CITY OF KELOWNA

BYLAW NO. 11913

Amendment No. 20 to Subdivision, Development and Servicing Bylaw No. 7900

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts that the City of Kelowna Subdivision, Development and Servicing Bylaw No. 7900 be amended as follows:

1. THAT **SCHEDULE 4 – DESIGN STANDARDS**, title page be amended by deleting the title for Section 3 that reads "**3. DRAINAGE**" and replace it with a new title that reads "**3. STORMWATER MANAGEMENT**";

2. AND THAT **SCHEDULE 4 – DESIGN STANDARDS, Section 1 – Water Distribution, 1.5 Fire Flows** be deleted that reads:

"**1.5 Fire Flows**

Fire flows shall be determined in accordance with the requirements of the current edition of "Water Supply for Public Fire Protection - A Guide to Recommended Practice", published by Fire Underwriters Survey.

The following minimum fire flows must be met for the noted zones under peak daily flow conditions (Table 1.5):

Table 1.5 Minimum Fire Flow Requirements

Developments (without sprinklers)	**Minimum Fire Flow**
Single Family &Two Dwelling Residential	60 L/s
Modular / Mobile Home	60 L/s
Three & Four Plex Housing	90 L/s
Apartments, Townhouses	150 L/s
Commercial	150 L/s
Institutional	150L/s
Industrial	225 L/s

The Design shall not use a fire flow greater than those listed in Table 1.5 to design their onsite fire protection systems. The maximum available fire flow for site development is the lesser of the actual available fire flow at the service connection or the fire flows in Table 1.5.

Subdivisions and main extensions may utilize hydraulic information from water model as provided by the City.

Actual required fire flows shall be determined for all new developments."

And replacing it with:

"1.5 Fire Flows

Fire flows are subject to the following minimum requirements (Table 1.5) for all offsite works.

Table 1.5 Minimum Required Fire Flow by Zoning Designation

General Zoning Designation	Minimum Fire Flow*
Single Family &Two Dwelling Residential	60 L/s
Modular / Mobile Home	60 L/s
Three & Four Plex Housing	90 L/s
Apartments, Townhouses	150 L/s
Commercial	150 L/s
Institutional	150 L/s
Industrial	225 L/s

*Off-site fire flow requirements are calculated in accordance with the requirements of the current edition of "Water Supply for Public Fire Protection - A Guide to Recommended Practice", published by Fire Underwriters Survey.

Subdivisions and main extensions must utilize hydraulic information from water model results provided by the City.
Onsite requirements are defined during the Building Permit process:

a) Fire flow requirements for structures are to be calculated based on the worst-case requirement consistent with Section 3.2.5.7 of the BC Building Code.
b) Where a structure design includes an automated sprinkler system to NFPA 13 as per Section 3.2.5.12 of the BC Building Code, then:
    i. The NFPA 13 fire flow result for the worst-case building shall be the fire flow requirement on site.
    ii. Confirmation of meeting the NFPA 13 requirement must be provided to the City.
c) The Owner or Developer must report to the City that the calculated fire flow does not exceed the minimum requirements for that zoning found in Table 1.5."

3. AND THAT **SCHEDULE 4 – DESIGN STANDARDS**, Section 3 be deleted in its entirety and replaced with a new Section 3 – Stormwater Management as attached to and forming part of this bylaw as Appendix A;

4. AND THAT **SCHEDULE 5 – CONSTRUCTION STANDARDS, 2. STANDARD DRAWINGS**, be amended by deleting the standard detailed drawings for **MANHOLE REQUIREMENT FOR SERVICES DRAWING SS-S50 and IDF Curves – City of Kelowna (YLW) SS-S56** and replacing the standard detailed drawings for **MANHOLE REQUIREMENT FOR SERVICES DRAWING SS-S50 and IDF Curves – City of Kelowna (YLW) SS-S56** as attached to and forming part of this bylaw as Appendix B and C;

5. AND THAT **SCHEDULE 5 – CONSTRUCTION STANDARDS, 2. STANDARD DRAWINGS** be amended by adding a standard detailed drawing for **GROUNDWATER RECHARGE SUITABILITY MAP DRAWING SS-S58** as attached to and forming part of this bylaw as Appendix D;

6. This bylaw may be cited for all purposes as "Bylaw No.11913, being Amendment No. 20 to Subdivision, Development and Servicing Bylaw No. 7900."

7. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first, second and third time by the Municipal Council this

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

3 Stormwater Management

3.1 General

The City stormwater system integrates surface water flows collected through the City's infrastructure and the natural watercourses that flow into Okanagan Lake. Proper integrated stormwater management practice mitigates impacts with the goal of maintaining Okanagan Lake as a high quality water source, with an abundant water supply, and with a balanced ecosystem. While urban, agricultural and natural areas all benefit from Okanagan Lake, drainage impacts from our systems must be mitigated, as well as be resilient to flood hazard and a changing climate.

The presence of an existing stormwater management facility does not imply that there is adequate capacity to receive the design flow, nor does it imply the facility is necessarily acceptable to the City. Where required, stormwater facilities must be upgraded to accommodate the appropriate flow as specified in this standard.

3.1.1 Outcomes

With respect to stormwater, the City's goals are to:

a) Improve and protect water quality from creek flows, outfalls and groundwater entering Okanagan Lake.

b) Reduce the risk of health hazard, life, and damage to property and infrastructure from flooding, and provide strategies to attenuate peak flows and volumes.

c) Preserve and protect aquatic and riparian habitat and provide opportunity for restoration.

d) Minimize risks to the Okanagan Lake drinking water source.

e) Increase the resiliency of our watersheds to climate change impacts.

This stormwater management standard applies the latest Best Management Practices (BMP) and processes in use in British Columbia. New systems and development within the City are to use the practices described within this Section as a *minimum* standard.

All flows must be routed through sewer pipe, ditching, water courses, riparian areas, or road allowances with the required capacity and right of way access for operation and maintenance. The City requires that major system flows must be safely routed downstream to an adequately sized municipal drain or natural watercourse without impacting private property.

3.1.2 Regulations

Stormwater management designs must conform to this standard, City of Kelowna bylaws, regulations and policies; in addition to federal and provincial statutes where applicable. These include but are not limited to the following:

- Supplementary Design Criteria
- Existing Master Drainage Plans,
- Local Government Act
- Fisheries Act of BC
- Water Sustainability Act
- BC Water Act
- Navigable Waters Protection Act
- Canada Wildlife Act
- Migratory Birds Convention Act
- Dike Maintenance Act
- Standards and Best Practices for Instream Works (Canada/BC)
- Land Development Guidelines for the Protection of Aquatic Habitat (Canada/BC)
- Urban Runoff Quality Control Guidelines for British Columbia
- National Guide to Sustainable Municipal Infrastructure (Canada)
- Canadian Dam Association Dam Safety Guidelines

3.1.3 Climate Change

The City accepts that climate patterns are changing, and that its customers are impacted by creek flooding, lake rises, temperature fluctuations and fire. The design standards for infrastructure outlined in this bylaw are to be considered a minimum expectation. The City requires that design professionals consider impacts of climate change, through potential changing weather patterns or water levels when implementing a design; particularly in components where critical and long term design decisions are being made, or in areas where the consequence of failure is high.

To account for a changing climate, the capacity of storm works will include an additional 15 percent (15%) upward adjustment, and applied to the rainfall intensity curve stage (IDF) in

Section 3.7.2. This is consistent with recommendations in EGBC (2018): Legislated Flood Assessments in a Changing Climate in BC.

The design professional will be required to consider debris flow and flow management as a result of higher peak flows.

On larger projects, basin characteristics are required elements of the Stormwater Management Plan (See Section 3.2.1). Developers will need to anticipate this form of analysis as part of their overall cost strategy.

3.1.4 Hillside Areas

Hillside areas or areas of poor infiltration conditions have been identified by the City in Drawing **SS-S58.**

a) For development in Hillside Areas, the City focus is on safe conveyance of water. Roof or site drainage must discharge directly to the storm system. This focus is to not allow infiltration to ground except for foundation drainage. Where storm drains are not available or not considered feasible, minor system designs (see 3.2.a below) will require a hydrogeological review provided by a qualified Professional (P.Eng. or P.Geo.) to ensure that site infiltration is possible while not exceeding pre-development conditions, not impacting slope stability or off-site seepage, or not directly impacting downhill properties. The terms of reference of the review must be confirmed by the City Engineer and approved as a condition for obtaining a Development Permit.

b) For new development where Groundwater Recharge is designated **Not Suited**, the City will not permit minor systems (see Item 3.2a) to infiltrate to ground.

3.2 Stormwater Flow Control

The City's Stormwater Management system consists of three main components:

a) **The Minor System** consists of sewer pipes, gutters, catch basins, driveway culverts, open channels, watercourses and storm water management BMPs designed to capture, convey, treat or modify flows up to a 5-year return design event as directed by the City.

b) **The Major System** consists of surface flood paths, roadways, roadway culverts, channels and storm water management facilities designed to capture, convey, treat or modify larger flows up to a 100-year return design event. A piped minor system may be enlarged or supplemented to accommodate major flows. Major roads and arterials, bridges and creek protection armouring are to be designed for the 1 in 200 year event. This is discussed further in Section 3.10.

c) **The Natural System** consists of all natural lakes, rivers, creeks, streams and ephemeral drains that flow naturally downstream ultimately to Okanagan Lake. Natural system capacity and water quality can be impacted negatively by incoming Minor or Major systems.

3.2.1 Stormwater Management Plan

Stormwater Management Plans are required for all municipal development. A plan should include the following:

a) Tributary areas in the catchment which identify existing and potential land uses or current development.

b) References to applicable Area Stormwater Drainage Plans.

c) Details indicating how the proposed site relates to the Master Plan and its recommendations. Contours at 0.5 m elevation intervals.

d) Conceptual lot grading patterns.

e) Existing watercourses, including environmental classifications and/ or fish presence information, if available.

f) Layouts of existing and proposed drainage systems.

g) Major flow paths to a municipal drain or natural watercourse without impacting private property.

h) Proposed control features to meet the water quantity and quality targets identified in the applicable Master Plan

i) Locations, sizes, design flows, volumes, and capacities of all existing and proposed works.

j) Capacity assessment of receiving downstream works, or reference to the applicable Master Plan demonstrating adequate capacity. The City will provide the required stormwater area plans upon request.

k) Minor and Major hydraulic grade line elevations on profiles for all proposed works.

l) Proposed service connection locations and their associated minimum building elevations (MBE). Pre and post development flows both entering and leaving the subject lands.

   i. Pre development is defined as the natural condition prior to any development changes, including those resulting from past development activities.

m) The City may exempt plan requirements for development in rural or agricultural areas upon request or determination by the City Engineer.

3.3 On-Site Stormwater Management and Practice

3.3.1 Storm Effluent Limitations to City Storm System

a) For structures designed or constructed above the proven high groundwater table, intermittent stormwater pumping will be permissible to the City stormwater system where approved by the City Engineer. All operations and testing must be consistent with the requirements in Sanitary Sewer/Storm Drain Regulation Bylaw 6618.

b) Where structures are designed or constructed below the proven high groundwater table, permanent groundwater pumping will not be permitted to discharge to the storm system. The City will approve designs that include provisions for eliminating groundwater penetration into the structure, while addressing buoyancy concerns. These design aspects must be reviewed and approved by the City Engineer.

c) Refer to the latest BC Building code for drainage discharge requirements in parkades.

3.3.2 Water Quality

Whether water is routed through creeks, pipelines or infiltration into ground, the City will require consideration for treatment, emergency management and maintenance of the stormwater infrastructure and water quality. Stormwater designs on private property must meet or exceed minimum water quality guidelines prior to entering the City storm system. Water quality for a minor system flow (50% of the 1 in 2-year) must meet minimum BC Ministry of Environment Recreational Water Quality Guidelines and as per Sanitary Sewer/Storm Drain Regulation Bylaw 6618 .

3.3.3 Construction Sites

The City storm system can be used for temporary site water management provided the water quality exiting the property meets BC Ministry of Environment Recreational Water Quality Guidelines. This temporary use must be approved by the City prior to issuance of the Development Permit and/or Building Permit, following a confirmation of capacity within the downstream system, and adequacy of the quality of storm effluent. There must be no discharge to the sanitary sewer system.

3.3.4 High Density Residential, Commercial and Industrial Storm Systems

a) A control manhole is to be installed within 3 metres of the property line, and downstream of any water quality enhancement system. The manhole will include provision for isolating runoff into the City Storm system.

b) The City requires access to the structure in an emergency and inspection. An SROW is required. Provisions must be considered for response to emergency toxic spills on site. Any costs associated with emergency response are the responsibility of the property owner.

c) Water quality enhancement systems such as oil/grit separators, fuel/water separator (where required), naturalized storm ponds or other approved systems are the responsibility of the site owner, and must be maintained on a regular basis. The City can request regular maintenance records.

d) Minor system flows must meet water quality guidelines described above prior to discharging to a creek or city storm system.

e) On industrial sites where perforated storm systems or dry wells are used, the design must include provisions to manage emergency spills on site and minimize groundwater impacts.

3.4 Runoff Analysis

Storm drainage design should be carried out using one or both of the following methods. Calculations are to be submitted with designs.

a) **Rational Method:** To be used only for hydrologically simple and uniform areas with contributing area less than 10 Ha.

b) **Hydrograph Method**: Applicable for all larger areas or more hydrologically complex catchments, or where stormwater management systems require more than basic conveyances. Use SWMM based models or approved equivalent to analyze these processes. Each model must include a level of complexity dependent on the watershed and the hydrologic processes that need to be considered (e.g., detention, groundwater recharge and infiltration, evapotranspiration, continuous simulation, etc.).

For all modelling, use the rainfall Intensity Duration Frequency (IDF) curves found in standard drawing **SS-S56**. Both historical data as well as climate change information must be incorporated into the runoff analysis.

3.5 Site and Lot Grading

Grading is to comply with the BC Building Code and the following:

a) Swales and site drainage must be constructed to prevent ponding within lots, with runoff routed, where possible, to storm services in public streets or other appropriate stormwater management system for the site.

b) Grade lots to drain to an approved City drainage system or roadway. Use 1% minimum grade. Grading directly to a natural drainage path must include adequate erosion control and water quality improvement measures.

c) Avoid drainage across adjacent lots. Where cross-lot drainage is unavoidable, provide adequate measures such as channelling, swales, inlets or piped connections to direct flow appropriately. A statutory right of way in favour of the City or private easement is required for unobstructed access.

d) Positive drainage is required for buildings and foundations.

e) Set building elevations above the hydraulic grade line (HGL) of the major drainage system as per Minimum Building Elevations (MBE) guidelines below.

3.6 Minimum Building Elevations (MBE)

The MBE applies to the elevation of the lowest floor slab in a building or the underside of the floor joists where the lowest floor is constructed over a crawl space. Crawl space is defined as the space between a floor and the underlying ground having a maximum height of 1.2 m to the underside of the joists and not used for the storage of goods or equipment damageable by flood waters.

The MBE is to be at least 0.60 m above the storm sewer service connection invert and 0.30 m above the major drainage system hydraulic grade line (HGL), whichever governs except where permissible on Hillside development where:

- foundation drains are disconnected from the storm main; or
- intermittent foundation pumping has backflow prevention.

For developments within close proximity to the Okanagan Lake shoreline, the MBE is elevation 343.66m. Further consideration shall be given to wind and wave action when setting the required MBE.

For sites near a watercourse where a floodplain elevation has been established through flood mapping, the MBE is to be a minimum of 300mm above the 200-year return period peak flood elevation or as per City of Kelowna Mill Creek Flood Plain Bylaw No. 10248. Where a flood elevation has not been established, setbacks are to be as per the Provincial guidelines or 1.5 metres above the natural boundary of any watercourse, lake, marsh or pond.

3.7 Rational Method

The Rational Method for calculation of peak flows is as follows:

Q = R A I N

Where:

Q = Peak flow in cubic metres per second (m^3/s)
R = Runoff Coefficient (C) x Adjustment Factor (C_{AFs})
A = Area of catchment in hectares (ha)
I = Intensity of rainfall (mm/hr)
N = 1/360

Factors for use in the Rational Formula are indicated below.

3.7.1 Runoff Coefficients (C)

The following runoff coefficients are for use with the Rational Formula. These coefficients are for general application only. Design values are subject to verification by the designer and approval by the City. Higher values may be applicable in those areas which experience rainfall during the winter when the ground is frozen.

Table 3.7.1 Runoff Coefficients (C)

Land Use	Percent Impervious	C	
		Minor Storm (1:5 year)	Major Storm (1:100 Year)
Residential			
• Suburban Residential (Lots>0.4 ha)	20%	0.35	0.40
• Low Density (Single Family)	40%	0.50	0.55
• Medium (Multi-Units Detached)	65%	0.60	0.65
• High Density (Multi-Units Attached)	90%	0.85	0.90
Commercial	90%	0.85	0.90
Industrial	90%	0.85	0.90
Institutional (e.g. Schools)	80%	0.75	0.80
Parks/Grasslands	20%	0.20	0.30
Cultivated Fields	30%	0.30	0.40

Runoff Coefficient Adjustment Factor (C_{AF})

An adjustment factor is to be applied to the runoff coefficient to reflect variations in soil permeability and slope.

Table 3.7.2 Runoff Coefficient - Soil Adjustment Factor (C_{AF})

Soil type and Slope	C_{AF}
Sandy soil with flat slope (up to 5%)	0.9
Sandy soil with steep slope (over 5%)	1.0
Clayey soil with flat slope (up to 5%)	1.0
Clayey soil with steep slope (over 5%)	1.1
Rock	1.1

Note: The above runoff coefficient adjustment factors are subject to verification by the designer. The product of C and C_{AF} can not exceed 1.0.

3.7.2 Rainfall Intensity (I)

Rainfall intensity for use in the Rational Method should be determined using the rainfall IDF curve in standard drawing **SS-S56** for the City of Kelowna. This curve was developed from the Atmospheric Environment Service recording station located at the Kelowna international Airport. To account for climate change, as noted in Section 3.1.3, **a <u>15 percent increase</u> (15%)** will be applied to the intensity derived from the IDF curve. The duration is equal to the Time of Concentration (Tc), as calculated below.

Time of Concentration (Tc)

The time of concentration is the time required for runoff to route from the most remote part of the catchment area under consideration to the design outlet node. The time of concentration can be calculated using the following formula:

$$T_c = T_i + T_t$$

Where:

T_c = time of concentration (minutes)
T_i = inlet or overland flow time (minutes)
T_t = travel time in sewers, ditches, channels or watercourses (minutes).

Inlet or Overland Flow Time (Ti)

Typical inlet times for urban areas, assuming BMP's are not applied, are as follows:

a) Single Family Lot — 10 minutes

b) Multi-Family Lot 8 minutes

c) Commercial/Industrial/Institutional 5 minutes

For relatively flat areas, the inlet time for larger areas can be calculated using the "Airport Method" as follows:

$$T_i = 3.26 \frac{(1.1 - C)\, L^{0.5}}{S^{0.33}}$$

Where:

T_i = inlet time (minutes)
C = runoff coefficient (See above)
L = travel distance (Maximum length = 300 m)
S = slope of travel path (%)

Travel Time

The travel time for routing in sewers, ditches, channels or watercourses can be estimated using the Modified Manning formula:

$$T_t = \frac{L\, n}{60\, R^{0.667}\, S^{0.5}}$$

Where:

T_t = travel time (minutes)
L = length of flow path (m)
n = Manning roughness coefficient:
- 0.050 Natural channels
- 0.030 Excavated ditches
- 0.013 Pipe and concrete lined channels.

R = Hydraulic radius = Area/Wetted Perimeter (m)
S = slope (m/m)

3.7.3 Design Summary Sheet

All design calculations are to be tabulated and shown on the design drawings, or in a report and summarized on design drawings.

3.8 Hydrograph Method

Analysis using the Hydrograph Method requires computer modeling capable of analyzing the hydrologic characteristics of the watershed and generating runoff hydrographs.

For City applications, SWMM based models are appropriate. The City of Kelowna must be consulted before selecting a more specialized software program.

3.8.1 Modelling Procedures

Modelling results are to be calibrated using observed historical rainfall and flow data from the design watershed. Sensitivity of the model predictions to variations of key parameters should be tested and the findings used to develop a realistic and conservative model.

At a minimum, post-development hydrographs are to be generated at key points of the drainage system for a 5-year and 100 year design storm with durations of 1, 2, 6, 12, and 24 hours for each development condition. A different range of storm durations may be appropriate, subject to City approval. This will identify the critical storm event to be used in designing the system component. Note that the storm durations that generate the critical peak flow may be different from the durations that generate the critical storage volume.

Systems with a number of interconnected ponds or with restricted outlet flow capacity may require a more detailed analysis for sequential storm events or modelling with a continuous rainfall record.

Detailed designs should include hydraulic grade lines (HGLs) of the minor and major systems plotted on profiles of the minor system components and compared with MBE to demonstrate flood protection.

3.8.2 Submission of Modelling Results

Modelling results are to be submitted to the City in a report or drawing containing at least the following information:

a) Stormwater Control Plan as defined in Section 3.2,

b) Name and version of modelling program(s)

c) Parameters and simulation assumptions.

d) Design precipitation details.

e) Pre-development and post-development hydrographs.

3.9 Minor System Design

The minor system includes all drainage works that collect, convey, detain, divert and intercept design storm runoff. The minor design event must be the 5-year design storm.

3.9.1 Pipe and Channel Capacity

Use Manning's formula.

$$Q = \frac{A\,R^{0.667}\,S^{0.5}}{n}$$

Where:

A = Cross sectional area in m^2
R = Hydraulic radius (area/wetted perimeter) in m
S = Slope of hydraulic grade line in m/m
n = Roughness coefficient:
0.013 for all smooth pipes.
0.024 for corrugated pipes and culverts.

3.9.2 Flow Velocities

a) Pipes/Culvert Flow

   i. Minimum design velocity for pipes flowing full or half full: 0.60 m/s.

   ii. Where grades are greater than 10%, measures are required to prevent pipe erosion and movement such as control structures and/or tie-backs and anchor blocks.

   iii. Where a storm sewer discharges into a watercourse, provide riprap bank protection and, if necessary, energy dissipation facilities. Avoid discharge perpendicular to stream flow.

b) Conveyance channels must be armoured and sized for a 1:100-year event. For riprap design chart see standard drawing **SS-S57**.

c) Road Ditches

   i. Maximum road ditch velocity is 0.5 m/s without armouring.

   ii. Ditch Inlets - Ditch inlets to storm sewers must include wing wall structures, safety grillage for large pipes (>600 mm diameter), debris screens and sedimentation basins.

3.9.3 Alignment

Except as indicated for Curved Sewers, horizontal and vertical alignments are to be straight lines between manholes.

3.9.4 Minimum Pipe Diameter

• Storm Sewers	250 mm
• Culverts crossing roads	450 mm
• Culverts crossing driveways	300 mm
• Catch Basin Leads	200 mm
• Double Catch Basin Leads	250 mm

Downstream pipe sizes are not to be reduced unless the downstream pipe is 600 mm diameter or larger and increased grade provides adequate capacity. Detailed hydraulic analysis is required. The maximum reduction is one standard pipe size.

3.9.5 Minimum Grade

Minimum grades of storm sewers are as required to obtain the minimum velocity of 0.6 m/s at design flow except for catch basin leads and service connections, for which minimum grades are as indicated in Section 3.9.12, Service Connections.

3.9.6 Curved Sewers

Where permitted by the City, horizontal and vertical curves may be formed using pipe joint deflections as follows:

a) The radius of the curve is to be no less than the recommended manufacturer's minimum radius of curvature at a constant radius.

b) Horizontal curves must be parallel to the centre line of road at a constant offset.

c) Only one horizontal curve is permitted between manholes, unless the mainline is installed and appropriately anchored outside the road on a steep hill slope requiring multiple vertical curves.

d) Where the pipe curve does not have a consistent offset from a road centre line, the offsets must be properly referenced on Record Drawings.

e) Subject to City Engineer approval, curved storm sewer systems larger than 600 mm diameter may include deflections formed by mitred bends to a maximum mitre of 45°.

3.9.7 Depth

The minimum depth of the sewer must be sufficient to provide all service connection piping with a minimum cover of 1.2m to the top of the service, anywhere within the finished right-of-way. In no instance shall the cover over the crown of the sewer main be less than 1.2m when installed in travelled areas. The depth of course can be reduced to 1.0m when installed outside of travelled areas.

a) The maximum depth of cover must be 4.5m, except under special circumstances and with permission of the City Engineer.

b) For catch basin leads, the minimum depth of cover is 0.90m.

3.9.8 Pipe Joints

All pipe joints are to be watertight.

3.9.9 Perforated Storm Pipe

a) The City will only consider the installation of perforated storm sewers and/or dry wells to discharge water back to the ground where soil conditions, slope and water table elevation are suitable. The perforated pipe system design must be designed to provide surcharge conditions.

b) Perforated pipes can only be installed in areas of the City described as "Possibly Suited" in the Groundwater Recharge Suitability Map in Standard Drawing **SS-S58** and confirmed by a hydro-geotechnical site investigation.

3.9.10 Manholes

a) Manholes are required at:

    i. Every 150m or less.
    ii. Every change of pipe size.
    iii. Every change in grade, except on curvilinear pipe alignments.
    iv. Every change in direction, except on curvilinear pipe alignments.
    v. All terminal sections.

vi. Every sewer main intersection.

b) Placement of manholes in existing or future wheel paths must be avoided.

c) Manhole sizes must be in accordance with the Standard Drawings: Manhole connection details as per MMCD S3 & S4, or City of Kelowna supplemental standard drawing **SS-S1a**".

d) Hydraulics: Crown elevations of inlet sewers not lower than crown elevation of outlet sewer. When connecting a collector sewer main to a trunk sewer 300 mm or greater, the invert of the collector main must not connect lower than 0.75D (¾ of the pipe diameter).

e) Minimum drop in invert elevations across manholes:

i. Straight run: 10 mm drop

ii. Deflections up to 45 degrees: 25 mm drop

iii. Deflections 45 to 90 degrees: 50 mm drop

f) Drop manhole and ramp structures should be avoided where possible by steepening inlet sewers. Where necessary, provide drop structures as follows (table 3.9.10):

Table 3.9.10 Drop Structures

Invert Difference	Structure
Up to 0.45m	Inside Ramp
0.45 to 0.90 m	Outside Ramp
Greater than 0.90 m	Outside Drop*

*Inside drop may be used if specifically approved by the City Engineer.

g) Drop manholes and outside ramps must be installed in accordance with standard drawings.

h) Hydraulic losses are to be calculated for manholes with significant change of grade or alignment. For high velocity flows, particularly for pipes 600 mm or larger, detailed analysis is required using the Froude number, or utilizing appropriate computer models. The Manning's equation should not be relied on for pipe slopes above 10%. For low to moderate velocities and smaller pipes, use the following formula:

$$\mathbf{H_L = k\, v^2/2g}$$

Where:

H_L = head loss (m)
v = flow velocity entering junction (m/s)
g = gravitational acceleration (9.81 m/s^2)
k = head loss coefficient (1.0 for channeled 90° bends and tees, to 1.5 without channelized benching)

Where benching is used, the minimum drops listed above are applicable for velocities below 1 m/s. Where flows exceed 1 m/s, H_L should be specifically computed and used as the drop across the junction.

3.9.11 Catch Basins

a) Catch basins are required at regular intervals along roadways, at intersections and at low points to:
   i. Prevent overflows to driveways, boulevards, sidewalks and private property.
   ii. Avoid interference with crosswalks.
   iii. Avoid low points in curb returns at intersections.

b) Catch basin leads are minimum 200 mm diameter.

c) Minimum grade of a catch basin lead is 1%.
   i. Catch basin leads require a 0.9 m minimum cover. If 0.9 m is not available, design to protect from freezing and traffic loads; design calculations must be provided.

d) Spacing is to provide sufficient inlet capacity to collect the entire minor flow or major flow, where required, into the sewer system.

e) Local suppliers are required to provide rating curves for available catch basin grates. As a general rule, space catch basins to drain maximum impervious areas of:
   i. 500 m^2 on roads with grades up to 4%,
   ii. 400 m^2 on roads with grades greater than 4% at 100 m maximum.

f) Lawn basins are required on boulevards and private properties where necessary to prevent ponding or flooding of sidewalks, boulevards, driveways, buildings and yards.

g) Double or twinned catch basins must not be connected directly together, rather one basin will be wyed into the lead of the other. Maximum lead length to the mainline must be 30 meters and be minimum 250mm diameter. Each CB will have a trapping hood (standard drawing **SS-S54**).

h) Double or twinned catch basins are to be provided at all sag points or sump locations as a minimum. Inlet calculations are required where the major storm needs to be accommodated, such as downhill cul-de-sacs or where there is potential for excessive ponding or overflow onto private property.

i) Oversized grates and/or secondary emergency inlets must be considered where leaves and/or debris collection is anticipated.

3.9.12 Service Connections

Service connections to the City storm system are required for all multi-family, commercial, industrial and institutional land uses.

Single Family Residential service connections to the City Storm system are required in instances where site conditions do not provide for safe infiltration or dispersal of storm water on site. The safe use of infiltration is to be confirmed by a qualified Professional.

a) Service connection requirements:

i. The minimum storm service diameter for any property is 150mm.

ii. Inspection chambers (ICs) are required to be installed as per **SS-S7** and **SS-S9**. Where this is not possible, identify offset on the record drawings and service card. An IC is not required on residential connections where the service is less than 2.5 m long and connected directly into a manhole.

iii. Refer to Drawing **SS-S50** for all service connection requirements to a storm mainline.

iv. All storm services 200 mm and larger require a manhole either on the storm mainline or on the storm service at the property line. The service manhole must be offset from the property line a sufficient distance to ensure replacement will not impact private property.

v. Flow control manholes are to be installed on the private side of the property line as per Drawing **SS-S55**.

vi. Service connections are permitted into manholes as per Drawing **SS-S1a**.

vii. Depth to be minimum 1.2 m.

viii. Minimum grade from property line to storm sewer main is 2%.

ix. Wye fittings are preferred for service connections into proposed City storm sewers. Insertable tees are permitted into 250mm or larger existing mains.

b) Roof Leaders (drains):

i. Where permissible and not in Hillside Areas, roof water is expected to be contained on site as part of best management practices to meet requirements for pre-development storm rate. Acceptable best management practices include splash-pad onto green space, rain harvesting systems or appropriately sized rock pits where soil infiltration parameters permit.

ii. Roof leaders are not permitted to be directed to any infiltration device or soak away pit near to or part of an engineered retaining wall or reinforced earth structure.

iii. Roof leaders or inlets from downward sloping driveways in Hillside Areas must be connected to the City storm sewer.

c) Perimeters Drains

i. Perimeter drains for buildings are required as per the British Columbia Building Code.

ii. Discharge may be to the surface or a soak away pit.

iii. Foundation perimeter drains are not permitted to be directed to any infiltration device or soak away pit that impacts an engineered retaining wall or reinforced earth structure.

iv. Foundation perimeter drains can be routed by gravity through a storm service to the storm sewer provided that:

- the elevation of the basement/crawlspace floor is at least 600 mm above the MBE (Section 3.6), or
- 600 mm above the anticipated or known high ground water table, or
- 600 mm above the 100 year hydraulic grade line within the sewer main at that point, whichever is higher.

v. Where a sump pump is required, a backflow prevention device must be installed as part of the mechanical configuration to prevent backflow into a basement from the City Storm sewer.

vi. As per Section 3.3.1, permanent groundwater pumping is not permitted to City storm sewers.

3.9.13 Perforated Sub-Drains

Perforated subsurface drainage systems designed for the purpose of permanent groundwater level reduction are not permitted to be connected to the City Storm sewer system.

3.9.14 Locations and Corridors

Wherever possible, storm sewers and service connections should be located within the public road right of way. Side or rear yard easements should be avoided where possible. Where it can't be avoided, statutory right-of-ways will be required for permanent City access.

3.10 Major System Design

The major drainage system includes all drainage pathways that convey, detain and/or intercept flows in excess of the capacity of the minor system. Its primary purpose is to provide flood protection for the 1:100 year return event. The major system generally includes surface flow paths such as ditches, swales, sewers, roadways, plus roadway culverts and watercourses.

3.10.1 Surface Flow Routing

All surface flows should have specially designed routes that are preserved and protected by right-of-ways and are accessible for maintenance. Design criteria include:

a) HGL is to be at least 600 mm below the MBE of adjacent buildings.

b) Maximum flow depth on roadways: 300 mm. Boulevards and intersecting driveway profiles will need to be set such that roadway surface flows are contained within the public right-of-way.

c) One lane, or a 3.5 m width at the crown of each roadway, is to be free from flooding.

d) Where a roadway is used as a major flow path, the road grades are to be designed to accommodate and control the flow at intersections.

e) Flood routing is not permitted on to private property except in engineered flow channels or sewers protected in a statutory right-of-way.

f) Overflow routes are required at all sags and low points in roadways and other surface flow routes.

g) Major flood routes are required to exit down-slope in cul-de-sacs with Statutory Rights of Way established.

3.10.2 Surface Flow Capacity

Flow capacity of road surfaces and swales can be calculated using the Manning formula, presented in Section 3.9.2, Time of Concentration. Typical values of the Manning Roughness Coefficient "n" are:

a) 0.018 for paved roadway

b) 0.03 for grassed boulevards and swales

c) 0.04 to 0.10 for irregular or treed channels.

Design detail is to include consideration of flow velocities and the potential requirement for erosion control measures. Ditches should be designed using a low n-value to determine velocity and provide the basis for stable channel design and a high n-value to determine ditch capacity and free board to prevent flooding or submergence of adjacent roadway subgrades.

3.10.3 Piped System

As noted in Section 3.2.1, the minor drainage system may be enlarged or supplemented to accommodate major flows in special circumstances. Modifications to the design criteria must be included in Stormwater Management Plan. Design considerations include:

a) Provision of adequate inlets to accommodate major flows. Capacity calculations are to be provided in the Stormwater Management Plan.

b) The requirement for surface overflow routes at potential surface ponding locations.

c) Flow depth and velocity.

d) Where applicable, design in accordance with minor drainage system guidelines.

3.10.4 Culverts and Bridges

The following service levels are to be used for design:

Road Class	Design Flood Frequency for Bridges and Culverts
Arterial and Collector	1:200 Year Flood
Local	1:100 Year Flood + provision for overflow if on major channel

The fishery value (aquatic classification) of the watercourse will establish the design requirements for the crossing. Particular designs will apply if fish passage is needed. Approvals are required under the BC Water Act and the Federal Fisheries Act, and may be required under the federal Navigable Waters Protection Act.

Culvert design is to be in accordance with the procedures outlined in an applicable design manual including but not limited to:

a) American Concrete Pipe Association - Concrete Pipe Design Manual
b) Corrugated Steel Pipe Institute - Handbook of Steel Drainage and Highway Construction Products.
c) Standards and Best Practices for In-stream Works - Culverts, Province of British Columbia and DFO.

Inlet and outlet protection is required for all major system culverts. Design considerations are to include inlet control and outlet control conditions, energy dissipation and erosion control measures.

The City requires all municipal channel culverts 500mm or greater to be constructed with headwalls, end-walls and safety grillage as per Standard Drawings.

3.10.5 Watercourses

Natural watercourses are integral components of both the major drainage system and the ecological system. Riparian areas are to be preserved and/or enhanced to sustain habitat for aquatic and other wildlife as well as convey storm runoff.

Increases in peak storm flows and volumes to major watercourses and receiving waters shall be minimized. Consideration must be given to fish bearing streams and to streams presently at capacity.

Designers must consider all federal, provincial and municipal laws, regulations and guidelines noted above, and must obtain comments and approvals from the appropriate agencies.

3.11 Runoff Controls

Runoff controls are required to meet the objectives indicated previously. The controls may include:

3.11.1 Detention Storage

Detention storage is used to capture and store water on site to assure that storm releases are limited to the pre-development release rate for a 1 in 5 year storm. Drainage Basin Plans are available upon request to the City Engineer.

As a guideline, detention storage is not required on any lands west of Richter Street between Bernard Avenue to the north and Wardlaw Avenue to the South unless approved by the City Engineer. Where peak flow rates or volumes are increased and will cause detrimental impacts, provisions for downstream improvements must be provided in order to mitigate the impacts.

Detention storage options and design guidelines include the following:

3.11.2 Parking Lot Storage

a) Requires detailed lot grading design to ensure proper drainage, pedestrian safety and convenience, and major flow paths .

b) Maximum ponding depth: 300 mm outside vehicle stalls, 150 mm within vehicle stalls, however, also with consideration to frequency of ponding and impact to users of the parking lot.

3.11.3 Underground Storage

a) Facilities include tanks and oversized pipes, with outlet controls.

b) Tanks, fencing and graded slopes to be constructed off-line and on-site.

c) Cross sections and inlet and outlet locations should be designed to minimize maintenance requirements.

d) Structural design to accommodate traffic loads and groundwater pressure.

e) Maintenance access provisions required.

3.11.4 Dry Detention Ponds

a) Intended to provide storage only during severe storm events.

b) May be on-line or off-line, although off-line is preferred. Fencing and graded slopes required.

c) May accommodate active recreational uses.

d) Overflow elevations to be coordinated with MBEs.

e) Emergency overflow spillway to be constructed for 1:100yr storm event.

f) Design details, other than discharge rates should be in accordance with current technologies as outlined in Land Development Guidelines for Protection of Aquatic Habitat (Canada/BC).

g) Provide warning signage indicating facility is a stormwater detention structure subject to flooding or rapid water level changes. Signs to be posted at all public access points or road frontages.

3.11.5 Wet Detention Ponds

a) Intention is to provide on-line detention storage and maintain a permanent minimum water levels.

b) Catchment area must be large enough to provide sufficient base flow to ensure wet storage and is sustained without becoming stagnant (based on local hydrologic characteristics).

c) Generally located off-site, and must include fencing and graded slopes on-site.

d) Can provide a public amenity within a passive park.

e) Overflow elevations to be coordinated with MBEs.

f) Design details, other than discharge rates, should be in accordance with current technologies as outlined in Land Development Guidelines for the Protection of Aquatic Habitat (Canada/BC), and related documents.

g) Provide warning signage indicating facility is a stormwater detention structure subject to flooding or rapid water level changes. Signs to be posted at all public access points or road frontages.

3.11.6 Subsurface Disposal / Infiltration Systems

a) These systems are intended to promote stormwater retention and groundwater recharge.

b) Suitable for high permeability soils with low groundwater elevation. Geotechnical investigation is required.

c) Design details should be in accordance with current technologies as outlined in Infiltration systems guidelines in land Development Guidelines for the Protection of Aquatic habitat (Canada/BC), and related documents.

d) Stormwater infiltration basins planned for Hillside Areas must be designed by a qualified Professional with experience in hydrogeology. The design must be reviewed and confirmed by the City Engineer. See Section 3.1.4.

3.12 Outlet Controls

Outlet controls for storage facilities may be designed using the standard orifice and weir equations:

Orifice Equation:

$$\mathbf{Q = C\,A\,(2\,g\,h)^{0.5}}$$

Where:

Q = release rate (m^3/s)
C = orifice coefficient (0.62 for sharp or square edge, 0.85 for rounded edge)
A = area of orifice (m^2)
g = gravitational acceleration (9.81 m/s^2)
h = net head on orifice (m)

Weir Equation:

$$\mathbf{Q = CLH^{1.5}}$$

Where:

Q = release rate (m^3/s)
C = weir coefficient
L = effective length of weir crest (m)
H = net head on weir crest (m)

Larger storage facilities are to include provisions for discharges at rates greater than the design release rate (i.e., major storm event and emergency conditions). Rapid drawdown of the water level may be necessary for emergency purposes or to restore the available storage to accommodate subsequent storm events. Simple reducers are permitted on smaller facilities.

Orifices shall be fixed and designed to pre-development outflow rate. Adjustable mechanisms such as slide gates or removable orifice plates are not permitted unless approved by the City Engineer.

Design of inlet and outlet structures is to include consideration of energy dissipation and erosion control. Safety grates are required over all inlet and outlet openings larger than 500 mm diameter. Locks for access hatches are required.

The following is an introductory list of some runoff controls focused on water quality treatment.

a) Bio-filtration Swales and Constructed Wetlands
b) Intended to provide bio-filtration and sediment removal.
c) May be designed to provide on-line detention storage as well as quality treatment.
d) May be located on-site or off-site.
e) Qualified professional required for design.
f) Design requires consideration of climatic conditions.

3.12.1 **Oil and Grit Separators**

Oil and Grit Separators are required:

a) On site with parking for 50 or more vehicles (does not apply to parkades).
b) On all industrial zoned properties, unless it can be proven that there is no risk of storm water contamination.
c) Supplier design details are required.

Design criteria for Oil and Grit Separators must include:

a) Devices must have a current Canadian Environmental Technology Verification (ETV) or ISO 14034 ETV verification.
b) A target Total Suspended Solids removal of 60% of the ETV Particle Size Distribution.
c) Performance predictions for all proposed units.
d) A maintenance plan and commitment from all Owners. This will be included in the business license renewal.
e) A location on-site, including a Statutory Right of Way or covenant on title should the City need to inspect the unit.

3.12.2 **Oil/Water Separators**

a) Required for gas stations, vehicle service areas and storage areas for highway vehicles and construction equipment.
b) Design details in accordance with current technologies as outlined in Urban Runoff Quality Control Guidelines for British Columbia.

3.13 Drainage Pump Stations

Drainage pump stations are not commonly used in the City. Where drainage pumping is required, the designer must review the design concept and proposed guidelines with the City, submit a pre-design report and obtain approval of the City before proceeding with design. At a minimum, the pre-design report should include the following:

a) Delineated catchment area map

b) Estimated flows and HGL

c) Pump station location

d) Connection to existing infrastructure.

3.14 Erosion and Sediment Control (ESC)

All construction projects in the City require an Erosion and Sediment Control (ESC) Plan approved by the City. Storm water runoff from construction sites commonly contains significantly higher contaminant concentrations than storm water from developed sites. Poor construction practices and lack of attention to detail are contributors to sediment transport, in turn impacting both downstream infrastructure, aquatic habitats and Okanagan Lake.

Erosion and Sediment Control will be managed as a separate process with a cost identified as a separate line item in the development planning process

The following policies will be administered:

a) No Person may cause, or permit another Person to cause, sediment or sediment-laden water to discharge into the storm system, with concentrations greater than 75 milligrams per litre (ppm) of total suspended solids (TSS). A sample measuring greater than 60 nephelometric turbidity units (NTU) will be the trigger point where the sample must also be sent to the lab for analysis.

b) A Security Deposit for ESC Works equal to 3% of the Consulting Engineer's opinion of probable costs of civil earthworks and infrastructure will be added to the Servicing Agreement.

   i. The Security Deposit submitted is to secure the full and proper compliance with the provisions of the By-law. In the event, that the Owner, Developer, or Person Responsible has not complied with the provisions of this By-law, the necessary funds from the security deposit may be drawn down, at the City's option, and the money used either by the City or its agents to protect the storm system from sediment or sediment-laden water in adherence with the terms and conditions of this By-law. Notwithstanding, the City is under no obligation to initiate or complete remedial works in or under the Land.

   ii. If the amount of the security deposit is insufficient for the City to complete the ESC Facilities, the Owner and Developer jointly and severally will pay any deficiency to the City on demand.

c) The Owner must retain a Qualified Professional (P.Eng, RPBio, P.Ag, AScT, CPESC, CISEC or CESCL) responsible for inspecting and monitoring the ESC Facilities weekly and after any rain event which exceeds the intensity of 25mm of total rainfall depth in a 24-hour period. All records and data must be made available to the City upon request. Should a site be determined to be non-compliant, the Professional will be responsible for submitting notification and presenting a remediation plan to the City within two days of the event.

d) The ESC will include a construction plan and site management plan ESC features must be installed before any clearing, excavation, or soils mobilization takes place.

e) The fundamental approaches to effective ESC include:

   i. reduce clearing and grading and preserve natural vegetation as much as possible;
   ii. phase construction to limit soil exposure at any one time, particularly in wet seasons;
   iii. stabilize exposed soils as quickly as possible, whether temporary or permanent;
   iv. protect slopes and cuts;
   v. prepare the site to limit soil tracked off-site by haul vehicles;
   vi. sweep off-site streets when dirt is tracked;
   vii. filter runoff water before it leaves the site;
   viii. install filters or barriers to protect downstream drains and inlets;
   ix. adjust ESC plan to suit changing weather and construction phasing;
   x. assess ESC practices after rain event; and
   xi. maintain the works throughout construction.

Ideally, practices and features are put in place to prevent erosion from occurring in the first place, but realistically some degree of erosion and sediment transport will occur. When it does, other practices and features are to intercept and capture the sediment before reaching vulnerable areas. As such, the following sub-sections introduce ESC practices in two core categories; erosion control and sediment control.

3.14.1 Erosion Control

Rainfall and wind can aggressively displace and transport soil, although rainfall tends to be the more damaging in BC climates. The soil composition has a significant bearing on its erosion potential. The first line of defense is to either maintain or provide protective cover to the soil. Ideally, natural vegetative cover is maintained for areas that do not need to be disturbed. Where soils do need to be exposed or stockpiled, temporary covers should be applied when rainfall events are imminent.

For exposed site areas, straw mulch is the most common form and can be effective with low cost. However, it is commonly not applied thick enough or replenished frequently enough. It is important that a uniform blanket be provided and refreshed as the straw decays or is displaced. For the most part, bare soil should not be visible.

For steeper slopes, or for areas exposed and inactive for considerable time, manufactured erosion control blankets may be most appropriate. There are many products available and local suppliers should be consulted for the selection of the appropriate one. While they have a higher purchase cost, with proper selection and installation they will provide longer and more effective service with far less maintenance than straw mulch.

For soil stockpiles, poly tarps should be applied when the stockpile is inactive, including short overnight periods if there is any threat of precipitation. If inactive for considerable time, other measures such as temporary seeding, mulching, or matting may be considered.

Once disturbance to an area is complete, permanent cover practices should be established as soon as possible. Top dressing the area with topsoil having high organic content in itself can be a significant benefit; a minimum of 100 mm should be applied for purposes of erosion control. Greater depth is often required to meet landscape growing medium and hydrologic management needs. Sodding, broadcast seeding, hydro-seeding, and drill seeding are acceptable methods to re-establish a blanket of vegetative.

Aside from maintaining good quality ground cover, there are a number of other techniques that can be applied as erosion control, including the following, but not necessarily limited to those below. They should be selected based upon the specific conditions and requirements of the site.

Construction of stable haul roads for transport vehicles coming and going from the site is required.

At a minimum, haul roads include 200 mm of a coarse granular running surface, but strong consideration for underlying filter fabric, and potentially geogrid reinforcing in weak soils, should be given;

a) Intercept trenches on the upstream edges of the working area to redirect runoff;

b) Terracing steeper slopes;

c) Scarifying the soil surface;

d) Bio-engineered protection of very steep slopes;

e) Rip-rap with appropriate underlying filter.

3.14.2 Sediment Control

Silt fences can be an effective barrier to contain soil, but are not an effective filter of sediment laden runoff. Their permeability is insufficient to allow water to pass through, and therefore more commonly act as a dam which is then often undermined or circumvented by the flow of water. When used appropriately as a soil containment barrier, they must be sufficiently installed and maintained. Design criteria include: stakes should be > 7.5cm in diameter and > 1.5m long and driven > 40cm into the ground; stakes should be < 2.4m apart unless wire backing is used; and bottom should be buried in a trench > 20cm.

a) Storm drains and catch basins potentially receiving site runoff are to be protected with filters.

b) Straw bales and gravel berms are to be used within flow paths to slow water and promote trapping of coarse sediment. Note that these are less effective for fine sediment.

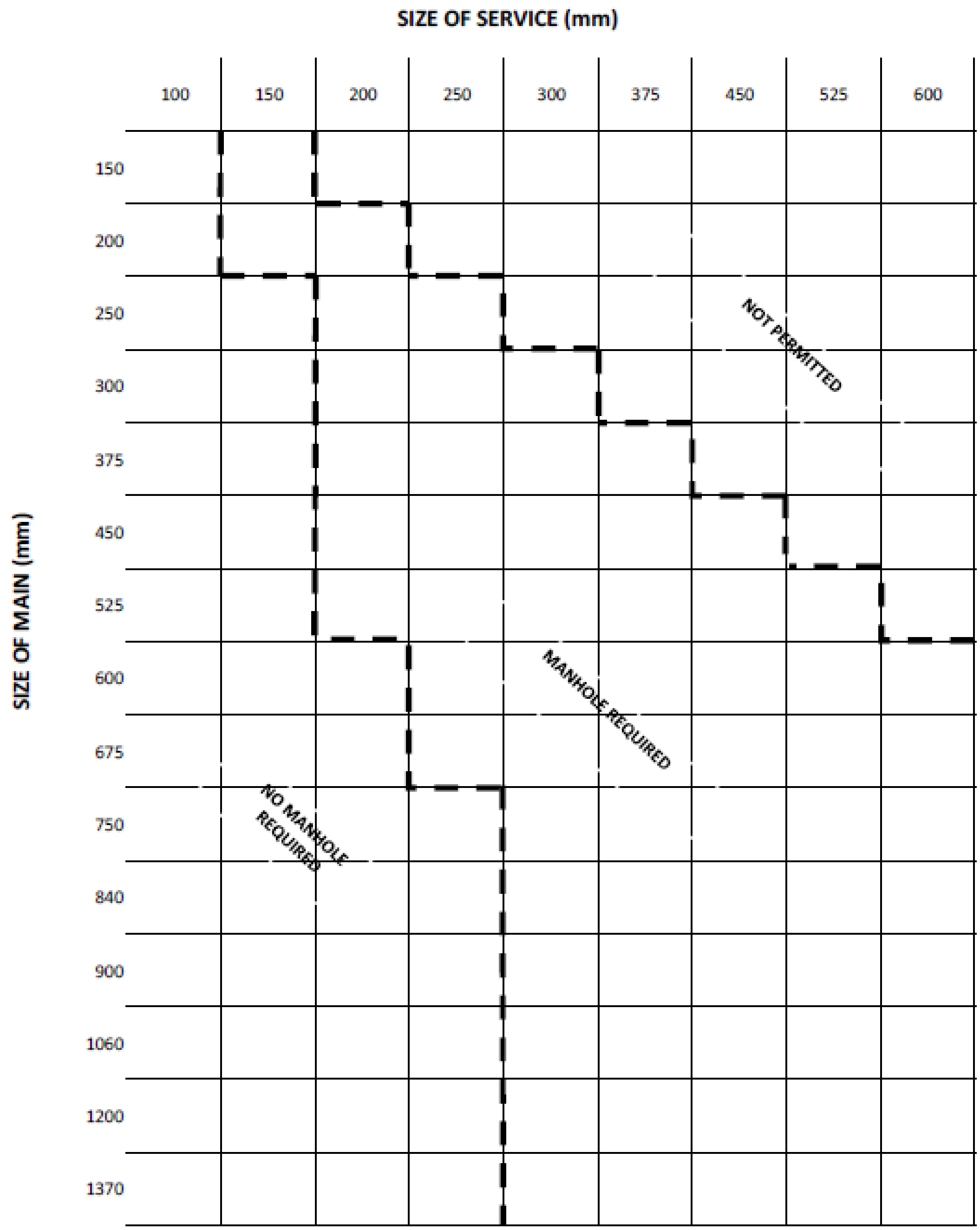
c) Dust control is required at all times.

d) Soil transport from vehicles coming and going from the site must be controlled. Where a wheel wash facility is constructed, wash water must be appropriately contained and treated prior to release off-site.

e) Sediment ponds (or basins) are generally applied to larger construction sites (> 2 hectares) to settle suspended sediments larger than 0.02mm. The outlet should consist of a perforated riser pipe with a gravel jacket. Internal gravel baffles are to be installed to create individual cells to reduce velocities and prevent short circuiting of flow to the outlet. As a design guideline, ponds should be sized to accommodate 125 m^3/ha of site area. Of this volume, at least 20% should be dedicated to a forebay. The remainder, as a permanent pool, should measure 1.3-1.8m in average depth, and not exceed 2.4m.

f) Sediment traps are similar to sediment ponds, but designed for small sites. Generally fed by swales, these facilities are located on the low-side of the site to receive site runoff water and allow settling of solids before discharge off-site.

STANDARD DETAIL DRAWINGS



MANHOLE REQUIREMENT FOR SERVICES | SS-S50

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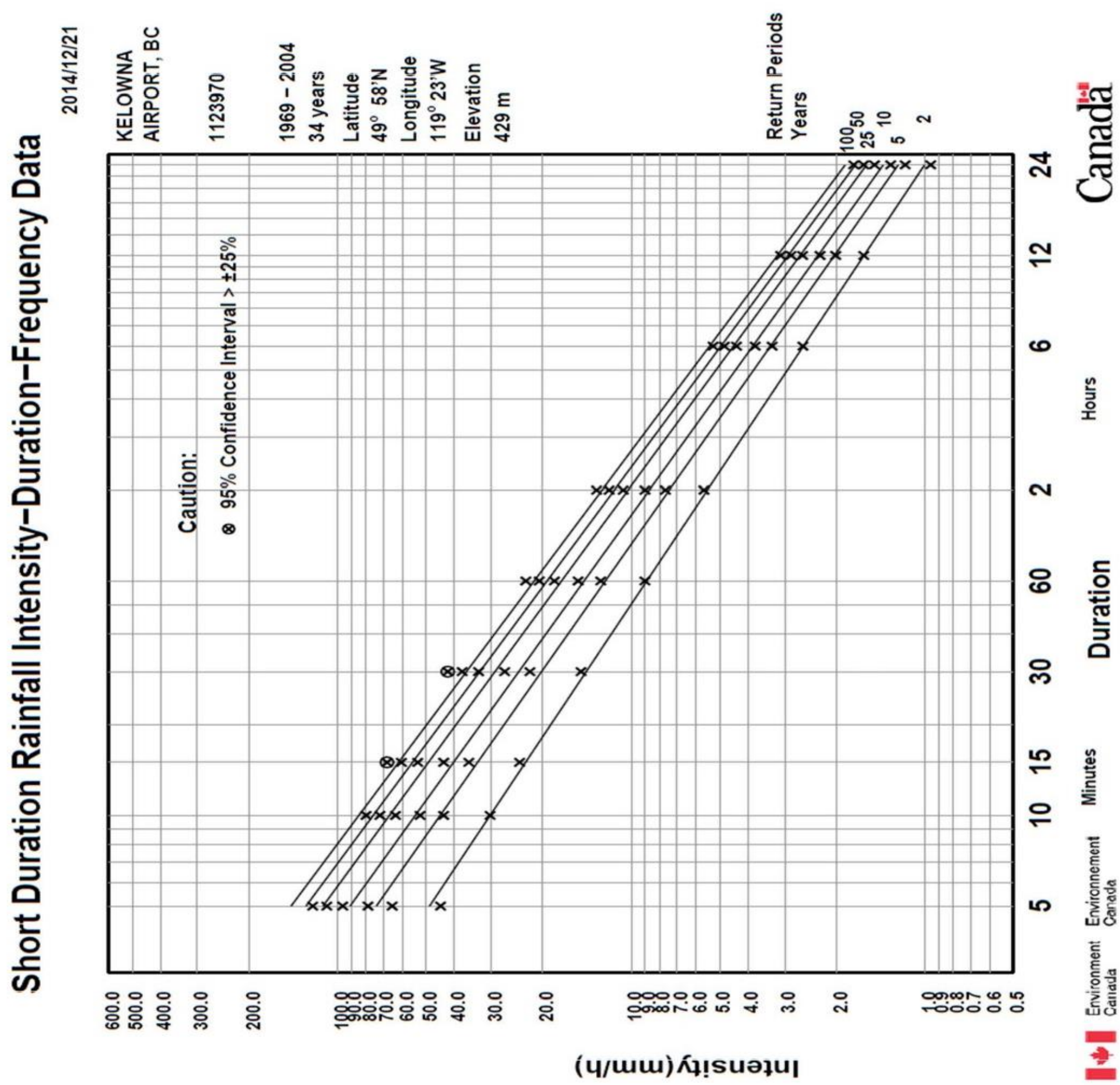
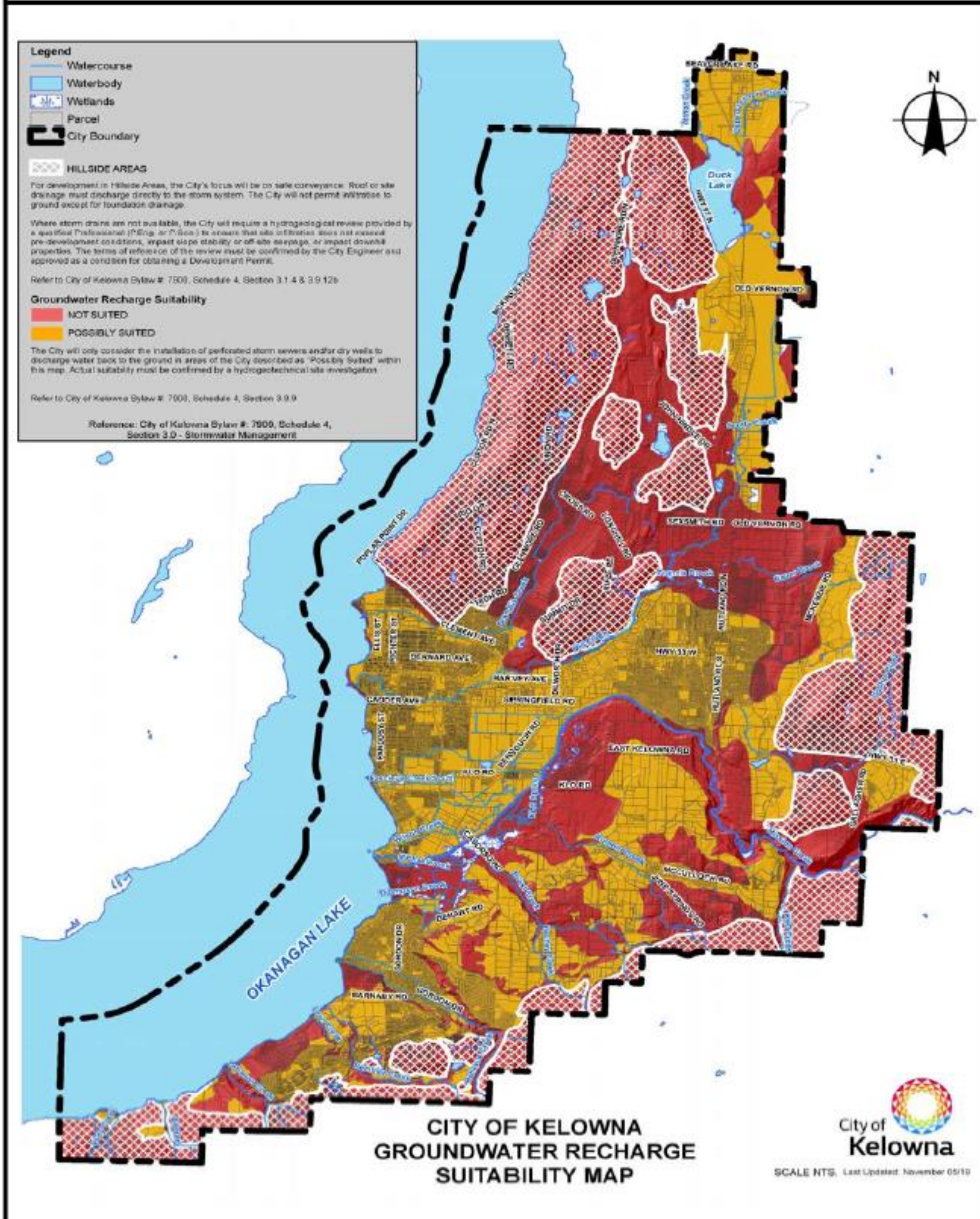
STANDARD DETAIL DRAWINGS



IDF Curves - City of Kelowna (YLW) | **SS-S56**

STANDARD DETAIL DRAWINGS



Groundwater Recharge Suitability Map	SS-S58