CITY OF PENTICTON
REPORT NUMBER: 20M-00462-00

STORMWATER MASTER PLAN

PENTICTON IIMP

JUNE 04, 2021

STORMWATER MASTER PLAN

CITY OF PENTICTON

FINAL

PROJECT NO.: 20M-00462-00
DATE: JUNE 04, 2021

WSP
LANDMARK VI
SUITE 700, 1631 DICKSON AVENUE
KELOWNA, BC B1Y 0B5

T : +1 250-980-5500
WSP.COM

June 04, 2021

Confidential

City of Penticton
616 Okanagan Avenue East
Penticton, BC V2A 3K6

Attention: Tobi Pettet, P. Eng., Project Manager

Dear Madam:

Subject: Stormwater Master Plan
Client ref.: 2020-RFP-01

WSP Canada Ltd. is pleased to submit to the City of Penticton one (1) digital copy of our Stormwater Master Plan, as part of the City of Penticton's Integrated Infrastructure Master Plan. This document summarizes the assumptions and key findings from the stormwater system analysis and provides recommendations to the City to inform the implementation of the 25 year capital programming for the infrastructure.

The analysis involved review of available background information, development of a new hydraulic model, coordination with City GIS databases, and integration of the water, sanitary and transportation infrastructure capital plans.

Should you wish to discuss the contents of this report further please do not hesitate to contact the undersigned.

Yours sincerely,

Stephen Horsman, P. Eng,
P.E.
Manager, Water

Encl.
cc:
WSP ref.: 20M-00462-00

Landmark VI
Suite 700, 1631 Dickson Avenue
Kelowna, BC V1Y 0B5
wsp.com

REVISION HISTORY

FIRST ISSUE

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Prepared by	Reviewed by	Reviewed by	Reviewed by	Approved By
Jay Patel, EIT	Clive Leung, P. Eng.			Stephen Horsman, P. Eng., P.E.
FINAL				
June 3, 2021	Issued for Client Use			
Prepared by	Reviewed by	Reviewed by	Reviewed by	Approved By
Jay Patel, EIT	Clive Leung, P. Eng.			Stephen Horsman, P. Eng., P.E.

SIGNATURES

PREPARED BY

June, 4, 2021

Jay Patel, EIT | Date

REVIEWED BY

Clive Leung, P.Eng. | Date

APPROVED[1] BY *(must be reviewed for technical accuracy prior to approval)*

2021-06-04

Stephen Horsman, P. Eng., P.E.
Manager, Water | Date

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CONTRIBUTORS

CLIENT

Project Engineer	Tobi Pettet, P. Eng.
City Engineer	Ian Chapman, P. Eng.
Development Infrastructure Manager	Michael Hodges, P. Eng.

WSP

Project Manager	Avi Thiessen, P.Eng.
Technical Manager	Stephen Horsman, P. Eng., P.E.
Senior Project Engineer	Clive Leung, P. Eng.
Project Engineer	Jay Patel, EIT

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EXECUTIVE SUMMARY

The City of Penticton (City) has retained WSP Canada Inc. (WSP) to complete the Integrated Infrastructure Master Plan (IIMP), which includes developing city-wide transportation, water, sanitary and stormwater infrastructure master plans. The purpose of the IIMP is to inform infrastructure capital planning to accommodate the growth and development plans set out in the latest Official Community Plan (OCP) 2045, adopted on August 6, 2019. The OCP 2045 estimates the population to increase from 34,000 in 2016 to 42,000 by 2046, which equates to approximately 0.65% annual growth. The City wishes to determine the required capacity of both existing and proposed infrastructure to support the population growth envisioned in the OCP.

The scope of work for the City's Stormwater Master Plan (SWMP) is as follows:

- Model development and validation;
- Capacity assessment with respect to the City's level of service criteria;
- Impact of future developments on the existing system;
- Capital improvement recommendations with Class "D" cost estimates; and
- Integrated schedule for implementation at 5-, 10-, and 25-year horizon.

The existing stormwater system provides service to approximately 1726 ha of the City, which consists of residential, industrial, commercial, institutional and agricultural land uses. The key components of the City's existing stormwater system are summarized in Table 0-1.

TABLE 0-1 EXISTING STORMWATER SYSTEM

ITEM	QUANTITY
Number of subcatchments and service area	1216 (1726 ha)
Number of discharge points	141
Number of manholes	1439
Number of drywells	215
Number and length of all gravity mains	1449 (88 km)
Number and length of open-channels (1)	38 (5 km)
Number and length of culverts	21 (< 1 km)
Number of detention facilities	7

(1) Additional features were added to the City's GIS database through discussions with the City

The piped network (minor system) conveys runoff generated from developed areas into adjacent surface water bodies including Penticton Creek, Ellis Creek, Okanagan Channel, Skaha Lake and Okanagan Lake. Detention facilities are located on the larger catchments to attenuate the runoff prior to discharging to the receiving water, which include: Golf Course, South Main Pond and the Oxbows along the Okanagan Channel.

The City's original Master Stormwater Plan was completed in 2007 with recommendations to address existing deficiencies and support known growth areas. Additionally, the Master Plan was most recently updated in 2017 with an emphasis on climate change and provided recommendations for low impact development (LID) design solutions for consideration in renewal and new development projects within the City.

Since the completion of the 2017 Update, the City has implemented several projects to enhance stormwater quality and quantity control. The City has also recognized the importance of developing integrated capital programs to address the future infrastructure needs, while coordinating with other companion initiatives such as the Penticton Creek and Ellis Creek Restoration Master Plans.

As part of this SWMP, WSP developed a model of the City's existing stormwater system using the InfoSWMM software suite (Innovyze Inc.) to integrate with the City's GIS database (Refer to **Technical Memorandum # 1** - Appendix A). The City's original XPSWMM model was used to infer data gaps, where needed. The hydraulic model consists of minor drainage features such as gravity mains and open-channels, and major drainage features such as detention facilities.

The primary sources of data used in the development of physical and non-physical parameters of the hydraulic model include the City's GIS database, physical information collected in the field by City staff, record drawings and the Subdivision and Development Bylaw 2004-81. WSP delineated subcatchments based on topology and conducted an impervious area analysis using the City's orthophotos.

Synthetic design storms with consideration for climate change were then simulated to assess the capacity of the stormwater system for existing and future OCP conditions, as presented in **Technical Memorandum # 3** (Appendix D). The City has been carbon-neutral since 2016 and has proactively considered climate change impacts to its community by developing a Community Climate Action Plan (CCAP, 2011). WSP increased the intensity of existing design storms by 15%, as recommended in the MMCD and the 2017 SWMP Update (15 – 20%) to incorporate climate change and eventually identify network improvements which will be design resilient, "Future-Ready".

For stormwater system assessment, the level of service criteria was established using the City's Subdivision and Development Servicing Bylaw 2004-81 – Schedule G and discussions with the City.

The modeling results indicate the minor system is mostly undersized to convey the 5-year return period event, resulting in overland flooding. The results are consistent with the previous Master Plans and can be largely attributed to the historical level of service criteria (typically 2-year return period event). Most of the stormwater system was originally constructed between 1960 to 1990 and as such, older assets may not meet current design standards, especially with climate change consideration.

The absence of flow monitoring data precluded detailed calibration of the model and hence only preliminary model validation was possible using anecdotal information collected at the knowledge transfer workshop on June 19, 2020. This limits the use of the model to planning level studies and conceptual recommendations only, with a lower confidence in results. Overall, WSP recommends flow monitoring at strategic locations (in the short term) with model calibration within the next 1 to 5 years to increase confidence. Calibrating the model will improve the model accuracy and allow the City to refine individual capital projects and the overall capital plan.

WSP developed a prioritized Capital Projects List to address stormwater deficiencies for the 5-,10-,20- and 25-year horizons. The prioritization approach considered the criticality and magnitude of the noted deficiencies (overland flooding in this case), and categorized improvement projects from high to low, most critical to least critical and lower confidence.

After an initial prioritization approach was completed, results were merged with transportation, sanitary and water system projects through a sophisticated projects integration approach supported by computer programming and spatial analysis in ArcGIS, with overlapping projects promoted for priority as possible to be implemented at the same time along the same construction corridors. A separate memorandum was produced to capture the integration approach in detail and provides results for those projects re-prioritized due to and across the assets. The updated prioritizations have been considered in this Master Plan.

The proposed improvements shown in Appendix F include stormwater main upsizing, new stormwater main construction, slope adjustments, sediment clean-out and water quality improvements, where applicable. Table 0-2 provides a cost summary of all projects with “Class D” cost estimates.

TABLE 0-2 CAPITAL COST ESTIMATE

IMPLEMENTATION SCHEDULE	NO. OF PROJECTS	TOTAL COST (2021 $)	
1 – 5 Year (High Priority)	8	$	6,644,300
5 – 10 Year (Medium Priority) (1)	4	$	2,435,400
10 – 20 Year (Low Priority) (1)	31	$	21,997,693
20 – 25 Year (Low Priority) (1)	27	$	26,921,526
Total	**70**	**$**	**57,998,919**

(1) Flow monitoring and model calibration is required to validate proposed projects

1 INTRODUCTION

1.1 PURPOSE

WSP Canada Inc. (WSP) was retained by the City of Penticton (City) to complete an Integrated Infrastructure Master Plan (IIMP), which includes developing city-wide transportation, water, sanitary and stormwater infrastructure master plans. The purpose of the IIMP is to inform infrastructure capital planning to accommodate the growth and development plans set out in the latest Official Community Plan (OCP) 2045, adopted on August 6, 2019.The OCP 2045 estimates the population to increase from 34,000 in 2016 to 42,000 by 2046, which equates to approximately 0.65% annual growth. The City wishes to determine the required capacity of both existing and proposed drainage infrastructure to support the population growth envisioned in the OCP.

Currently, the City's stormwater system services approximately 1726 ha of urban and rural catchments. The City's original SWMP in 2007 notes the piped network was generally undersized for the 5-year return period due to historical design criteria. The original plan provided an extensive list of improvement projects (total cost of $80 M) that were reassessed with Low-Impact Development (LID) recommendations as part of the 2017 SWMP Update. This, combined with the need to accommodate future growth presents a challenge for the City's OCP 2045 objectives.

1.2 SCOPE OF WORK

The SWMP scope of work for the SWMP is as follows:

- Develop a hydrologic and hydraulic model of the stormwater system with consideration for climate change;
- Conduct a capacity assessment to identify existing deficiencies;
- Recommend infrastructure improvements to meet City's level of service assessment criteria and accommodate 2045 OCP growth;
- Provide capital improvement projects with Class "D" cost estimates; and
- Recommend an integrated implementation schedule for the next 5-,10-, 20- and 25-year horizon.

According to the discussions with the City, flow monitoring to increase model confidence was considered outside the scope of work. In the absence of model calibration, the modeled results were compared to the previous model and discussed with City staff.

All recommend capital projects consider water quality improvements such as an oil-grit separators (OGS) or sediment clean-out, if feasible. Potential LID features such as swales are also proposed to maximize infiltration as applicable.

1.3 DATA COLLECTION

The City provided all GIS geodatabases used to build the model. Table 1-1 lists the data collected and reviewed by WSP to develop the SWMP. The information was mainly collected in electronic format, and consists of geospatial data, aerial orthophotos, drawings and reports of previous relevant studies.

TABLE 1-1 DATA COLLECTION SUMMARY

DESCRIPTION	DATA TYPE	SOURCE	PURPOSE
Stormwater utility (gravity mains, culverts, open channel ditches, manholes, catchbasins, service connections, detention areas and discharge points)	Shapefiles	City	Model Development
Base map information (1m contours, city parcels, soil stability areas and watercourses)	Shapefiles	City	Model Development
BC Soil Information	Shapefile	Ministry of Environment	Base Map
2013 Orthophotos	TIFF	City	Impervious Area Analysis
Penticton Stormwater Master Plan – Final Report July 2007 by Earth Tech	PDF	RFP	Background
Penticton Stormwater Master Plan Update – Final Report July 2017 by AECOM	PDF	RFP	Background
The City of Penticton Subdivision and Development Servicing Bylaw	PDF	City	Level of Service Criteria
MMCD Design Guidelines 2014	PDF	MMCD	Level of Service Criteria

A detailed review of the GIS data was completed to address data gaps and connectivity issues. A knowledge transfer workshop was conducted with the City on June 19, 2020 to identify known deficiencies and potential areas of concern. The City also provided information on special system characteristics such as open channels that were not represented in the City's GIS.

1.4 ACKNOWLEDGEMENTS

WSP acknowledges the support and cooperation of the City of Penticton and extends its appreciation to Tobi Pettet, P. Eng., Ian Chapman, P. Eng., and Michael Hodges, P. Eng. for their assistance to the project team in preparing this report and completing this project.

1.5 ABBREVIATIONS

AC	Asbestos Cement
AES	Atmospheric Environment Service (of Environment Canada)
BC	British Columbia
BMP	Best Management Practice for mitigating impacts of stormwater runoff
CCTV	Closed-Circuit Television
CMP	Corrugated Metal Pipe
DCC	Development Cost Charges
GIS	Geographic Information System
GPS	Global Positioning System
Ha	Hectare
HDPE	High Density Polyethylene
IDF	Intensity-Duration-Frequency
L/s	Liters per second
LID	Low-Impact Development
m	Meter
m/s	Meters per second
MBE	Minimum Building Elevation
mm	Millimeter
MMCD	Master Municipal Constructions Document
MoTI	Ministry of Transportation and Infrastructure
OCP	Official Community Plan 2045
PVC	Polyvinyl Chloride
SWMM	Stormwater Modeling and Management
SWMP	Stormwater Master Plan

2 EXISTING STORMWATER SYSTEM

The City operates and maintains a system of stormwater pipes, which collect and convey rainfall away from impervious surfaces such as roads and driveways and discharge runoff into natural watercourses. The service is currently funded through a general property tax fund. Recent amendments to the Fees and Charges Bylaw No. 2014-07 propose property owners pay a flat fee for stormwater management, which will be allocated towards planned system improvements.

2.1 OVERVIEW

The stormwater services within the City are mainly provided by surface drainage through catch basins, stormwater mains, open channel ditches, culverts, and local creeks. Table 2-1 provides a summary existing drainage features in the City's GIS database.

TABLE 2-1 EXISTING STORMWATER SYSTEM

ITEM	QUANTITY
Number of subcatchments and service area	1216 (1726 ha)
Number of discharge points	141
Number of manholes	1439
Number of drywells	215
Number and length of gravity mains	1449 (88 km)
Number and length of open-channels (1)	38 (5 km)
Number and length of culverts	21 (< 1 km)
Number of detention facilities	7

(1) Additional features were added to the City's GIS database through discussions with the City

All stormwater runoff is ultimately conveyed to Penticton Creek, Ellis Creek, Okanagan Channel, Okanagan Lake and Skaha Lake through numerous discharge points within the City. Urban areas within the City are serviced by approximately 88 km of piped system and 7 detention facilities for peak flow attenuation. Several drywells, representing approximately 10 percent of the stormwater manholes are also installed at scattered locations across the City to maximize infiltration into the native soils, based on recommendations of the 2007 SWMP.

Rural areas north and south of the City consist of more natural drainage features such as roadside ditches and culverts. Currently, majority of the gravity mains and culverts have a diameter of less than 450 mm, as shown in Figure 2-1 and Figure 2-2, respectively.

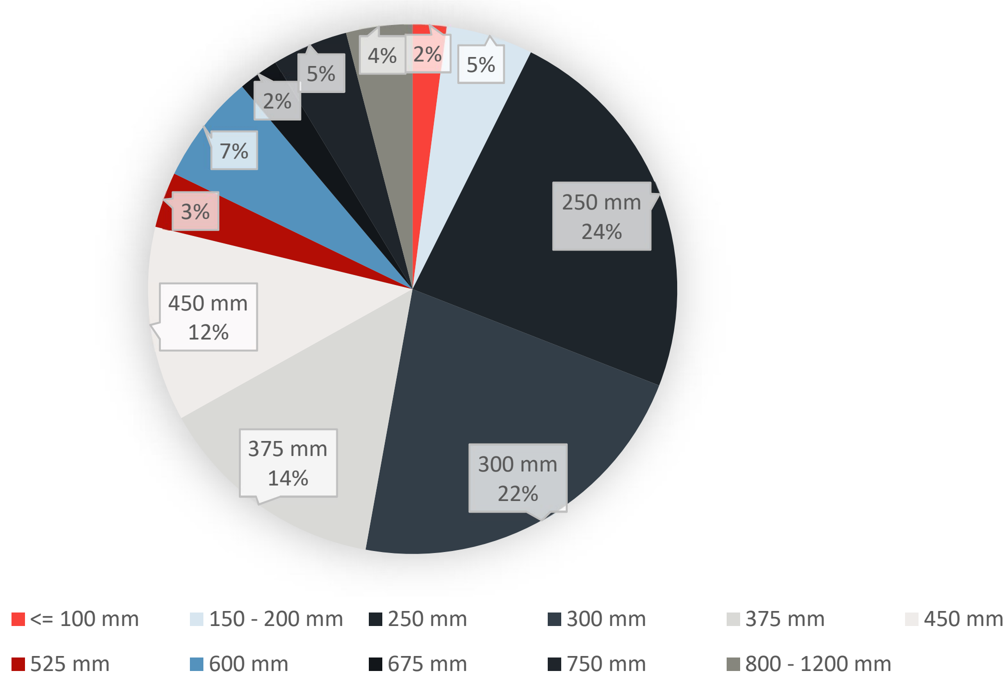


FIGURE 2-1 GRAVITY MAIN SIZE DISTRIBUTION

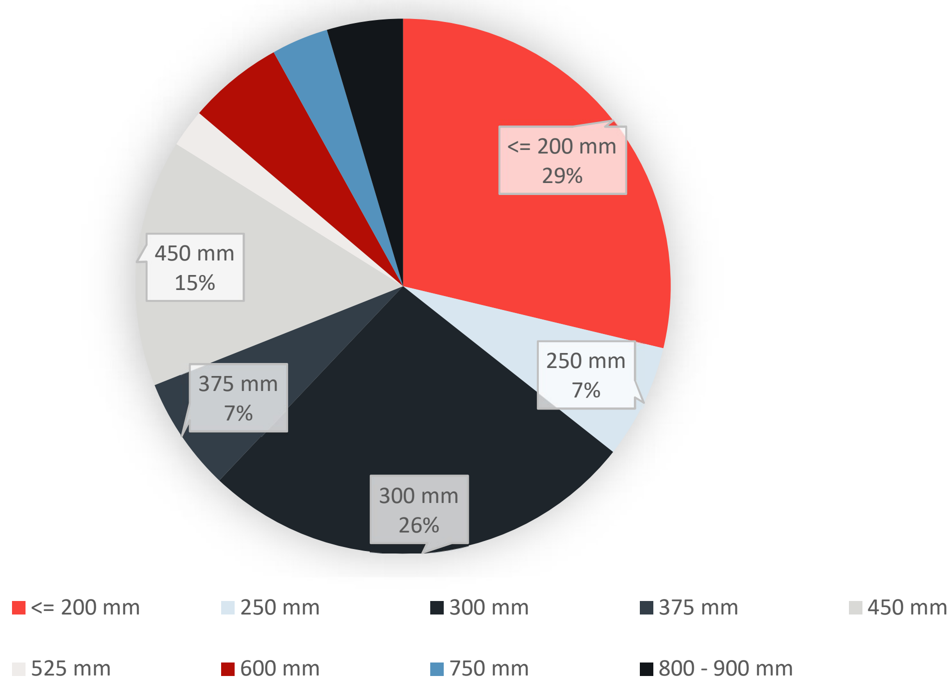


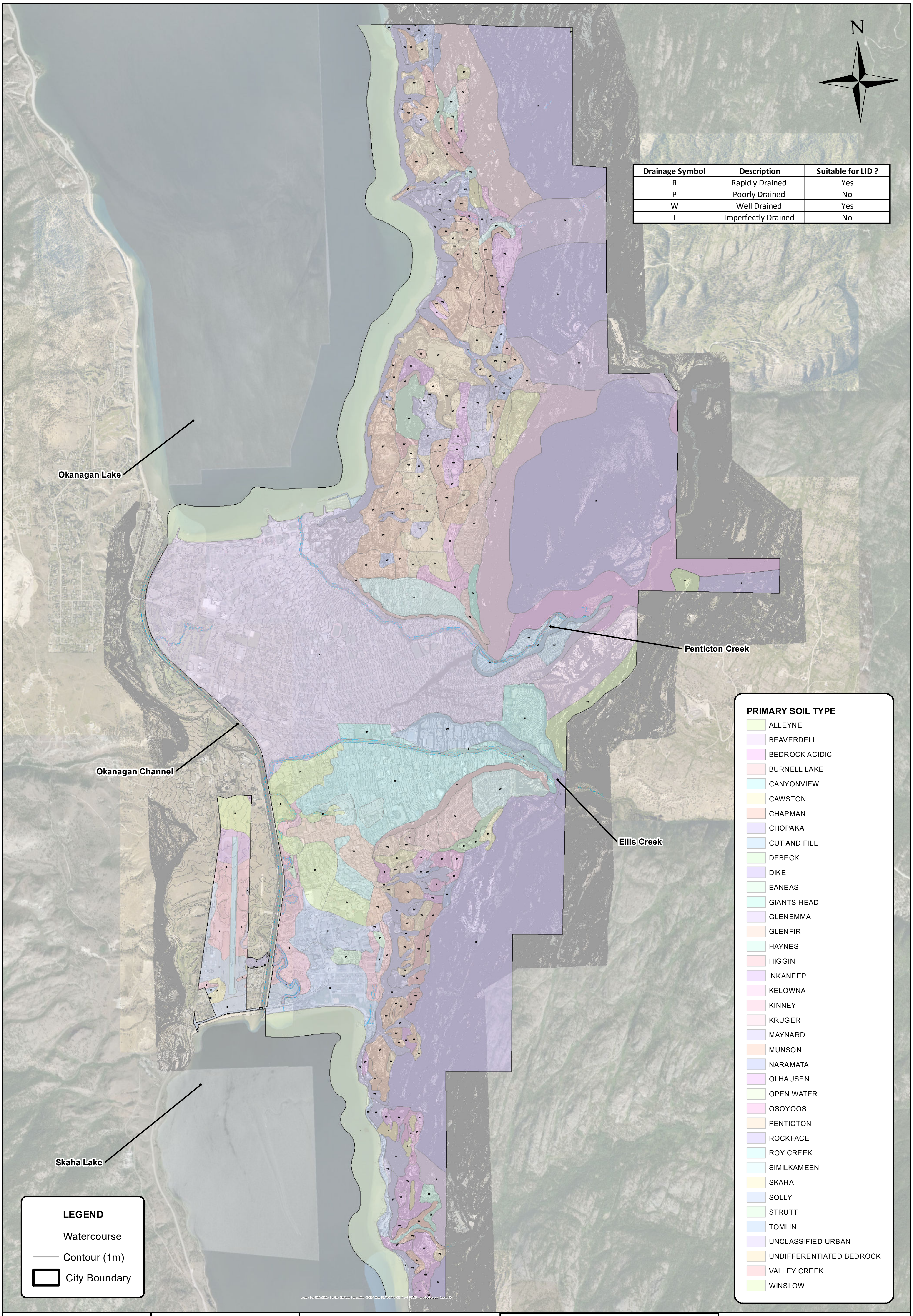
FIGURE 2-2 CULVERT SIZE DISTRIBUTION

2.2 TOPOLOGY AND SOILS

The City is situated on a moderate to steep terrain with a general slope towards Okanagan Channel, located at the west boundary of the City. The topography of the City revealed that storm runoff generally flows from northeast to southwest along Penticton and Ellis Creeks, which ultimately discharge into the Okanagan Channel. The downtown area is mostly flat with steeper slopes east of Main Street. The City core area is generally flat and surrounded by hills sloping up to the east and bordered by naturally vegetated mountainsides further east.

Figure 2-3 shows the varying soil types in the City of Penticton, as procured from Ministry of Environment BC Soils Information System. There is limited soil information available at the north end of the City, which is mostly identified as "unclassified urban". The west side of the City is classified as rockface soil, which is comprised of mineral particles and exhibits good drainage characteristics. The subsurface soils in the south side of the City vary greatly but generally have good to fair drainage characteristics. Subsurface conditions surrounding the Skaha and Okanagan Lakes consist of sandy soils with high groundwater table.

The Low Impact Development alternatives proposed to manage stormwater runoff in the 2017 SWMP Update are carried forward within this study (where applicable and identified in project sheets) based on soil drainage characteristics. The local groundwater levels from the BC's Ministry of Environment and Climate Change interactive map should be investigated prior to implementation of capital projects.



Drainage Symbol	Description	Suitable for LID ?
R	Rapidly Drained	Yes
P	Poorly Drained	No
W	Well Drained	Yes
I	Imperfectly Drained	No

WSP PENTICTON IIMP

North Vancouver Office, #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: City of Penticton

CITY OF Penticton

1:40,000

NAD83 CSRS UTM zone 11N

Meters: 0 260 520 1,040 1,560

SUBSURFACE SOILS

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 2 - 3

DATE: Jan 2021

Path: C:\Users\CAJP063517\Desktop\TMP\Penticton\2. Figures\stm mxd\Figure 2--3 - Soils.mxd

2.3 KNOWN ISSUES

Most of the stormwater system was originally constructed between 1960 to 1990, with a historical level of service criteria. Older assets may not meet current design standards, especially with climate change consideration. A lower level of service with additional on-site controls was recommended in the 2007 SWMP provided there was no risk of overland flooding. The 2017 SWMP Update further recommended innovative Low-Impact-Development controls to mitigate capacity issues.

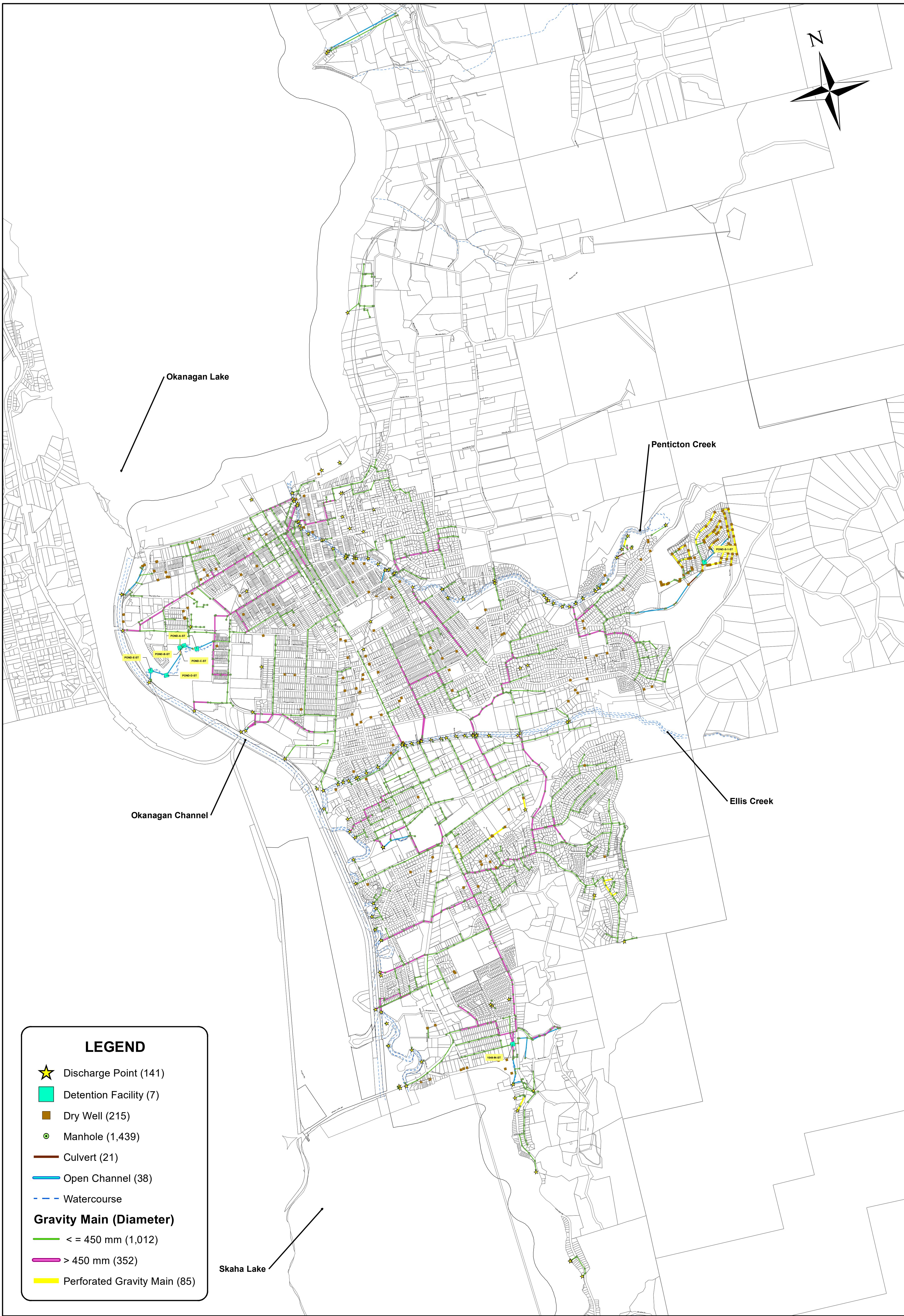
Recent stormwater management issues observed by the City and discussed at knowledge transfer workshop are as follows;

- **North of Westminster Avenue and Eckhardt Avenue W. –** Frequent surcharging and overland flooding has been currently observed during significant rainfall events. This is largely due to high lake levels in the downstream Okanagan Channel. The Hydrometric Station south of Riverside Park recorded a maximum water level of 3 m (340.785 m Geodetic) in the Okanagan Channel in July 2020, consistent with the maximum levels observed in July 2019. The potential backwater effects from the submerged outfall creates a flood hazard along Riverside Drive.
- **South Main Street Detention Facility** – High water levels are currently observed in the detention facility during both dry and wet periods with little to no attenuation. The facility was originally constructed in 1987 with a normal water level of 1.2 m and a freeboard of 0.6 m. A FLYGT pump was originally installed to draw down the pond to the normal operating level during rainfall events. The City Operations Staff note this pump operates regularly during wet weather periods. Sediment removal should be considered given the age of the facility.
- **Water quality and sediment accumulation at Oxbows along Hwy. 97** - High phosphorous levels were previously observed in the oxbows following significant rainfall events. The oxbows located along the southwest corner of the City provide runoff treatment prior to discharge into natural watercourses. The water quality data from August 2012 indicated high phosphorus loading from upstream catchments, which led to pre-treatment recommendations in the 2017 SWMP Update. Subsequently, the City installed 7 oil-and-grit separators (OGS) at several outfalls as part of their capital plan. OGSs require regular maintenance, especially following major rainfall events to maintain the desired level of treatment. Although no water quality updates are available at this time, WSP will provide recommendations for additional pre-treatment controls, as applicable.
- **South of Warren Avenue W. and Atkinson St**. - Overland flooding was previously observed during rainfall events due to high water levels in the downstream open channel. In 2016, the City facilitated emergency sediment removal works to mitigate flooding and have not reported any current issues. Infill growth or future developments along this corridor should consider an alternate discharge point, where feasible.

3 MODEL DEVELOPMENT

3.1 SOFTWARE SELECTION AND DATA SOURCES

The hydraulic model of the City's stormwater system was developed using the InfoSWMM software suite available from Innovyze Inc., as evaluated in **Technical Memorandum # 1** (Appendix A) and selected by the City due to GIS integration capabilities. The model includes minor and major components of the existing stormwater system including manholes, gravity mains, open channels, culverts, detention facilities and discharge points. Other drainage components such as catchbasins, service connection laterals and private infrastructure are excluded from the model. Figure 3-1 illustrates the modeled stormwater system.



WSP
PENTICTON IIMP
North Vancouver Office, #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: City of Penticton

CITY OF Penticton

1:32,000

NAD83 CSRS UTM zone 11N

Meters: 0, 205, 410, 820, 1,230

MODELED NETWORK

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 3 -1

DATE: Apr 2021

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As agreed with the City, major system features such as the Penticton Creek and Ellis Creek are excluded from the model as they are assessed in separate Plans (PCRI, 2017 and ECMP, 2020) developed by the City. The stormwater system at the Penticton Airport, Campbell Mountain and Carmi Road Landfill (RDOS) are localized and also excluded from the model. All City infrastructure including dummy nodes and links created for connectivity follow the asset naming convention detailed in **Technical Memorandum # 2** (Appendix B).

The City's GIS database forms the primary source of data used for model development. Some of the notable data gaps were resolved by the City's operations staff through field surveys in June and September 2020. All remaining data gaps were inferred from the previous model, record drawings requested by WSP, City's elevation contours and assumptions based on the Subdivision and Development Servicing Bylaw.

3.2 HYDRAULICS

The hydraulic component of the model routes stormwater runoff from source to the discharge point and consists of the following infrastructure:

- Gravity Mains and Culverts;
- Open channels to connected isolated piped systems;
- Manholes;
- Detention facilities and drywells; and
- Discharge points.

3.2.1 GRAVITY MAINS AND CULVERTS

Gravity mains and culverts act as conveyance features that are represented as circular conduits in the model. City's GIS database for gravity mains and culverts provided information containing size, material, length, and invert offsets. Several dummy mains were created in the model for logical connectivity and recorded in Appendix C for reference. The Manning's "n" roughness coefficients were assigned to each conduit based City's Subdivision and Servicing Bylaw – Schedule G and *Open Channel Hydraulics* (Chow, 1959), as shown in Table 3-1.

TABLE 3-1 ROUGHNESS COEFFICIENTS

MATERIAL	MANNING'S "N"	PERCENTAGE (%)
Concrete (1)	0.013	28
Polyvinyl Chloride (PVC) or High Density Polyethylene (HDPE) (2)	0.013	45
Asbestos Cement (2)	0.011	2
Corrugated Metal (2)	0.024	3
Steel (2)	0.012	7

Unknown / Other [1]	**0.013**	**15**

(1) City Bylaw
(2) Open Channel Hydraulics (Chow, 1959)

Perforated pipes have been included in the model as typical gravity mains with seepage losses to simulate exfiltration into permeable soils. A seepage rate of 18 mm/hr is applied based on City's Subdivision and Development Bylaw. The results indicate significant exfiltration losses for long-duration (24-hour), low-intensity rainfall events but little to no impact under the small-duration (1-hour), high-intensity events.

The GIS database did not include information pertaining to culvert headwall, wingwalls and embankment. In the absence of culvert inspection records, all modeled culverts were assigned entrance and exit loss coefficients of 0.5 and 1.0, respectively. This assumes that all culverts consist of a typical square-edged entrance headwall.

3.2.2 OPEN CHANNELS

Open channels are naturalized conveyance features that are often represented as trapezoidal or triangular conduits in the model. The City's GIS database contained a limited number of open channel features that were mostly contained in the southeast corner of the City. Additional features were added to the modeled network (Appendix C) to represent actual conditions as discussed at the knowledge workshop meeting.

Open channel geometry was not included in the GIS data. Typical open channel characteristics were assumed from record drawings (Sendero Canyon Drawing No. 6104-20, 2012) and *Open Channel Hydraulics* (Chow, 1959), as presented in Table 3-2.

TABLE 3-2 OPEN CHANNEL GEOMETRY

CHARACTERISTICS	INPUT
Cross-section	Triangular / Trapezoidal
Depth (m)	0.3 - 1.8 (Varies)
Bottom Width for Trapezoidal Channels (m)	3
Side slope for all Channels (H:V)	2:1
Top Width for Triangular Channels (m)	2.5 – 3 (Varies)
Manning's n Roughness Coefficient [1]	0.030

(1) Open Channel Hydraulics (Chow, 1959)

Typical cross-sections obtained from the record drawings (Golf and Country Club Stormwater Detention Ponds Drawings D-100, D-200, D-300 and G-100, 1988) were used to represent various open channels located within the Penticton Golf and Country Club. The modeled transects are shown in Appendix C for reference.

3.2.3 MANHOLES

Stormwater manholes are represented as junctions in the model. Junctions receive runoff from tributary subcatchments and provide connectivity between gravity mains, culverts and open channels. Several dummy junctions were created to connect isolated piped systems, where applicable.

The invert and rim elevations were obtained from the GIS database or assumed as outlined in Appendix C. All missing rim elevations were inferred from the City's elevation contours.

3.2.4 DETENTION FACILITIES AND DRYWELLS

Detention facilities are represented as storage units in the model with design rating curves that provide peak flow attenuation. These facilities provide stormwater quality treatment and allow for a controlled discharge into the downstream system. Detention facilities are designed as end-of-pipe controls to restrict the post-development flows and provide storage for a major (100-year return period) storm event.

Operating set points for detention facilities were obtained from the XPSWMM model or extracted from record drawings, as indicated in Appendix C. The inlet and outlet control structures for each facility were defined by either conduits or weirs according to the record drawings. All detention facilities included in the model are shown in Table 3-3.

TABLE 3-3 DETENTION FACILITIES

NAME	RECEIVING WATERBODY	TRIBUTARY CATCHMENT (HA)	CATCHMENT LAND USE	CONSTRUCTION YEAR (AGE)	ORIGINAL DESIGN CONSIDERATIONS
South Main Street Detention Pond (Skaha Lake Pond)	Open channel ultimately discharging into Skaha Lake	166	Residential and ICI (fully developed urban lands)	1987 (33 Years)	Wet pond with a normal water level of 1.2 m and total storage volume of 6500 m^3 Submerged 1050 mm diameter inlet pipe 750 mm diameter outlet pipe with a Flygt pump (BS-2066, 230 V, 2.5 Hp, Single Phase) Level of service unknown
Sendero Canyon Pond	Open channel along Lawrence Ave.	28	Residential (partially developed rural lands)	2011 (9 Years)	Dry pond with total active storage volume of 508 m^3 250 mm diameter inlet pipe A typical 0.5 m deep and 2.5m wide inlet channel Two 250 mm diameter outlet pipes discharge to a flow control manhole Designed to attenuate minor system flows from Sendero Canyon Development
Golf Course and Country Club Detention Ponds A to E	Okanagan Channel	82	Residential and ICI (fully developed urban lands)	1989 (31 Years)	Pond A - Wet pond with a normal water level of 1.2 m and total storage volume of 2300 m^3 Pond B - Wet pond with a normal water level of 1.0 m and total storage volume of 1200 m^3 Pond C - Wet pond with a normal water level of 1.2 m and total storage volume of 2100 m^3 Pond D - Wet pond with a normal water level of 0.8 m and total storage volume of 2000 m^3 Pond E - Wet pond with a normal water level of 1.1 m and total storage volume of 2200 m^3 Outflow controlled via a weir structure

Drywells are also modeled as storage units with a typical volume of 6 m^3 according to the Sendero Canyon record drawings. They were originally proposed in the 2007 SWMP to maximize infiltration into the native soils. Each drywell has been modeled with an assumed seepage rate of 18 mm/hr to simulate exfiltration losses, which are mostly observed under long-duration events. The seepage rate was also applied to perforated gravity mains as detailed in Section 3.2.1 Gravity Mains and Culverts and represents moderately permeable soils.

3.2.5 DISCHARGE POINTS

The discharge points act as downstream boundary conditions, which discharge runoff to natural watercourses such as Penticton and Ellis Creeks. They are represented as outfalls in the model. A few dummy outfalls are created to connect isolated systems.

For the minor system assessment, outfall water levels were inferred from the old model or the average water level recorded at the Environment Canada Hydrometric Station located along the north end of the Okanagan Channel. For the major storm events, outfall water levels were based on the 200-year water levels obtained from the Ellis Creek Master Plan or the maximum water level recorded at the Environment Canada Hydrometric Station.

A total of five outfalls (SWN-311, SWDP-120, SWN-289, SWDP-44, SWSC-250) discharge directly into the Okanagan Channel while all remaining outfalls discharge into creeks or oxbows. Majority of the outfalls were assumed submerged to incorporate potential backwater effects on the upstream system.

Missing invert and rim elevations are obtained from the previous model or inferred from the City's elevation contours. Refer to Appendix C for a detailed review of boundary conditions.

3.3 HYDROLOGY

The hydrologic component of the model is responsible for generating runoff through synthetic design storm events and subcatchment parameters that mimic actual surface response to rainfall.

3.3.1 RAINFALL DATA AND CLIMATE CHANGE

The City's Intensity-Duration-Frequency (IDF) curves available in the City's Subdivision and Development Servicing Bylaw – Schedule G were used to develop synthetic design storm events (5-min. intervals) for all return periods. The projected impact of climate change is considered by increasing existing rainfall intensity by 15 %, as recommended in the MMCD. The critical design storm events are further summarized in **Technical Memorandum # 3** (Appendix D).

For modeling purposes, it is necessary to transform the total rainfall depths obtained from IDF analysis into a storm distribution which describes the variation of rainfall intensity over time. Various storm distributions are available to practitioners – the most widely used include; the Atmospheric Environment Service (AES, now known as the Meteorological Service of Canada) distributions, the US Soil Conservation Service (SCS) distributions, and the Chicago Design Storm. No specific storm distribution is specified in the current City standards; therefore judgment has been applied to select a rainfall distribution that is most representative of hydrologic patterns in the study area. A range of storm durations and distributions are provided in the model and were considered to identify critical events.

The AES distribution was selected given its widespread use in BC, and the fact that it offers modifications to the distribution to suit different regional rainfall patterns (in this case BC Interior). This decision is supported by the Master Municipal Constriction Documents Design Guidelines (MMCD, 2014), which recommends use of AES rainfall distributions for cases where the local authority has no specific guidelines.

A 1-hour storm duration has been selected as suitable for minor system assessment and conveyance issues under consideration as it generates high runoff rates but relatively low volume. A 24-hour storm duration has been selected to assess detention facilities and storage issues under consideration because it generates large volume but low runoff rates.

3.3.2 SUBCATCHMENTS

A subcatchment is a hydrologic unit of land that is characterized by its topology and drainage system elements. The City is delineated into numerous subcatchments (mostly less than 2 ha) based on City's elevation contours, location of service connections, catchbasins and laterals. Stormwater runoff from each subcatchment is directed into the nearest manhole using GIS spatial analysis tools.

The time of concentration represents the time it takes for overland flow to reach from the furthest point in a subcatchment to the discharge point. It is typically calculated as the sum of the inlet time required to reach a manhole and the travel time in the conveyance system from the manhole to the discharge point. A review of catchments draining into each discharge point was conducted to confirm the estimated time of concentration was less than the critical storm duration from Section 3.3.1.

InfoSWMM calculates the time of concentration based on the following parameters:

- Flow Length (or Width) – represents overland flow for sheet flow runoff to travel from the furthest point in the subcatchment to the receiving manhole. The flow path length varies based on subcatchment size and shape, and is estimated from GIS Spatial analysis.
- Slope – defines the average gradient of the subcatchment. Slopes were estimated using City's elevation contours and then divided by '2'. This assumption is based on past modeling experience and engineering judgement.
- Roughness coefficient - reflects surface resistance that overland flow encounters as it discharges to the loading point. Roughness coefficients of 0.018 and 0.35 were assigned to impervious and pervious areas, respectively, based on past modeling experience.

Other subcatchment input parameters are as follows:

- Depression storage – quantifies the available storage within each subcatchment prior to runoff generation. Impervious and pervious surface values were estimated as 1.5 mm and 5 mm, respectively, based on industry publications and engineering judgement.
- Horton Infiltration – represents subsurface infiltration rates that vary depending on soil types. Table 3-4 shows the modeled infiltration parameters that were assumed from the XPSWMM model and moderately porous soils such as sand, or coarse sand and gravel. WSP recommends further calibration to capture spatial variation in infiltration rates and increase model confidence.

TABLE 3-4 HORTON INFILTRATION PARAMETERS

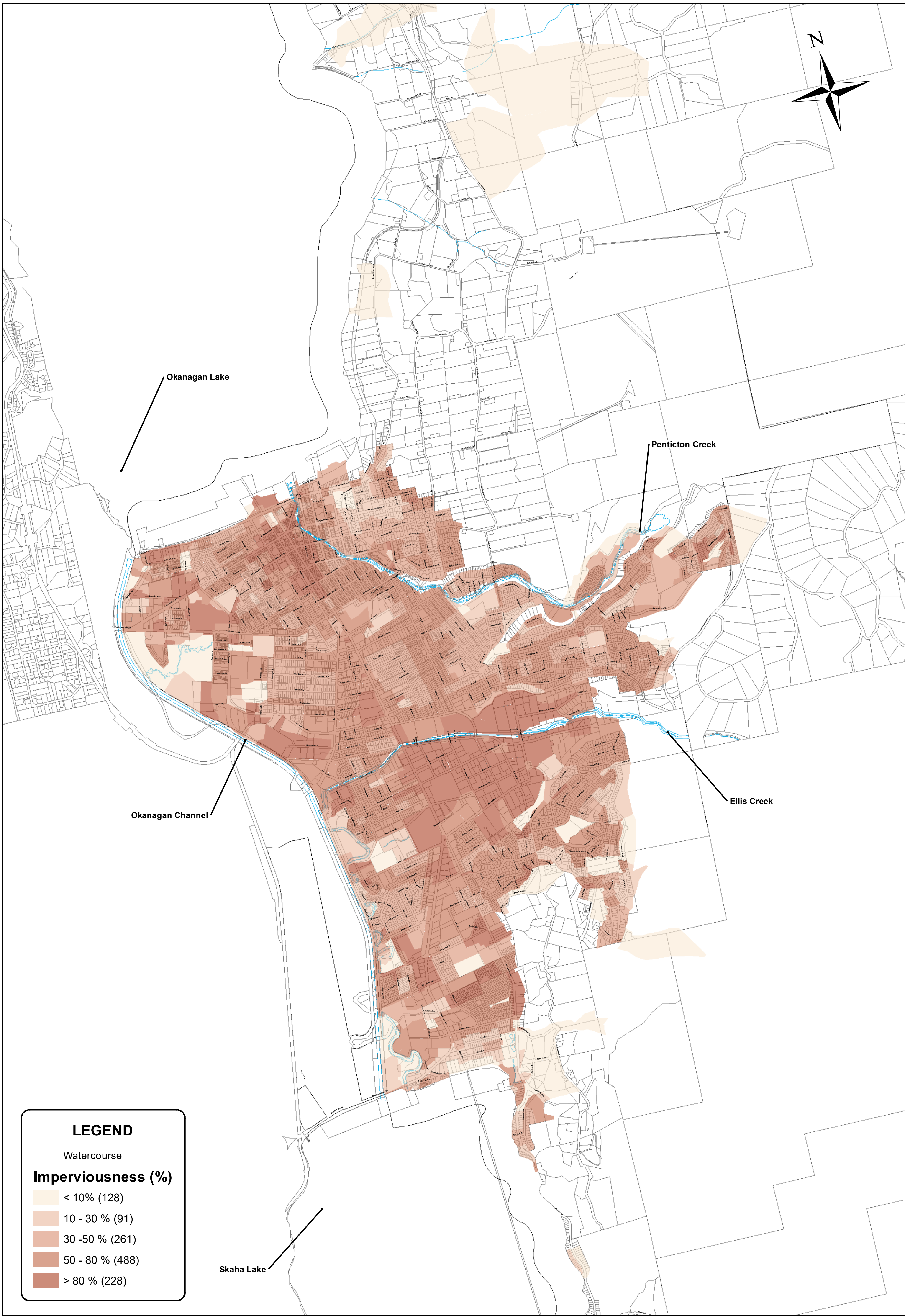
PARAMETER	INPUT
Initial Infiltration Rate (mm/hr)	**75**
Final Infiltration Rate (mm/hr)	**7.5**
Decay Constant (hr^{-1})	**4.14**
Drying Period (days)	**7**

- Impervious percentage – defines the impervious cover within each subcatchment. Impervious percentages were estimated from City's 2013 Orthophotos as illustrated in Figure 3-2 and represent actual conditions. These values were adjusted based on engineering judgement such that the maximum imperviousness does not exceed 90 % and the minimum imperviousness is at least 0.5 %. The model assumes 20% of the impervious areas are routed to pervious surfaces before entering the piped network. Some of the impervious surfaces such as roofs may be directly connected to the loading point via downspouts whereas some roof leads may discharge to the front yard and slowly enter entering the piped system. This assumption was applied based on past modeling experience and engineering judgement.

Existing system subcatchment statistics are summarized in Table 3-5.

TABLE 3-5 SUBCATCHMENT STATISTICS

ITEM	QUANTITY
Number of Subcatchments and Service Area	**1216 (1726 ha)**
Average Area (ha)	**1.5**
Average Flow Path Length (m)	**269**
Average Slope (%)	**4.2**
Average Imperviousness (%)	**54**



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IMPERVIOUS COVER

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 3 -2

DATE: Jan 2021

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3.4 MODEL VALIDATION

Model calibration is an iterative process of comparing the model with observations and revising the input parameters until the predicted results are considered acceptable. In contrast, model validation is the process of testing the accuracy of an existing or previously calibrated model using observations.

In general, two data sources could be used for model calibration/validation:

- Short-term flow monitoring program, which involves running the model with observed rainfall data and calibrating the corresponding hydrographs with observations (calibration); and
- Historical (anecdotal) data, which requires knowledge of known system issues and behavior (validation).

A flow monitoring program was considered outside the scope of this report and as such, calibration was not performed. For validation, anecdotal information collected at the knowledge transfer workshop was used to validate modeled results. This limits the use of the model to planning level studies and conceptual recommendations only.

Generally, the results are consistent with the findings of the 2007 SWMP and the 2017 SWMP Update. However, WSP strongly recommends the City undertake flow monitoring surveys during subsequent design phases solely for the purposes of model calibration.

4 LEVEL OF SERVICE

4.1 CRITERIA

The following sources are used to establish the level of service criteria for the SWMP:

- The City of Penticton Creek Subdivision and Development Servicing Bylaw – Schedule G; and,
- Master Municipal Construction Document (MMCD) Design Guideline Manual (2014).

Table 4-1 provides list of assessment criteria used to assess the stormwater system, as discussed and agreed upon with the City.

TABLE 4-1 LEVEL OF SERVICE CRITERIA

COMPONENT	CRITICAL STORM	CRITERIA	HYDRAULIC INDICATOR
Gravity Mains, Culverts and Open Channels	5-Year 1-hour AES	Convey runoff from a 5-year return period event such that a minimum freeboard of 0.5 m is maintained in the connected manholes (1)	Asset is considered deficient if minimum freeboard in the connected manholes is less than 0.5 m
Detention Facilities (2)	100-Year 24-hour AES	Store and treat runoff from a 100-year return period event without flooding	Asset is considered deficient if surface flooding occurs
Future Developments	5-Year 1-hour AES	Runoff must be limited to the 5-year pre-development conditions (1)	N/A

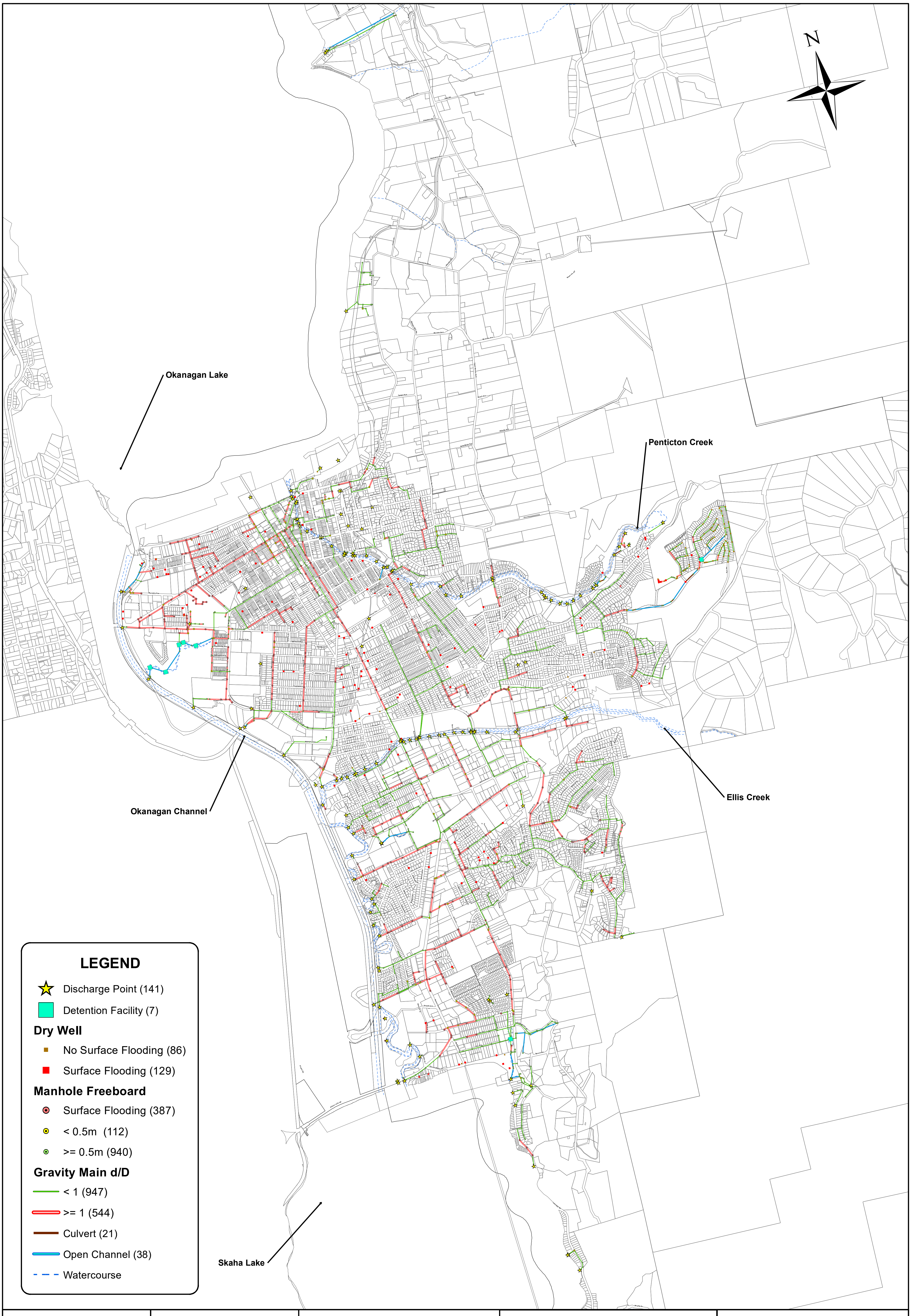
(1) City Bylaw

(2) The MMCD Guidelines suggest detention facilities should attenuate peak flows and release at a controlled discharge rate based on a 24-hour drawdown time to meet stormwater water quality objectives (80% TSS removal). As the existing detention facilities were originally constructed for a historical level of service, this criterion is not assessed in the SWMP but should be required for all newly constructed facilities.

5 STORMWATER SYSTEM ASSESSMENT

5.1 EXISTING CONDITIONS

Figure 5-1 displays the minor system capacity under the 5-year 1-hour AES storm event. The modeled results indicate that majority of the piped network does not meet the freeboard requirements. This is largely due to the age of the assets and historical criteria used at the time of the original design. The modeled design storm also accounts for climate change (**TM #3**), which results in higher peak flows than modelled in previous master planning studies.



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MINOR STORM CAPACITY

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 5 -1

DATE: Apr 2021

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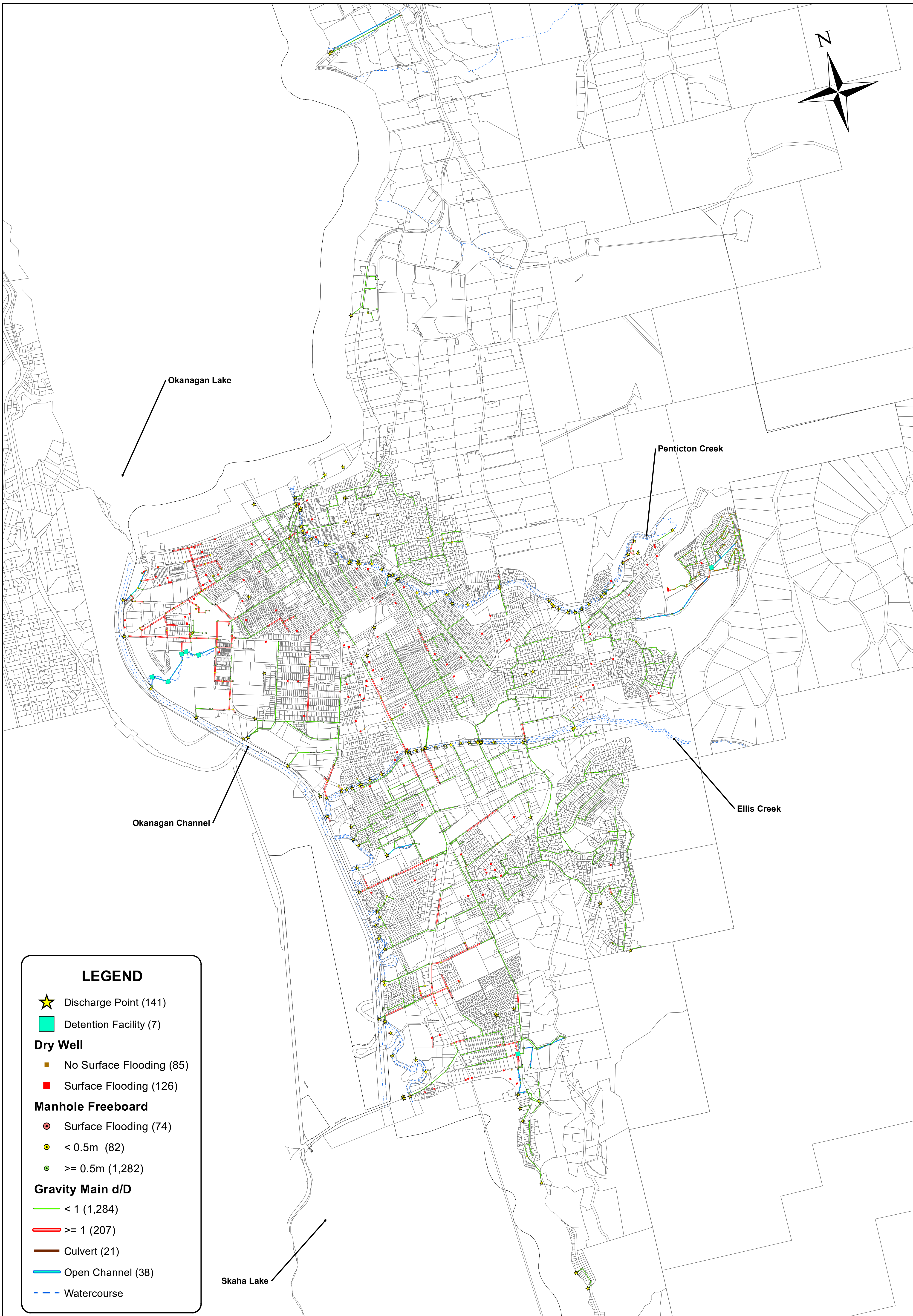
Figure 5-2 displays the major system capacity under the 100-year 24-hour AES storm event. The modeled results do not indicate surface flooding at the detention facilities as shown in Table 5-1.

TABLE 5-1 EXISTING DETENTION FACILITY PERFORMANCE

FACILITY	MAX. CAPACITY (M^3)	PEAK 100-YR, 24-HOUR VOLUME (M^3)	PERCENT FULL (%)	MIN. FREEBOARD (M)
South Main Street Detention Pond (Skaha Lake Pond)	6500	4814	74	0.7
Sendero Canyon Pond	508	188	37	1.6
Golf Course and Country Club Detention Pond A	2300	2077	90	0.2
Golf Course and Country Club Detention Pond B	1200	1010	84	0.3
Golf Course and Country Club Detention Pond C	2100	1780	85	0.3
Golf Course and Country Club Detention Pond D	2000	397	20	1.5
Golf Course and Country Club Detention Pond E	2200	709	32	1.4



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MAJOR STORM CAPACITY

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 5 -2

DATE: Apr 2021

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5.2 FUTURE CONDITIONS

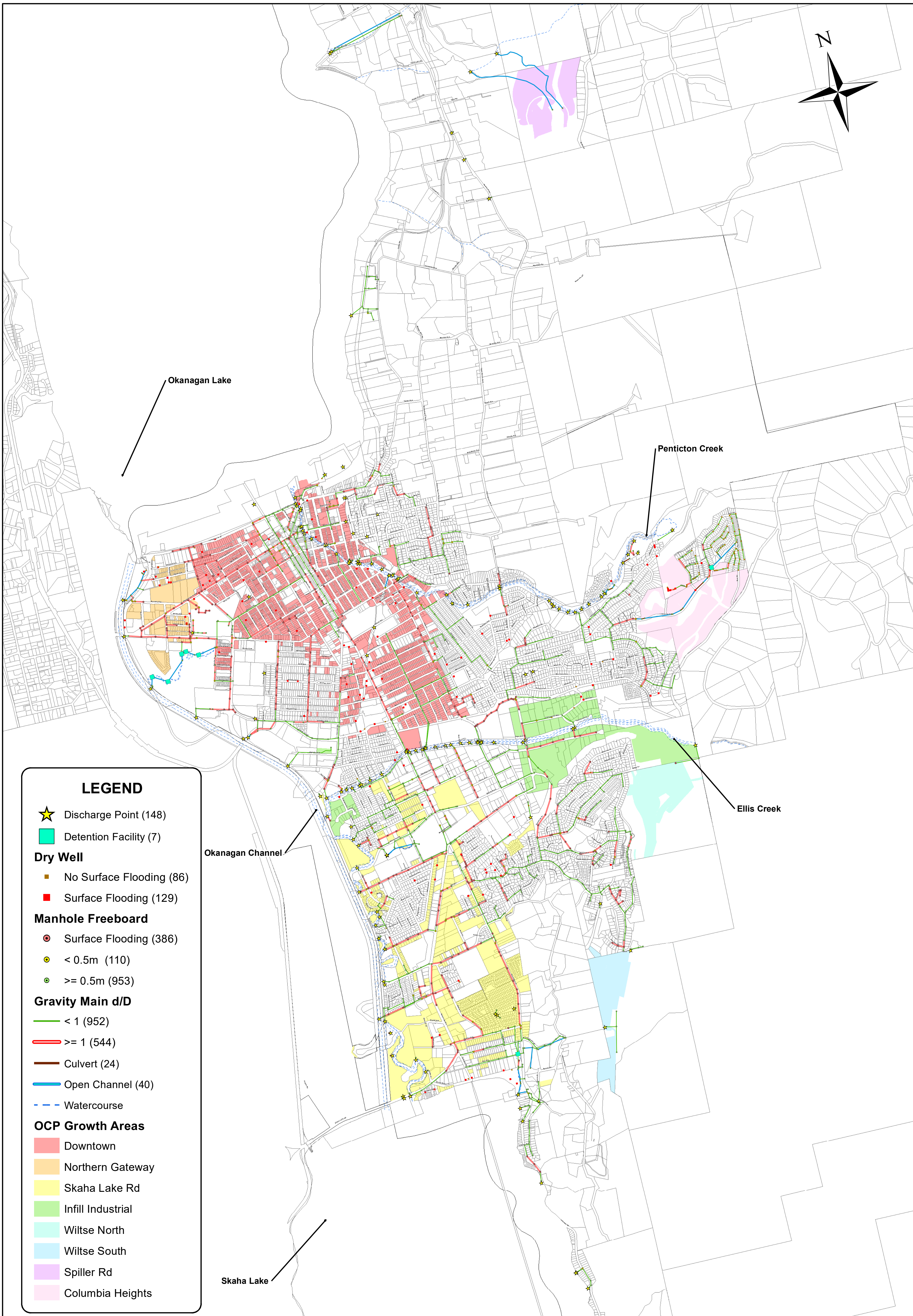
Key future developments identified in the OCP 2045 include Wiltse South, Wiltse North, Spiller Road and Columbia Heights, as summarized in **Technical Memorandum # 5** (Appendix E).

Developers are responsible to provide adequate pre-to-post-control for the 5-year return period event, as stipulated in the City Bylaw. The OCP 2045 scenario is created by adding additional subcatchments that represent strategic development areas. Dummy elements are created in the OCP model to represent potential service connection points, which should be investigated further by the developer.

The preliminary servicing results from OCP conditions are as follows:

- **Wiltse South** – proposed discharge to an existing watercourse west of the site with pre-treatment controls. This system is not connected to the City's network.
- **Wiltse North and Industrial Infill** – proposed discharge into Ellis Creek with pre-treatment control. This system is not connected to the City's network.
- **Spiller Road** – localized roadside ditches that discharge into an existing watercourse which runs through the site. This system is not connected to the City's network. Downstream drainage routing to be considered with development review.
- **Columbia Heights** – proposed discharge into Ellis Creek with pre-treatment controls. This system is not connected to the City's network.

Alternative service connection options should be investigated by the developer during subsequent design phases. Similar to the existing system assessment, overland flooding is observed for both minor and major rainfall events, as shown in Figure 5-3.



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FUTURE MINOR STORM CAPACITY

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 5 -3

DATE: Apr 2021

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The major rainfall results for the 100-year, 24-hour storm are provided in Figure 5-4. Table 5-2 provides a summary of the modeled detention facilities, which are similar to the existing model results. Overall, flooding is not observed at the detention facilities.

TABLE 5-2 FUTURE DETENTION FACILITY PERFORMANCE

FACILITY	MAX. CAPACITY (M^3)	PEAK 100-YR, 24-HOUR VOLUME (M^3)	PERCENT FULL (%)	MIN. FREEBOARD (M)
South Main Street Detention Pond (Skaha Lake Pond)	6500	4868	75	0.7
Sendero Canyon Pond	508	188	37	1.6
Golf Course and Country Club Detention Pond A	2300	2077	90	0.2
Golf Course and Country Club Detention Pond B	1200	1010	84	0.3
Golf Course and Country Club Detention Pond C	2100	1780	85	0.3
Golf Course and Country Club Detention Pond D	2000	397	20	1.5
Golf Course and Country Club Detention Pond E	2200	709	32	1.4

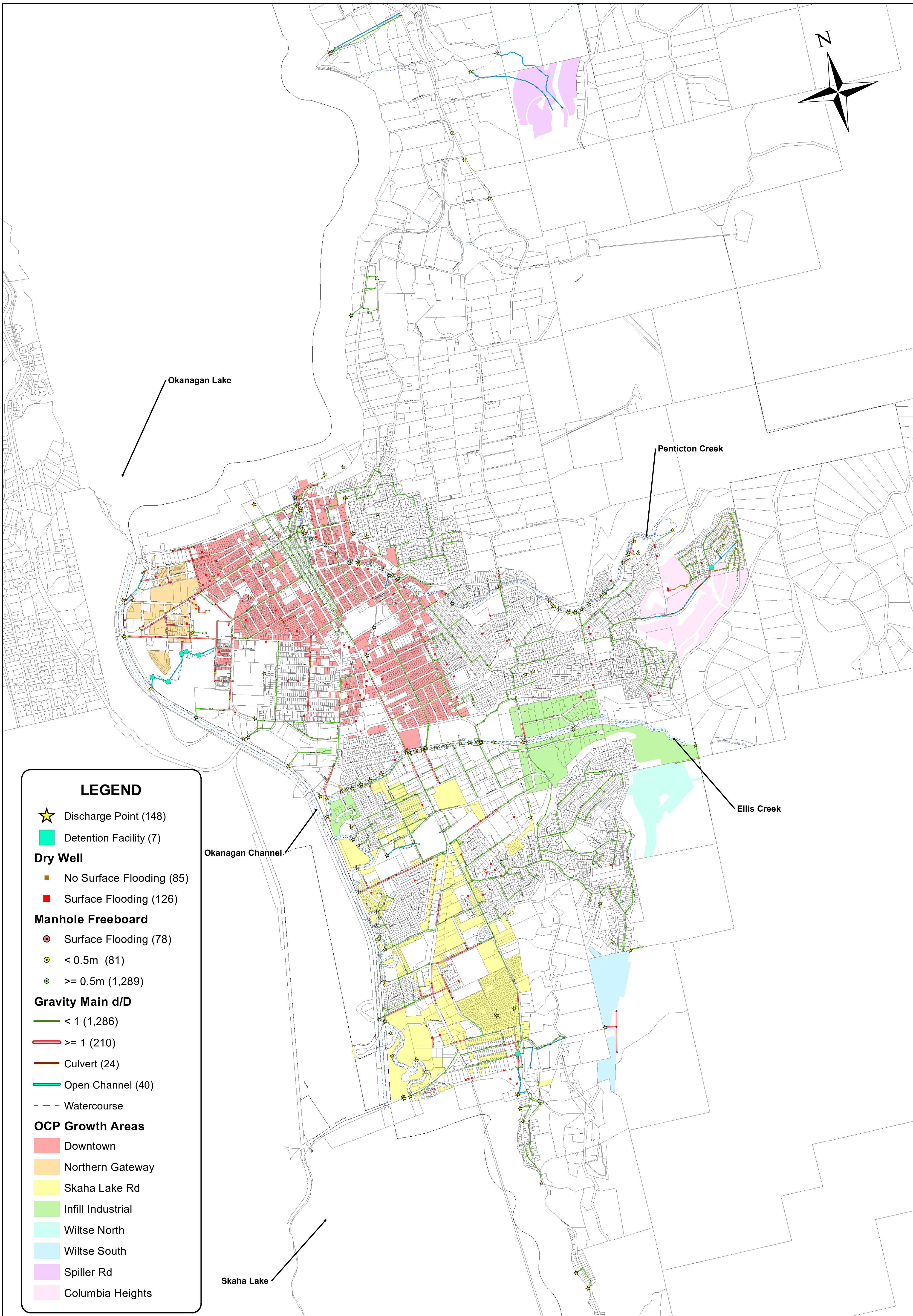
Although detention facilities are not considered deficient within the model, the available freeboard within the Skaha Lake Pond and the Golf Course Ponds is likely reduced due to sediment deposition. Therefore, sediment removal is recommended to ensure the ponds operate as originally designed and continue providing runoff treatment to reduce the contaminants from tributary catchments.

Urban runoff has been identified as one of the main sources contributing to the deterioration of water quality in receiving waterbodies. Stormwater runoff from urbanized areas commonly contains a wide range of contaminants including suspended solids, nutrients and heavy metals at concentrations significantly higher than runoff from undeveloped watersheds. In order to maintain the original design performance, sediment removal should be considered for the Skaha Lake and Gold Course ponds, which were originally constructed in the late 1980s.

Maintenance is a necessary and important aspect to ensure detention facilities continue providing adequate runoff treatment. In order to facilitate maintenance, it is advisable to prepare an annual maintenance report of each facility. The report should provide the following information annually:

- General condition including evidence or occurrence of overflows;

- Vegetation growth in the surrounding areas or evidence of algae in the ponds;
- Structural condition of inlet and outlet structures;
- Trash build-up near inlet and outlet structures;
- Monitoring results, if flow or quality monitoring was undertaken; and
- Recommendations for improvements that benefit the local community (aesthetic features such as park benches, water fountains or recreation path resurfacing).



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FUTURE MAJOR STORM CAPACITY

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 5 -4

DATE: Apr 2021

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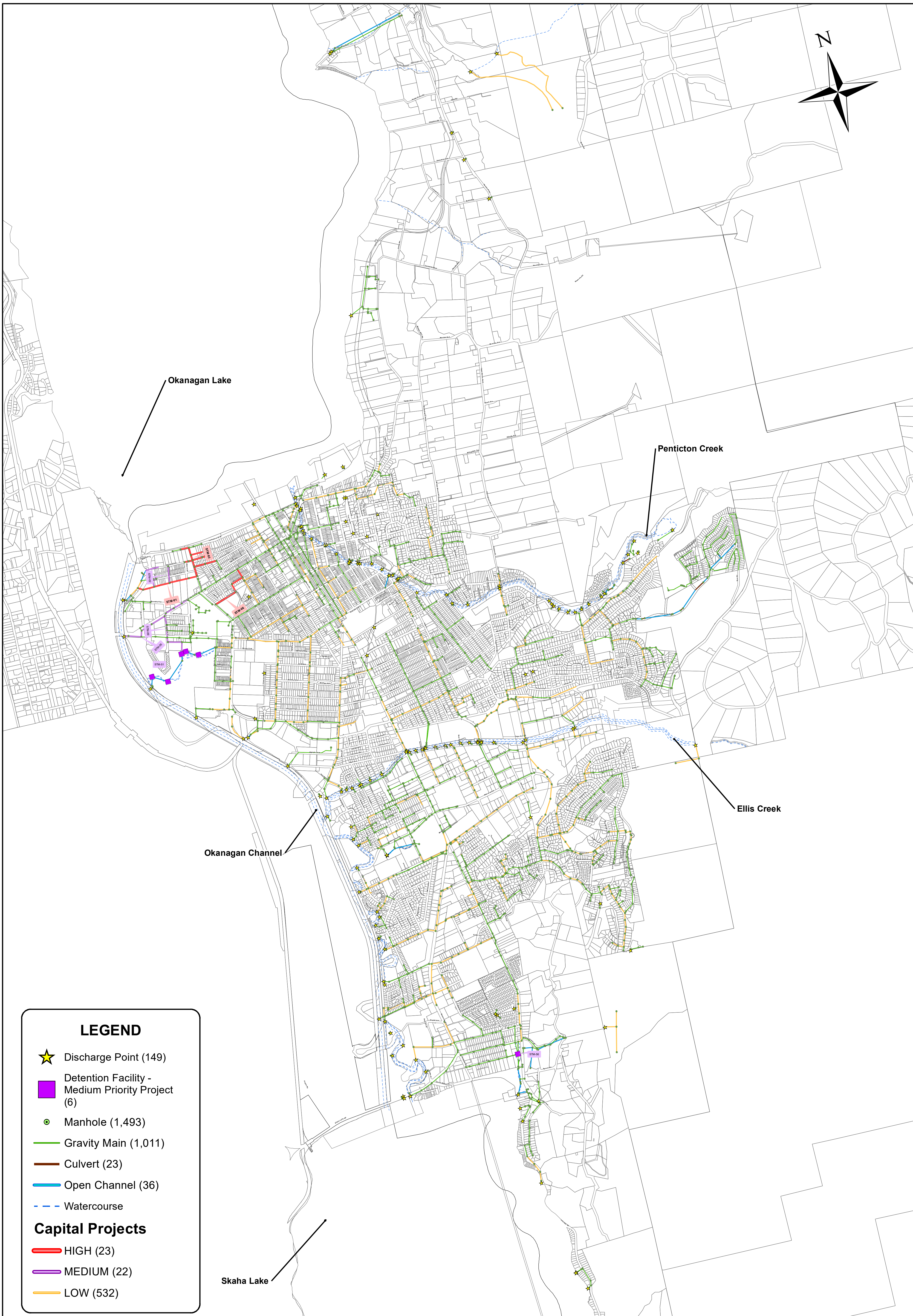
6 CAPITAL PROJECTS

6.1 OVERVIEW

Capital improvement projects are developed using the OCP conditions and shown in Appendix F. All proposed improvements include but are not limited to the following design considerations:

- Upsizing of existing gravity mains;
- Construction of new gravity mains;
- Slope and invert adjustments to create additional capacity;
- Opportunities for flow diversion;
- Twinning;
- Sediment-clean out;
- Water quality treatment controls such as OGS; and
- Opportunities for LID

Figure 6-1 displays the proposed capital works for the next 25-years.



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CAPITAL PROJECTS

Stormwater Master Plan

PROJECT NO. 20M-00462-00

FIGURE NO: 6 -1

DATE: Apr 2021

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6.2 PROJECTS PRIORITIZATION APPROACH

Table 6-4 provides the framework used to assign project priority and an implementation schedule. Refer to Appendix F for the individual project sheets.

TABLE 6-1 PROJECT PRIORITY

IMPLEMENTATION SCHEDULE	PRIORITY	INDICATOR
1 to 5 Year	High	• Deficient in the model due to existing issues (designed with future capacity included) • Validated in the field by City Operations Staff
5 to 10 Year (1)	Medium	• Deficient in the model due to existing issues (designed with future capacity included) where treatment has been implemented in 2020 (continue to observe for any continued deficiencies before implementation) • Validated in the field by City Operations Staff
10 to 20 Year (1)	Low / Low Confidence	• Assets required to service future development areas, where costs fall entirely on the developer • Deficient in the model • Not validated in the field by City Operations Staff; low confidence due to uncalibrated model • Assets constructed from 1960 to 1990
20 to 25 Year (1)	Low / Low Confidence	• Deficient in the model • Not validated in the field by City Operations Staff; low confidence due to uncalibrated model • Assets constructed from 1990 to 2010

(1) Flow monitoring and model calibration are required to validate proposed projects

WSP strongly recommends the City undertake flow monitoring surveys and model calibration exercise to increase model confidence prior to the implementation of medium and low priority projects.

6.3 COST ESTIMATE BASIS

All cost estimates ("Class D") associated with high and medium priority projects were determined on a unit-cost basis with consideration for mobilization, earthworks, restoration and land acquisition, as shown in the project sheets in Appendix F. An engineering and contingency of 40% is also applied globally to all projects. Table 6-2 lists the unit cost rates provided in the project sheets in Appendix F. These unit cost rates are developed from relevant past projects within BC and WSP's cost database, adjusted to 2021 dollars.

TABLE 6-2 UNIT COST SUMMARY

PIPE DIAMETER (MM)	UNIT COST (2021 $ / M)
200	$750
250	$800
300	$900
375	$1,050
450	$1,100
525	$1,300
600	$1,500
675	$1,650
750	$1,800
900	$2,000
1050	$2,300
1200	$2,650

6.4 PROJECT LIST

The methodology for implementation is as follows:

- High priority (5-year horizon) projects are identified as deficient in the model and validated in the field by the City. Projects STM-01, STM-03 and STM-06 are located within the northwest corridor of the City, which is classified as a flood hazard area due to high lake levels in the Okanagan River and Okanagan Channel. The City should consider increasing the minimum building elevation (MBE) for all proposed developments within this corridor to mitigate potential flood risk. Projects STM-04, STM-08, STM-52 and STM-56 do not involve construction or upsizing of linear assets and can potentially fall under the City's annual Operation and Maintenance (O&M) budget. A flow monitoring program and model calibration are strongly recommended as part of project STM-08 to confirm design flows and increase model confidence, prior to the implementation of medium and low priority projects. The cost estimates provided for flow monitoring assume data collection at 5 sites for a period of 2 months and include model calibration.

- Medium priority (10-year horizon) projects represent deficient assets, which were addressed by the City in 2020 using drywells. WSP recommends the City continue to observe for any deficiencies prior to the implementation of these projects. STM-53 and STM-54 represent capital projects carried forward from previous master plan.
- Low priority (20 to 25-year horizons) projects are identified as deficient in the model but not validated in the field by the City. Projects STM-11, STM-29 and STM-28 represent service connections to tie-in future developments envisioned in the OCP 2045. These service connections can vary depending on developer grading plans and should be further investigated during subsequent design phases. Flow monitoring and model calibration are required prior to the implementation of these projects.

TABLE 6-3 IMPROVEMENT PROJECTS

PROJECT TYPE	PROJECT ID	FIGURE NO.	PROJECT NAME	TOTAL COST (2021 $)	DEVELOPER FUNDED	PRIORITY	HORIZON
Capital	STM-01	F-1	Riverside Drive Diversion	$ 1,065,100		High	5-Year
Capital	STM-02	F-2	Churchill Avenue Improvements	$ 403,800		High	5-Year
Capital	STM-03	F-3	Power St. (North) Improvements	$ 1,080,300		High	5-Year
Operational	STM-04	F-4	Install Rain Gauge	$ 21,800		High	5-Year
Capital	STM-06	F-6	Power Street (South) Diversion	$ 968,300		High	5-Year
Operational	STM-08	F-8	Flow Monitoring Program and Model Calibration	$ 145,000		High	5-Year
Capital – Previous Master Plan	STM-53	F-53	Campbell Mountain Landfill R Drainage	$ 1,430,000	Partially	High	5-Year
Capital – Previous Master Plan	STM-54	F-54	Carmi Road Major System Upgrades	$ 1,530,000	Partially	High	5-Year
Capital	STM-05	F-5	Westminister Ave	$ 1,465,200		Medium	10-Year
Capital	STM-09	F-9	Comox Street Diversion	$ 828,600		Medium	10-Year
Operational	STM-51	F-51	Golf Course Ponds - Sediment Removal	$ 70,800		Medium	10-Year
Operational	STM-56	F-56	Skaha Lake Pond - Sediment Removal	$ 70,800		Medium	10-Year
Capital	STM-07	F-7	Rigsby Street	$ 628,116		Low	20-Year
Capital	STM-10	F-10	Dauphin Ave. and Brandon Ave. Upgrades	$ 3,133,973		Low	20-Year
Capital	STM-11	F-11	Wiltse North Development	TBD – Not connected to City System	Yes	Low	20-Year
Capital	STM-12	F-12	Channel Parkway	$ 845,556		Low	20-Year
Capital	STM-13	F-13	Eckhardt Ave, W to Golf Course Ponds	$ 853,795		Low	20-Year
Capital	STM-14	F-14	Orchard Ave and Eckhardt Ave. W.	$ 483,803		Low	20-Year
Capital	STM-15	F-15	Orchard Ave. and Winnipeg St.	$ 476,365		Low	20-Year
Capital	STM-16	F-16	Eckhardt Ave, W to Orchard Ave	$ 830,706		Low	20-Year
Capital	STM-17	F-17	Latimer Street Upgrades	$ 129,292		Low	20-Year
Capital	STM-18	F-18	Channel Parkway/Railway St. Swale System	$ 74,643		Low	20-Year
Capital	STM-20	F-20	Government Street Upgrades (South)	$ 547,304		Low	20-Year
Capital	STM-22	F-22	Argyle Street Improvements	$ 1,064,526		Low	20-Year
Capital	STM-24	F-24	Duncan Avenue Improvements	$ 782,637		Low	20-Year
Capital	STM-25	F-25	Main Street Diversion and Upgrades	$ 1,006,443		Low	20-Year
Capital	STM-26	F-26	Dafoe St. and Brentview Crt. Upgrades	$ 283,776		Low	20-Year
Capital	STM-27	F-27	Duncan Avenue (East) Improvements	$ 1,494,540		Low	20-Year
Capital	STM-28	F-28	Wiltse South Development	TBD – Not connected to City System	Yes	Low	20-Year
Capital	STM-29	F-29	Spiller Road Development	TBD – Not connected to City System	Yes	Low	20-Year
Capital	STM-30	F-30	Main Street to Robinson Street Improvements	$ 1,933,006		Low	20-Year
Capital	STM-32	F-32	Winnipeg Street Improvements	$ 916,939		Low	20-Year
Capital	STM-33	F-33	Laneway East of Martin Street Upgrades	$ 369,702		Low	20-Year
Capital	STM-39	F-39	North of Front St. Upgrades	$ 211,183		Low	20-Year
Capital	STM-43	F-43	Forestbrook Place Upgrades	$ 111,068		Low	20-Year
Operational	STM-44	F-44	Riverside Drive Wetland Improvements	$ 50,757		Low	20-Year
Capital	STM-45	F-45	Debeck Road Upgrades	$ 278,627		Low	20-Year
Capital	STM-50	F-50	Yorkton Ave. Skaha Lake Road Diversion	$ 967,168		Low	20-Year

PROJECT TYPE	PROJECT ID	FIGURE NO.	PROJECT NAME	TOTAL COST (2021 $)		DEVELOPER FUNDED	PRIORITY	HORIZON
Capital	STM-57	F-57	Pineview Drive Improvements	$	463,468		Low	20-Year
Capital	STM-58	F-58	Cleland Dr. and Columbia St. Upgrades	$	1,613,992		Low	20-Year
Capital	STM-62	F-62	Kinney Avenue (West) Upgrades	$	595,143		Low	20-Year
Capital	STM-64	F-64	Okanagan Ave. W Improvements	$	735,216		Low	20-Year
Capital	STM-68	F-68	Green Avenue W. Upgrades	$	1,115,949		Low	20-Year
Capital	STM-19	F-19	South Main Street Upgrades	$	1,104,019		Low	25-Year
Capital	STM-21	F-21	Moosejaw Street Improvements	$	976,370		Low	25-Year
Capital	STM-23	F-23	Fairview Road Improvements	$	1,849,223		Low	25-Year
Capital	STM-31	F-31	Wiltse Boulevard Improvements	$	2,434,413		Low	25-Year
Capital	STM-34	F-34	Balsam Avenue Improvements	$	973,224		Low	25-Year
Capital	STM-35	F-35	Vancouver Avenue Upgrades	$	809,710		Low	25-Year
Capital	STM-36	F-36	Uplands Ave. to Cambie Pl. Upgrades	$	736,207		Low	25-Year
Capital	STM-37	F-37	McConnachie Pl., Kruger Pl., Turo St., Ash St. and Aider St. Upgrades	$	545,384		Low	25-Year
Capital	STM-38	F-38	Haven Hill Rd. and Creekside Rd. Upgrades	$	303,753		Low	25-Year
Capital	STM-40	F-40	Lakeside Road Upgrades	$	308,855		Low	25-Year
Capital	STM-41	F-41	Government Street Upgrades (North)	$	452,674		Low	25-Year
Capital	STM-42	F-42	Dartmouth Dr. to Dartmouth Rd. Upgrades	$	2,794,293		Low	25-Year
Capital	STM-46	F-46	Dartmouth Road Upgrades	$	214,810		Low	25-Year
Capital	STM-47	F-47	South of Carmi Avenue Improvements	$	1,192,521		Low	25-Year
Capital	STM-48	F-48	Carmi Avenue Upgrades	$	871,079		Low	25-Year
Capital	STM-49	F-49	Ridgedale Ave. and MaCleave Ave. Upgrades	$	650,212		Low	25-Year
Capital	STM-52	F-52	Kinney Avenue (East) Upgrades	$	909,207		Low	25-Year
Capital	STM-55	F-55	South Main Street Improvements	$	933,216		Low	25-Year
Capital	STM-59	F-59	Ridgedale Avenue Upgrades	$	1,211,255		Low	25-Year
Capital	STM-60	F-60	Evergreen Drive Upgrades	$	899,044		Low	25-Year
Capital	STM-61	F-61	Waterford Avenue Upgrades	$	2,719,344		Low	25-Year
Capital	STM-63	F-63	Baskin Street Upgrades	$	314,625		Low	25-Year
Capital	STM-65	F-64	Laneway North of Warren Street Improvements	$	541,526		Low	25-Year
Capital	STM-66	F-66	Amherst Street Upgrades	$	601,373		Low	25-Year
Capital	STM-67	F-67	Camrose Street Upgrades	$	838,619		Low	25-Year
Capital	STM-69	F-69	Okanagan Avenue E. Upgrades	$	297,112		Low	25-Year
Capital	STM-70	F-70	Dawson Avenue Upgrades	$	1,439,458		Low	25-Year
Total				**$**	**57,998,919**			**25-Year**

6.5 SUMMARY

Table 6-4 provides anticipated Capital budget for the 5-,10-,20- and 25-year horizon.

TABLE 6-4 TOTAL CAPITAL COSTS

IMPLEMENTATION SCHEDULE	NO. OF PROJECTS	TOTAL COST (2021 $)	
1 – 5 Year (High Priority)	8	$	6,644,300
5 – 10 Year (Medium Priority) (1)	4	$	2,435,400
10 – 20 Year (Low Priority) (1)	31	$	21,997,693
20 – 25 Year (Low Priority) (1)	27	$	26,921,526
Total	**70**	**$**	**57,998,919**

(1) Flow monitoring and model calibration are required to validate proposed projects

6.6 RECOMMENDATIONS

Stormwater runoff quantity and quality are adversely impacted by urbanization. The City of Penticton should consider at-source, conveyance and end-of-pipe controls, where applicable, to maintain the desired level of service. The following recommendations can be drawn from the completion of the SWMP:

- Infill growth or future developments within the southwest corridor of the City should consider pre-treatment runoff controls such as OGS to improve the quality of runoff discharging into the Oxbows along Hwy. 97;
- Infill growth or future developments within the northwest corridor of the City should consider increasing the minimum building elevation (MBE) requirements, to minimize potential flood risk caused by high-water levels in the Okanagan Channel;
- BMP LID controls such as rain gardens, bioswales and vegetated filters listed in the 2017 SWMP Update should be assessed on a case-by-case basis contingent on subsurface soils and local groundwater levels;
- Continue to monitor the performance of implemented BMPs to develop case history for the City to inform future drainage operations, planning and capital upgrades.
- Conveyance controls such as installing inlet control devices (ICDs) at catchbasins should be implemented on a case-by-case basis to restrict the runoff entering the piped network, especially in flood hazard areas; and
- Model calibration is recommended to increase model confidence prior to the implementation of medium and low priority projects.

APPENDIX

A

TECH. MEMO #1: WATER AND SANITARY SEWER MODELLING SOFTWARE REVIEW

MEMO

TO: Tobi Pettet, P. Eng., Project Manager, City of Penticton

FROM: Stephen Horsman, P. Eng., P.E., Clive Leung, P.Eng.

SUBJECT: **Technical Memo #1: Water and Sanitary Sewer Modelling Software Review**

DATE: **June 4, 2020**

WSP Canada Group Limited (WSP) is pleased to provide the following technical memorandum (Memo) detailing a review of hydraulic water and sanitary modeling software alternatives for the City of Penticton (City).

INTRODUCTION

The City has retained WSP to complete the Integrated Infrastructure Master Plan (IIMP), which includes developing city-wide transportation, water, sanitary and stormwater infrastructure master plans. The purpose of the IIMP is to inform infrastructure capital planning to accommodate the growth and development plans set out in the latest Official Community Plan (OCP) 2045, adopted on August 6, 2019.The OCP 2045 estimates the population to increase from approximately 34,000 in 2016 to 42,000 by 2046, which equates to approximately 0.65% annual growth. The City wishes to determine the required capacity of both existing and proposed infrastructure, to support the population growth envisioned in the OCP.

The City currently uses an EPANET water model (current to 2016), and XPSWMM sanitary and stormwater models (current to 2010) as planning tools to support infrastructure planning and prioritize infrastructure upgrades.

This memo provides an evaluation of potential software alternatives and recommendations to meet the hydraulic modelling needs of the City.

BACKGROUND

A hydraulic model is an analytical tool generally used by engineers to assist in the planning, design, analysis and operation of municipal distribution and collection systems. A typical model consists of a network of nodes and links, where nodes represent hydrants, manholes or service connection points, and links represent pipes, siphons, pumps and other conveyance structures. Models also include hydrologic parameters that can be used to characterize subsurface conditions within the study area.

Most industry standard software suites can solve complex mathematical equations through various approximation methods (dynamic and static) which simulate gravity and pressure hydraulics under various conditions (e.g. winter and summer peak flows for water utilities, dry and wet weather conditions for sanitary sewer systems). Model output generally consists of flows (rates and volumes), pressure, water levels, and pipe capacity ratios.

Suite 700 – 1631 Dickson Avenue
Kelowna, BC, Canada V1Y 0B5
wsp.com

EVALUATION CRITERIA

The selection of an appropriate hydraulic modeling software varies based on many factors including but not limited to the intended purpose, functionality and end-user requirements. Based on discussions with the City, the preferred software suites will be used for three main applications:

1. Master Utility Plans
2. Development reviews and servicing studies (level of service assessments)
3. Concept and detail design projects (pipe/storage sizing, pump station retrofit etc.)

Additionally, key considerations noted by the City for evaluation include GIS integration, and ease of use. Overall, six categories of criteria summarized in **Table 1** are established to define the hydraulic modelling needs of the City.

TABLE 1 EVALUATION CRITERIA

CATEGORY	DESCRIPTION
GIS and Data Integration	• Direct link with ArcGIS (if available) • GIS compatibility including the ability to import and export shapefiles with associated attributes such as asset IDs and pipe sizes • AutoCAD and MicroStation compatibility • Standalone (Desktop and Cloud) or integrated platform and limitations of each
Ease of Use	• Easy-to-use graphic user interface • Intuitive interface which allows users unfamiliar with the software to pick it up new, or when away from it for a long time • Ability to manipulate large sets of data and layers simply, clearly and accurately • Ability to create quality figures for reports • Adequacy of vendor support and training programs
Functionality and Capability	• Useful and reliable decision-making tool for developing Master Utility Plans, conducting servicing reviews and designing infrastructure • Capable of modelling all City pipes with a high level of detail, including street-by-street representation of all links within the network (a minimum of 2000 links required for water and 3000 links for sanitary/stormwater) • Compatibility with existing models (EPANET or SWMM calculation engine) • Ability to conduct a full dynamic wave analysis as per City's Subdivision and Development Bylaw 2004-81 (applicable for sewer model only)
Model Simulation Time and Stability	• Ability to complete simulations efficiently within a practical run time and without continuity errors

CATEGORY	DESCRIPTION
Features and Tools	• Data validation tools to review input data and identify potential data gaps or connectivity issues such as missing invert elevations or missing links • Ability to create and manage multiple modeling scenarios and track modifications or links between scenarios • Methodology and tools to calibrate model in accordance with City requirements • Asset management capabilities such as ability to track asset life, condition reports, SCADA records etc. • Methodology and flexibility for water quality modeling (applicable for sewer model only) • Ability to simulate Low Impact Development (LID) treatment systems (applicable for sewer model only) • Infiltration inputs such as Green-Ampt, Horton's Infiltration etc. (applicable for sewer model only)
Financial	• Software license costs including annual renewal fees

The City has also expressed the preference for the models to be maintained and updated in-house by trained staff members. It is assumed that the end-user will be a City engineer with proficiency in GIS applications and a strong understanding of hydraulic principles. Ultimately, the City's intended use and specific requirements will dictate the software selection process.

SOFTWARE ALTERNATIVES

A short-list of industry standard software suites that meet the primary objectives of the City are provided in **Table 2**.

TABLE 2 SOFTWARE ALTERNATIVES

MODEL	SOFTWARE	VENDOR
Water	WaterCAD	Bentley Systems
	WaterGEMS	Bentley Systems
	InfoWater	Innovyze
	InfoWater Pro	Innovyze
Sanitary / Stormwater	SewerCAD	Bentley Systems
	SewerGEMS	Bentley Systems
	InfoSWMM	Innovyze

MODEL	SOFTWARE	VENDOR
	XPSWMM	Innovyze
	PCSWMM	CHI

The short-listed alternatives are commonly utilized by local municipalities throughout British Columbia. Brief descriptions of the alternatives are as follows:

- **WaterCAD**: a stand-alone desktop-based platform capable of modeling water distrubtion systems using an EPANET-based calculation engine. This software offers an easy-to-use interface with a high-level of integration with Microstation, CAD and GIS databases.

- **WaterGEMS**: has options for a stand-alone desktop-based or integrated with ArcGIS platform with similar functionality as WaterCAD. In addition to all the features from WaterCAD, model files use the same file format as WaterCAD and therefore can be easily accessed by WaterCAD users.

- **InfoWater**: a desktop-based water distribution software that runs on the ArcGIS platform. This software offers ArcGIS integration through having been set up to operate from within the ArcGIS platform, and uses an an enhanced version of the EPANET calculation engine for hydraulic and water quality analyses.

- **InfoWater Pro**: a cloud-based platform that runs on ArcGIS Pro with similar functionality as InfoWater. This software offers direct ArcGIS Pro integration with ability to create 3D maps. A file conversion is required to share models with InfoWater users.

- **SewerCAD**: a stand-alone desktop-based platform capable of modeling sanitary and stormwater collection systems. A key limitation of SewerCAD is that it is a static model and therefore has limited applications. This software is similar to WaterCAD in terms of user interface and data integration with Microstation, CAD and GIS databases.

- **SewerGEMS**: has options for a stand-alone desktop-based or integrated with ArcGIS platform with similar interface as SewerCAD. In addition to all the features from SewerCAD, SewerGEMs is a fully dynamic model (capable solving full St. Venant equations) with a SWMM-based calculation engine.

- **InfoSWMM**: a desktop-based sanitary and stormwater modelling software that runs on the ArcGIS platform. This software offers ArcGIS integration through having been set up to operate from within the ArcGIS platform, and uses a SWMM-based calculation engine for variety of applications.

- **XPSWMM**: a stand-alone desktop-based platform currently utilized by the City to assess sanitary and stormwater infrastructure. This software allows users to easily import/export GIS data and conduct hydrologic, hydraulic, water quality and 2D flooding analyses using the SWMM-based calculation engine.

- **PCSWMM**: a stand-alone desktop-based platform commonly used to model sanitary and stormwater collection systems. This software is well known for its GIS integration, SWMM5 engine capabilities, practical model run times and affordable licensing costs.

Refer to **Appendix A** for detailed product information obtained from vendors.

EVALUATION

In accordance with the RFP (2.1.2), each short-listed alternative is comparatively and qualitatively evaluated with respect to criteria developed in **Table 1**.

1 The results for water and sanitary alternatives are displayed in **Table 3** and

Table 4, respectively with cost estimates detailed in Appendix B. Each alternative is assigned an overall relative ranking, where 1 represents the preferred alternative.

Table 3 Water Modeling Software Evaluation

CATEGORY	WATERCAD	WATERGEMS	INFOWATER	INFOWATER PRO
GIS and Data Integration	• User can import and export GIS data in shapefile format with attributes • Users can open models directly from MicroStation or AutoCAD environments • Desktop-based platform requires users to access models from a designated computer or laptop	• Users can open models directly from ArcGIS, MicroStation or AutoCAD environments, allowing for an easier import and export of data with all associated attributes • Desktop-based platform requires users to access models from a designated computer or laptop	• Users can open models directly from the ArcGIS environment, allowing for easier import and export of GIS data with all associated attributes • There is a big concern regarding the smoothness of GIS data compatibility and transfers between the model and ArcGIS database, often requiring the modeller to press buttons in the software to save every attribute entered. It has been observed that database convergence has been an issue currently and extensively in the past. • Not compatible with AutoCAD or MicroStation (additional effort required to convert data) • Desktop-based platform requires users to access models from a designated computer or laptop	• Users can open models directly from the ArcGIS Pro environment, allowing for easier import and export of GIS data with all associated attributes • Not compatible with AutoCAD, MicroStation or any desktop-based platform • Cloud-based platform allows user to access the model online on any computer or laptop
Ease of Use	• Simple, intuitive, and user-friendly interface • Users can easily edit large sets of data through customizable tables (which can also be copied to external programs such as Excel) and undo changes with keyboard shortcuts • Adequate for generating quality figures • Adequate technical support, training videos and articles readily available through the Vendor website, strong online community for troubleshooting issues,	• Similar to WaterCAD	• ArcGIS interface with additional toolbars, less user friendly and intuitive compared to WaterCAD/GEMS.. • Users can edit large sets of data through database tables (which can also be copied to external programs such as Excel) or ArcGIS tools • Excellent for generating high quality figures • Adequate technical support and training programs provided by the Vendor through paid subscriptions and courses.	• ArcGIS Pro interface with additional tools and controls • Similar to InfoWater in terms of data manipulation, figure production and vendor support
Functionality and Capability	• Adequate for developing Water Master Plans, conducting development reviews and designing infrastructure • Adequate for modelling a network comprised of 4000 links • Compatible with EPANET calculation engine • Adequate for steady-state and transient analysis	• Similar to WaterCAD	• Adequate for developing Water Master Plans, conducting development reviews and designing infrastructure • Adequate for modelling a network comprised of 4000 links • Uses an enhanced version of the EPANET calculation engine • Adequate for steady-state and transient analysis	• Similar to InfoWater
Model Simulation Time and Stability	• Fast and stable results	• Similar to WaterCAD	• Adequate simulation time and stability for static runs, fire flow runs for large domains can take a long time to process. • Past experience from professional users indicates instabilities and performance issues with large networks	• Adequate simulation time and stability
Features and Tools	• Includes data validation tools • Excellent tree-based scenario manager that supports inheritance and allows users to assess and compare an unlimited number of scenarios • Includes calibration tools • Includes asset management tools	• Similar to WaterCAD with 6 additional modules that provide advanced asset management and design tools	• Similar to WaterCAD, • Scenario manager is more rigid and less easy to change/modify after the fact.	• Similar to InfoWater

CATEGORY	WATERCAD	WATERGEMS	INFOWATER	INFOWATER PRO
Financial	Fixed License not available Concurrent License (2,000 Links) ○ Initial purchase cost - $ 13,979 ○ Annual maintenance cost - $ 3,354	Fixed License not available Concurrent License (2,000 Links) ○ Initial purchase cost - $ 22,719 ○ Annual maintenance cost - $ 5,454	Fixed Licence (2,000 Links) ○ Initial purchase cost - $ 9,100 ○ Annual maintenance cost - $ 1,820 Floating Licence (2,000 Links) ○ Initial purchase cost - $ 13,650 ○ Annual maintenance cost - $ 2,730	Fixed Licence (3,000 Links) ○ Initial purchase cost - $ 12,495 ○ Annual maintenance cost - $ 2,499 Floating Licence (3,000 Links) ○ Initial purchase cost - $ 18,743 ○ Annual maintenance cost - $ 3,749
Ranking	**2**	**3**	**1**	**4**

TABLE 4 SANITARY MODELING SOFTWARE EVALUATION

CATEGORY	SEWERCAD	SEWERGEMS	INFOSWMM	XPSWMM	PCSWMM
Functionality and Capability	• Adequate for developing Sanitary and Stormwater Master Plans, conducting development reviews and designing infrastructure • Adequate for modelling a network comprised of 3000 links • Compatible with SWMM calculation engine • Inadequate for full dynamic wave analysis (can only conduct static / steady-state modeling)	• Similar to SewerCAD, however, SewerGEMS can perform full dynamic analysis per City needs	• Adequate for developing Sanitary and Stormwater Master Plans, conducting development reviews and designing infrastructure • Adequate for modelling a network comprised of 3000 links • Compatible with SWMM calculation engine • Can perform full dynamic analysis per City needs	• Similar to InfoSWMM	• Similar to InfoSWMM
Data Integration	• User can import and export GIS data in shapefile format with attributes • Users can open models directly from MicroStation or AutoCAD environments • Desktop-based platform requires users to access models from a designated computer or laptop	• Users can open models directly from ArcGIS, MicroStation or AutoCAD environments, allowing for an easier import and export of data • Desktop-based platform requires users to access models from a designated computer or laptop	• Users can open models directly from the ArcGIS environment, allowing for easier import and export of GIS data with all associated attributes • Not compatible with AutoCAD or MicroStation (additional effort required to convert data) • Desktop-based platform requires users to access models from a designated computer or laptop	• User can import and export GIS data in shapefile format with attributes • Not compatible with AutoCAD or MicroStation (additional effort required to convert data) • Desktop-based platform requires users to access models from a designated computer or laptop	• Similar to XPSWMM
Ease of Use	• Simple and user-friendly interface • Users can easily edit large sets of data through customizable tables (which can also be copied to external programs such as Excel) and undo changes with keyboard shortcuts • Adequate for generating quality figures • Adequate technical support and little to no training programs provided by the Vendor	• Similar to SewerCAD	• ArcGIS interface with additional toolbars • Users can edit large sets of data through database tables (which can also be copied to external programs such as Excel) or ArcGIS tools • Excellent for generating high quality figures • Adequate technical support and training programs provided by the Vendor	• Similar to SewerCAD	• Similar to SewerCAD, however, PCSWMM vendor provides excellent technical support and annual training courses, with step-by-step online instructions for a variety of tasks and analyses available through the support website.
Model Simulation Time and Stability	• Fast and stable results	• Similar to SewerCAD	• Adequate simulation time and stability, however past experience from professional users indicates instabilities and performance issues with large networks	• Adequate simulation time and stability	• Fast and stable results

CATEGORY	SEWERCAD	SEWERGEMS	INFOSWMM	XPSWMM	PCSWMM
Features and Tools	• Includes data validation tools • Excellent tree-based scenario manager that supports inheritance and allows users to assess and compare an unlimited number of scenarios • Includes calibration tools • Includes asset management tools • Not capable of water quality modeling • Not capable of simulating LID controls • No infiltration inputs	• Similar to SewerCAD with 6 additional modules that provide tools for water quality modeling, creating design storms, defining infiltration parameters as well as modeling LID controls	• Includes data validation tools • Excellent tree-based scenario manager that supports inheritance and allows users to assess and compare an unlimited number of scenarios • Includes calibration tools • Includes asset management tools • Capable of water quality modeling • Capable of simulating LID controls • Includes infiltration inputs	• Includes data validation tools • A specialized scenario management tool which can simulate multiple storms in a single run • Includes calibration tools • Limited asset management capability • Capable of water quality modeling • Capable of simulating LID controls • Includes infiltration inputs	• Includes data validation tools • A dedicated scenario management function where combinations of various input data sets and simulation options can be easily selected, and results compared • Includes calibration tools • Limited asset management capability • Capable of water quality modeling • Capable of simulating LID controls • Includes infiltration inputs
Financial	Fixed License not available Concurrent License (2,000 Links) ○ Initial purchase cost - $ 13,979 ○ Annual maintenance cost - $ 3,354	Fixed License not available Concurrent License (2,000 Links) ○ Initial purchase cost - $ 22,719 ○ Annual maintenance cost - $ 5,454	Fixed Licence (3,000 Links) ○ Initial purchase cost - $ 12,250 ○ Annual maintenance cost - $ 2,450 Floating Licence (3,000 Links) ○ Initial purchase cost - $ 18,375 ○ Annual maintenance cost - $ 3,675	Unavailable as software is no longer supported	Fixed Licence (Unlimited Links) • Initial purchase cost - $ 0 • Annual maintenance cost - $ 1,440/user
Ranking	**4**	**3**	**2**	**5**	**1**

SUMMARY & RECOMMENDATIONS

WSP reviewed nine alternative software suites capable of modelling water and sanitary sewer networks. Each alternative was evaluated with respect to user-specific requirements that best meet City objectives. All of the softwares evaluated herein will meet the City's needs, however the following recommendations are provided for consideration by the City.

For water modelling, WaterCAD and InfoWater are the most common water modelling softwares used by municipalities throughout BC, speaking to their relative benefits. InfoWater is the slightly more cost effective and operates on the City's ArcGIS platform. It is noted that WaterCAD offers superior ease of use and model simulation speed, stability, and reliability, however, the has noted that they place a high priority on the GIS compatibility. Based on this, WSP recommends that the City proceed with the procurement of an InfoWater license to develop, update and maintain city-wide water utility data.

For sewer modelling, PCSWMM is the most cost-effective option while meeting the City's needs, however offers slightly less functionality and lower compatibility with ArcGIS. WSP recommends the City proceed with the use of either PCSWMM, or procurement of a InfoSWMM licenses to develop, update and maintain city-wide stormwater and sanitary utilities.

CLOSURE

We trust you will find the foregoing letter report suitable. Please do not hesitate to contact the undersigned should you have any questions.

Stephen Horsman, P.Eng., P.E.
Manager, Water

APPENDIX A - PRODUCT INFORMATION

APPENDIX B – COST ESTIMATES

Table B1 – Water Software Costs

CATEGORY	WATERCAD	WATERGEMS	INFOWATER	INFOWATER PRO
Purchase Cost – **Fixed License** (No. of Max. Links)	n/a	n/a	$ 9,100 (2,000 links)	$12,495 (3,000 links)
Annual Maintenance Cost	n/a	n/a	$ 1,820	$ 2,499
Purchase Cost – **Floating / Concurrent License** (No. of Max. Links)	$ 13,979 (2,000 links)	$ 22,719 (2,000 links)	$ 13,650 (2,000 links)	$18,743 (3,000 links)
Annual Maintenance Cost	$ 3,354	$ 5,454	$ 2,730	$ 3,749

Table B2 – Sanitary/Stormwater Software Costs

CATEGORY	SEWERCAD	SEWERGEMS	INFOSWMM	XPSWMM	PCSWMM
Purchase Cost – **Fixed License** (No. of Max. Links)	n/a	n/a	$ 12,250 (3,000 links)	n/a	$ 0 (Unlimited links)
Annual Maintenance Cost	n/a	n/a	$ 2,450	n/a	$ 1,440
Purchase Cost – **Floating License** (No. of Max. Links)	$ 13,979 (2,000 links)	$ 22,719 (2,000 links)	$ 18,375 (3,000 links)	n/a	n/a
Annual Maintenance Cost	$ 3,354	$ 5,454	$ 3,675	n/a	n/a

The following applies to WaterCAD, WaterGEMS, SewerCAD and SewerGEMS products:

- Prices provided in CAD
- A 10% discount on purchase costs may be applied after negotiation with the sales team
- No fixed licences are available. “Concurrent” licenses are available where multiple users can share the same license, although there is tracking for using the same license at the same time, so if the City has multiple users on the same license at the same time, the City will be sent an invoice.

The following applies to InfoWater, InfoWaterPro, InfoSWMM and XPSWMM products:

- All prices were converted from USD to CAD at the rate of 1 USD = 1.39 CAD
- Fixed and Floating (“Concurrent”) licences are available. “Floating” licenses are available where multiple users can share the same license, and there are controls to block multiple users from accessing the same license at the same time.

APPENDIX

B

TECH. MEMO #2: INFRASTRUCTURE MODELS ASSET NAMING CONVENTION

MEMO

TO: Tobi Pettet, P.Eng., Project Manager, City of Penticton

FROM: Stephen Horsman, P.Eng., P.E., Michael Levin, P.Eng.

SUBJECT: **Technical Memo #2: Infrastructure Models Asset Naming Convention**

DATE: **June 4, 2020**

WSP Canada Group Limited (WSP) is pleased to provide the following technical memorandum outlining the proposed naming conventions of the asset groups within the individual water, sanitary and stormwater hydraulic models for the City of Penticton (City). The purpose of this memorandum is to document the rational for development of the asset naming conventions for updating the proposed hydraulic models and identify how the model asset IDs will correlate to the City's GIS database.

WATER MODEL NAMING CONVENTIONS

The City's existing EPANET water model (current to 2016) was developed prior to the City moving to a GIS platform for managing their infrastructure data. As such, the water model naming conventions are not consistent with the City's current GIS database. The existing hydraulic water model naming convention uses the respective Pressure Zone ID along the modelling element prefix to label the various junctions, pipes, tanks, pump stations, and PRVs elements.

WSP reviewed the City's GIS database naming conventions in relation to the existing model database and recommend updating the naming convention for water structure facilities, such as pump stations and reservoirs, based on the City's current GIS convention, while following the existing naming convention historically used for watermains and hydrants. Renaming the modelled watermains with the GIS pipe dataset would result in multiple clashes between the modelled and GIS asset databases (e.g. one hydraulic model link may correlate to multiple GIS watermain IDs) offers little benefit. Additionally, this approach allows the primary elements, namely the junctions and watermains, to retain the Pressure Zone ID as set out in the existing model, which allows efficient special locating when reviewing model results.

To assist the City's capital planning and rehabilitation works programs, WSP will correlate the model ID and the City's GIS FACILITYID field within the capital project descriptions so that the associated asset improvements and cost estimates can be readily incorporated into the City's planning cycle and asset management systems.

Based on the foregoing, the following presents the proposed naming conventions that will be used for the existing model elements:

- Point assets such as reservoirs, pumps and PRVs will have prefixes obtained from the FACILITYID field and a one letter tag identifying the type of asset, followed by a numerical identifier; and
- Watermains and junctions representing pipe connections, valves, and hydrants will follow the existing naming convention based on associated pressure zone.

Table 1 lists the proposed naming convention for existing water model elements.

TABLE 1 WATER MODEL NAMING CONVENTION

ASSET TYPE	MODEL ELEMENT	PREFIX
Hydrants/Valves/Pipe Connections	Junction	J-(Pressure Zone ID)-###
Watermains	Pipe	P-(Pressure Zone ID)-###
Water Supply Source	Reservoir	WSR--###
Storage Reservoir	Tank	WST--###
Pump	Pump	WSP--###
PRV	PRV	WSV--###

SANITARY AND STORMWATER MODEL NAMING CONVENTIONS

Similar to the water model files, the City's existing sanitary and stormwater XPSWMM model files (current to 2010) do not follow the City's current GIS naming convention. Based on our review of the existing model naming conventions and the City's current GIS database, WSP proposes to rename all elements to match the City's GIS database. The following outlines our proposed naming convention for existing and dummy[1] model elements for the new sanitary and stormwater models.

All existing model elements will use prefixes that match the FACILITYID field, obtained direct from the City's GIS database, followed by a numerical identifier.

Table 2 and Table 3 lists the recommended naming conventions for different asset groups.

TABLE 2 STORMWATER MODEL NAMING CONVENTION

ASSET TYPE	MODEL ELEMENT	PREFIX
Manhole	Junction	SWMH-###
Discharge Point	Outfall	SWDP-###
Network Structure	Storage	SWNS-###
Stormwater Structure	Storage	SWST-###
Stormwater Detention Area	Storage	SWDA-###
Gravity Main	Conduit	SWGM-###
Culvert	Conduit	SWCU-###
Open Channel/Ditch	Conduit	SWOD-###

[1] Refers to elements required for model network connectivity, which are unique to the hydraulic model and do not correlate to a physical asset.

TABLE 3 SANITARY MODEL NAMING CONVENTION

ASSET TYPE	MODEL ELEMENT	PREFIX
Manhole	Junction	SSMH-###
Pump	Pump	SSPU-###
AWWTP Discharge	Outfall	SSDP-###
Lift Station	Storage	SSNS-###
Gravity Main	Conduit	SSGM-###
Forcemain	Conduit	SSFM-###

For elements required for model network connectivity (i.e. dummy links to connect inlet points or represent conveyance features), which are unique to the hydraulic model development, WSP will assign a prefix of asset group (sanitary or stormwater), followed by type of feature (node or link) and a unique numerical identifier to junctions and pipes respectively.

Table 4 lists the recommended naming conventions for these elements.

TABLE 4 NAMING CONVENTION FOR NETWORK CONNECTIVITY ELEMENTS

ASSET TYPE	MODEL ELEMENT	PREFIX	EXAMPLE
Manhole	Junction	SSN-### SWN-###	Connect isolated conveyance features/links south and north of the City to the Sanitary or Stormwater network
Pipe or Channel	Conduit	SSL-### SWL-###	Connect isolated manholes to the Sanitary or Stormwater network and accurately capture the sewer loading or runoff discharging to the manhole

PROPOSED ELEMENTS NAMING CONVENTION (ALL MODELS)

As part of the model development and planning exercises for all three hydraulic models, the future model files will include proposed assets that are required to service future development areas or replace existing assets. These proposed elements are appended to an existing model to evaluate the behaviour of a system under future conditions. WSP will assign a prefix "P-" (Proposed) followed by asset group, type of feature and a unique locational or numerical identifier.

Table 5 lists the recommended naming conventions.

TABLE 5 NAMING CONVENTION FOR PROPOSED MODEL ELEMENTS

ASSET TYPE	MODEL ELEMENT	PREFIX	EXAMPLE
Facility (Storm or Sanitary ONLY)	Storage	P-SWNS-(Location)-# P-SWST-(Location)-# P-SWDA-(Location)-# P-SSNS-(Location)-#	Detention Pond, Lift Station
Manhole or Outfall	Junction	P-SSN-### P-SSDP-(Location)-# P-SWN-###	New manhole to tie-in future developments
Pipe or Channel	Conduit	P-SSL-### P-SSL-###	New gravity main to service future developments
Hydrants/Valves/Pipe Connections	Junction	P-####	New hydrant or tie-in location for future development
Watermains	Pipe	P-####	New watermain for looping or servicing future development
Storage Reservoir	Tank	P-WST-(Location)-#	New tank or additional cell to existing tank
Pump	Pump	P-WSP-(Location)-#	New pump station or existing pump station upgrades
PRV	PRV	P-WSV-(Location)-#	New PRV station

HYDRAULIC DATA INPUT NAMING CONVENTION (ALL MODELS)

The individual utility models will also include various components such as demand patterns and storage/pump curves. Table 6 and Table 7 lists the recommended naming conventions for hydraulic data with example applications.

TABLE 6 PATTERN NAMING CONVENTION AND APPLICATIONS

TYPE	APPLIES TO	EXAMPLE APPLICATION	PREFIX
Demand Pattern	Junction	System Demand Analysis	D-
Demand Charge Pattern	Pump	Pump Cost Estimates	CH-
Variable Head Pattern	Reservoir	Water Source Analysis	VH-
Pump Energy Rate Pattern	Pump	Energy Management	EG-
Variable Pump Speed Setting Pattern	Pump	Pump Station Optimization	VS-
Water Quality Pattern	Reservoir, Tank or Junction	Water Quality Analysis	WQ-

TABLE 7 CURVE NAMING CONVENTION AND APPLICATIONS

TYPE	APPLIES TO	EXAMPLE APPLICATION	PREFIX
Storage Curve	Storage	Detention Pond Rating Curve	STG-
Pump Curve	Pump	Pump Capacity Analysis	PC-
Efficiency Curve	Pump	Energy Management	EF-
NPSH Curve	Pump	Cavitation Analysis	NS-
Volume Curve	Tank	Variable Area Tank	VC-
Headloss Curve	Valve	General Purpose Valve	HL-
Minor Loss Curve	Valve	Motorized Throttle Valve	ML-
Pressure Demand Curve	Junction	Pressure-dependent Demand	PR-

APPENDIX

C

MODEL ASSUMPTIONS

Table C-1 Dummy Manholes

Name	Tag	Invert Elev. (m)	Invert Elevation Data Source	Rim Elev. (m)	Rim Elevation Data Source
P-SWN-63	Dummy	509.5	Assumed_1m_Cover	510.7	1 m Contours
SWIN-1630	Dummy	402.7	Assumed_3m_Cover	405.7	1 m Contours
SWIN-1825	Dummy	398.4	assumed_1.5m_Cover	399.9	1 m Contours
SWMH-1269	Dummy	340.1	Assumed_2m_Cover	342.2	1 m Contours
SWN-1	Dummy	338.8	Old_Model	341.0	1 m Contours
SWN-10	Dummy	478.9	Assumed_1.5m_Cover	480.4	1 m Contours
SWN-100	Dummy	442.7	Assumed_1.5m_Cover	444.2	1 m Contours
SWN-1000	Dummy	358.0	Assumed_1.5m_Cover	359.6	1 m Contours
SWN-101	Dummy	442.1	Linear_Interpolation	442.8	1 m Contours
SWN-102	Dummy	441.7	Linear_Interpolation	442.7	1 m Contours
SWN-104	Dummy	441.4	Linear_Interpolation	442.0	1 m Contours
SWN-105	Dummy	456.4	Assumed_1.5m_Cover	457.9	1 m Contours
SWN-106	Dummy	453.0	Assumed_1.5m_Cover	454.5	1 m Contours
SWN-107	Dummy	339.1	Assumed_1.5m_Cover	340.8	1 m Contours
SWN-108	Dummy	452.6	Assumed_1.5m_Cover	454.1	1 m Contours
SWN-109	Dummy	551.5	Linear_Interpolation	553.3	1 m Contours
SWN-11	Dummy	386.3	Assumed_1.5m_Cover	387.8	1 m Contours
SWN-110	Dummy	524.5	Linear_Interpolation	525.8	1 m Contours
SWN-111	Dummy	522.0	Linear_Interpolation	523.3	1 m Contours
SWN-112	Dummy	514.5	Linear_Interpolation	516.1	1 m Contours
SWN-114	Dummy	461.9	Linear_Interpolation	463.8	1 m Contours
SWN-115	Dummy	513.2	Linear_Interpolation	514.8	1 m Contours
SWN-116	Dummy	490.0	Linear_Interpolation	491.9	1 m Contours
SWN-117	Dummy	338.6	Assumed_1m_Cover	339.6	1 m Contours
SWN-118	Dummy	484.7	Linear_Interpolation	486.3	1 m Contours
SWN-119	Dummy	588.9	Linear_Interpolation	590.0	1 m Contours
SWN-12	Dummy	366.7	Assumed_1.5m_Cover	368.2	1 m Contours
SWN-13	Dummy	367.5	Assumed_1.5m_Cover	369.0	1 m Contours
SWN-14	Dummy	337.0	Old_Model	338.6	1 m Contours
SWN-16	Dummy	337.0	Old_Model	339.0	1 m Contours
SWN-17	Dummy	337.2	Assumed_1.5m_Cover	338.7	1 m Contours
SWN-18	Dummy	337.0	Old_Model	338.4	1 m Contours
SWN-19	Dummy	337.0	Assumed_2m_Cover	338.8	1 m Contours
SWN-2	Dummy	363.7	Assumed_1.5m_Cover	365.2	1 m Contours
SWN-20	Dummy	413.4	Assumed_1.5m_Cover	414.9	1 m Contours
SWN-2000	Dummy	343.5	Assumed_1.5m_Cover	345.0	1 m Contours
SWN-22	Dummy	337.0	Assumed_2m_Cover	339.1	1 m Contours
SWN-24	Dummy	342.8	Assumed_1.5m_Cover	344.3	1 m Contours
SWN-25	Dummy	342.2	Assumed_1.5m_Cover	343.7	1 m Contours
SWN-26	Dummy	341.3	Assumed_1.5m_Cover	342.8	1 m Contours
SWN-27	Dummy	362.9	Assumed_1.5m_Cover	364.4	1 m Contours
SWN-28	Dummy	338.5	Assumed_1.5m_Cover	340.0	1 m Contours
SWN-3	Dummy	366.6	Assumed_1.5m_Cover	368.1	1 m Contours
SWN-30	Dummy	358.2	Assumed_1.5m_Cover	359.7	1 m Contours

SWN-3000	Dummy	470.9	Assumed_2m_Cover	472.7	1 m Contours
SWN-31	Dummy	342.0	Assumed_1m_Cover	343.0	1 m Contours
SWN-32	Dummy	338.7	Assumed_1.5m_Cover	340.2	1 m Contours
SWN-33	Dummy	338.9	Assumed_1.5m_Cover	340.4	1 m Contours
SWN-34	Dummy	337.0	Assumed_1.5m_Cover	338.5	1 m Contours
SWN-35	Dummy	337.1	Assumed_1.5m_Cover	338.6	1 m Contours
SWN-36	Dummy	338.8	Pond_E	341.0	1 m Contours
SWN-37	Dummy	339.5	Assumed_1.5m_Cover	341.0	1 m Contours
SWN-38	Dummy	341.6	Assumed_1.5m_Cover	343.1	1 m Contours
SWN-39	Dummy	382.2	Linear_Interpolation	384.0	1 m Contours
SWN-4	Dummy	372.7	Assumed_1.5m_Cover	374.2	1 m Contours
SWN-40	Dummy	356.3	Linear_Interpolation	360.1	1 m Contours
SWN-41	Dummy	377.2	Assumed_2m_Cover	379.0	1 m Contours
SWN-43	Dummy	374.7	Linear_Interpolation	377.1	1 m Contours
SWN-44	Dummy	340.5	Assumed_1.5m_Cover	342.0	1 m Contours
SWN-45	Dummy	343.7	Linear_Interpolation	345.6	1 m Contours
SWN-46	Dummy	349.5	Assumed_1.5m_Cover	351.0	1 m Contours
SWN-47	Dummy	349.5	Assumed_1.5m_Cover	351.0	1 m Contours
SWN-48	Dummy	341.1	Pond_A	343.3	1 m Contours
SWN-49	Dummy	340.3	Pond_B	342.3	1 m Contours
SWN-5	Dummy	377.1	Assumed_1.5m_Cover	378.6	1 m Contours
SWN-50	Dummy	339.5	Pond_C	341.6	1 m Contours
SWN-51	Dummy	357.8	Assumed_1.5m_Cover	359.3	1 m Contours
SWN-52	Dummy	374.8	Assumed_2m_Cover	376.8	1 m Contours
SWN-53	Dummy	338.8	Assumed_1.5m_Cover	340.2	1 m Contours
SWN-54	Dummy	343.0	Assumed_1.5m_Cover	344.5	1 m Contours
SWN-56	Dummy	350.0	Assumed_1.5m_Cover	351.5	1 m Contours
SWN-57	Dummy	339.0	Assumed_1m_Cover	340.0	1 m Contours
SWN-58	Dummy	338.6	Assumed_1.5m_Cover	340.1	1 m Contours
SWN-59	Dummy	361.9	Assumed_1m_Cover	362.9	1 m Contours
SWN-6	Dummy	387.9	Assumed_1.5m_Cover	389.4	1 m Contours
SWN-60	Dummy	342.6	Linear_Interpolation	345.0	1 m Contours
SWN-61	Dummy	339.5	Assumed_1.5m_Cover	341.0	1 m Contours
SWN-62	Dummy	433.0	Assumed_1.5m_Cover	434.5	1 m Contours
SWN-63	Dummy	388.5	Assumed_2m_Cover	390.5	1 m Contours
SWN-64	Dummy	337.9	Linear_Interpolation	340.5	1 m Contours
SWN-66	Dummy	422.1	Assumed_1.5m_Cover	423.6	1 m Contours
SWN-67	Dummy	337.7	Assumed_1.5m_Cover	339.2	1 m Contours
SWN-68	Dummy	376.4	Assumed_1.5m_Cover	377.9	1 m Contours
SWN-69	Dummy	458.3	Assumed_1.5m_Cover	459.7	1 m Contours
SWN-70	Dummy	346.2	Linear_Interpolation	348.2	1 m Contours
SWN-71	Dummy	340.4	Assumed_1.5m_Cover	341.9	1 m Contours
SWN-72	Dummy	430.4	Assumed_1.5m_Cover	431.9	1 m Contours
SWN-73	Dummy	358.4	Assumed_1.5m_Cover	359.9	1 m Contours
SWN-74	Dummy	420.7	Assumed_1.5m_Cover	422.2	1 m Contours
SWN-75	Dummy	414.7	Assumed_1m_Cover	415.7	1 m Contours
SWN-76	Dummy	380.1	Assumed_1.5m_Cover	381.6	1 m Contours

SWN-77	Dummy	453.3	Old_Model	458.4	1 m Contours
SWN-78	Dummy	338.5	Assumed_1.5m_Cover	340.0	1 m Contours
SWN-79	Dummy	356.8	Assumed_1.5m_Cover	358.3	1 m Contours
SWN-8	Dummy	343.3	Assumed_1.5m_Cover	344.8	1 m Contours
SWN-80	Dummy	337.1	Assumed_1m_Cover	338.1	1 m Contours
SWN-81	Dummy	356.7	Assumed_1.5m_Cover	358.2	1 m Contours
SWN-82	Dummy	359.3	Assumed_1.5m_Cover	360.8	1 m Contours
SWN-83	Dummy	367.5	Assumed_1.5m_Cover	369.0	1 m Contours
SWN-84	Dummy	371.7	Assumed_2m_Cover	373.7	1 m Contours
SWN-85	Dummy	371.5	Assumed_1.5m_Cover	373.0	1 m Contours
SWN-86	Dummy	343.5	Assumed_0.5m_Cover	344.1	1 m Contours
SWN-87	Dummy	394.4	Assumed_1.5m_Cover	395.9	1 m Contours
SWN-88	Dummy	390.6	Assumed_1.5m_Cover	392.1	1 m Contours
SWN-89	Dummy	420.5	Assumed_2m_Cover	422.5	1 m Contours
SWN-9	Dummy	342.3	Assumed_1.5m_Cover	343.8	1 m Contours
SWN-90	Dummy	422.9	Assumed_1.5m_Cover	424.4	1 m Contours
SWN-91	Dummy	346.6	Assumed_1.5m_Cover	348.1	1 m Contours
SWN-92	Dummy	453.3	Old_Model	458.4	1 m Contours
SWN-93	Dummy	427.3	Assumed_1.5m_Cover	428.8	1 m Contours
SWN-94	Dummy	430.6	Assumed_1.5m_Cover	432.1	1 m Contours
SWN-95	Dummy	431.5	Assumed_1.5m_Cover	433.0	1 m Contours
SWN-96	Dummy	437.5	Assumed_1.5m_Cover	439.0	1 m Contours
SWN-97	Dummy	438.8	Assumed_1.5m_Cover	440.3	1 m Contours
SWN-98	Dummy	584.2	Linear_Interpolation	585.5	1 m Contours
SWN-99	Dummy	443.4	Assumed_1.5m_Cover	444.9	1 m Contours

Table C-2 Dummy Pipes

Name	Tag	Roughness	Modeled Diameter (mm)	Length (m)	Inlet Node	Outlet Node	Inlet Elev. (m)	Outlet Elev. (m)	Cross-Section
P-SWL-41	Dummy_Main	0.013	300	22	SWMH-1603	P-SWN-63	528.230	509.509	CIRCULAR
SWL-1	Dummy_Main	0.013	300	16	SWN-47	SWDP-58	349.491	348.150	CIRCULAR
SWL-10	Dummy_Main	0.013	300	15	SWN-105	SWDP-50	456.413	455.666	CIRCULAR
SWL-11	Dummy_Main	0.013	300	20	SWN-34	SWDP-62	337.014	336.593	CIRCULAR
SWL-12	Dummy_Main	0.013	300	8	SWN-106	SWDP-57	453.033	452.198	CIRCULAR
SWL-13	Dummy_Main	0.013	300	25	SWN-97	SWDP-133	438.818	438.471	CIRCULAR
SWL-14	Dummy_Main	0.013	300	20	SWN-96	SWDP-136	437.500	435.491	CIRCULAR
SWL-15	Dummy_Main	0.013	300	13	SWN-95	SWDP-71	431.474	431.472	CIRCULAR
SWL-16	Dummy_Main	0.013	300	18	SWN-94	SWDP-213	430.582	428.635	CIRCULAR
SWL-17	Dummy_Main	0.013	300	22	SWN-93	SWDP-178	427.315	424.820	CIRCULAR
SWL-18	Dummy_Main	0.013	300	15	SWN-87	SWDP-123	394.421	393.313	CIRCULAR
SWL-19	Dummy_Main	0.013	300	22	SWN-88	SWDP-114	390.562	388.417	CIRCULAR
SWL-2	Dummy_Main	0.013	300	19	SWN-38	SWDP-78	341.628	341.228	CIRCULAR
SWL-20	Dummy_Main	0.013	300	18	SWN-84	SWDP-177	371.704	368.961	CIRCULAR
SWL-21	Dummy_Main	0.013	300	15	SWN-85	SWDP-197	371.496	369.490	CIRCULAR
SWL-22	Dummy_Main	0.013	300	21	SWN-33	SWDP-210	338.856	338.445	CIRCULAR
SWL-23	Dummy_Main	0.013	300	17	SWN-83	SWDP-142	367.477	365.306	CIRCULAR
SWL-24	Dummy_Main	0.013	300	15	SWN-81	SWDP-90	356.692	355.134	CIRCULAR
SWL-25	Dummy_Main	0.013	300	18	SWN-79	SWDP-51	356.835	355.907	CIRCULAR
SWL-26	Dummy_Main	0.013	300	20	SWN-51	SWDP-107	357.824	355.727	CIRCULAR
SWL-3	Dummy_Main	0.013	300	170	SWMH-635	SWMH-1475	455.960	443.035	CIRCULAR
SWL-34	Dummy_Main	0.013	300	14	SWMH-1430	SWDP-73	341.822	340.940	CIRCULAR
SWL-4	Dummy_Main	0.013	300	18	SWN-35	SWDP-92	337.060	336.890	CIRCULAR
SWL-42	Dummy_Main	0.013	300	16	SWN-9	SWDP-15	342.326	341.386	CIRCULAR
SWL-5	Dummy_Main	0.013	300	26	SWN-6	SWDP-29	387.890	382.150	CIRCULAR
SWL-6	Dummy_Main	0.013	300	26	SWN-5	SWDP-155	377.093	371.770	CIRCULAR
SWL-68	Dummy_Main	0.013	300	18	SWN-32	SWDP-183	338.736	338.664	CIRCULAR
SWL-69	Dummy_Main	0.013	600	19	SWN-53	SWN-137	338.800	341.767	CIRCULAR
SWL-7	Dummy_Main	0.013	300	23	SWN-4	SWDP-132	372.692	371.770	CIRCULAR
SWL-70	Dummy_Main	0.013	300	26	SWN-17	SWN-128	337.192	336.824	CIRCULAR
SWL-71	Dummy_Main	0.013	300	25	SWIN-760	SWDP-143	422.922	422.569	CIRCULAR
SWL-72	Dummy_Main	0.013	300	36	SWN-80	SWN-129	337.145	336.953	CIRCULAR
SWL-73	Dummy_Main	0.013	450	34	SWN-57	SWN-131	338.997	338.500	CIRCULAR
SWL-74	Dummy_Main	0.013	300	35	SWN-58	SWN-130	338.580	338.507	CIRCULAR
SWL-75	Dummy_Main	0.013	300	11	SWIN-1825	SWDP-75	398.438	396.115	CIRCULAR
SWL-76	Dummy_Main	0.013	300	16	SWN-78	SWN-132	338.479	337.809	CIRCULAR
SWL-78	Dummy_Main	0.013	300	17	SWN-56	SWDP-116	350.026	351.680	CIRCULAR
SWL-79	Dummy_Main	0.013	300	21	SWN-54	SWDP-38	342.979	343.200	CIRCULAR
SWL-8	Dummy_Main	0.013	300	22	SWN-3	SWDP-39	366.587	361.990	CIRCULAR
SWL-80	Dummy_Main	0.013	300	3	SWDP-133	SWN-127	438.471	437.706	CIRCULAR
SWL-81	Dummy_Main	0.013	300	61	SWMH-1468	SWDP-99	344.902	347.750	CIRCULAR
SWL-82	Dummy_Main	0.013	300	45	SWN-73	SWN-136	358.379	350.852	CIRCULAR
SWL-9	Dummy_Main	0.013	300	24	SWN-2	SWDP-2	363.714	361.990	CIRCULAR

Table C-3 Open Channels

Name	Tag	Roughness	Length (m)	Inlet Node	Outlet Node	Inlet Elev. (m)	Outlet Elev. (m)	Cross-Section	Depth (m)	Top Width for Triangular Channels (m)	Bottom Width For Trapezoidal Channels (m)	Left and Right Side Slope	Transect for Irregular Channels
SWOD-8	Open_Drain	0.03	205	SWN-11	SWN-13	386.295	367.517	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWOD-24	Open_Drain	0.03	80	SWMH-917	SWN-19	340.405	336.970	TRAPEZOIDAL	0.500	N/A	3.000	2	N/A
SWOD-23	Open_Drain	0.03	102	SWDP-9	SWN-14	337.039	337.000	TRAPEZOIDAL	1.300	N/A	3.000	2	N/A
SWOD-22	Open_Drain	0.03	29	SWN-14	SWN-16	337.000	336.990	TRAPEZOIDAL	1.300	N/A	3.000	2	N/A
SWOD-21	Open_Drain	0.03	90	SWN-18	SWN-19	336.980	336.970	TRAPEZOIDAL	1.300	N/A	3.000	2	N/A
SWOD-20	Open_Drain	0.03	6	SWN-19	SWN-22	336.970	336.960	TRAPEZOIDAL	1.300	N/A	3.000	2	N/A
SWOD-17	Open_Drain	0.03	72	SWN-12	SWMH-1030	366.736	363.141	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-67	Dummy_Open_Drain	0.03	95	SWN-37	SWDP-42	339.450	339.150	TRIANGULAR	1.500	3.000	N/A	N/A	N/A
SWL-66	Dummy_Open_Drain	0.03	33	SWDP-229	SWN-140	340.900	340.800	TRIANGULAR	1.800	3.000	N/A	N/A	N/A
SWL-65	Dummy_Open_Drain	0.03	127	SWN-98	SWDA-01	584.230	564.900	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-64	Dummy_Open_Drain	0.03	28	SWN-100	SWN-101	442.702	442.087	TRIANGULAR	0.500	3.000	N/A	N/A	N/A
SWL-63	Dummy_Open_Drain	0.03	11	SWMH-1470	SWN-102	441.821	441.720	TRIANGULAR	0.500	3.000	N/A	N/A	N/A
SWL-62	Dummy_Open_Drain	0.03	43	SWN-104	SWDP-133	441.446	438.471	TRIANGULAR	0.500	3.000	N/A	N/A	N/A
SWL-61	Dummy_Open_Drain	0.03	56	SWDP-100	SWN-109	556.220	551.500	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-60	Dummy_Open_Drain	0.03	202	SWMH-1609	SWN-110	543.000	524.500	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-59	Dummy_Open_Drain	0.03	145	SWMH-1419	SWMH-1361	375.927	370.548	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-58	Dummy_Open_Drain	0.03	6	SWMH-1361	SWMH-1360	370.548	370.148	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-57	Dummy_Open_Drain	0.03	50	SWMH-1360	SWMH-1250	370.148	368.000	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-56	Dummy_Open_Drain	0.03	80	SWN-111	SWN-112	522.000	514.500	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-55	Dummy_Open_Drain	0.03	45	SWN-119	SWN-98	588.900	584.230	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-54	Dummy_Open_Drain	0.03	52	SWN-115	P-SWN-63	513.200	509.509	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-53	Dummy_Open_Drain	0.03	201	P-SWN-63	SWN-116	509.509	490.000	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-52	Dummy_Open_Drain	0.03	54	SWN-118	SWMH-484A	484.725	484.000	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-51	Dummy_Open_Drain	0.03	182	SWDP-201	SWN-98	595.000	584.230	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-50	Dummy_Open_Drain	0.03	81	SWDP-112	SWMH-593	477.888	476.493	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-49	Dummy_Open_Drain	0.03	74	SWN-61	SWN-37	339.492	339.450	TRIANGULAR	1.500	3.000	N/A	N/A	N/A
SWL-48	Dummy_Open_Drain	0.03	181	SWDP-257	SWDP-17	346.268	343.439	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-47	Dummy_Open_Drain	0.03	88	SWDP-17	SWN-126	343.439	341.000	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-46	Dummy_Open_Drain	0.03	9	SWN-1	SWN-53	338.810	338.800	IRREGULAR	N/A	N/A	N/A	N/A	Transect
SWL-45	Dummy_Open_Drain	0.03	116	SWDA-E	SWN-36	338.900	338.810	IRREGULAR	N/A	N/A	N/A	N/A	Outfall_Inlet_Channel
SWL-44	Dummy_Open_Drain	0.03	183	SWDP-157	SWDA-A	341.500	341.130	IRREGULAR	N/A	N/A	N/A	N/A	Pond_E_Outlet_Channel
SWL-43	Dummy_Open_Drain	0.03	99	SWN-48	SWDA-B	341.130	340.320	IRREGULAR	N/A	N/A	N/A	N/A	Pond_A_Inlet_Channel
SWL-41	Dummy_Open_Drain	0.03	26	SWN-49	SWDA-C	340.320	339.450	IRREGULAR	N/A	N/A	N/A	N/A	Pond_B_Inlet_Channel
SWL-40	Dummy_Open_Drain	0.03	283	SWN-50	SWDA-D	339.450	339.200	IRREGULAR	N/A	N/A	N/A	N/A	Pond_C_Inlet_Channel
SWL-39	Dummy_Open_Drain	0.03	169	SWDA-D	SWDA-E	339.200	338.900	IRREGULAR	N/A	N/A	N/A	N/A	Pond_D_Inlet_Channel
SWL-38	Dummy_Open_Drain	0.03	44	SWMH-1473	SWN-71	340.424	340.422	TRIANGULAR	1.500	3.000	N/A	N/A	Pond_E_Inlet_Channel
SWL-37	Dummy_Open_Drain	0.03	62	SWN-71	SWN-61	340.422	339.492	TRIANGULAR	1.500	3.000	N/A	N/A	N/A
SWL-36	Dummy_Open_Drain	0.03	61	SWDP-42	SWN-107	339.150	339.140	TRIANGULAR	1.650	3.000	N/A	N/A	N/A
SWL-35	Dummy_Open_Drain	0.03	474	SWMH-301	SWN-138	422.492	342.000	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-33	Dummy_Open_Drain	0.03	130	SWN-52	SWN-123	374.781	374.027	TRIANGULAR	0.500	3.000	N/A	N/A	N/A
SWL-32	Dummy_Open_Drain	0.03	146	SWN-63	SWN-52	388.474	374.781	TRIANGULAR	0.500	3.000	N/A	N/A	N/A
SWL-31	Dummy_Open_Drain	0.03	107	SWDP-27	SWN-84	372.089	371.704	TRIANGULAR	0.500	3.000	N/A	N/A	N/A
SWL-30	Dummy_Open_Drain	0.03	196	SWN-82	SWDP-32	359.347	346.563	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-29	Dummy_Open_Drain	0.03	75	SWDP-32	SWSC-70	346.563	339.630	TRIANGULAR	0.500	2.500	N/A	N/A	N/A
SWL-28	Dummy_Open_Drain	0.03	687	SWN-75	SWN-59	414.678	361.928	TRIANGULAR	1.000	3.000	N/A	N/A	N/A
SWL-27	Dummy_Open_Drain	0.03	28	SWN-59	SWN-30	361.928	358.231	TRIANGULAR	1.000	3.000	N/A	N/A	N/A

Table C-4 Transects

Outlet_Inlet_Channel		Pond_A_Inlet_Channel		Pond_B_Inlet_Channel		Pond_C_Inlet_Channel	
Source: Golf Course Drainage Pond Drawings		Source: Golf Course Drainage Pond Drawings		Source: Golf Course Drainage Pond Drawings		Source: Golf Course Drainage Pond Drawings	
Station (m)	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**
3.60	339	0.00	343	0.00	342	0.00	341
0.00	340	0.10	342	0.10	341	0.10	341
0.10	340	3.60	341	3.60	340	3.60	339
5.55	339	5.55	341	5.55	340	5.55	339
9.14	340	9.14	342	9.14	341	9.14	341
9.15	340	9.15	343	9.15	342	9.15	341

Pond_D_Inlet_Channel		Pond_E_Inlet_Channel		Pond_E_Outlet_Channel	
Source: Golf Course Drainage Pond Drawings		Source: Golf Course Drainage Pond Drawings		Source: Golf Course Drainage Pond Drawings	
Station (m)	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**
0.00	341	0.00	341	0.00	340
0.10	340	0.10	340	0.10	340
3.60	339	3.60	339	3.60	339
5.55	339	5.55	339	5.55	339
9.14	340	9.14	340	9.14	340
9.15	341	9.15	341	9.15	340

Table C-5 Detention Facilities

Name	Tag	(m)	Rim Elev. (m)	Data Source	Curve Name
SWDA-01	Dry_Pond_No_NWL	564.5	567.0	Sendero Canyon Record	Pond-S-1-ST
SWDA-02	Wet_Pond_NWL	336.4	339.0	Skaha Lake Pond Record Drawings	1049-IN-ST
SWDA-A	Wet_Pond_NWL	341.1	343.3	Golf Course Drainage Record Drawings	Pond-A-ST
SWDA-B	Wet_Pond_NWL	340.3	342.3	Golf Course Drainage Record Drawings	Pond-B-ST
SWDA-C	Wet_Pond_NWL	339.5	341.6	Golf Course Drainage Record Drawings	Pond-C-ST
SWDA-D	Wet_Pond_NWL	339.2	341.1	Golf Course Drainage Record Drawings	Pond-D-ST
SWDA-E	Wet_Pond_NWL	338.9	341.0	Golf Course Drainage Record Drawings	Pond-E-ST

Table C-6 Detention Rating Curves

1049-IN-ST		Pond-A-ST		Pond-B-ST		Pond-C-ST		Pond-D-ST		Pond-E-ST		Pond-S-1-ST	
Source: Skaha Lake Record Drawings and Old Model, which assumed storage provided as a rectangular basin with total storage volume of 6500 m3		Source: Golf Course Drainage Record Drawings and Old Model, which assumed storage provided as a rectangular basin with total storage volume of 2300 m3		Source: Golf Course Drainage Record Drawings and Old Model, which assumed storage provided as a rectangular basin with total storage volume of 1200 m3		Source: Golf Course Drainage Record Drawings and Old Model, which assumed storage provided as a rectangular basin with total storage volume of 2100 m3		Source: Golf Course Drainage Record Drawings and Old Model, which assumed storage provided as a rectangular basin with total storage volume of 2000 m3		Source: Golf Course Drainage Record Drawings and Old Model, which assumed storage provided as a rectangular basin with total storage volume of 2200 m3		Source: Sendero Canyon Record Drawings, which assumed a total storage volume of 508 m3	
Depth (m)	**Area (m^2)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**	**Station (m)**	**Elevation (m)**
0.00	2,453	0.00	1,060	0.00	606	2.15	977	0.00	1,053	0.00	1,048	0.00	199
2.65	2,453	2.17	1,060	1.98	606	0.00	977	1.90	1,053	2.10	1,048	2.55	199

Table C-7 Outfalls

Name	5-Year Fixed Water Level (m)	100-Year Fixed Water Level (m)
SWDP-10	358.00	361.99
SWDP-103	341.31	341.31
SWDP-106	350.49	350.49
SWDP-107	355.73	355.73
SWDP-113	340.00	343.20
SWDP-114	388.42	388.42
SWDP-116	339.61	351.68
SWDP-120	340.51	341.47
SWDP-121	373.07	373.07
SWDP-123	393.31	393.31
SWDP-126	372.60	372.60
SWDP-130	339.61	347.75
SWDP-132	368.35	371.77
SWDP-134	424.20	424.20
SWDP-136	435.49	435.49
SWDP-137	470.46	470.46
SWDP-139	339.61	343.20
SWDP-142	365.31	365.31
SWDP-143	422.57	422.57
SWDP-146	360.30	361.99
SWDP-147	430.00	430.00
SWDP-149	418.61	418.61
SWDP-15	341.39	341.39
SWDP-152	340.82	340.82
SWDP-155	368.35	371.77
SWDP-156	337.12	337.12
SWDP-159	358.59	358.59
SWDP-16	342.24	342.24
SWDP-167	346.71	346.71
SWDP-172	336.90	336.90
SWDP-173	343.51	343.51
SWDP-177	368.96	368.96
SWDP-178	424.82	424.82
SWDP-179	348.78	348.78
SWDP-18	403.39	403.39
SWDP-181	337.00	337.00
SWDP-183	338.66	338.66
SWDP-186	341.81	341.81
SWDP-189	403.00	403.00
SWDP-19	337.97	337.97
SWDP-192	337.41	337.41

SWDP-197	369.49	369.49
SWDP-199	341.03	341.03
SWDP-2	358.00	361.99
SWDP-202	415.20	415.20
SWDP-204	378.74	378.74
SWDP-209	340.75	340.75
SWDP-210	338.45	338.45
SWDP-213	428.64	428.64
SWDP-226	339.61	343.20
SWDP-230	524.90	524.90
SWDP-231	415.20	415.20
SWDP-232	400.00	400.49
SWDP-233	339.61	343.20
SWDP-234	338.57	338.57
SWDP-237	336.95	336.95
SWDP-238	338.87	338.87
SWDP-240	338.00	338.00
SWDP-241	340.00	340.00
SWDP-242	339.74	339.74
SWDP-244	337.42	337.42
SWDP-246	356.00	361.99
SWDP-247	355.40	361.99
SWDP-248	337.40	337.40
SWDP-249	453.24	453.24
SWDP-250	387.70	387.70
SWDP-251	341.03	341.03
SWDP-252	340.94	340.94
SWDP-259	373.07	373.07
SWDP-26	360.05	361.99
SWDP-29	382.15	382.15
SWDP-34	371.10	371.10
SWDP-35	397.22	397.22
SWDP-36	336.82	336.82
SWDP-38	339.61	343.20
SWDP-39	358.00	361.99
SWDP-41	340.82	340.82
SWDP-44	339.02	339.02
SWDP-50	455.67	455.67
SWDP-51	355.91	355.91
SWDP-55	430.14	430.14
SWDP-57	452.20	452.20
SWDP-58	348.15	348.15
SWDP-59	340.57	340.57
SWDP-6	336.77	336.77
SWDP-60	361.99	361.99

SWDP-62	336.59	336.59
SWDP-71	431.47	431.47
SWDP-73	340.94	340.94
SWDP-75	396.12	396.12
SWDP-77	356.00	357.93
SWDP-78	339.61	339.61
SWDP-8	363.88	363.88
SWDP-84	339.61	347.75
SWDP-85	338.08	338.08
SWDP-87	337.80	337.80
SWDP-90	355.13	355.13
SWDP-92	336.89	336.89
SWDP-94	356.00	361.99
SWDP-97	403.53	403.53
SWDP-98	341.00	341.00
SWDP-99	339.61	344.58
SWMH-1435	339.85	339.85
SWMH-1445	438.53	438.53
SWMH-1460	381.90	381.90
SWN-120	340.82	340.82
SWN-121	339.84	340.80
SWN-123	374.03	374.03
SWN-124	358.73	358.73
SWN-125	338.00	338.00
SWN-126	341.00	341.00
SWN-127	437.71	437.71
SWN-128	336.82	336.82
SWN-129	336.95	336.95
SWN-130	338.51	338.51
SWN-131	338.50	338.50
SWN-132	337.81	337.81
SWN-133	353.12	353.12
SWN-134	422.57	422.57
SWN-135	403.00	403.00
SWN-136	350.85	350.85
SWN-137	340.80	341.76
SWN-138	342.00	342.00
SWN-139	500.17	500.17
SWN-140	340.82	340.82
SWN-141	337.60	337.60
SWN-142	449.07	449.07
SWN-143	453.13	453.13

SWSC-250	342.20	343.16

APPENDIX

APPENDIX

D

TECH MEMO. # 3: DESIGN STORMS

PENTICTON IIMP

MEMO

TO: Tobi Pettet, P. Eng., Project Manager, City of Penticton

FROM: Stephen Horsman, P. Eng., P.E., Jay Patel, E.I.T.

SUBJECT: **Technical Memo #3: IDF Curves and Design Storms**

DATE: **August 5, 2020**

WSP Canada Group Limited (WSP) is pleased to provide the following technical memorandum (Memo) detailing a review of intensity-duration-frequency (IDF) curves and design storms for the City of Penticton (City).

INTRODUCTION

IDF curves characterize the relationship between rainfall intensity, rainfall duration and frequency of occurrence (return period). They are typically used in the design of urban drainage systems to estimate runoff rates and volume.

The City's IDF curves from the Subdivision and Development Bylaw 2004-81 - Drawing S-S31 (**Appendix A**) are developed based on frequency analysis of rainfall observations at the Penticton Airport Climate Station, which include 34 years (1953 – 1990) of historical data.

Under a changing climate, it is understood that high intensity rainfall events will occur more frequently in the future. As such, historically derived IDF curves may not be appropriate to assess existing infrastructure. The City must adapt to anticipated climate patterns to ensure that adequate levels of service are maintained for the 2045 Official Community Plan (OCP) horizon. This Memo summarizes the methodology used to identify future IDF curves for the City's stormwater model.

REVIEW OF IDF CURVES

Many regional climate change models have become readily available over the recent years and can be applied locally to project changes in rainfall intensity. Future IDF curves for the City are estimated using the IDF+CC tool, which is a web-based application developed by the University of Western Ontario. The tool generates IDF curves at Climate Stations across Canada based on several global climate models that account for the affects of Greenhouse Gas (GHG) concentrations in the atmosphere.

This tool considers four scenarios of future GHG concentrations known as Representative Concentration Pathways (RCPs). These RCPs provide a range of possible trajectories of how global land use, GHG emissions and air pollutants may change throughout the 21st century. They are named according to their radiative forcing values (the change in net irradiance in the troposphere due to external drivers) in the year 2100: 2.6, 4.5, 6.0, and 8.5 Wm-2. RCP 2.6 represents the least carbon intensive pathway, which corresponds to a level of decarbonization that exceeds the most ambitious decarbonization scenarios, while RCP 8.5 represents the most carbon intensive pathway, corresponding to a 'business as usual' scenario.

There is a scientific consensus that the RCP 8.5 pathway represents the ongoing trend in GHG emissions worldwide. For this reason, and because it is the most conservative option, the RCP 8.5 pathway was selected as the most realistic worst-case scenario. The following parameters were selected to run the IDF+CC tool:

- Penticton Airport Climate Station (ID 1126150);
- All ensemble models (bias corrected) for the projection period of 2020 to 2100; and
- RCP 8.5 scenario

To manage the range in uncertainty within the RCP 8.5 results, the following projections were obtained:

- Low Projection (25th Percentile)
- Moderate Projection (50th Percentile)
- High Projection (75th Percentile)
- Very High Projection (90th Percentile)

Figure 1 and

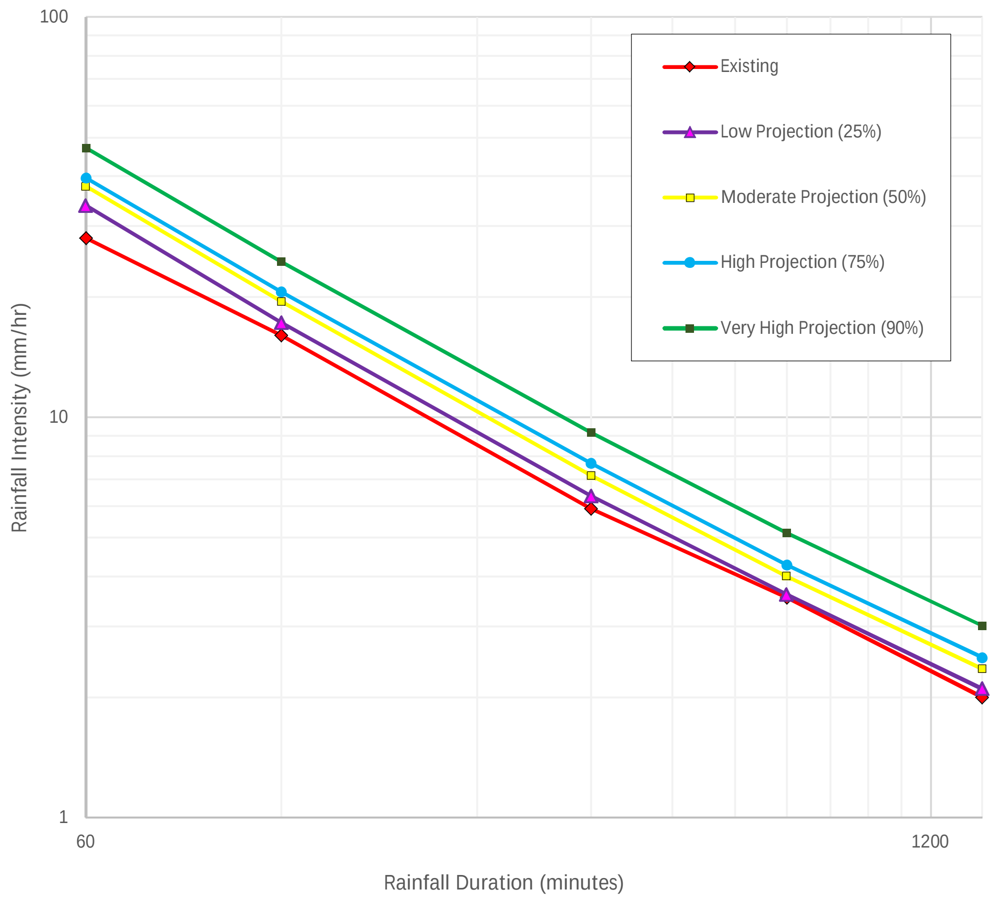


Figure 2 illustrates the 5-year (minor) and 100-year (major) return period IDF Curves, with existing (Bylaw) and climate change projected adjustments as applied per the IDF+CC tool as noted above, respectively.

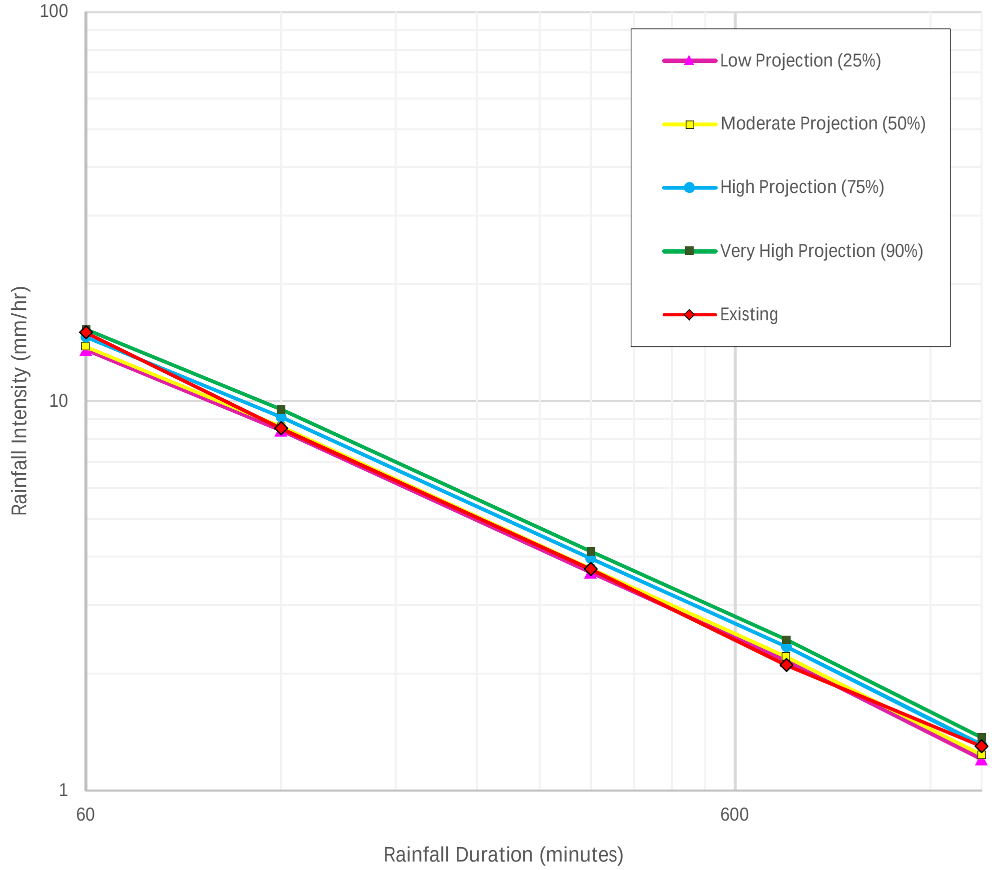


Figure 1- 5-Year Return Period IDF Curves

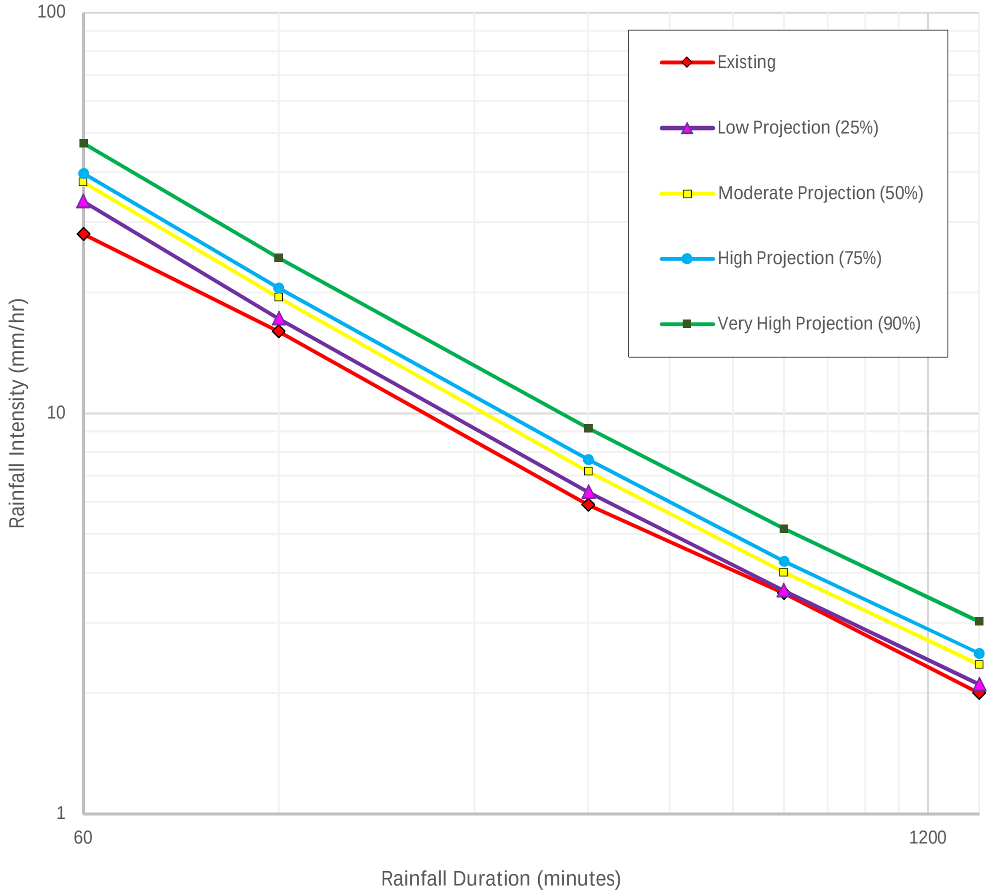


Figure 2 - 100-Year Return Period IDF Curves

For the 5-year return period, it can be observed that there is little difference in rainfall intensities between the City's existing IDF and the climate change IDFs. This is due to the uncertainty in sub-hourly projections. The IDF+CC tool predicts future sub-daily rainfall intensities directly from historical sub-daily data and Global Climate Models (GCM) daily maximum data from the Pacific Climate Impacts Consortium (PCIC), effectively using a daily to sub-daily ratio of 1.0. The scaling factor was identified by GHD in their 2018 assessment for Metro Vancouver as being the most sensitive variable with respect to uncertainty in future projections, resulting in the underestimation of sub-hourly projections.

In contrast, the very high projected rainfall intensities for the 100-year return period are 50 to 80 % higher than existing for all durations.

ASSUMPTIONS AND LIMITATIONS

There is an inevitable level of uncertainty to consider in using climate modeling as it relies on our understanding of future GHG emissions and how the earth's climate system will respond to the changes in GHG concentrations in the atmosphere. Additional uncertainty in the results presented includes assumptions related to how projections of sub-daily extreme precipitation are extrapolated from daily information and the uncertainty associated with these assumptions is not adequately defined. These assumptions can result in underestimating the sub hourly intensities and therefore flows.

A review of current industry practices to project future climate change IDF parameters was undertaken. While the IDF+CC Tool is typically used in most cases, it is well known that the tool has its shortcomings when estimating climate change influenced short duration storm events, and, as detailed above, will only increase the City of Penticton's storm intensity by a factor of ~2 %. As a result, WSP has reviewed other common tools, such as the Metro Vancouver climate change tool, as well as the 2014 Design Guideline Manual published by the Master Municipal Construction Documents (MMCD) Association for an alternate approach to future IDF estimation. As per recommendations from MMCD, we have decided to take the approach to approximate future design storms for the City of Penticton by increasing the intensity of the City's existing design storms by 1.15 (2014, p. 31). The future design storm created will be used to assess stormwater network deficiencies under future conditions and to size associated recommended upgrades.

WSP additionally notes that there is currently no industry consensus to derive climate change IDF curves for future conditions. There are much more detailed reviews which can be undertaken to develop climate change IDF curves, but these are typically much larger and completed as comprehensive and separate investigations. We would suggest that the City of Penticton can investigate the development of more accurate climate change IDF curves as a future project.

DESIGN STORMS FOR MODELLING

For modelling purposes, it is necessary to transform the total rainfall depths obtained from IDF analysis into a storm distribution which describes the variation of rainfall intensity over time. Various storm distributions are available to practitioners – the most widely used include; the Atmospheric Environment Service (AES, now known as the Meteorological Service of Canada) distributions, the US Soil Conservation Service (SCS) distributions, and the Chicago Design Storm.

The AES storm distribution (BC Interior region)—as defined in Table 9.3 and Figure 9.3 of the Hydrology of Floods in Canada: A Guide to Planning and Design (1989, p. 159) is selected to assess the performance of City's stormwater infrastructure. The AES distribution is selected given its widespread use in BC, and the fact that it offers modifications to the distribution to suit different regional rainfall patterns (in this case BC Interior). This decision is supported by the MMCD (2014, p. 31), which recommends use of AES rainfall distributions for cases where the local authority has no specific guidelines.

The 1-hour storm duration is selected as suitable for assessment of the urban flooding and storm conveyance while the 24-hour storm duration is selected as suitable for evaluation of storage issues under consideration. A future design storm which is 15% higher than the existing bylaw IDF curve has also been provided.

Figure 3 and **Figure 4** displays the design storms for the 5-year and 100-year return periods, which will be used for the stormwater master planning assignment, respectively.

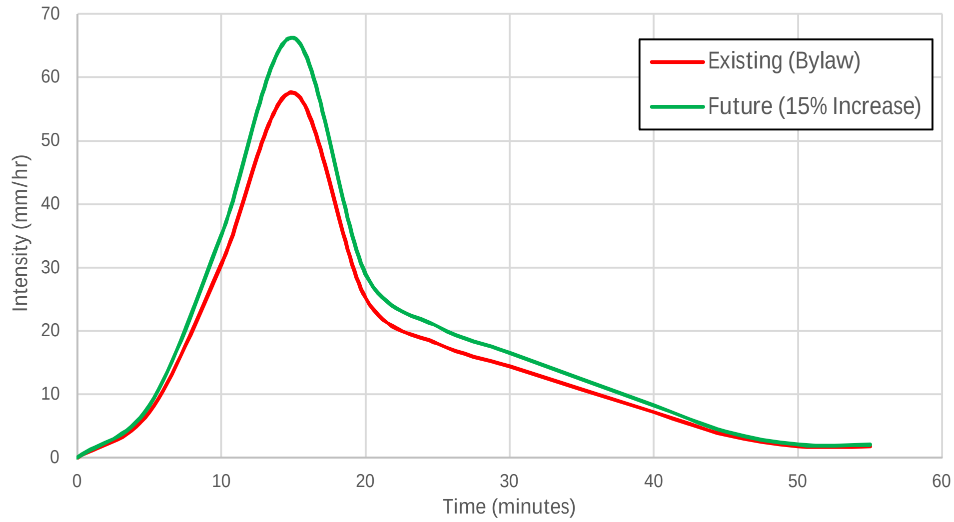


Figure 3 – 1-Hour AES Type 2 (BC Interior) Distribution for the 5-Year Event

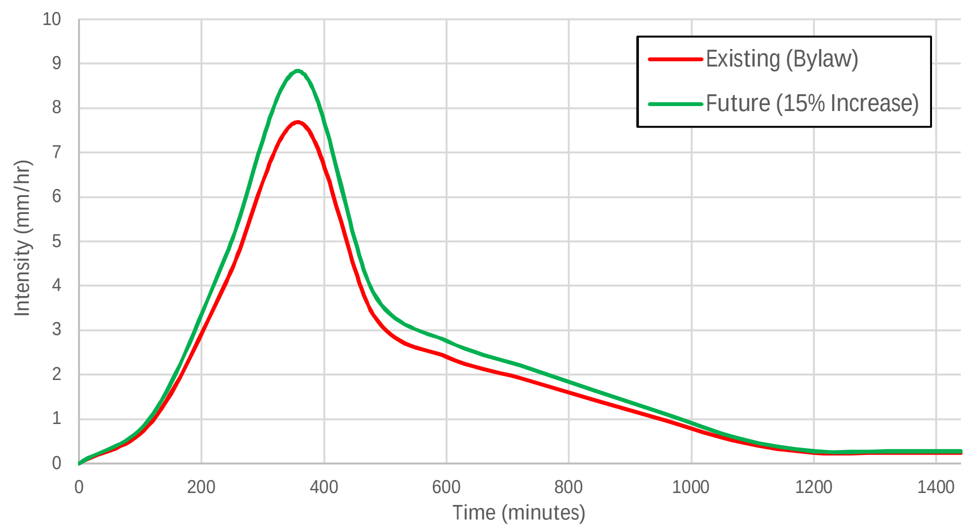


Figure 4 - 24-Hour AES Type 2 (BC Interior) Distribution for the 100-Year Event

SUMMARY

WSP compared existing and projected IDF curves for future conditions by using a web-based tool that considers the potential impacts of climate change (**Figure 1** and **Figure 2**). The results do not show a significant increase in the short-duration events for the 5-year return period due to the limitations of the tool.

As such, WSP increased the intensity of existing storms by 15 %, as recommended in the MMCD and the 2017 Stormwater Master Plan Update (15 – 20 %) to incorporate climate change and design resilient, "Future-Ready" infrastructure. IDF curves represented in **Appendix A** are used to derive corresponding design storms shown in **Figure 3** and **Figure 4**.

The 1-hour AES Type 2 Storm (BC Interior) will be used to assess capacity of minor system components such as gravity sewers, open channels and ditches while the 24-hour AES Type 2 storm (BC Interior) will be used to assess the capacity of major system components such as detention ponds and culverts.

CLOSURE

We trust you will find the foregoing letter report suitable. Please do not hesitate to contact the undersigned should you have any questions.

Stephen Horsman, P.Eng., P.E.
Manager, Water

REFERENCES

GHD. (2018). *Study of the Impacts of Climate Change Precipitation and Stormwater Management*. Greater Vancouver Sewerage and Drainage District.

Master Municipal Construction Documents Association. (2014). *Design Guidelines 2014.* Master Municipal Construction Documents Association.

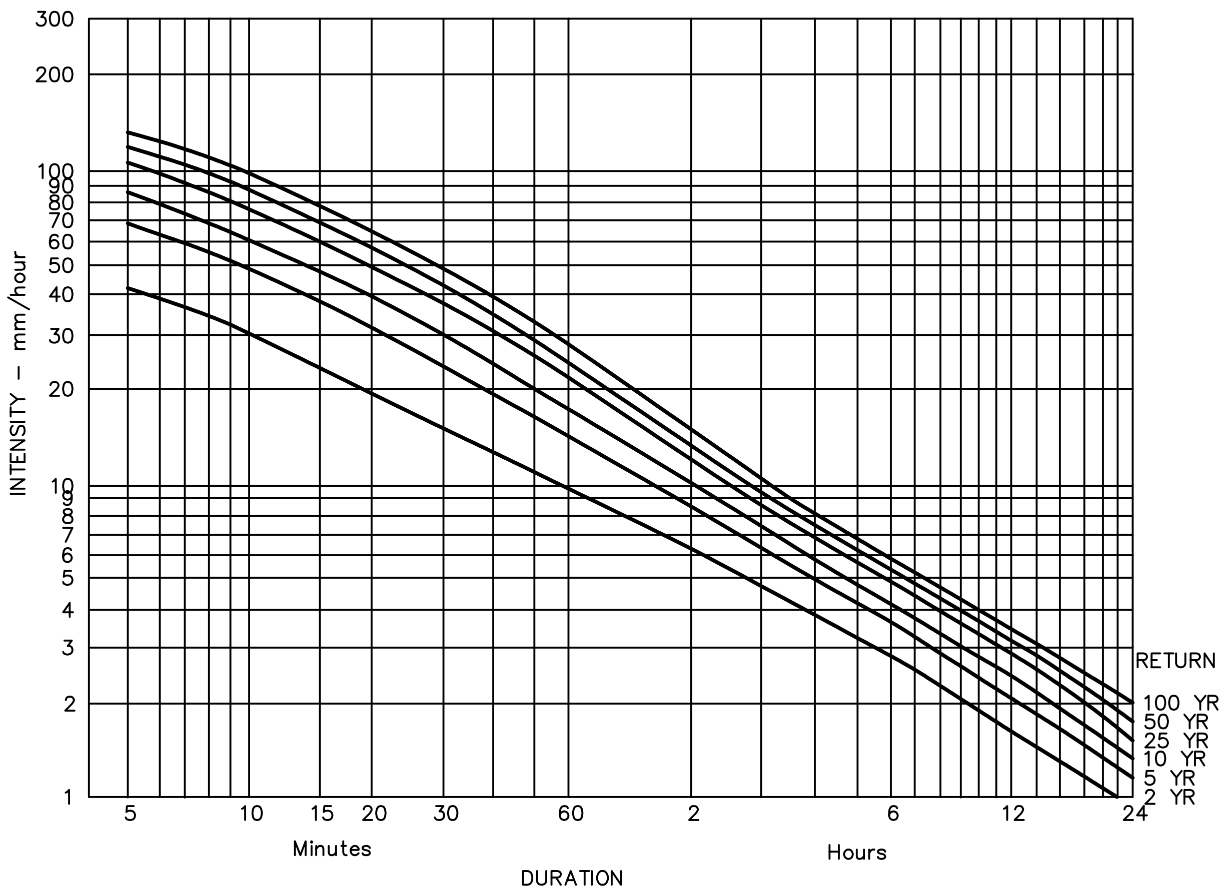
Watt, W. E. (1989). *Hydrology of floods in Canada: A Guide to Planning and Design*. National Research Council Canada.

APPENDIX A

STANDARD DETAIL DRAWINGS

PENTICTON AIRPORT

INTENSITY DURATION FREQUENCY CURVES



BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD OF 1953–1990 (34 YEARS RECORDED)

LATTITUDE 49°28', LONGITUDE 119°36', ELEVATION 341m

2004

RAINFALL INTENSITY DURATION FREQUENCY CURVES	APPROVED	DRAWING NUMBER:
	NOVEMBER, 2004	S–S31

APPENDIX

APPENDIX

E

TECH. MEMO #5: POPULATION PROJECTIONS

PENTICTON IIMP

MEMO

TO: Tobi Pettet, P.Eng., Project Manager, City of Penticton

FROM: Stephen Horsman, P.Eng., P.E.

SUBJECT: **Technical Memo #5: Population Projections**

DATE: **September 4, 2020**

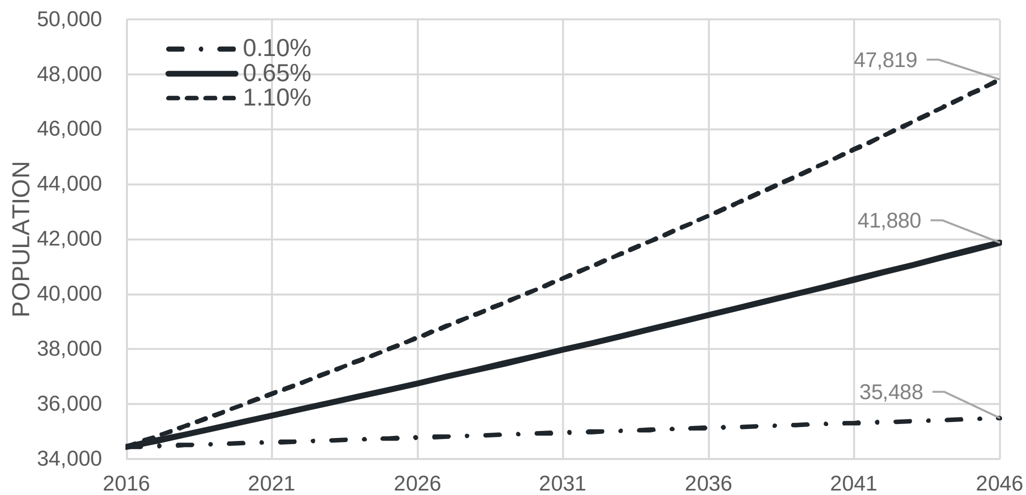
WSP is pleased to provide the following technical memorandum outlining the proposed population projections and future growth planning for the Integrated Infrastructure Master Plan (IIMP). The purpose of this memorandum is to build on the planned growth within the City based on the 2045 Official Community Plan (OCP) to inform the develop and analysis of future infrastructure needs for the City's transportation, water, stormwater and sanitary infrastructure.

POPULATION GROWTH

Based on the most recent 2016 census data, the City's adjusted population was identified to be 34,440 in 2016. over the past twenty years the City has seen moderate but steady population growth, averaging at approximately 0.48% between 2006 and 2016. Based on the 2002 OCP, the City had planned for a population of approximately 45,000 by 2018, however actual growth was significantly less. The 2045 OCP, the City identified a lower growth rate that more closely aligned with historical rates resulting in a median growth rate for future planning within the City to 0.65% between 2016 and 2046. High and low rate projects are listed as 1.1% and 0.1%, respectively.

Figure 1 presents the population projections based on the median, high and low growth rates proposed in the 2045 OCP.

FIGURE 1 2045 OCP POPULATION PROJECTIONS



POPULATION DENSITY

The assumptions for all future residential and future commercial/mixed use areas, when applied to the all quarter sections to be developed within the next 25 years, were calculated to meet the OCP population projections.

RESIDENTIAL

The 2016 Statistics Canada population breakdown by dwelling type (i.e. single-detached house, semi-detached, apartment or flat in a duplex, etc) was extrapolated to the 2017 baseline scenario to determine typical occupancy rates for single family and multi-family dwellings based on the available unit counts for each residence from the City's GIS database, as follows:

- Single Family Detached Dwellings – occupancy rate of 2.6 persons per lot.
- Multi-Family semi-detached, row house, duplex and other attached dwellings – occupancy rate of 2.4 persons per unit.
- Multi-Family movable dwellings and apartments – occupancy rate of 1.6 persons per unit.

The occupancy rates were then applied to the 25-year population forecast to develop dwelling unit counts which were compared to the 2018 Report by Urbanics Consultants Ltd. entitled *City of Penticton Population Projections and Housing Needs Review*. The final population forecasts and unit counts by each year developed for this assignment are comparable to the 2018 Urbanics Report, although some adjustments to dwelling unit counts were required to align population estimates.

Table 1 summarizes the forecasted residential dwelling unit breakdowns to the 2045 OCP horizon.

TABLE 1 RESIDENTIAL DWELLING UNITS BREAKDOWN TO THE 2046 OCP HORIZON

Year	Horizon	Single Family (Detached)	Multi-Family (Category 1) (1)	Multi-Family (Category 2) (2)	Total Residential Units
2016	Latest Census	6,749	3,032	6,047	15,828
2017	Baseline	6,796	3,081	6,038	15,915
2021	-	6,982	3,278	6,013	16,273
2025	5-year horizon	7,126	3,469	6,079	16,675
2026	-	7,162	3,517	6,099	16,778
2030	10-year horizon	7,284	3,712	6,215	17,211
2031	-	7,314	3,761	6,246	17,321
2036	-	7,488	4,038	6,334	17,860
2040	20-year horizon	7,627	4,278	6,396	18,301
2041	-	7,662	4,338	6,414	18,414
2045	25-year OCP horizon	7,676	4,524	6,780	18,980

(1) Multi-Family Category 1 includes semi-detached, row house, duplex and other attached dwellings.
(2) Multi-Family Category 2 includes movable dwellings and apartments.

Table 2 summarizes the forecasted residential population breakdowns to the 2045 OCP horizon.

TABLE 2 RESIDENTIAL POPULATION BREAKDOWN TO THE 2046 OCP HORIZON

Year	Horizon	Single Family (Detached)	Multi-Family (Category 1) (1)	Multi-Family (Category 2) (2)	Total Residential Units
2016	Latest Census	17,455	7310	9,675	34,440
2017	Baseline	17,575	7429	9,661	34,665
2021	-	18,057	7903	9,620	35,581
2025	5-year horizon	18,430	8364	9,727	36,521
2026	-	18,523	8480	9,758	36,760
2030	10-year horizon	18,837	8950	9,944	37,731
2031	-	18,916	9068	9,994	37,978
2036	-	19,366	9736	10,135	39,237
2040	20-year horizon	19,726	10314	10,233	40,273
2041	-	19,816	10459	10,262	40,537
2045	25-year OCP horizon	19,851	10908	10,848	41,608

(1) Multi-Family Category 1 includes semi-detached, row house, duplex and other attached dwellings.
(2) Multi-Family Category 2 includes movable dwellings and apartments.

INSTITUTIONAL, COMMERCIAL/MIXED USE, AND INDUSTRIAL

Population equivalents were calculated for existing ICI properties using the latest available annual water consumption meter data from 2017 for the entire Penticton water network. An overall residential per capita demand rate was applied to ICI metered consumption to estimate population equivalents.

For the OCP horizon, commercial and industrial population equivalents were assumed to increase according to the medium demand projections from the 2018 Report by Colliers International entitled *City of Penticton Commercial and Industrial Capacity Study*. Institutional population equivalents were assumed to increase proportionately to the growth projected in residential populations (i.e. using a median growth rate of 0.65%), while rural areas were not allocated any future growth population equivalents. Table 3 summarizes the forecasted 2045 ICI population equivalents breakdown by land use type.

TABLE 3 ICI POPULATION EQUIVALENTS BREAKDOWN TO THE 2046 OCP HORIZON

Year	Horizon	Institutional	Commercial	Industrial	Rural
2016	Latest Census	-	-	-	-
2017	Baseline	2942	8713	851	1019
2021	-	3020	9195	890	1019
2025	5-year horizon	3100	9705	931	1019
2026	-	3120	9837	941	1019
2030	10-year horizon	3202	10385	985	1019
2031	-	3223	10543	996	1019
2036	-	3330	11379	1012	1019

Year	Horizon	Institutional	Commercial	Industrial	Rural
2040	20-year horizon	3418	12097	1025	1019
2041	-	3440	12284	1028	1019
2045	25-year OCP horizon	3531	13063	1042	1019

PLANNED GROWTH AREAS

The 2045 OCP identified several growth priorities for the City with an increased focus on intensification within the existing developed landbase and reduced focus on expanding service to peripheral areas including hillside developments. The following sections describes each of the planned growth areas, as identified in the OCP.

Table 4 summarizes the population increase for each major OCP growth area.

TABLE 4 2045 POPULATION GAIN BREAKDOWN BY MAJOR OCP GROWTH AREAS

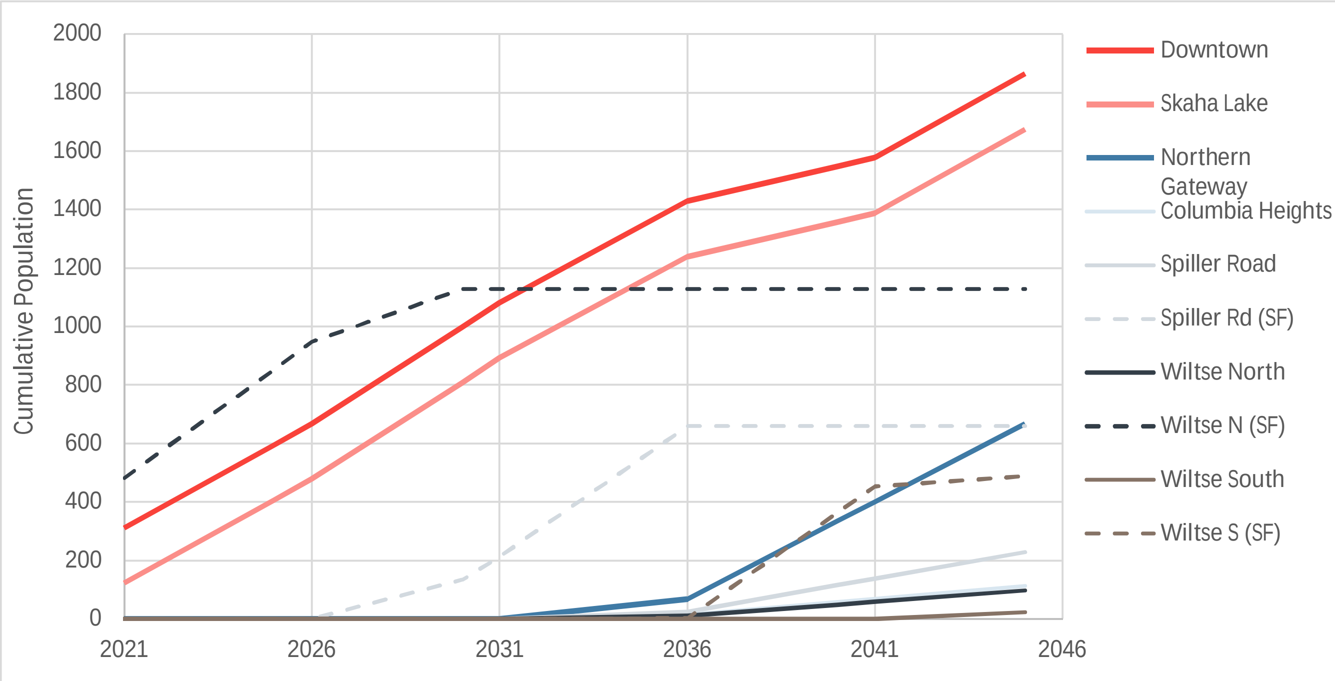
OCP Growth Area(1)	Single Family Population	Multi Family Population	ICI Population Equivalents
Downtown	0	1,865	2,523
Skaha Lake Rd	0	1,674	1,610
Northern Gateway	0	668	807
Infill Industrial	0	0	191
Columbia Heights	0	113	0
Spiller Rd	659	228	0
Wiltse North	1,128	97	0
Wiltse South	488	22	0
Total Population Change	**2,276**	**4,667**	**5,131**

(1) Future OCP areas designated for Agricultural, Natural and Conservation Areas, and Parks zoning were not allocated population equivalents.

It should be noted that subdivision plans were available for the Wiltse and Spiller Rd growth areas which were allocated specific population estimates based on available plans. Plans for redevelopment of the El Rancho Motel property in the Northern Gateway area was also included. However, the remaining growth areas were allocated future populations based on a proportion of rezoned parcels within each growth area.

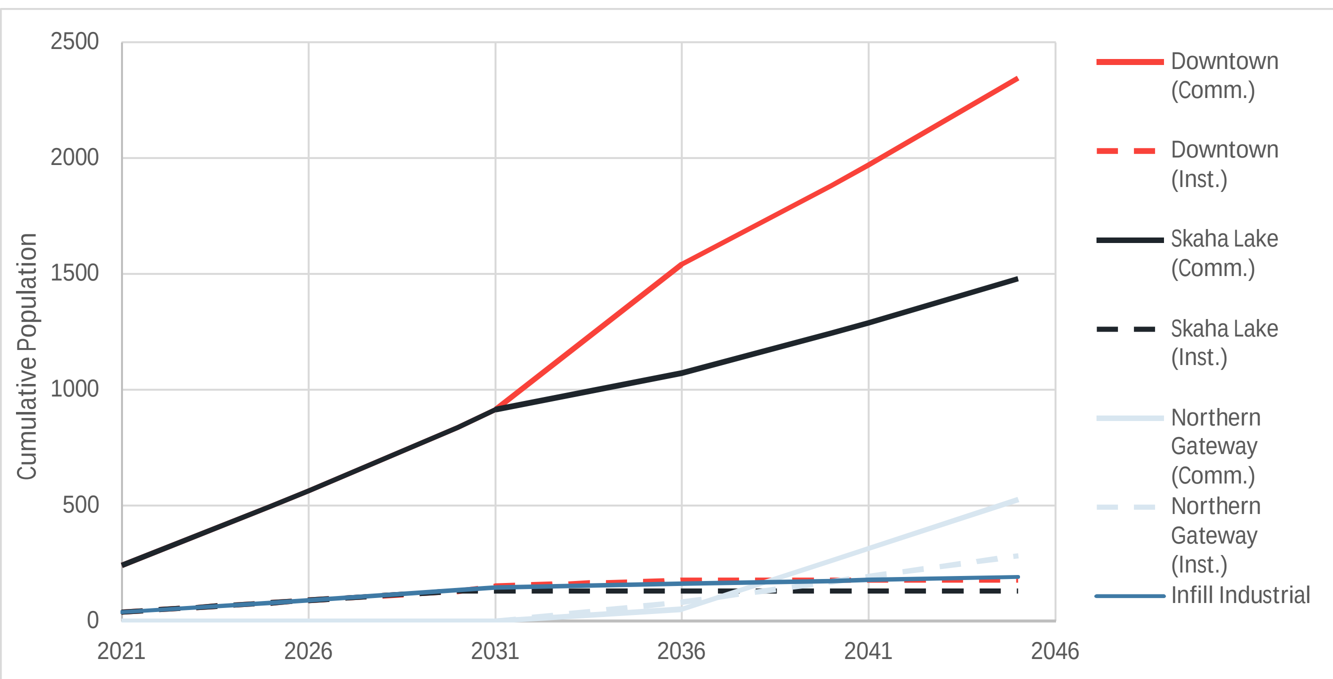
Based on discussions with City planning staff regarding the likely timing of buildout within the major OCP growth areas identified, and the forecasted populations from Tables 2 and 3 for all interim years between present and OCP conditions, the population breakdown per development area was split over the 25-year planning horizon, as illustrated in Figures 2 and 3.

FIGURE 2 CUMULATIVE POPULATION LOADING PER MAJOR OCP GROWTH AREA (SINGLE FAMILY & MULTI-FAMILY)



As illustrated in Figure 2, single family infill and growth is predominantly allocated to the Wiltse North and Spiller Road areas in the short-term, with additional single family growth in Wiltse South in the 15 to 20 year horizon. Multi-Family infill and growth is primarily in the Downtown and Skaha Lake areas in the short term, with these areas assumed to see steady growth to the 2045 OCP horizon. Additional multi-family infill and growth is assumed to occur in surrounding areas in the 15 to 25 year horizon.

FIGURE 3 CUMULATIVE POPULATION EQUIVALENT LOADING PER MAJOR OCP GROWTH AREA (ICI)



As illustrated in Figure 3, ICI growth is predominantly within commercial sectors in the Downtown and Skaha Lake areas, with steady institutional and industrial growth across the 25-year horizon. Figure 4 illustrates the locations of the planned growth areas within the City.

FIGURE 4 OCP GROWTH AREAS (ESTIMATED)