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Storm Drainage Design **Section 4**

4.01 Introduction

The City of Parksville Storm Drainage Master Plan shall be used as a reference in the design of individual drainage networks.

The City will conduct a modelling analysis using the City's network model at the expense of the developer. The analysis will review the design for conformance to City specifications and guidelines, and assess downstream capacity of the storm sewer network to the outfall. Upon request, the Consultant shall submit parameters for input into the model including design flows and lengths, diameters and grades of all new pipes.

The presence of an existing City drainage system does not mean or imply that it has adequate capacity to receive the proposed flow; nor does it indicate that the existing system configuration is acceptable to the City. Existing facilities which are undersized or inadequate to accept additional storm water must be upgraded at the Applicant's expense to accommodate the additional flow. Alternative drainage proposals may be considered.

Rainwater capture and infiltration works that reduce peak flows and mimic natural rainwater and storm water regimes are encouraged, and may be required, depending on site conditions. Downstream storm sewer design shall assume that all infiltration facilities have failed, i.e., downstream design must accommodate the 1:100 year storm.

All developments or works which will discharge storm water into existing municipal drainage systems, drainage ditches or water courses must ensure that no sediment or debris enters those systems.

Design and construction of storm drainage facilities are subject to the requirements of the Ministry of Environment, Fisheries and Oceans Canada and any other agencies having jurisdiction.

4.02 Minor and Major Systems

Ultimate land use for the purpose of storm drainage calculations shall be determined by referring to the current "Official Community Plan", and for areas outside the City by the current Official Regional District Settlement Plans. Each drainage system shall consist of the following:

a) The Minor System shall consist of pipes and ditches which convey flow of a 10 year return frequency.

b) The Major System shall consist of surface flood paths, roadways, and watercourses which convey flow of a 100 year return frequency. Major flood path routing may allow

for minor inconveniences but no major damage shall result from the 100 year return period storm. Any allowances for inconveniences shall be outlined in the servicing report and approved by the City Engineer.

Roadway crossings shall be designed to accommodate the 100 year return storm event. Surcharging at the inlet for the 100 year flow is acceptable, provided the headwater profile does not intersect habitable property. Consideration must be given to inlet facilities becoming blocked or restricted. In these cases, the major flow must be contained within the storm drain pipes.

The contributing catchment areas shall be governed by the contours of the land. The overall drainage areas established by the City of Parksville shall be referenced.

4.03 Open Channels

The design of open channels to carry minor or major flows shall be restricted to the following maximum velocities:

a) Unlined channel: 1.5 metres/second

b) Suitably lined channel: 3.0 metres/second

If the mean velocity exceeds that permissible for the particular kind of soil or is greater than 1.5 metres per second, the channel shall be suitably lined to protect it from erosion. The maximum depth of flow shall not exceed 300 millimetres with a freeboard of 150 millimetres. The side slopes on channels shall not exceed 3 horizontal to 1 vertical.

4.04 Drainage Design Methods and Flows

Storm drainage systems shall be designed using conventional methods and storm water management techniques. Pipes shall be designed to flow at a maximum of 80 percent of full capacity.

a) Conventional Systems shall be designed using the Rational Formula (generally for developments where the tributary areas are less than 10 hectares).

Rational Method $Q = RAIN$

where

- Q = Flow in cubic metres/second (m^3/s)
- R = Runoff coefficient
- A = Drainage area in hectares
- I = Rainfall intensity in millimetres/hour
- N = 0.00278

Or, design shall incorporate the use of hydrographs (generally for larger areas and for any drainage system which includes detention facilities). The storm used for computer modelling shall be the Canadian AES 1 hour storm with rainfall = 100 mm using a K = 5 (BC coast), dt = 3 minutes, and TP (time to peak) = 28 (BC coast).

The Applicant shall provide the City with all calculations pertinent to the design of the proposed drainage system. All designs shall take into account post-development upstream flow.

b) Storm Water Management Systems

Storm water management shall incorporate such techniques as lot grading, surface infiltration, sub-surface disposal, storage or other acceptable methods to limit the peak runoff from the development during frequent storm events. Such allowances will not be considered applicable for long storm events (e.g. 10 years and 100 years) unless approved by the City Engineer.

Storm water management shall be used for all comprehensive developments, and should be included, where feasible, for conventional developments.

A storm water management plan shall include all drainage facilities, lot grading (showing pre-and post-development elevations), major flood path routing and all other appropriate information pertinent to the design.

The computer or modeling program calculations shall be to the satisfaction of the City Engineer.

4.05 Runoff Coefficients

The following runoff coefficients shall be used in the calculations for the Rational Formula:

Type of Area	Coefficient		
	Low	High	Standard
Low density housing	0.45	0.55	0.50
Medium density housing	0.55	0.65	0.60
High density housing	0.60	0.80	0.70
Commercial, Industrial	0.80	0.90	0.80
Institutional	0.70	0.90	0.80
Park or golf course	0.15	0.25	0.20
Churches or schools	0.60	0.85	0.75
Grassland	0.15	0.30	0.20
Cultivated	0.30	0.50	0.40
Woodland	0.10	0.40	0.25
Roofs or pavements	0.90	1.00	0.95

Low values are applicable to areas with high soil permeability. High values are applicable to areas with low soil permeability. Standard values are for general application. The Consultant should verify the coefficient applicable to the area involved. The City Engineer shall be the final authority on the coefficient to be utilized.

4.06 Drainage Areas

Contour maps provided on the City digital map are reasonably indicative of the actual condition. However, Consultants are cautioned not to interpret them to be exact and correct. It is the Consultant's responsibility to ensure that true and accurate elevations are obtained for the development site utilizing a topographic survey.

4.07 Rainfall Intensities

a) Time of Concentration

Storm flow in pipes, ditches, channels or watercourses and overland shall be considered in computing the time of concentration by using the following formula:

$$T_c = \frac{C_t L n}{12 S^{0.5}}$$

where:

T_c	=	Time of concentration in minutes
C_t	=	Concentration coefficient depending on the type of flow
	=	0.5 for natural watercourses or ditches
		1.4 for overland flow
		0.5 for storm drain flow
L	=	Length of watercourse, conduit or overland flow in metres, along the drainage path from the furthest point in the basin to the outlet (maximum length = 300 metres)
n	=	Channel friction factor
	=	0.050 Natural channels
	=	0.030 Excavated ditches
	=	0.016 Overland flow on smooth paving
	=	0.400 Overland flow on natural areas
	=	0.013 Concrete pipe
	=	0.011 smooth PVC
S	=	Basin slope in metre/metre

Actual flow velocities in storm drains shall be used. A composite value for T_c shall be calculated in cases where the type of flow along the longest path varies or the slope changes.

b) Inlet Time in Developed Basins

Inlet times for various development conditions are provided in the following table to ensure uniformity in unit runoff and storage computations.

Individual Lot Sizes square metres (m^2)	Minimum Inlet Time (minutes)	Maximum Inlet Time (minutes)
500 or less	10	10
700	10	10
2,000	15	20
4,000	15	30

c) Rainfall Return Frequency

The following return frequencies shall be used for design:

i) Minor Systems 10 year return
ii) Major Systems 100 year return

d) IDF Curves

Rainfall Intensity/Duration/Frequency (IDF) curves are to be used. The City of Parksville standard is shown on the municipal standard drawing.

4.08 Site and Lot Grading

Developments in the City of Parksville shall incorporate proper site and lot grading techniques.

The following criteria shall be used:

a) Each lot should be graded to drain to a municipal drainage system, independent of adjacent lots. Minimum lot grades are to be 1.0 percent.

b) Areas around building (or proposed building sites) shall be graded away from the (proposed) foundations to prevent flooding.

c) Lots lower than adjacent roadways shall be avoided or acceptable storm water management techniques incorporated to direct drainage to an existing or proposed drainage system. Storm water drainage easements at the back of the property shall be avoided.

d) Buildings or proposed buildings must be sited a minimum 0.3 m above the major system hydraulic grade line. The minimum building elevation (MBE) shall be noted.

e) Individual lot(s) will not be permitted to direct storm water into any natural watercourse, park or green belt area with a single point discharge. Sheet flow may be permitted.

NOTE: The Applicant is advised that lot grading, sediment control and onsite storm water management are considered essential services, and are required prior to the issuance of building permits.

4.09 Minimum Building Elevations

The MBE means the elevation of the top of the lowest concrete floor slab in a building, top of the skim coat in the crawl space, or underside of floor joists of the first floor, whichever is lowest.

A gravity connection to the municipal storm drainage system may be made only where the habitable portion of a dwelling or any portion of the building that will contain goods or services damageable by water is 0.3 metre (as per Section 4.21) above the major system hydraulic grade line.

The MBE shall be set at not less than 0.6 metre above the storm drain service connection invert at property line or 0.3 m above the 100 year hydraulic grade line elevation, whichever is greater.

Accepted MBE's may not be revised without approval of the City Engineer.

4.10 Roof Drainage

The storm drainage system shall be designed to accommodate the anticipated flows from roof and perimeter drains and from overland lot drainage.

4.11 Storage Facilities

Developments may be required to provide detention of storm water to the pre-development flow, subject to approval by the City Engineer.

Due to a variety of site-specific characteristics and numerous possible storage facility designs, it is not feasible to describe all the unique or typical situations that may exist for any one particular area. Designers shall review all proposals for storage systems with the Engineering Department prior to detailed design.

Storage facilities shall be designed to ensure the facility is dry when not in use. Wet storage facilities should be avoided. The design of permanent storage facilities shall consider safety, appearance and economical maintenance of operations as it relates to the storage of storm water.

Storage facilities shall conform to all requirements of WorkSafe BC, in particular regarding confined space. Any confined space shall be designed so that it can be isolated, for example with the use of a valve.

The Consultant shall submit an Operations and Maintenance Plan upon facility completion. A certified safety Consultant shall submit documentation that includes confined space safe entry procedures and a confined space hazard assessment.

Accesses shall have hatch type lids with specifications and size to the satisfaction of the City Engineer. The design of accesses via stairwells is encouraged.

Generally, permanent storage facilities shall consider the following points in their design:

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

b) The storage facility shall be designed using the 100 year storm event as the design storm with a freeboard of 300 millimetres.

c) A three metre wide paved access shall be provided to the storage facility if it is not in a road to allow the passage of maintenance vehicles.

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

e) An overflow shall be provided.

f) The outlet control for storage facilities shall be designed for easy access and maintenance.

4.12 Pipe Capacities

Pipes shall be designed to flow at a maximum of 80 percent of full capacity. The following equation shall be referred to when calculating flow capacities for storm drain and open channels.

Use Manning's equation: $$Q = \frac{AR^{0.667}S^{0.5}}{n}$$

where Q = Design flow in m^3/s
A = Cross-sectional area in m^2

R = Hydraulic radius in m (pipe cross-sectional area divided by the wetted perimeter)
S = Slope of hydraulic grade line in m/m
n = Roughness coefficient
= 0.011 for smooth PVC pipe
= 0.013 for asbestos cement, clay and concrete pipe
= 0.024 for corrugated steel pipe
= 0.020 for gravel lined channels
= 0.013 for concrete or asphalt lined channels
= 0.050 for natural streams and grassed channels

NOTE: Downsizing of storm drain pipes from the size of the pipe that is upstream is not acceptable.

4.13 Storm Drain Location/Corridors

Storm drains shall be located within the road right-of-way as noted on the applicable standard road cross section (refer to Section 7.0).

If the storm drain crosses private land, the required right-of-way shall be a minimum 4.0 metres wide. Where both a storm drain and a sanitary sewer are in one right-of-way, the width shall be a minimum 5.6 metres wide.

If manholes, valve chambers or other appurtenances that require maintenance are located within the right-of-way, the Applicant shall provide a constructed road access from a City road for maintenance vehicles. The maintenance access shall be designed and constructed so as to be able to support the maintenance vehicles for which the access is intended.

All storm drain mains shall be installed at a minimum clear horizontal distance of 3.0 metres and a vertical distance of 0.5 metres from any water main, with the water main on top. If the minimum horizontal clearance cannot be obtained, then the water main shall be protected to the satisfaction of the Regional Public Health Engineer. If a minimum clear vertical separation of 0.5 m cannot be established, then the water main is to be fully concrete encased or wrapped with petrolatum tape at all joints within 3.0 metres of either side of the crossover point.

4.14 Minimum Pipe Sizes and Materials

The minimum storm main line pipe diameter shall be 300 millimetres, except that in residential areas 250 millimetres diameter is acceptable in the final section of a storm drain where not more than one catch basin connects to it and extension in the future will not take place.

The following pipe is permitted for drains:

Size Range	Material	Use	Specification
150 millimetres	Polyvinyl Chloride (PVC)	Service connections	SDR28 minimum, ASTM D2412 and CSA B182.1
200 to 450 millimetres	Polyvinyl Chloride (PVC)	Mains or catch basin leads and larger service connections	SDR35 minimum, ASTM D3034, ASTM F679 and ASTM D2412
Greater than 450 millimetres	Reinforced concrete	Mains	ASTM C76M Class III or higher
Other	As approved by the City Engineer		

Catch basin leads shall be a minimum 200 millimetres in diameter.

Culverts shall be designed based on flow and loading.

4.15 Minimum Depth of Cover

The minimum depth of cover shall be 1.2 metres for storm drain pipes up to 600 millimetres and 0.3 metre for culverts across roads and driveways, subject to the correct pipe loading criteria. For pipe sizes larger than 600 millimetres, an engineering design for cover will be required. The minimum cover requirements, as set out above, may be reduced upon approval of the City Engineer.

The elevation of storm drains at the upstream tributary points must be of sufficient depth to service all of the tributary lands.

4.16 Minimum/Maximum Velocity

The minimum velocity for pipes shall be 0.91 metres/second. There is no maximum velocity; however, where grades exceed 15 percent, scour protection may be required and anchor blocks will be required.

Where drainage discharge enters a natural watercourse, the Ministry of Environment generally requires adequate rip-rap protection and maximum velocity under 1.0 metre/second. If the velocity is greater than 1.0 metre/second, see Section 4.25 Inlet and Outlet Structures.

4.17 Curvilinear Storm Drains

Horizontal curves may be installed only if deemed necessary and only if permitted by the City Engineer. Horizontal curves will require a constant offset and/or shall be uniform throughout the curve. The design velocity shall exceed 0.91 metre/second and the minimum grade shall be 1.0 percent. Where pipe deflection is permitted, the maximum joint deflection shall be one-half of the pipe manufacturer's recommendations. There shall be no bending of the pipe. Each joint shall be located by survey prior to covering the pipe.

4.18 Manholes

a) Manholes are required at:

- all changes in grade
- all changes in direction
- all terminal sections unless a cleanout is permitted
- every intersecting storm drain
- all changes in pipe size
- every 120 metres for pipes less than 375 millimetre diameter
- every 150 metres for pipes between 400 millimetre diameter and 750 millimetre diameter inclusive
- every 180 metres for pipes larger than 900 millimetres
- the downstream end of curvilinear storm drains

b) Stubs shall be installed in manholes to allow for future connections. The length of the stubs shall be 0.60 metre maximum from the outside of the manhole, unless otherwise requested, and the end shall be securely capped.

c) Storm drain manhole rim elevations in off road areas shall be designed to be:

- below the adjacent sanitary sewer manhole rim elevation and
- above the surrounding ground so that infiltration from ponding will not occur.

4.19 Hydraulic Losses in Manholes

The following criteria shall be used.

a) Generally the crown of the downstream pipe shall not be higher than the crown of the upstream pipe.
b) Minimum drop in invert levels across manholes shall be as follows.
   i) straight run - no drop required - minimum of 0.5 percent slope required;
   ii) deflections up to 45^{o} - 20 millimetre drop;
   iii) deflections 45^{o} to 90^{o} - 30 millimetre drop.
c) Outside drop manholes shall be provided wherever the drop exceeds 0.6 metres.
d) Inside ramps will be permitted up to 450 millimetres from invert to channel bed.
e) Drops between 450 millimetres and 600 millimetres are not allowed.

4.20 Cleanouts

Cleanouts may be provided at terminal sections of a main, provided that:

a) the length of storm drain to the downstream manhole does not exceed 45.0 metres;

b) the depth of the pipe does not exceed 2.0 metres at the terminal point; and
c) extension of the main is proposed or anticipated.

4.21 Service Connections

Existing service connections are to be connected to the new proposed main.

New service connections shall:

a) be installed to all parcels fronting the main (except where lands have an acceptable alternative existing drainage system), so that the lots are provided with a gravity-flow connection. An inspection chamber shall be installed at the property line complete with a concrete service box. All services shall enter the main as depicted on the standard drawings.

b) be single connections only, unless approved by the City Engineer;

c) be connected to new mains using wye fittings, and be connected to existing mains using wye saddles;

d) have a minimum diameter of 150 millimetres for residential and 200 millimetres for industrial/commercial (the designer shall design for potential carriage homes where applicable);

e) The minimum depth of a service at the property line shall be 1.0 metre;

f) have a slope of not less than 2.0 percent from the main to the property line.

4.22 Catch Basins

Catch basins shall be provided at regular intervals along roadways, at intersections and at low points. Double catch basins shall be installed at locations of high runoff and sag curves. Catch basins shall be constructed as shown on the municipal standard drawings.

Catch basins shall be located at the higher end of the curb returns of intersections, at the lowest point of sag vertical curves, and at spacing not greater than the following:

Maximum Spacing of Catch Basins	
Pavement Area	Grade of Road
500 m^2	less than or equal to 3 percent
350 m^2	greater than 3 percent

Adequate allowance shall be made to handle runoff from cul-de-sac bulbs and turnarounds, by installing catch basins in the cul-de-sac bulb or turnaround, and catching storm water before it leaves the cul-de-sac bulb or turnaround.

Catch basin leads shall be minimum 200 millimetres diameter for single catch basins and 250 millimetres for double catch basins. Where possible, catch basin leads should be taken into manholes.

Catch basins shall be located just upstream of sidewalk letdowns, and at pedestrian and driveway crossings to intercept any runoff prior to the crossing.

Side-inlet catch basins shall be used if the curb type is barrier (non-mountable).

4. 23 Oil/Silt Separators

Oil/silt separators are required at all repair garages, car washing facilities, gas stations, car dealerships, automotive parts retailers, parking lots larger than 1000 square metres and any businesses that handle oil and grease. They shall be designed so the concentration of total suspended solids in the discharge does not exceed 25 milligrams/litre. The total hydrocarbon concentration in the storm water discharge shall be less than 1 milligram/litre.

The oil/silt separator shall be designed such that high flows from 100 year storm events do not result in the re-suspension of contaminants in the separator and the discharge of these contaminants into the receiving environment or the storm sewer system. The design of oil/silt separators or the selection of a commercially available oil/silt separator shall be done by a Professional Engineer. The designer should consider specific site conditions, such as topography, the expected level of pollutants and overall storm water management for the catchment area.

Oil/silt separators shall be installed within the property, adjacent to the property line and upstream of the inspection chamber. They should be installed in the most downstream portion of the property. Oil/silt separators should be located so that all contaminated runoff from a property is treated and the discharge of contaminants into the storm drain system is prevented.

4.24 Swales

Swales required for lot grading shall be a maximum 300 millimetres deep, have a minimum 1 percent grade and a maximum wall slope of 3:1. A swale is to be lined with clean rock or sod with a minimum of 150 millimetres of topsoil. Swales must be directed to lawn basins on each lot. Swales for major flood path routing shall be designed to accommodate the anticipated 100 year storm event flow.

4.25 Inlet and Outlet Structures

Outlets having discharge velocities in excess of 1.0 metre/second require rip-rap protection and/or an acceptable energy dissipating structure to control erosion.

A safety grillage is required at the outlets of all storm drains 375 millimetres or greater in diameter and for those that exceed 30 metres in length. Trash racks at the inlets are required on all storm drains which utilize safety grillages. Handrails shall be installed for safety where the vertical drop from the top of the structure to the invert of the pipe is 1.2 metres or greater.

4.26 French Drains

French drains shall be installed only where the topography, soil and groundwater conditions prove the need for such drains. The use of these drains is to be approved by the City Engineer. A soils report prepared by a geotechnical engineer is required to confirm the suitability of the soil.

French drains shall be constructed behind the curb line of all roads that are constructed in areas with extreme groundwater conditions. These drains shall be connected to a manhole, and provided with a cleanout structure at the upstream end.

4.27 Rock Pits

The use of rock pits will only be permitted at the discretion of the City Engineer, and if engineered. Rock pits will only be considered in certain areas of the City where it can be demonstrated that the soil allows storage and percolation of the 10 year storm. A soils report prepared by a geotechnical engineer will be required to confirm the suitability of the soil.

This does not preclude the requirement for major flood path routing. Rock pit design shall incorporate an overflow to a major flood path route for rainfall in excess of the 10 year storm. If major flood path routing is not possible, the rock pit shall be designed to store and infiltrate the 100 year storm.

4.28 Erosion and Sediment Control

No person shall perform any land disturbing activity without first obtaining permission from the City Engineer. An erosion and sediment control plan sealed by a Professional Engineer or Geoscientist is required. Good engineering practice and provincial best management practices shall be followed.

Consultants are required to demonstrate how work will be undertaken and completed so as to prevent the release of sediment, raw concrete, concrete leachate or other deleterious substances onto any road or into any ditch, storm drain, watercourse or ravine. Construction

and excavation wastes, overburden, soil or other deleterious substances shall be disposed of or placed in such a manner as to prevent their entry into any watercourse, ravine, storm drain system or restrictive covenant area.

Details of the proposed sediment control works are to be included in the accepted drawings and shall be installed as part of the works. All sediment control works shall be situated to provide ready access for cleaning and maintenance.

Sediment control works shall be maintained throughout the course of construction and to the end of the maintenance period (final acceptance). Sediment controls works shall be specified appropriately for the construction phase, i.e., land clearing, construction, and post-construction works will require different approaches.

Storm Drainage Construction Section 4

4.29 Scope

These specifications govern the installation of all drain pipe and drain appurtenances within the City.

4.30 General

The flow in all existing drains, ditches, watercourses and service connections shall be maintained during construction. The contents of any new drain pipe or service connection shall not be allowed to flow into the trench or into the main except when permission is given by the City Engineer. All offensive matter capable of contaminating or obstructing storm drains shall immediately be removed from the proximity of the work, using such precautions as may be required by the Works Inspector.

4.31 Excavation

4.31.1 Blasting can proceed only with permission from the City Engineer.

4.31.2 In locations other than under pavement, sidewalk, driveway or gravel shoulder, all topsoil to a maximum depth of 300 millimetres shall be removed and stockpiled for replacement.

4.31.3 The trench shall be excavated to the required alignment, width, depth and grade as shown on the standard drawing. When trenching along or across a paved surface, pavement shall first be saw cut in straight lines parallel to the trench centerline. The total width of cut pavement shall not be greater than the specified maximum trench width at the ground surface shown on the drawings. Where, in the opinion of the City Engineer, existing pavement is in such poor condition that a saw cut is not warranted, pavement may be cut by trenching equipment.

4.31.4 Where trenches are excavated on the travelled portion of a road, all excavated matter shall be removed from the site, except in cases where approval is recommended by a geotechnical engineer and given by the Works Inspector for the use of this material as backfill. The Contractor shall take measures to ensure that existing asphalt surfaces will not be scarred by track equipment. Should damage to the pavement occur the Contractor shall provide a pavement overlay to the satisfaction of the City Engineer.

4.31.5 The clear width of trench at the top of the pipe shall be no greater than that specified on the standard drawing. Where this is exceeded, the Consultant shall obtain the City Engineer's approval before further construction continues.

4.31.6 If, in the opinion of the City Engineer, trench width exceeds the maximum allowable for pipe support, the Contractor shall provide a higher class of bedding, a pipe with a higher strength class or concrete encasement.

4.31.7 If the bottom of the trench is organic or other unsuitable material, the trench shall be excavated to firm ground or other remedial measures shall be taken as required by the Consultant, subject to the approval of the City Engineer.

4.31.8 Any excavation carried out below the pipe invert shall be backfilled with appropriate granular pipe bedding. This material shall be compacted with approved mechanical compactors in maximum 150 millimetre lifts. The trench bottom shall be firm and capable of supporting the pipe to be installed.

4.31.9 All water, soft silt or disturbed material shall be removed from the bottom of the trench prior to placement of bedding.

4.31.10 All solid rock boulders and large stones shall be removed to provide a minimum clearance of 150 millimetres around the pipe. When the end of the service connection is in solid rock, the rock must be blasted 3.0 metres past the end of the connection.

4.31.11 Where an existing structure or underground installation may be affected by the works, it is the responsibility of the Consultant to inform the owner of the potential impacts in advance of construction so that the owner can implement protective measures.

4.31.12 Where an unforeseen obstruction is encountered that interferes with the designed alignment, the Consultant shall stop construction and not proceed until such time as revised design is approved by the City Engineer.

4.32 Bedding

4. 32.1 Bedding shall be well graded. Bedding material shall be granular in nature, free of organics, silt and clay and shall conform to the following gradation limits when tested in accordance with ASTM C136.

Sieve Designation	Gradation Limits (Percent by Weight Passing	
	Type 1*	Type 2**
19.0 millimetres	100	90 – 100
12.5 millimetres		65 – 85
9.5 millimetres	85 – 100	50 – 75
4.75 millimetres	70 – 100	25 – 50
2.36 millimetres		10 – 35
1.18 millimetres	20 – 65	

Sieve Designation	Gradation Limits (Percent by Weight Passing	
	Type 1*	Type 2**
0.850 millimetres		5 - 20
0.600 millimetres	0 – 45	
0.425 millimetres		0 - 15
0.180 millimetres		0 – 8
0.150 millimetres	0 – 10	
0.075 millimetres	0 – 5	0 - 5

4.32.2 Type 1 is the standard bedding type and shall be used for dry trench conditions. Type 2 shall be used for wet trench conditions as determined by the City Engineer or Consultant prior to use. If there is a potential for migration of soils from trench walls, filter fabric may be required.

4.32.3 Bedding installation shall be in accordance with the standard drawing. Bedding material shall be compacted to a minimum 95 percent Modified Proctor Density in compliance with ASTM D1557.

4. 32.4 Bedding shall be compacted in equal lifts not exceeding 150 millimetres and under the pipe by means of a hand tamping bar. Refer to the standard drawing.

4. 32.5 Field compaction tests of pipe bedding will be conducted a minimum of once per day. All compaction tests are to be submitted to the Consultant and to the Municipal Works Inspector for review.

4. 32.6 Alternate bedding materials may be proposed for use only where approved by a geotechnical engineer. Alternate material will require approval by the City Engineer (subject to sieve analysis at the cost of the proponent).

4.33 Materials

All pipes shall be free of defects and shall be of the size and class shown on the design drawings. Corrugated steel pipe will not be permitted for use under any circumstance.

4.34 Installation

4.34.1 Pipes shall be handled, stored and laid in accordance with the recommendations of the pipe manufacturer. It is unacceptable to pass chains or cables through pipe bore so that the weight of the pipe bears on the pipe ends. Gaskets shall be installed according to manufacturer's specifications on all pipes.

4.34.2 All pipes shall be laid on a prepared bed, true to line and grade. The barrel of each pipe shall be in contact with the shaped bed along its full length. Line and grade shall be established using lasers or other approved methods.

4.34.3 All pipe must be laid to the designed alignment and grade within the following tolerances:

a) Horizontal tolerance from true line shall not be greater than 50 millimetres from the designed location. The rate of deviation shall not exceed 40 millimetres in 10 metres.

b) Vertical tolerance from true grade varies with the grades and shall not exceed the limitations as detailed in the table below.

Grade	Maximum Departure from Design Elevation	Maximum Rate of Deviation
over 5 percent	30 millimetres	6 millimetres in 3 metres
5 percent or less	15 millimetres	3 millimetres in 3 metres

4.34.4 All service connections shall be installed as shown on the standard drawings. An inspection chamber must be provided at the property line in a concrete box.

4.34.5 Service connections shall be installed perpendicular to the main unless otherwise approved by the Engineer.

4.35 Manhole, Cleanout, Silt Trap, Catch Basin and Oil/Silt Separator Construction

4.35.1 Standard manholes shall be constructed and benched as shown on the municipal standard drawings.

4.35.2 Where approved by the City Engineer, riser manholes will be constructed.

4.35.3 Cast-in-place manholes will be allowed provided that the following criteria are met.

a) Concrete shall attain a minimum strength of 28 megapascals at 28 days;

b) Minimum wall thickness shall be 150 millimetres;

c) Minimum internal dimensions are to be as specified on the municipal standard drawing.

4.35.4 Manhole frames shall sit on a minimum of two grade rings that shall be parged on both sides with a mortar paste composed of one part cement and three parts of sand and only sufficient water for workability. The grade separation between the frame and the manhole top shall be greater than 100 millimetres and be less than 200 millimetres.

4.35.5 Within the road allowance, heavy duty frames and covers, per the municipal standard drawing, shall be installed on manholes, silt traps and cleanouts.

4.35.6 Within untraveled easements and right-of-ways, low profile frames and covers may be installed on manholes, silt traps and clean outs.

4.35.7 All storm drain cleanout structures shall be constructed per the standard drawings. Two 6 millimetre diameter drain holes shall be drilled in the pipe where it meets the structure's base to allow water to drain out.

4.35.8 Storm manholes and cleanouts located in the boulevard shall be set to finished landscaped elevation or 50 millimetres above grade if the landscaped elevation is not available so that infiltration into the manhole will not occur.

4.35.9 Silt traps shall be precast structures. The area around the silt trap shall be graded so that surface runoff enters the grated lid.

4.35.10 Catch basins shall be precast structures constructed in accordance with the details shown on the the municipal standard drawings.

4.35.11 Oil/silt separators shall be installed so that all parts are easily accessible for inspection, maintenance and sampling. Installation shall be per the approved plans and the manufacturer's recommendations.

4.36 Service Connections to Existing Mains

Service connections to existing storm drain systems are to be made by the Contractor unless otherwise directed by the City Engineer. The connections shall be installed with the Works Inspector present, to the Engineering Standards and Specifications requirements and to the satisfaction of the City Engineer. Plugs shall be removed from inspection chambers (IC's) prior to installation.

4.37 Backfill

4.37.1 Where a pipe is installed beneath an existing or future pavement, sidewalk, driveway or gravel shoulder, the backfill shall be imported granular fill or equal, compacted to a minimum 95 percent Modified Proctor Density.

Backfill used in untraveled areas such as boulevards and easements shall be compacted to a minimum 90 percent Modified Proctor Density. Compaction shall be in layers of 150 millimetres using a plate compactor or in 300 millimetre layers using a hydraulic compactor.

4.37.2 If required to meet optimum moisture content, a controlled amount of water shall be added to the gravel to ensure compaction.

4.37.3 Imported granular fill used for backfill shall consist of well graded granular material, with not more than 8 percent passing the 0.075 millimetre sieve. It shall contain no stones larger than 150 millimetres in diameter and no stumps, roots, organic or other deleterious material.

4.37.4 Suitable native materials may be used as backfill in road areas provided it has been tested and approved by the geotechnical engineer. Backfill in these cases shall be free of stones over 150 millimetre size, frozen material, and organic or other perishable or objectionable material that would prevent proper consolidation or cause subsequent settlement.

Approved native backfill material shall under no circumstance have a silt and clay content exceeding 30 percent by volume.

4.37.5 Where it is required to replace topsoil it shall occupy the upper 300 millimetres of the trench and shall be heaped and compacted on top to allow for settlement. If the installation is under a lawn, the soil shall be fine raked during the appropriate season and sown with a top quality grass seed at the rate of 50 grams of seed per square metre and rolled. In certain conditions, the City Engineer may request the placement of sod over the trench.

4.37.6 Pavement that has been removed to permit trenching shall be disposed of as waste material and shall not be placed in the trench under any circumstances.

4.37.7 Field compaction tests of trench backfill shall be conducted a minimum of once per day and shall act as a method of quality control for the Contractor. All compaction tests are to be submitted to the Municipal Works Inspector for review.

4.38 Clean Up

4.38.1 The Contractor shall take precautions to prevent debris and mortar droppings from entering any part of the storm drain system and shall leave all pipes, manholes, cleanouts, silt traps, catch basins and other appurtenances in a thoroughly clean condition to the satisfaction of the Municipal Works Inspector.

4.38.2 The Contractor shall remove excess materials and clean up the construction area immediately in order to maintain site safety.

4.38.3 The Contractor shall restore all disturbed surfaces to a condition equal to or better than the condition that existed prior to construction to the satisfaction of the Municipal Works Inspector.

4.38.4 The construction shall not be considered complete until the City Engineer has provided final acceptance of the works.

4.39 Cleaning, Flushing and Testing

4.39.1 Cleaning and Flushing

Upon completion of storm drain pipe installation, the pipe shall be cleaned to the satisfaction of the Works Inspector by power flushing with water to remove all foreign material from the system. Flushing shall continue at least until flow from the most distant point has reached the discharge point and until the discharged water is clean and clear. Silt and debris shall be prevented from entering the downstream system during flushing.

The use of City water for flushing may or may not be permitted depending on water restrictions in effect at the time. The Contractor shall contact the Operations Department for a hydrant use permit prior to using any City hydrant as a water source. When flushing close to environmentally sensitive areas, the use of sodium thiosulfate is required for removal of chlorine from flushing water.

4.39.2 Video Inspection Test

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

A camera video of the storm drain system is required for all gravity mainlines, service connections and laterals such as catch basin leads. The inspection shall be recorded on a DVD complete with a printed report in WRc format and key plan. Prior to paving, the video inspection shall be completed and reviewed by the Consultant to ensure the pipe is true to grade and clear of debris, and has been installed in accordance with the City of Parksville Engineering Standards and Specifications. Any deficiency that is found during this test shall be promptly remedied by the Applicant at his expense.

Following the review, the Consultant will forward the final video records with a certified report to the City confirming that the pipe installation meets the City of Parksville Engineering Standards and Specifications. DVD's and records will become the property of the City of Parksville upon submission. The Consultant must retain copies for their own records. The Applicant shall re-video one month prior to the end of the one year maintenance period. The Consultant shall review this video and make a written recommendation to accept or reject the works based on the results of the video.