ± | 50 mm |
| Grade | = | ± | 10 mm |

7.41 PIPE CUTTING

.1 Pipe cutting shall be done in the manner recommended by the pipe manufacturer employing tools designed for this purpose.

7.42 PIPE INSTALLATION

.1 Pipe shall be installed in strict accordance with the manufacturer's recommended practice. Joint gaskets are required unless stated otherwise by the Engineer.

.2 Pipe shall 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.

.3 The open end of the pipe in the trench shall be suitably covered to prevent entrance of trench water and other material during periods when pipe is not being installed.

.4 Precautions shall 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 be removed from the trench and re-laid.

.5 Lifting holes in concrete pipe shall be plugged with prefabricated plugs in non-shrink grout, or other plugs recommended by the pipe manufacturer.

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

7.43 JOINTS AT RIGID STRUCTURES

.1 A flexible joint shall be provided at locations where the pipe is held in fixed position by a rigid support or structure. The distance from the support or structure shall depend on the diameter and type of pipe being installed and shall 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.

7.44 HORIZONTAL AND VERTICAL CURVES

.1 Pipe on horizontal and vertical curves shall be laid true to the curve of the radius shown on the drawings. Variations in vertical curves and grades within the allowable joint deflection as specified in Section 7.06.6 and only where approved by the Engineer. ***(REVISED MAY 2020)***

7.45 DEFLECTION

.1 The amount of pipe deflection at joints and couplings shall be the limit as specified in Section 7.06.6. ***(REVISED MAY 2020)***

7.46 FITTINGS AND JOINTS

.1 Fittings shall be installed at the locations shown on the construction drawings or as directed by the Engineer. Fittings shall be installed in accordance with the manufacturer's specifications.

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

(a) Pipe shall be joined by the thermal butt fusion method.
(b) The contractor shall make arrangements to have the pipe jointing carried out by the pipe manufacturer or certified personnel, familiar with the jointing technique, using equipment and techniques specifically designed for the pipe diameter and material being jointed.
(c) Where required, flanged joints shall be used for connecting long pipe sections.
(d) The joint shall consist of a polyethylene stub end butt fused to the end of pipe and a carbon steel slip-on flange.
(e) Flanged joints and flange bolts shall be stainless steel, complete with isolation washers.
(f) 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 made by City of Nanaimo forces unless otherwise authorized by the City Engineer.

.2 All connections to existing piping and services shall 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. ***(REVISED MAY 2020)***

.3 The use of field joints or rubber repair couplings shall require the approval of the Engineer.

.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 be used on PVC pipes. Rubber repair couplings are not to be used on PVC pipes.

7.48 SERVICE CONNECTION JUNCTIONS

.1 Service connection junctions shall be installed at the locations shown on the construction drawings or as directed by the Engineer during construction.

.2 Where service connections are not installed in conjunction with the main, fittings shall be installed in the sewerline to accommodate the service connections, and caps or plugs shall be installed in the fittings. Markers shall be installed as specified in Section 7.61 – Service Connection Installation, clause 7.61.3 (i).

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

(a) Field break-in and mortar patch joints shall not be used unless approved by the City Engineer. If approved, the following shall apply:

(i) Service connections shall be manufactured using a sanded PVC male end stub pipe with integral bell.
(ii) Break into the pipe by corning to within 40mm of the outside diameter of the service stub. All exposed reinforcing steel shall be removed.
(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 be equivalent to the thickness of the concrete pipe wall and length of the stub's integral bell.
(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 be inspected by the Engineer prior to backfilling.

(b) Refer to Section 7.23 for service junction specifications.

.4 PVC Pipe (Smooth Profile):

(a) Service saddle connections shall not be used unless approved by the Engineer.
(b) If approved, installation of service saddle connections shall conform to the following:

(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 approval by the City Engineer. Saddles shall be rigid PVC material complete with rubber seating gasket. Saddle to be attached to pipe with stainless steel banding straps.
(iii) Attach service saddle in accordance to the manufacturer's specifications.

(c) Refer to 7.23 for service junction specifications.

.5 PVC Pipe (Ribbed Profile):

(a) Installation of service saddle connections shall conform to Section 7.48.4.
(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 be in strict accordance with manufacturer's instructions.
(b) Connection of HDPE service junctions to non-pressurized PVC service pipe shall be made with flexible couplings. Flexible couplings shall be manufactured from elastomeric PVC and be held in place with series 300 stainless steel worm gear clamps.
(c) Refer to Section 7.23 service junction specifications.

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

(a) Installation of service saddle connections shall conform to Section 7.48.4.
(b) Refer to 7.23 for service junction specifications.

7.49 CAST IN PLACE MANHOLE CONCRETE BASES

.1 All water shall be removed from the excavation prior to placing base concrete. The base shall be constructed such that the first section of a precast section can be set plumb with uniform bearing throughout its full circumference.

.2 If material in the bottom of the trench is unsuitable for support, the bottom shall be overexcavated to firm base as determined by the Engineer 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. ***(REVISED MAY 2020)***

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

.4 Concrete manhole bases shall be constructed as shown on the drawings. Pipes and fittings through the manhole shall 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.

.5 Invert elevations of pipes a the manhole shall 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.

.6 Variations in manhole inverts from established grade or elevations shall be corrected.

.7 Manhole channeling shall be constructed as shown on Standard Drawings or as shown on the construction drawings. Channeling shall be constructed to have a minimum 0.3 m straight section before the change in direction within the manhole.

.8 The channels in the base of manholes shall be shaped and finished to provide smooth passage for the storm water in order to minimize head losses and deposits at bends and at junctions of channels.

.9 Channels shall be accurately formed. The practice of forming channels roughly to shape and finishing with cement mortar will not be permitted. The channels shall be steel trowel finished.

.10 Benching in manholes shall be sloped to drain. While green, the concrete benching shall be given a broom finish to produce a non-skid surface.

7.50 <u>-NOT USED-</u>

7.51 <u>PRECAST MANHOLE SECTIONS</u>

.1 Precast manhole barrel sections shall be placed plumb.

.2 Joints between the top riser and the cover slab shell be made watertight with cement mortar. Prior to placing sections, the mating face shall 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 removed and the joint made flush inside and out.

.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 be filled with cement grout to a smooth finish.

.4 Damaged o-ring manhole joints require removal and replacement of damaged manhole section. Mortar patching of damaged area, if approved by the Engineer, shall require removal of the o-ring gasket and installation as per Section 7.51.2.

.5 Refer to Section 7.25A for precast manhole section specifications.

7.52 PRECAST MANHOLE BASES

.1 Installation of precast manhole bases shall conform to Section 7.49 - Cast In Place Manhole Concrete Bases.

.2 Precast manhole bases shall be placed on 150 mm thick base if 38 mm drain rock.

.3 Plastic and concrete pipes installed in the precast manhole base shall utilize rubber manhole adaptor rings to seal the connection.

.4 Refer to 7.25B for precast manhole bases specifications.

7.53 CONCRETE

.1 Cast in place concrete shall conform to Section 11.0 - Cast In Place Concrete Works. ***(REVISED MAY 2020)***

7.54 FRAMES AND COVERS

.1 Frames shall be set on precast concrete grade rings to bring the cast iron manhole frame up to grade as shown on the Standard Drawings. Contractor to install concrete grade rings to a minimum of 50 mm thick and to a maximum of 100mm thick. The concrete grade rings shall be laid in common bond with racked mortar joints and shall be mortared inside and outside of the manhole.

(a) Fine grade elevation adjustments of frames shall be done with a minimum of 3, steel only, shims equally spaced.

.2 Manhole covers shall be installed:

(a) for unpaved areas: Covers shall have a 1.5 m x 1.5 m, 50 mm thick asphalt apron. Covers shall be set flush with the asphalt surround.

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

.3 Steel manhole riser rings shall be used in easements only.

.4 The inside surface of the manhole frame shall be painted green with an enamel rust paint in accordance with the manufacturer's specifications.

.5 Refer to Section 7.25D for manhole covers and frames specifications.

7.55 MANHOLE STEPS

.1 Manhole steps shall be installed in manhole sections by the manufacturer unless circumstance dictates otherwise in which case approval must be received from the Engineer.

.2 The distance from the top of the manhole cover to the first manhole step, shall conform to WorkSafeBC requirements.

.3 All steps shall 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.

.4 Refer to Section 7.25E for manhole steps specifications.

7.56 DROP MANHOLE STRUCTURES

.1 Manhole drop structures shall be constructed as shown on Standard Drawing No. SW-14 - Storm Drop Manhole.

7.57 STUBS

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

7.58 TEMPORARY CLEANOUTS

.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 be installed in accordance with the Standard Drawings.

.2 Catch basin leads shall 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 not exceed 45˚ and there shall be a minimum 1.0 m separation between mitre bend hubs.

.3 Catch basin leads taken into manholes shall be benched in the same manner as main line piping.

.4 Catch basin grates are to be set 20 mm below the gutter line. The gutter and blacktop are to be shaped to form a dish around the inlet.

.5 Construction and finishing of catch basins shall be the same as for manholes as described in Section 7.54 - Frames and Covers.

.6 Catch basin leads are to protrude 50mm into the catch basin barrel and shall be grouted inside and outside of the barrel in accordance with the Standard Drawings.

.7 There shall be a 400 mm minimum clearance between the outside of the catch basin barrel and the trench wall to allow for compaction.

.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. Where the depth of the service connection exceeds 2.0 m, the service shall 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 be done during the installation of the service connection from the main to the property.

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

.2 Grade and Alignment of Service Connections:

(a) Trenches shall 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 be installed at grade of not less than 2% unless otherwise directed by the Engineer. Service pipe shall 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.

.3 Storm Sewer Service Connection Installation:

(a) Pipe shall be installed in strict accordance with the manufacturer's recommended practice.
(b) Pipe shall 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.
(c) The Contractor shall use methods for installing pipe in an auger hole or casing pipe as shown on the construction drawings.
(d) The trench shall be excavated to provide a minimum cover of 0.75 m over the service connection pipe at property line.
(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 be graded to form a continuous support along the service pipe. All rocks or projections which might prove detrimental to the pipe shall be removed.
(g) Joints shall be made using the specified couplings. Glued joints shall not be made.
(h) At the terminus of each sewer service approved watertight caps suitably supported by sandbags shall be installed to prevent leakage.
(i) A 38 mm x 89 mm pressure treated wood marker stake shall be placed at the service terminus as shown on the drawings to facilitate future location of the service pipe. This stake shall extend in locations where the extension of the stake above ground surface would prove hazardous, in which case the stake shall be cut off flush with the ground surface. The stake shall be marked in an approved manner to show the depth of the service pipe invert below the top of the stake. The stakes shall be painted green to visually identify the storm sewer service connections. The Engineer will take invert elevations of the service connection assembly prior to placement of the cap by the Contractor.
(j) Inspection assemblies shall be installed as shown on the standard drawings.
(k) The service box shall be installed plumb with the lid 25 mm above finished grade in unpaved areas and 0 - 6 mm below finished grade in paved areas.

.4 Riser Service Connections:

(a) Riser service connections shall 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.

7.62 NOTIFICATION TO THE CITY OF NANAIMO

.1 The City of Nanaimo Works Inspector shall be given 48 hours' notice of all tests.

7.62A CLEANING AND FLUSHING

.1 The pipes shall 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 and the Inspector. Cleaning shall be completed by power flushing with water to remove all foreign matter. ***(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 remain unimpeded at all times while snow chains are installed.

.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, the Inspector, or by the City of Nanaimo CCTV contract administrator.

.4 Manholes shall be cleaned after the upstream section of pipe has been successfully cleaned and approved by the Engineer, the Inspector, or by the City of Nanaimo CCTV contract administrator.

.5 Pipes shall be cleaned in the direction of flow and shall not be flushed in a backflush direction unless approved by the City Engineer, by the Inspector, or by the City of Nanaimo CCTV contract administrator.

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

.7 Dispose of the debris at approved dump sire such as the Regional District of Nanaimo's landfill or by the CCTV contract administrator's approved alternative.

.8 Decanting of liquid waste accumulated during debris removal is permitted at a controlled release rate, to a maximum of 8l/s, at a location approved by the City of Nanaimo CCTV contract administrator.

.9 Timeframe between cleaning and video inspection of pipeline shall not exceed 24 hours unless approved by the City Engineer.

.10 Ensure all environmental mitigation is in accordance to current BC Ministry of Environment and Department of Fisheries and Oceans Standards.

7.63 VIDEO INSPECTING MAINS

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

.2 The contractor shall 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 and the Inspector. ***(REVISED MAY 2020)***

.3 For gravity sewers and service connections, the contractor shall 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 also arrange for a video inspection of the existing sewer pipe at the location of the crossing. ***(REVISED MAY 2020)***

(a) Illumination depth of field shall 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 be visible in the middle of this depth of field viewing area.
(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 not be visible at either side of the pipe during normal camera travel or during Pan & Tilt operation. Configuration or camera/guides shall be altered to alleviate this problem.
(f) CCTV push camera work shall be video captured (complete with skids for centering) from the main wye pulling back to entrance point to avoid an invert only view.
(g) A winch line shall be provided to support camera travel in steep, slippery, or relined pipe sections.

(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 not exceeding 310 mm: and
(iii) 0.20 m/s for diameters exceeding 310 mm

.4 The inspection shall include the preparation of:

(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 not exceed 1.7GB in size. ***(REVISED MAY 2020)***

(b) a Microsoft Access database CD of the Header and Observation codes as specified by the City Engineer.

(c) a pipe condition assessment paper report.

All submitted to the Engineer.

.5 The Engineer 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)***

.6 The pipe condition report and certification shall become the property of the City of Nanaimo. ***(REVISED MAY 2020)***

.7 Variations in line of grade of pipe, from that established by the Engineer prior to installation, and any jointing, pipe cleaning, or other deficiencies discovered during the inspection, shall be rectified. Re-inspection of the pipe may be required by the Engineer at the Contractor’s expense.

.8 During the test, manhole construction and invert elevations shall be checked and any variations from the established grade, drawing, or specifications, shall be rectified.

.9 Video inspection and pipe condition coding shall be undertaken only by personnel with current Canadian certification by a City approved agency.

***(REVISED MAY 2020)***

7.63A SMOKE TESTING

.1 The Engineer shall arrange for smoke testing of all installed storm mains in the presence of the City of Nanaimo Works Inspector.

.2 The Engineer shall provide as-built service location information to the City of Nanaimo works Inspector prior to smoke testing.

.3 Cross-connections noted during the smoke testing shall be corrected and the as-built information revised.

7.64 DRAINAGE DITCH CONSTRUCTION

.1 Drainage ditches shall be excavated to the line and grade shown on the construction drawings or as otherwise determined by the Engineer.

7.65 CULVERT INSTALLATION

.1 Trenches for culvert installation shall be excavated to the required depth and grade and backfilled in accordance with the requirements for storm mainlines.

.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 be constructed as shown on the Standard Drawings.

.2 "Wet-mix" Sandbags:

(a) The sandbag sacks shall 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 be placed and lightly tamped to conform with the slope, culvert pipe, and adjacent sacks in-place.
(c) Sacked concrete shall be laid in courses such that joints in succeeding courses are staggered. Courses shall be a minimum of ten per vertical metre. Dirt and debris shall be removed from the top of sacks before the next course is laid thereon.
(d) Prior to sacked concrete setting, courses of bags shall be tied by driving a 15M reinforcing bar vertically from top to bottom through each course so that

displacement will not occur after the final set of concrete. Top of reinforcing bar shall be bent over on top.

.3 Headwalls shall be protected from heavy rainfall and from contacting water for a period of at least 24 hours after placing.

.4 Composite culvert headwalls shall be installed as per manufacturer's recommendations and Engineer approved design drawings.

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 be installed on the bottom half of the pipe.

.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 to finish grade.

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

7.68 INLET AND OUTLET STRUCTURES

.1 Inlet and outlet structures shall be installed in accordance with Standard Drawings.

.2 Excavate to the lines and grades as shown on the construction drawings. If subgrade is unsuitable for support as determined by the Engineer, the bottom shall be excavated and backfilled to the required grade with road base gravel compacted to 95% modified proctor or drain rock.

.3 Structure shall 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.

.4 Cast in place concrete shall conform to Section 11.0 - Cast In Place Concrete Works. ***(REVISED MAY 2020)***

7.69 RIPRAP

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

.2 Geotextile material and placement, where required, shall be as shown on the drawings.

.3 At the toe of sloped riprap, larger rocks shall be placed regularly enough to form a firm foundation, 50% thicker than the required nominal thickness.

.4 Other large rocks shall be regularly spaced. Smaller rocks shall be well positioned to form an interlocking, even surface.

7.70 PIPE VIDEO AND MANHOLE CONDITION REPORT FORMAT

.1 Reference plans shall accompany reports with manholes labeled and inspected sections highlighted. Manhole and pipe numbering shall conform to the construction drawings, or if available, City of Nanaimo pipe and manhole numbers. Reports shall be submitted in both digital and hardcopy formats.

.2 All sewer defects shall be photographed and included with the report and referenced by numbers accordingly.

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

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 |

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%. |

The following additional information shall be included for each sewer section as the CCTV Title Page:

(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 Name or RW No.).
(i) Distance from the manhole rim to pipe invert.
(j) Length of Capture.
(k) Total of Captured CCTV.
(l) Current weather information.

.4 All pipe video inspections shall include an annotated map with the following information:

(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).
(d) Catch basin I.D. numbers (as per the City of Nanaimo GIS numbering system).

.5 Computer database file to contain identical survey report information as the printed report exclusive of photographs. Index numbers and distance of survey information shall numerically increase. For an individual survey, whether the information is sorted by index or distance, the result will be in the same order.

.6 All pipe video inspections operators shall be thoroughly trained with current Canadian certification by a City approved agency.

.7 Manhole video inspection is not required. Manholes shall be rated as per the following table, and form part of the video inspection report.

MANOLE RATING SYSTEM

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