Bowker Creek

URBAN WATERSHED RENEWAL INITIATIVE

Bowker Creek Master Drainage Plan

Final Report
October 2007

Bowker Creek Master Drainage Plan

Final Report
October 2007

KWL File No. 283.288

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EXECUTIVE SUMMARY

INTRODUCTION

Bowker Creek lies within a 1,018 ha watershed located in the District of Saanich, City of Victoria and District of Oak Bay. With headwaters at the University of Victoria, Bowker Creek flows 7.9 km through storm drains, culverts and open channels to an ocean discharge in Oak Bay.

The Bowker Creek Watershed Management Plan was completed in 2003 (BCWMP). The BCWMP outlined 4 goals and 11 objectives for the Bowker Creek watershed. One of the objectives of the BCWMP is to, “base watershed management decisions based on a comprehensive understanding of the hydrological characteristics of the drainage system”. One of the action items identified to achieve this objective is the preparation of a master drainage plan.

This master drainage plan (MDP) will ultimately be the first phase of the Bowker Creek Watershed Integrated Stormwater Management Plan (ISMP). The MDP has addressed the hydrotechnical (hydrology and hydraulics) components of the ISMP, identifying areas with deficient drainage capacity (flooding) and developing potential solutions. The second phase of the ISMP is the Environmental Plan. Combined, the MDP and the Environmental Plan will form the Bowker Creek ISMP.

WORK PROGRAM

Tasks undertaken in preparation of this master drainage plan included a background review and inventory, a land use assessment, hydraulic modelling, evaluation of alternatives, solutions and costs, and preparation of this report.

RESULTS

Fifteen sites of high erosion were identified along the open channel sections of Bowker Creek. Flooding has been observed on Bowker Creek in areas with known hydraulic limitations at the Fireman’s Park storm drain and the Trent Street to Fort Street storm drain.

The Bowker Creek watershed was found to have an impervious (hard surfaces) area of about 50%, which greatly increases peak stormwater runoff. It is estimated that in 25 years the watershed may be about 56% impervious area. Future model scenarios have included an estimated increase in precipitation intensities to account for climate change.

The existing conveyance system has inadequate capacity and flooding occurs during the 10-year return period (occurring on average every 10 years) storm event. The municipal standard for Bowker Creek is to have no flooding during the 25-year storm event, and therefore upgrades are required to meet this standard.

An XP-SWMM hydrodynamic computer model was developed that can predict flow rates with a reasonable level of accuracy. The hydraulic model has been run for seven scenarios as follows:

- Scenario 1 – existing land-use, existing hydraulics;
- Scenario 2 – 25-year future land-use, existing hydraulics;
- Scenario 3 – existing land-use, upgraded hydraulics;
- Scenario 4 – 25-year future land-use, upgraded hydraulics;
- Scenario 5 – existing land-use, upgraded hydraulics and daylighting;
- Scenario 6 – 25-year future land-use, upgraded hydraulics and daylighting; and
- Scenario 7 – 25-year future land-use, upgraded hydraulics, daylighting and detention.

The model simulated the 6-month, 2-year, 5-year, 10-year, 25-year, 100-year and 200-year return period storm events. From a hydrotechnical perspective, it is preferred to improve hydraulics through daylighting (i.e. removing culverts and re-establishing creek channels).

The most likely scenarios to be adopted would be a combination of upgraded hydraulics (Scenario 4 and upgraded hydraulics and daylighting (Scenario 6). From an environmental perspective, daylighting to improve hydraulic capacities is the preferred option. From a social perspective, the benefits of daylighting need to be evaluated in relation to conflicting current land-uses and the property acquisition costs. In general, the priorities for hydraulic improvements go from downstream to upstream. The following table outlines the approximate number of buildings that currently could be flooded and how upgrading could reduce the flood risk.

Approximate Number of Flooded Houses or Buildings

Return Period	Approximate Number of Flooded Houses of Buildings		
	Scenario 1 – Existing Land-use, Existing Hydraulics	Scenario 4 Future Land-use, Upgraded Hydraulics	Scenario 6 Future Land-use, Upgraded Hydraulics and Daylighting
10-Year	38	0	0
25-Year	72	0	0
100-Year	193	72	27
200-Year	297	78	44
Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.			

COSTS

The Class 'D' preliminary estimated design, construction and property acquisition cost for these upgrades range between $22M and $46M (2007 dollars) depending on the option chosen and the specifics of property acquisition. The amount of property that may have to be acquired would depend on a number of factors including timeframe for hydraulic upgrades, rate of development, size of development parcels, and municipal policies. The estimated costs for the work within each municipality would need to be worked out as part of a cost sharing arrangement.

RECOMMENDATIONS

1. Present this information to municipal councils with the recommendation that the MDP be incorporated into the future ISMP and implemented as part of a long-term strategy.

2. Implement hydraulic upgrade priorities to the Bowker Creek system based on the Master Drainage Plan and as amended by the environmental and social priorities from the future Bowker Creek ISMP. The MDP priorities are:

   - Address High Erosion Sites

   Hydraulic Upgrades

     - Beach Drive Culvert
     - Fireman's Park Storm Drain
     - Hampshire Road Culvert
     - Trent Street to Oak Bay High
     - Bee Street Culvert
     - Fort Street to Bee Street
     - Trent Street to Fort Street
     - Haultain Street to Trent Street
     - Haultain Street Culvert
     - Richmond Avenue to Haultain Street
     - Newton Street to Richmond Avenue
     - Richmond Elementary
     - North Dairy Road to Pearl Street
     - McRae Avenue to Wordsworth Street
     - Gordon Head Road to Knight Street.

   These upgrade recommendations are a result of evaluating and prioritizing the hydrotechnical solutions based on drainage modelling results and current background information.

3. Consider an implementation plan that develops short-term and long-term cost-share strategies that includes external funding, possible reduction in levels of service (where possible) and development cost charges to fund future upgrades.

4. Continue with completion of the Bowker Creek ISMP.

5. Revisit future land-uses in 5 to 10 years to determine if the estimations outlined in this report are approximately correct.

6. Revisit the assumptions made regarding changes in precipitation intensities as a result of climate change as more becomes known, in particular for shorter durations.

Section 1

Introduction

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1. INTRODUCTION

1.1 BACKGROUND

Bowker Creek lies within a 1,018 ha watershed located in the District of Saanich (Saanich), City of Victoria (Victoria) and District of Oak Bay (Oak Bay). With headwaters at the University of Victoria (UVic), Bowker Creek flows 7.9 km through storm drains, culverts and open channels to an ocean discharge in Oak Bay.

The Bowker Creek watershed has been studied previously including in 2000, the Bowker Creek Watershed Assessment (BCWA)[i]. This document provided an overview of water quality, aquatic biota, riparian condition, creek hydraulics and the recreational potentials of Bowker Creek. Although detailed hydraulic calculations or modelling were not completed in the BCWA, sections of the creek with hydraulic limitations were identified. The BCWA indicated that the most severe hydraulic limitations occur at the entrances to enclosed sections at Monterey Avenue and Trent Street. The BCWA also states that "resolving flooding issues on Bowker Creek represents a complex problem with potentially high costs for remediation".

The Bowker Creek Watershed Management Plan (BCWMP)[ii] was completed in 2003. The BCWMP was developed under the sponsorship of the CRD as part of the Watershed Management Strategy that was approved by the Environmental Committee in 1997. The BCWMP outlined 4 goals and 11 objectives for the Bowker Creek watershed. One of the objectives of the BCWMP is to, "base watershed management decisions based on a comprehensive understanding of the hydrological characteristics of the drainage system". One of the action items identified to achieve this objective is the preparation of a master drainage plan (MDP).

1.2 SCOPE OF STUDY

This MDP provides the hydrologic and hydraulic basis for making informed watershed management decisions.

The objectives of this MDP are as follows:

- To document the existing hydraulic condition of Bowker Creek and the tributary from Cedar Hill Golf Course;
- To develop a calibrated hydraulic/hydrologic model of Bowker Creek and the tributary from Cedar Hill Golf Course for existing and future conditions;
- To identify and prioritize the hydrotechnical drainage problems in the watershed;

- To evaluate the likely hydraulic impacts of further development and redevelopment;
- To identify and evaluate potential hydraulic improvements that are consistent with the goals and objectives of the BCWMP;
- To outline the benefits of the solutions;
- To provide capital cost estimates for the recommended solutions; and
- To recommend solutions that will address the hydrotechnical problems.

In order to achieve these objectives, the scope of work outlined in the following table was developed.

Table 1-1: Bowker Creek MDP – Scope of Work

Major Tasks		Sub-Tasks
1	Project Initiation	1.1 Meeting #1 - Project Initiation
2	Background Review and Inventory	2.1 Review existing studies 2.2 Compile information using GIS 2.3 Topographic Survey of Channel and Data Gaps 2.4 Review Water Quality Data 2.5 Inventory of Features and GIS Mapping 2.6 Erosion and Flooding Inventory 2.7 Technical Memorandum 1 and Base Map 2.8 Meeting #2 - Progress Meeting with BCI Committee
3	Land Use Assessment	3.1 Review Zoning and Land Use Patterns 3.2 Review CRD Regional Growth Strategy and OCP 3.3 Establish Future Land Use 3.4 Calculate Runoff Parameters for Existing and Future use
4	Hydraulic Model	4.1 Review Hydrologic Data (rainfall and flow monitoring) 4.2 Develop Hydraulic Model (SWMM) 4.3 Run Model for Existing Scenario, Calibrate and Verify 4.4 Model Runs (6-month, 2,5,10,25,100,200-year storms) for 7 Scenarios 4.5 Technical Memorandum 2- Hydraulic Model Results 4.6 Meeting #3 - Hydraulic Modelling Results
5	Evaluation of Alternatives and Solutions	5.1 Flood and Erosion Priorities 5.2 Future Flooding Impacts 5.3 Existing Infrastructure Capacity Assessment 5.4 Evaluate Impacts of Scenarios and Capital Costs 5.5 Land Acquisition Priorities 5.6 Hydrotechnical Recommendations 5.7 Identify Trail Connections and Linkages 5.8 Prioritize Hydrotechnical Solutions 5.9 Meeting #4 - Results Workshop
6	Report	6.1 Prepare Draft MDP Report 6.2 Meeting #5 - Present Report to BCI Committee 6.3 Finalize Report 6.4 Meeting #6 - Workshop Presentation of Final Report

1.3 MASTER DRAINAGE PLAN AND THE INTEGRATED STORMWATER MANAGEMENT PLAN

This MDP will ultimately be the first phase of the Bowker Creek Watershed Integrated Stormwater Management Plan (ISMP). The MDP addresses the hydrotechnical components of the ISMP, identifying drainage problems and developing potential solutions. The second phase of the ISMP is the Environmental Plan. Combined, the MDP and the Environmental Plan will form the Bowker Creek ISMP.

The MDP includes evaluating and prioritizing the hydrotechnical solutions based on drainage modelling results and current background information. However, prior to the completion of the ISMP, all solutions for Bowker Creek and watershed cannot be fully evaluated or prioritized. The ISMP should set priorities, the acceptable level of service for flood protection and determine the implementation plan for required hydraulic improvements.

1.4 PROJECT TEAM

The project team included the following members from KWL:

- Dave Murray, P.Eng., AScT, CPESC, Project Manager;
- Chris Johnston, P.Eng., Senior Technical Review;
- Jeff Howard, P.Eng., Project Engineer; and
- Paul Berrington, AScT, Drafting and Mapping.

Special thanks to the following individuals who provided valuable information and guidance throughout the project:

- Lehna Malmkvist, Swell Environmental Consulting;
- Jody Watson, CRD;
- Tanis Douglas, CRD;
- Dave Marshall, District of Oak Bay;
- Ed Robertson, City of Victoria;
- Steven Fifield, City of Victoria;
- Dwayne Halldorson, District of Saanich;
- Ian Graeme, Bowker Creek Urban Watershed Renewal Initiative;
- Chris Jensen, Bowker Creek Urban Watershed Renewal Initiative; and
- Rob Miller, Bowker Creek Urban Watershed Renewal Initiative.

1.5 FORMAT OF REPORT

This report is formatted into the following key sections:

Table 1-2: Report Format

Section	Title	Purpose
1	Introduction	Provides background information, outlines the scope of the study, and explains how this report fits into the ISMP.
2	Drainage Overview	Provides an overview of the study area, background information, survey work and erosion and flooding inventory.
3	Hydrologic and Hydraulic Modelling	Describes the hydrologic modelling that was undertaken including the calculation of runoff parameters, catchment delineation, impacts of climate change, and model development and calibration.
4	Model Scenarios	Outlines the seven model scenarios and presents the results.
5	Evaluation of Alternatives	Evaluates the upgrade alternatives for solving hydrotechnical issues for Bowker Creek.
6	Master Drainage Plan	Outlines the recommendations for hydrotechnical improvements for Bowker Creek.
7	Summary and Recommendations	Outlines the summary and recommendations of the study.

Section 2

Drainage Overview

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2. DRAINAGE OVERVIEW

2.1 INTRODUCTION

This section provides a general overview of the existing Bowker Creek drainage system and watershed. The 1,018 ha Bowker Creek watershed and 7.9 km creek is illustrated on the attached Figure 2-1. The creek alignment as indicated on mapping from the 1930s is also shown on Figure 2-1.

The Bowker Creek watershed is nearly completely developed (see Figure 2-1). The majority of this watershed is currently being used for single-family residential developments and other land-uses include multi-family residential, commercial, institutional, recreational, and some undeveloped parcels. The development of the watershed has resulted in higher than natural peak flows within the creek.

The ground slopes within the watershed are generally flat (less than 5%) with a few isolated areas that are much steeper (e.g. Mount Tolmie). Surficial geology mapping[iii] obtained from the Geological Survey of Canada (GSC) indicates that the majority of the underlying soil within the catchment is clay. There are also some areas of sands and gravels and sands, and bedrock outcrops. The topography and the underlying soil types within the watershed are illustrated on Figure 2-2.

Other than the tributary from Cedar Hill Golf Course, all of the stormwater infrastructure contributing flows to Bowker Creek are enclosed.

Only 2.9 km (37%) of Bowker Creek is open channel with the rest being enclosed within storm drains and culverts. The reaches of Bowker Creek are summarized in the following Table 2-1.

Table 2-1: Bowker Creek Summary

Reach	Length (km)	Description
UVic Faculty Club to Gordon Head	0.5	Open channel and road culverts
Gordon Head to Knight	2.8	Enclosed in concrete and wood stave storm drains
Knight Street to North Dairy	0.6	Open channel and road culvert
North Dairy to Pearl (at Townley)	1.3	Enclosed in concrete storm drains
Pearl to Newton	0.4	Open channel
Newton to Richmond	0.2	Enclosed in concrete storm drains
Richmond to Trent	0.6	Open channel and road culvert
Trent to Fort	0.2	Enclosed in concrete storm drains
Fort to Monterey	0.7	Open channel (mostly concrete bottom and rock sides) and culverts
Monterey to Monteith	0.3	Enclosed in concrete storm drains
Monteith to Outlet	0.3	Open channel and road culvert
Total	**7.9**	

2.2 BACKGROUND INFORMATION

In addition to the reports mentioned previously, key background information used in preparation of the MDP is summarized in the following Table 2-2.

Table 2-2: Background Information

Information	Source	Description
Legal Cadastral	CRD, Saanich, Victoria, Oak Bay	Lot, roadway and right of way legal boundaries
Aerial Photograph	CRD	High resolution, colour aerial photograph of the entire watershed
Contours	Saanich, Victoria, Oak Bay	Contours within the watershed at 0.5 m or 1.0 m intervals
Storm Drains	Saanich, Victoria, Oak Bay	Locations of the municipal storm drains within the watershed
As-Constructed Drawings	Saanich, Victoria, Oak Bay	As-Constructed drawings of the storm drains which convey Bowker Creek
Flow Monitoring Data	CRD	Flow monitoring of Bowker Creek at Trent and Monteith and 6 small catchments within the watershed
Precipitation Data	CRD, Environment Canada	Precipitation data for weather stations in the area in 5-minute (CRD) and 1-hour (EC) time steps
Extreme Tide Information	Canadian Hydrographic Service	Higher high water large tide and extreme observation information

We have also had correspondence with individuals who have witnessed or provided us with second-hand accounts of flooding in the area of Bowker Creek. This information has assisted us with calibration of our hydraulic model.

2.3 TOPOGRAPHIC SURVEY

As constructed, drawings provided by Saanich, Victoria and Oak Bay were comprehensive for the enclosed sections of Bowker Creek. However, little detailed information was available regarding elevations, size and shape of the open sections of the Creek. In order for an accurate hydraulic model to be developed, a topographic survey was required.

The topographic survey was completed in November of 2006 and included 40 cross-sections of Bowker Creek and 5 cross-sections of the tributary from Cedar Hill Golf Course. The cross-section locations were selected based on changes in channel shape, grade or alignment to facilitate the development of the hydraulic model. The cross-sections typically extended beyond the top of banks on either side of the channel. In addition to channel cross-sections, other features affecting the channel hydraulics were surveyed including culverts, bridges and weirs.

Integrated monuments located throughout the area were used for survey control. The survey information was compiled in NAD 83 coordinate system format and all elevations were geodetic. This coordinate system is consistent with the mapping and contour information provided by the CRD.

2.4 EROSION AND FLOODING INVENTORY

An inventory of the erosion and flooding along Bowker Creek has been completed as part of this project. The erosion inventory was completed by way of a thorough walk through of the creek. The flooding inventory was completed primarily through correspondence with individuals who have witnessed or provided us with second-hand accounts of flooding. There is also a small amount of flooding information on mapping received and in the BCWA report.

EROSION INVENTORY

The open channel sections of Bowker Creek were investigated to determine the potential risk of erosion and identify erosion features. The open channel sections of the creek were classified as either having low, medium or high erosion rates. These classifications are defined as follows:

- **Low** – No or very little erosion (considered stable).
- **Medium** – Damage to public/private property may result in the near future.

- **High** – Private/public property damage is likely or has occurred.

The erosion classifications for the open channel sections of Bowker Creek are illustrated on Figure 2-3.

Fifteen sites of high erosion were identified as shown on Figure 2-3. A table describing these areas of high erosion and photos are provided in Appendix A. A summary of the areas of high erosion is provided in the following Table 2-3.

Table 2-3: Erosion Inventory

Erosion Feature	Location
E1	Downstream of Monteith Culvert (has now been addressed)
E2	Downstream of Haultain Culvert, 0+190 to 0+201
E3	Downstream of Haultain Culvert, 0+96 to 0+109
E4	Downstream of Richmond Rd., 0+150 to 0+165
E5	Downstream of Richmond Rd., 0+025
E6	Downstream of Pearl St. Culvert, 0+245 to 0+410
E7	Downstream of Pearl St. Culvert, 0+195
E8	Downstream of Pearl St. Culvert, 0+50
E9	Downstream of Knight Ave. Culvert, 0+434
E10	Downstream of Knight Ave. Culvert, 0+390
E11	Downstream of Knight Ave. Culvert, 0+365
E12	Downstream of Knight Ave. Culvert, 0+325
E13	Downstream of Knight Ave. Culvert, 0+265
E14	Downstream of Knight Ave. Culvert, 0+060
E15	Downstream of 600 mm Culvert on Cedar Hill Golf Course

These areas of high erosion are included in the planned improvements as part of this MDP.

FLOODING INVENTORY

We have received information regarding flooding along Bowker Creek. This flooding has occurred in four locations as illustrated on Figure 2-4 and summarized in the following Table 2-4.

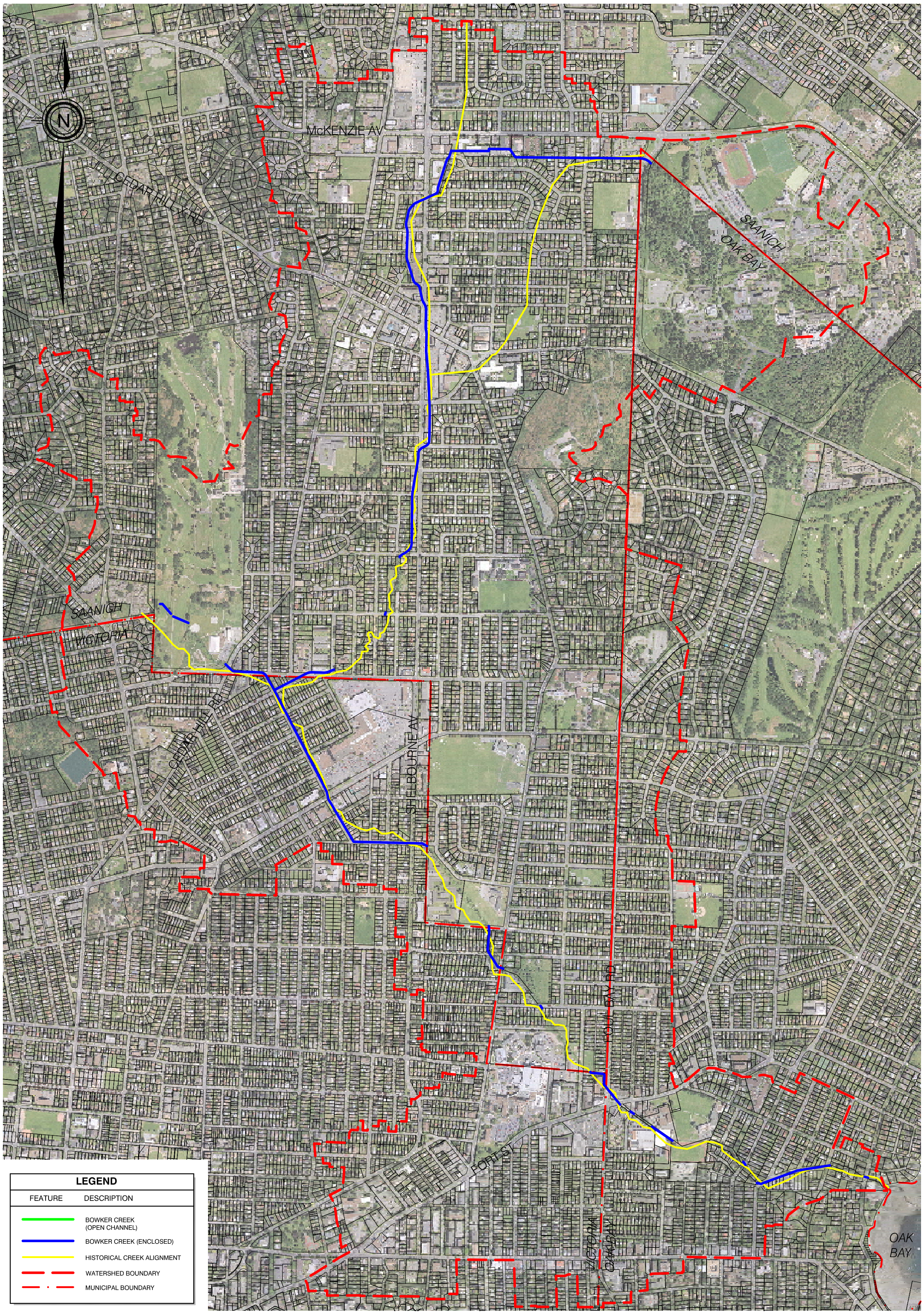
Table 2-4: Flooding Inventory

Flooding Feature	Location	Description
A	1725 Beach	▪ Flooding in the past (non specific) prior to construction of the retaining wall. No known flooding since. DM
B	1741 Moneith and Fireman's Park	▪ Insufficient culvert capacity has resulted in flow overland through park and flooding of 1741 Monteith and in Nov. 1990 and Jan. 7, 2007. DM ▪ Photos of flooding provided by property owner showing flow across park and into garage.
C	Oak Bay Recreation Centre	▪ Flooding in the past (non specific). DM ▪ "Limited Channel Capacity" indicated in BCWA report.
D	Upstream of Foul Bay Road including Haultain Area	▪ Flooding in the past (non specific) as a result of insufficient capacity of the storm drain. BCI ▪ "Area Subject to Flooding" indicated in BCWA report. ▪ 25-year flood El. 15.07 m and flood extent as shown. Mapping received from Saanich, Bowker Creek Dye Test Results. ▪ Residents of 1700 block of Haultain reported the water beyond the creek banks on Jan. 7, 2007. GP ▪ Owner of 1834 Haultain reported basement flooding and 0.3 m of water over Haultain. TD

Notes:
- DM – Dave Marshall, Oak Bay Director of Engineering
- BCI – Bowker Creek Urban Watershed Renewal Initiative
- GP – Gary Pleven, Victoria
- TD – Tanis Douglas, CRD

- all descriptions are based on looking downstream

This flooding information was compared with results from the calibrated hydrologic and hydraulic model, in order to confirm the accuracy of the model.



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Project No.	Date
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Scale in Metres 1:15000

BOWKER CREEK MASTER DRAINAGE PLAN

WATERSHED AND CREEK

FIGURE 2-1

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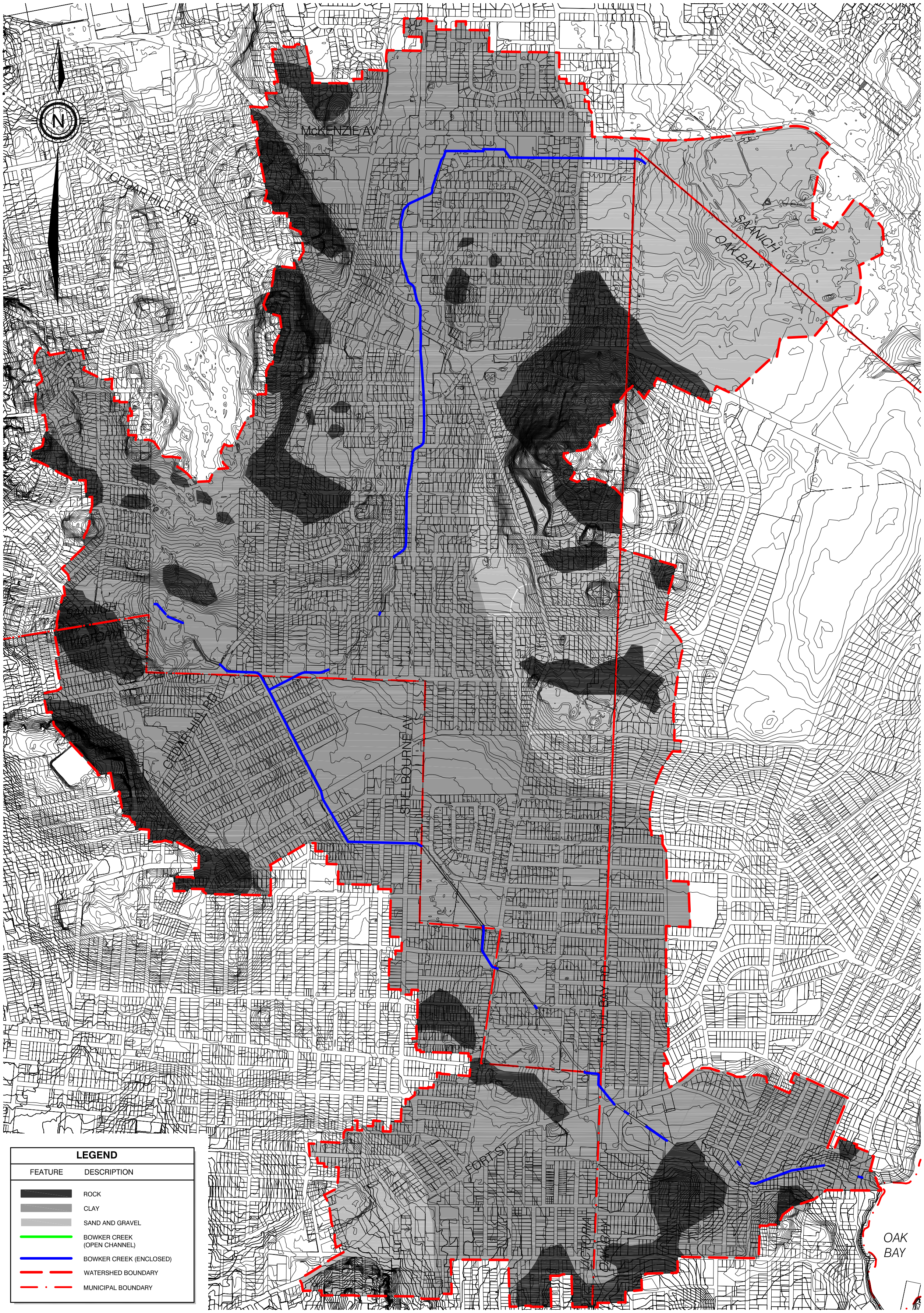

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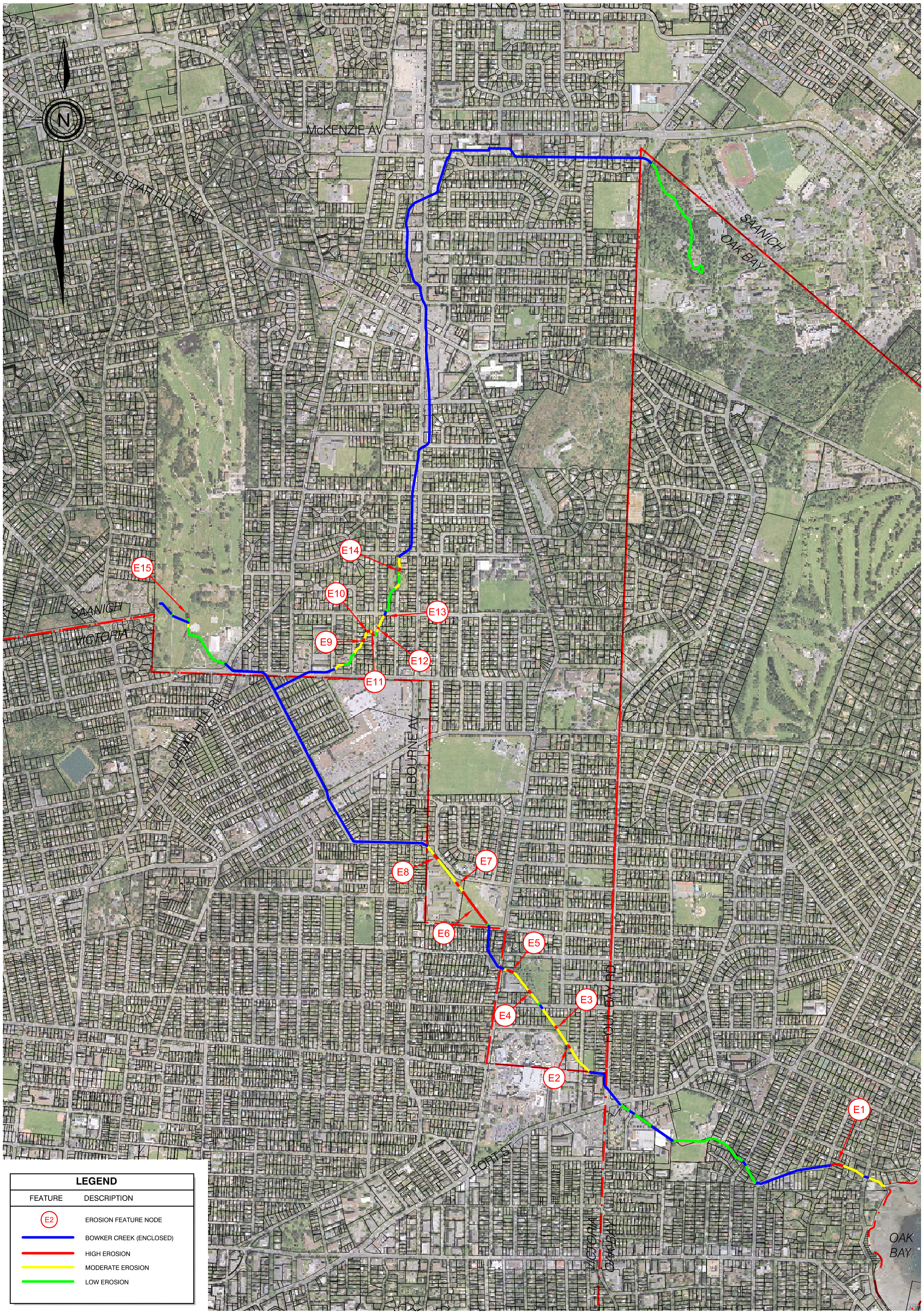
Scale in Metres 1:15000

BOWKER CREEK MASTER DRAINAGE PLAN
TOPOGRAPHY AND UNDERLYING SOILS

FIGURE 2-2



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Date MARCH 2007

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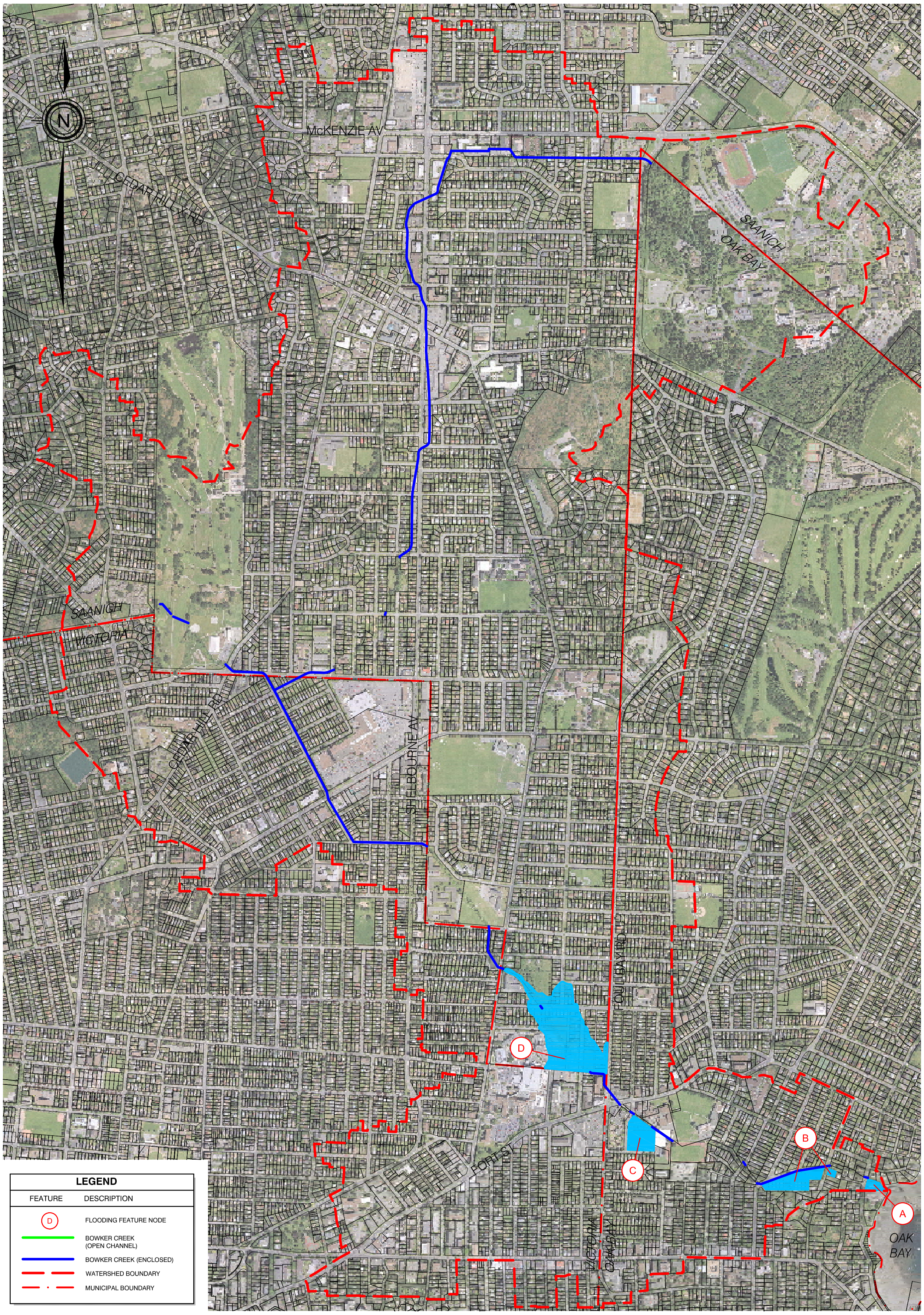
BOWKER CREEK MASTER DRAINAGE PLAN

EROSION INVENTORY

FIGURE 2-3



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BOWKER CREEK MASTER DRAINAGE PLAN
FLOODING INVENTORY

FIGURE 2-4

Section 3

Hydrologic and Hydraulic Modelling

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3. HYDROLOGIC AND HYDRAULIC MODELLING

3.1 INTRODUCTION

This section summarizes the hydrologic and hydraulic modelling undertaken for the Bowker Creek MDP. The software XP-SWMM Version 9.5 was used. XP-SWMM is a dynamic unsteady flow model that can account for the effects of detention within the creek and floodplain. A dynamic model is important in predicting accurate flows for drainage systems, which detain significant volumes of water.

The XP-SWMM RUNOFF module was used to generate the rainfall/runoff response for each of the sub-catchments. The HYDRAULICS module was used for the hydraulic computations needed to analyze the conveyance systems. The upstream extents of the hydraulic model are UVic at Gordon Head Road and the Cedar Hill Golf Course 14th Hole Pond.

3.2 RUNOFF PARAMETERS

The key factors that affect the volume and rate of runoff are imperviousness, soil hydraulic conductivity and retention, ground slope and catchment shape.

In order to determine the imperviousness (hard surfaces resisting infiltration) of each sub-catchment within the watershed, the software Feature Analyst produced by Visual Learning Systems was used. Once manually trained, this software was used to automatically delineate impervious areas based on the air photo provided by the CRD. In manually checking the software's delineation of impervious areas it was found that it slightly overestimated the impervious areas. For sample areas the impervious areas were manually delineated and compared with the automatic delineation. Based on the sample areas, the impervious areas automatically delineated were reduced by 7%. It was found that the entire Bowker Creek watershed is approximately 50% impervious.

Soil hydraulic conductivity and retention are important parameters in the Green Ampt Equation used in the RUNOFF Module. To assist in developing these parameters, 5 storm drains within the Bowker Creek watershed were monitored prior to the start of the MDP project. Information for each of these flow-monitoring locations is provided in the following Table 3-1 and hydrographs are shown in Figures 3-4 to 3-9.

Table 3-1: Storm Drain Flow Monitoring

Location	Catchment Area (ha)	Flow Monitoring Period
3914 Stamboul	3.9	Dec. 19, 2005 to May 31, 2006
1700 Teakwood	3.5	Dec. 19, 2005 to Feb. 10, 2006
3996 Cedar Hill	4.7	Dec. 19, 2005 to Feb. 10, 2006
Cranmore at Monteith	3.1	Dec. 19, 2005 to Feb. 13, 2006
Dalhousie by Cadboro Bay	1.8	Dec. 19, 2005 to Feb. 9, 2006

During the flow-monitoring period no storm events of significant precipitation intensities occurred (i.e., not significant enough to generate measurable runoff from pervious areas). Therefore, this storm drain flow monitoring was not useful in generating the Green Ampt Equation parameters for pervious areas. We have used values from previous projects with similar conditions for the Green Ampt Equation parameters.

The ground slope and catchment shape parameters affect how rapidly runoff responds to precipitation. The more rapid the response the higher the peak flow rates. The majority of the watershed is of low slope, but because the watershed is nearly completely developed, runoff is quickly captured in the storm drain system. This could result in runoff being generated very soon after the precipitation occurs. The ground slope and catchment shape parameters used reflect this rapid response of the catchments.

3.3 CATCHMENTS

For modelling purposes, the Bowker Creek watershed was divided into 22 sub-catchments. These sub-catchments and the hydraulic nodes that they contribute to are illustrated on Figure 3-1.

EXISTING LAND-USE

Parameters for each of these sub-catchments for the existing land-use scenarios are summarized in the following Table 3-2.

Table 3-2: Existing Sub-Catchment Parameters

Sub-Catchment Number	Impervious (%)	Area by Underlying Soil Type (ha)			Total Area (ha)
		Clay	Bedrock Rock	Sand & Gravel	
10	56.5	24.3	4.5	0.0	28.9
20	57.7	13.9	6.1	0.0	19.9
30	67.3	72.8	10.7	27.7	111.3
31	54.5	38.1	1.8	15.2	55.1
38	53.0	43.4	6.3	2.5	52.2
46	44.6	36.4	0.0	1.5	37.9
53	56.8	62.1	6.1	0.0	68.2
69	48.1	37.2	3.7	10.6	51.6
75	38.3	44.8	14.3	12.8	71.9
76	50.7	23.0	17.9	0.0	40.9
78	57.7	30.8	2.2	1.5	34.4
79	47.8	30.2	12.1	0.0	42.3
81	48.2	16.6	0.0	4.6	21.2
84	50.0	4.5	0.0	4.6	9.1
85	36.9	0.0	12.0	84.6	96.6
102	51.1	43.0	13.7	0.0	56.7
109	29.5	37.8	6.5	0.0	44.4
111	9.7	3.0	0.4	0.0	3.4
201	56.1	30.3	0.0	1.7	32.0
113b	49.7	11.8	5.2	0.0	17.0
49a	47.8	56.4	10.9	34.6	101.9
75a	54.1	17.2	4.5	0.0	21.7
Total	**50.0**	**677.7**	**138.9**	**201.9**	**1,018.6**

FUTURE LAND-USE

For modelling future scenarios, the predicted land-use in 25 years was established. The BCWMP recommends considering timelines of up to 100 years for implementation of the plan. However, it was determined by the BCI Committee that 25 years is the maximum practical timeframe that future land-use could be reasonably predicted. This future land-use should be revisited periodically (say every 5 to 10 years) to determine if it is still approximately correct.

The CRD's Regional Growth Strategy (RGS)[iv] and the Official Community Plans (OCPs) for Oak Bay, Victoria and Saanich were reviewed. It was found that these documents do not provide adequate detail to predict future impervious areas. We therefore met with planning representatives from each of the municipalities to establish their "best guess" of land-use in 25 years. During these meetings, plans were marked-up to reflect the predicted changes in land-use.

Figure 3-2 summarizes these predicted changes within the municipalities. The future impervious calculations are based on the areas identified as 'Areas of Increased Development' becoming 100% impervious, and the areas identified as 'Equivalent to a Change from Single Family to Multi-Family or Commercial' becoming 90% impervious.

Development at UVic is also another factor that has been considered. The UVic Campus Plan[v] provides an increase in building areas of 25% in 20 years based on a "hypothetical" annual growth rate of 2%. Over 25 years this would equate to an increase in building area of 28%. This was discussed with a representative from UVic. In UVic's opinion, the impervious area in 25 years would increase by much less than 28%. UVic is moving towards parking below buildings and in parkades. UVic felt that a 10% increase in impervious area would be a conservatively high value in 25 years.

Additionally, to account for the increase in impervious areas as a result of general building, parking and other hard surface expansion, the impervious area percentage was increased by 5% throughout the watershed (excluding areas previously identified to redevelop and UVic).

The change in impervious percentages, for each of these sub-catchments for the future land-use scenario is summarized in the following Table 3-3.

Table 3-3: Future Sub-Catchment Parameters

Sub-Catchment Number	Existing Impervious (%)	Future Impervious (%)
10	56.5	61.5
20	57.7	63.9
30	67.3	72.6
31	54.5	59.5
38	53.0	59.4
46	44.6	56.9
53	56.8	64.3
69	48.1	54.9
75	38.3	45.3

Sub-Catchment Number	Existing Impervious (%)	Future Impervious (%)
76	50.7	56.9
78	57.7	63.5
79	47.8	53.7
81	48.2	53.2
84	50.0	56.6
85	36.9	41.6
102	51.1	57.1
109	29.5	36.1
111	9.7	14.7
201	56.1	67.8
113b	49.7	55.7
49a	47.8	54.4
75a	54.1	62.1
Total	**50.0**	**56.4**

3.4 HYDRAULIC MODEL

The hydraulic model was developed based on "as-constructed" drawings, survey information, photographs, and field observations and measurements. Additionally, for areas that input beyond the survey cross-sections was required, the contour elevations were used.

Bowker Creek and the Cedar Hill Golf Course tributary were divided into 112 nodes for hydraulic modelling purposes. The hydraulic model nodes are illustrated on Figure 3-3. Details of the input to the hydraulic model are provided in Appendix B.

A key factor affecting capacities of enclosed and open channel sections of the creek is the Manning's Roughness Coefficient 'n'. The Manning's 'n' values used are summarized in the following Table 3-4.

Table 3-4: Manning's Roughness Coefficient 'n'

Manning's 'n'	Description
0.013	Concrete/Asphalt/Wood Stave - Smooth
0.015	Concrete - Float Finish
0.017	Concrete - Rough
0.018	Concrete & Mortar Rock
0.018	Asphalt 70%, Grass 30%
0.020	Mortar Rock
0.020	Corrugated Steel Pipe
0.025	Concrete Bottom and One Wall, Light Brush Side
0.030	Grass Short
0.035	Grass Tall
0.035	Stone Bottom, Weedy Banks
0.040	Cobble Bottom, Grass Banks
0.040	Grass, Few Trees
0.045	Concrete Wall, Clean Bottom, Dense Brush Side
0.050	Clean Bottom, Brush Banks
0.050	Light Brush
0.050	Overland Through Developed Area (Buildings)
0.050	Gabion Wall, Clean Bottom, Dense Brush Side
0.060	Not Clean Bottom, Dense Brush Banks
0.070	Dense Brush
0.080	Dense Weeds, Bottom & Banks
0.100	Dense Timber

The above information was input into XP-SWMM for modelling.

3.5 CLIMATE CHANGE

The term "climate change" is commonly used to describe significant change in weather and temperature patterns. The Intergovernmental Panel on Climate Change report, *Climate Change 2007: The Physical Science Basis*[vi], states, "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level". Because the BCWMP recommends considering timelines of up to

100-years, potential impacts of climate change have been addressed in this MDP. Additionally, drainage infrastructure upgrades on Bowker Creek should have adequate capacity for their entire life span (approximately 100 years), therefore should be designed for the future flows in 100 years.

KWL has examined climate change in the recent past for the Greater Vancouver Regional District (GVRD). This project produced the report, *Development of Precipitation Scenarios*[vii], which examined trends in historical precipitation from GVRD precipitation gauges. This report concludes, "There is little evidence that precipitation intensities have increased systematically over the period of record (approximately 40 years) for all GVRD stations except DN25 (District Hall of North Vancouver), whose data is suspect in latter years and VW 14 (District Hall of West Vancouver)". Additionally, his report recommends, "There is no urgent need for installation of higher capacity sewers and drainage systems anywhere in the GVRD based on precipitation intensity trend analysis". However, examining 40 years of historical precipitation data cannot, with certainty, predict changes in precipitation over the next 100 years.

As part of this project we met with a professor from UVic's School of Earth and Ocean Sciences. This professor directed us to a paper produced by the Canadian Centre for Climate Modelling and Analysis (CCCma), Estimating Extremes in Transient Climate Change Simulations[viii]. This paper describes the impacts of climate change on extreme precipitation events predicted by CCCma's coupled global climate model (second version) for two different CO_2 "equivalent" concentrations scenarios. The model predicts that in North America the 20-year return period, 24-hour rainfall amount may increase by 14.5% and 6.0% by the year 2090 for each scenario, respectively.

The CCCma provided an additional paper addressing changes in extreme precipitation events, Changes in Temperature and Precipitation Extremes in the IPCC Ensemble of Global Coupled Model Simulations[ix]. This paper compares the results of 16 climate models prepared by various agencies around the world for three different CO_2 "equivalent" concentrations scenarios. Statistical analysis performed on this data for the period of 2081 to 2100 found that the models estimated the 20-year return period, 24-hour rainfall intensity will increase by 5.0% to 23% for North America. For the three CO_2 "equivalent" concentrations scenarios, the median rainfall increases are 10%, 14% and 15% for North America.

With respect to flooding, for the majority of urban infrastructure (including Bowker Creek) the critical rainfall intensity duration is significantly shorter than 24 hours. As a result, the peak flows in Bowker Creek will not increase unless the shorter duration rainfall intensities also increase. We are not aware of any reliable and specific sources of information that address the change in rainfall intensities for durations shorter than 24 hours in 100 years. In the absence of this information, we have assumed that the current rainstorm patterns remain unchanged. Therefore, we have assumed that rainstorm intensities increase the same amount for all durations. Changes in rainfall intensities for durations shorter than 24 hours for this region should be studied in further detail, possibly as a separate project undertaken by the CRD.

Based on the papers obtained from the CCCma and the highest CO_2 "equivalent" concentrations scenarios, we have increased precipitation by 15% during the 20-year return period event for modelling of all future land-use scenarios. These papers do not predict the change in precipitation for more extreme return periods (e.g. 200-year return period).

If all rainfall amounts were increased by 15%, the 25-year and 200-year future 24-hour rainfall amounts would be 98.0 mm and 139.8 mm, respectively. Using the current Gonzales IDF curve the return periods for these rainfall amounts would be approximately 40-year and 640-years, respectively. For this 15% increase in precipitation, the change in return period for the 200-year event appears to be excessive, compared with the 25-year event. Because an increase in intensity of 15% for the 200-year return period appears to be unreasonable, it was decided a shift in the rainfall amounts would be more appropriate.

In order to determine the increase in precipitation for other return periods, a logarithmic trend line was fit to the existing rainfall amounts. This curve was then shifted up by 15% for the 20-year return period (or 12.85 mm) to determine the future rainfall values. The existing and future (as a result of climate change) rainfall amounts are illustrated on Figure 3-10 and summarized in the following Table 3-5.

Table 3-5: Existing and Future Rainfall

Return Period	24-Hour Rainfall		Increase (%)
	Existing	Future	
10-Year	75.6	87.7	16.0%
25-Year	85.2	102.0	19.7%
100-Year	112.8	123.6	9.6%
200-Year	121.6	134.4	10.6%

The future rainfall amounts above have been developed based on the worst-case results (i.e., highest greenhouse gas concentration scenario) from climate models. These model results are the best method currently available for predicting rainfall intensities 100 years in the future. However, modelling changes in rainfall extremes as a result of climate change is a relatively new field and there is a level of uncertainty in the results. Additionally, there is little known about how rainfall intensities will change in the future for durations shorter than 24 hours. Therefore, there is uncertainty in future rainfall amounts developed for this MDP, which should be re-visited as more is known about changes in future extreme event rainfall intensities, in particular for shorter durations.

3.6 MODEL CALIBRATION

The XP-SWMM model was run for the existing scenario from January 2006 to January 2007. The model flow and water level results were compared to the measured water levels (and corresponding flows) at Trent and Monterey. The rating curves for the Trent and Monterey water level sensors are illustrated in Appendix C.

The precipitation data used for calibrating the model was developed from three CRD precipitation gauges. The Thiessen Polygon method was used to generate weighting factors for the Boundary, Harling and Penrhyn precipitation gauges. The weighting factors used are summarized in the followings Table 3-6.

Table 3-6: Precipitation Weighting Factors

Gauge	Thiessen Polygon Area (ha)	Weighting Factor
Boundary	242.1	0.2377
Harling	205.5	0.2017
Penrhyn	571.0	0.5606
Total	1,018.6	1.0000

The above weighting factors were multiplied by the 5-minute time step data for each gauge, and then summarized to develop the precipitation for the Bowker Creek Watershed.

The calibration indicated that the runoff factors (e.g., imperviousness, soil hydraulic conductivity and retention, ground slope and catchment shape) did not need to be adjusted. However, the factors which affect the rate that groundwater enters the creek were adjusted to obtain a fit between the model and the measured data.

Figures 3-4 to 3-9 illustrate the ability of the calibrated model to accurately predict flows at the Trent and Monterey flow measurement sites. Figure 3-10 shows the IDF relationship for the Gonzales Rain Gauge.

The Nash-Sutcliffe efficiency coefficient is a commonly used method of determining the prediction accuracy of hydrologic models. The Nash-Sutcliffe formula is as follows:

$$E = 1 - \frac{\sum_{t=1}^{T}\left(Q_o^t - Q_m^t\right)^2}{\sum_{t=1}^{T}\left(Q_o^t - \overline{Q_o}\right)^2}$$

Definitions
Q_o – Observed Flow
Q_m – Model Flow

A model that matches the observed flow rates perfectly, would have a Nash-Sutcliffe efficiency coefficient of 1.0. The Nash-Sutcliffe efficiency coefficients at the Trent and Monterey flow monitoring locations for January 2006 to January 2007 are 0.52 and 0.71, respectively.

The likely reason for the error are a combination of errors in precipitation, errors in the rating curves for the Trent and Monterey flow monitoring locations and inaccuracy in low flow measurements. Additionally, the XP-SWMM model was primarily developed to predict peak flows. For example, the Nash-Sutcliffe efficiency coefficients at the Trent and Monterey flow monitoring locations increase to 0.72 and 0.75, respectively when only considering observed flows greater than 0.5 m^3/s. One possible reason for the significantly greater increase in accuracy at the Trent Street location is that the removable weir downstream of Node 30. The rating curve at the Trent flow monitoring station was developed when the downstream weir was not in place. When the weir is in place, and the flows are low enough to be significantly affected by this weir, the observed low flows are inaccurate.

Considering the above, the model can predict flow rates in Bowker Creek with a reasonable level of accuracy. The model can predict flow rates with greater certainty during storm events compared with periods of lower flows.

3.7 RAINSTORMS

In order to perform the analysis for each of the modelling scenarios, rainstorms were developed. The Soil Conservation Service (SCS) synthetic rainstorm pattern 1A was used. This pattern accurately represents rainstorm patterns for Coastal B.C. The SCS 1A rainstorms generated for the existing land-use scenarios are illustrated on Figure 3-11.

For future land-use scenarios the rainstorms have been increased to account for climate change as indicated above. The SCS 1A rainstorms generated for the future land-use scenarios are illustrated on Figure 3-12.

To confirm that the SCS 1A rainstorm patterns are suitable for Bowker Creek, the model results for the Jan. 7th, 2007 rainstorm were compared with the model results for the SCS 1A rainstorm.

The rainfall intensities during the Jan. 7th, 2007 rainstorm were compared with the rainfall intensities from the Gonzales Rain Gauge intensity duration frequency (IDF) curves. This comparison is illustrated on Figure 3-13. This comparison shows that the Jan. 7th, 2007 rainstorm has a return period of between 5 and 10-years for the 4-hour duration. On January 7th, 2007, the peak flow in the lower sections of the creek occurred approximately 2 hours after the middle (equal amount of rainfall on either side) of the precipitation event. This is a good indicator of the critical return period duration for the watershed. For the 2-hour duration, the return period of the Jan. 7th, 2007 storm event has a return period between 2 and 5-years. Therefore, for the lower sections of the creek the Jan. 7th, 2007 storm should result in peak flow rates between the SCS 1A 2-year and SCS 1A 5-year return period storms.

The Jan. 7th, 2007 rainstorm had a return period of less than 2 years for durations less than 1 hour. Therefore, for creek sections higher in the watershed, where the critical rainfall duration is less than 1 hour, the flows from the Jan. 7th, 2007 storm event should be less than the 2-year return period.

The peak flow results from the model comparing the SCS 1A storms with the Jan. 7th, 2007 storm are shown in the following Table 3-7.

Table 3-7: SCS 1A and Jan. 7th, 2007 Rainstorm Comparison

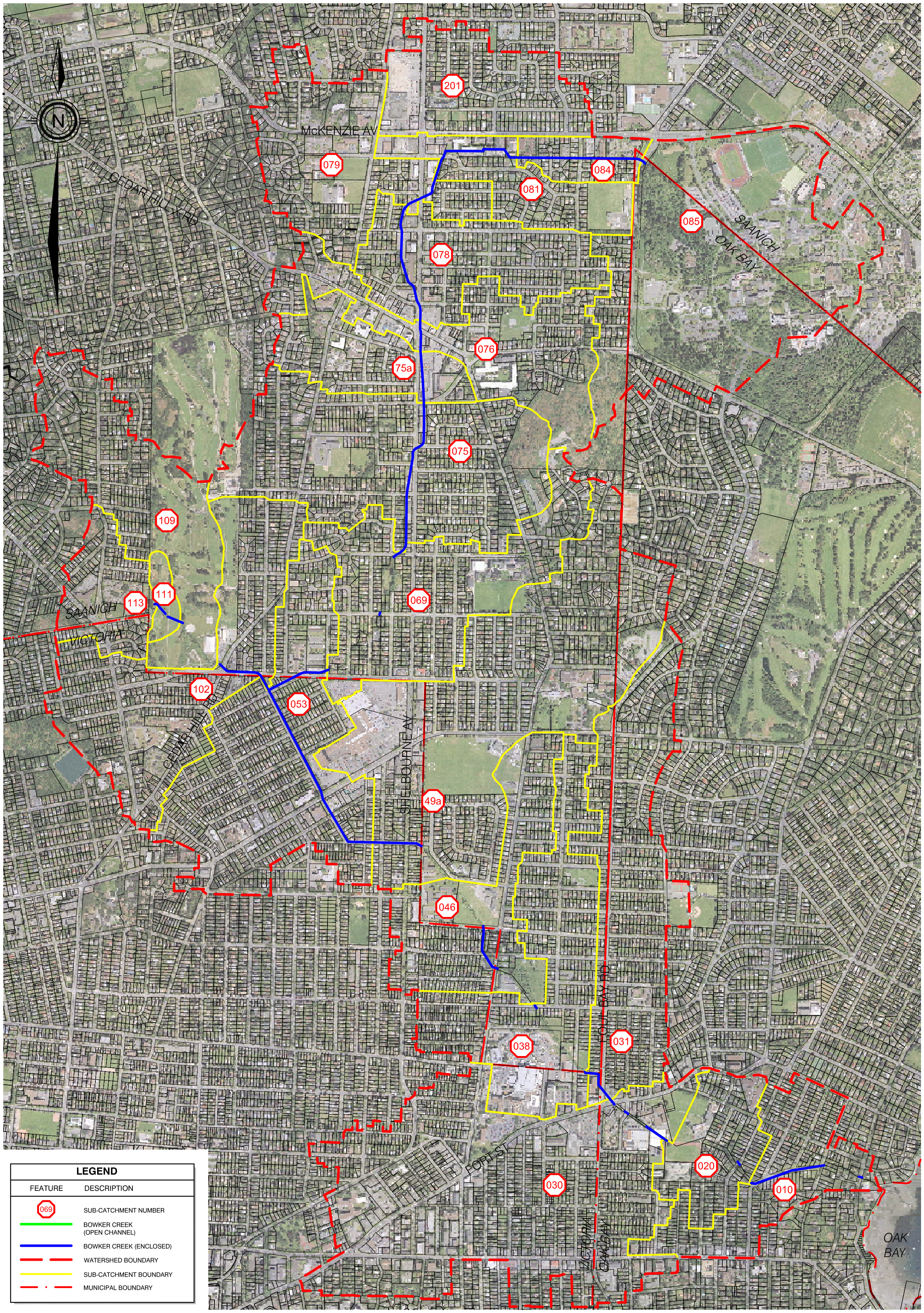
Link	Location	Peak Flow (m^3/s)		
		2-Year SCS 1A	5-Year SCS 1A	Jan. 7th, 2007
10-9	Fireman's Park[1]	10.99	15.24	12.52
32-31	Storm Drain at Trent Street	9.85	12.64	9.58
100-52	Downstream End of Cedar Hill Tributary	1.52	2.66	1.46
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	7.43	10.78	6.64
70-69	Storm Drain at Knight	5.79	8.46	4.75

Note: 1- Includes overland flow

The above table indicates that the SCS 1A storm distribution may be slightly conservative when compared to the Jan. 7th, 2007 storm event. In particular, the peak flow in the storm drain at Trent Street during the 2-year SCS 1A, exceeds the peak flow from the Jan. 7th, 2007 storm. However, we have continued to use the SCS storm distribution for the following reasons:

- The SCS storm distribution is only slightly conservative.
- Being slightly conservative when modelling peak flows is appropriate when considering other uncertainties.
- Shorter duration (less than 1-hour) rainfall intensities may have a greater impact on creek peak flows than previously estimated.

Additionally, the model indicates that the maximum water level upstream of the Trent to Foul Bay storm drain for the SCS 1A 25-year return period event is El. 15.17 m. This compares well with the mapping received from Saanich that identifies the 25-year flood elevation to be El. 15.07 m (see Table 2-4). This further confirms that the SCS 1A rainfall distribution is appropriate and the model reasonably predicts water levels in this area.



KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

600 0 600

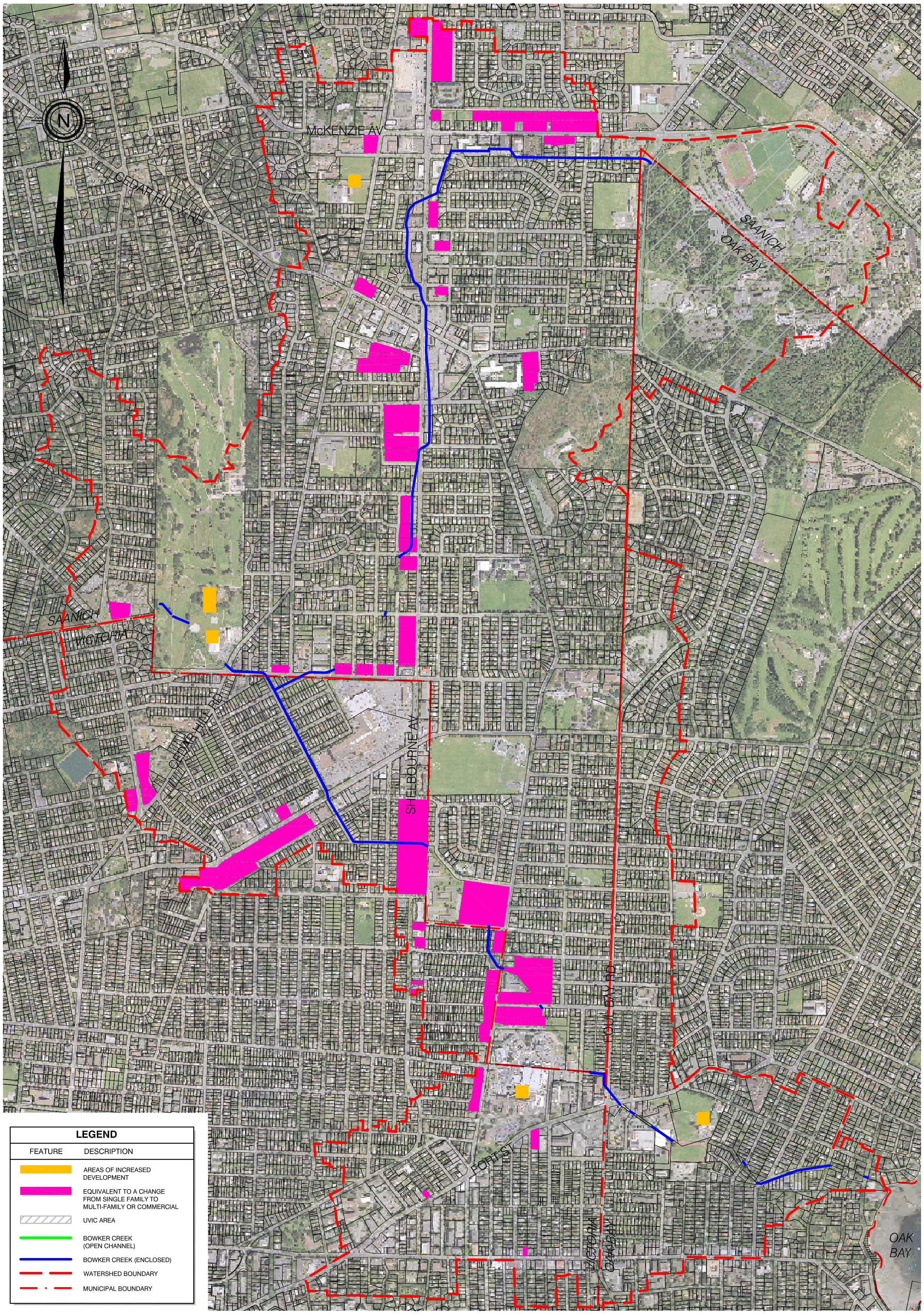
Scale in Metres 1:15000

BOWKER CREEK MASTER DRAINAGE PLAN

SUB-CATCHMENTS

FIGURE 3-1

Z:\0000-0999\0200-0299\283-288\500-Drawings\283288-FIGURES.dwg Plot Date: Feb. 27/08 11:07 AM Save Date: Feb. 27, 08 10:44 AM



KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

600 0 600
Scale in Metres 1:15000

BOWKER CREEK MASTER DRAINAGE PLAN
FUTURE LAND USE

FIGURE 3-2

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

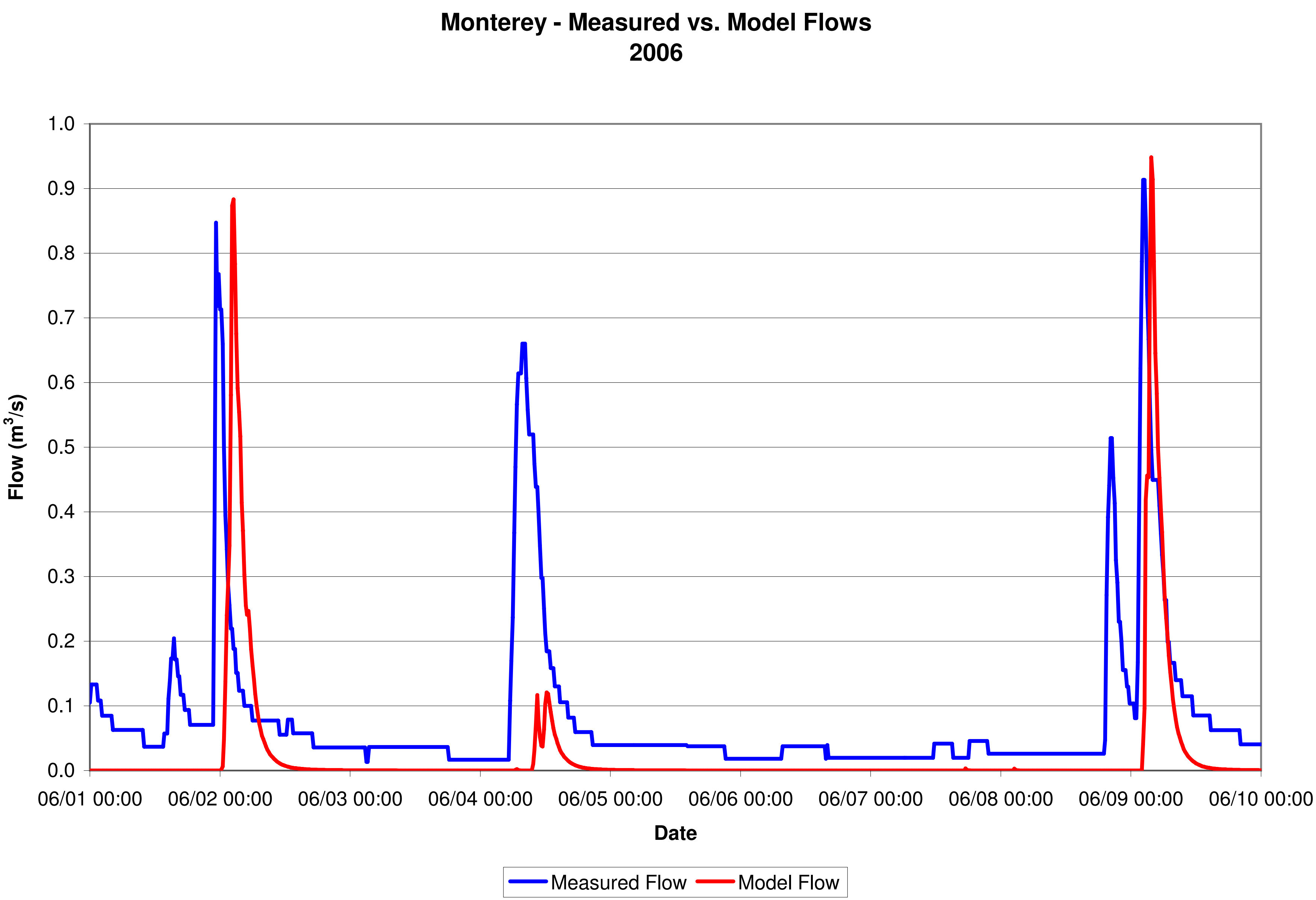
CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

200 0 200
Scale in Metres 1:7500

BOWKER CREEK MASTER DRAINAGE PLAN
HYDRAULIC MODEL

FIGURE 3-3



Monterey - Measured vs. Model Flows
2006
Flow (m3/s)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
06/01 00:00
06/02 00:00
06/03 00:00
06/04 00:00
06/05 00:00
06/06 00:00
06/07 00:00
06/08 00:00
06/09 00:00
06/10 00:00
Date
Measured Flow
Model Flow

Figure 3-4

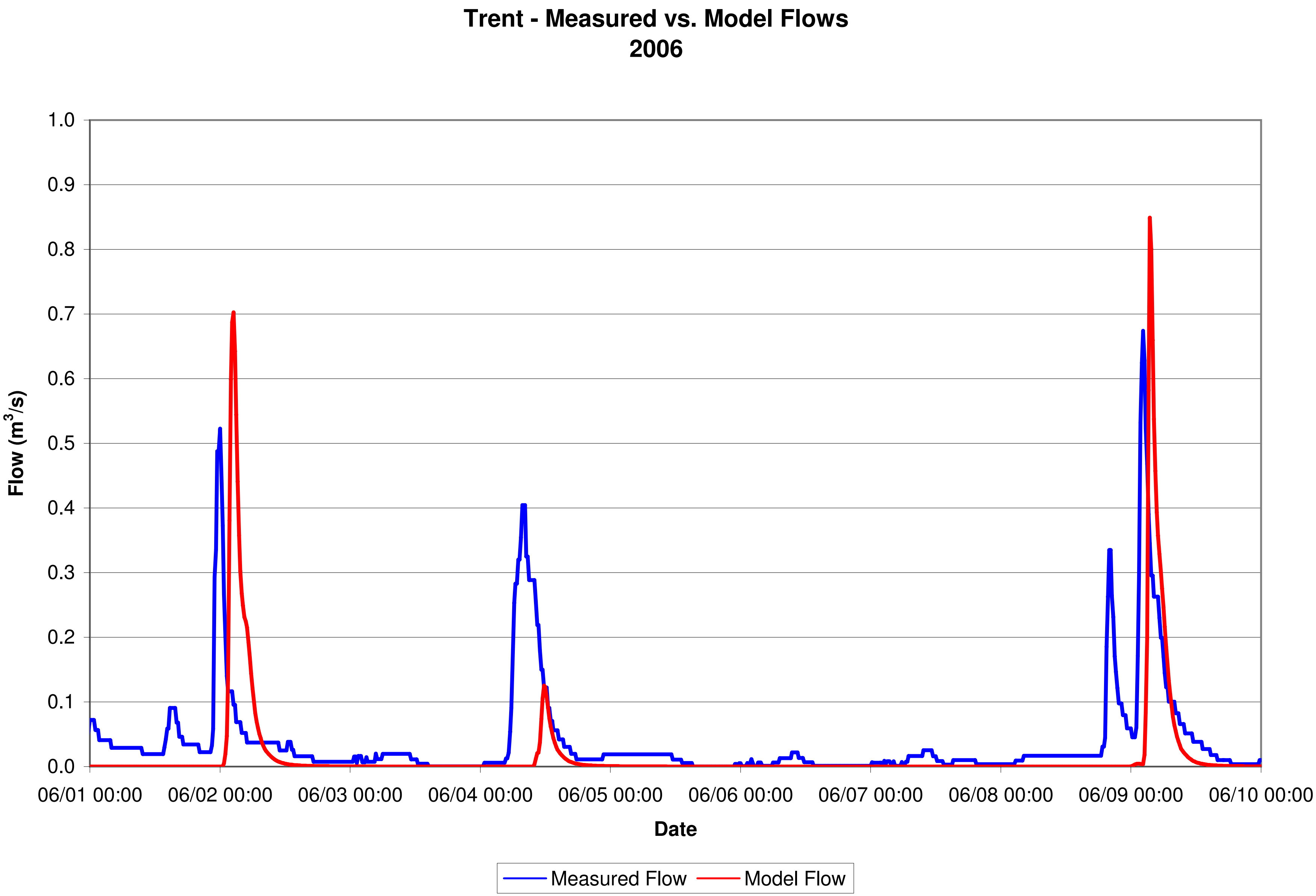

Trent - Measured vs. Model Flows
2006
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (m^3/s)
06/01 00:00
06/02 00:00
06/03 00:00
06/04 00:00
06/05 00:00
06/06 00:00
06/07 00:00
06/08 00:00
06/09 00:00
06/10 00:00
Date
Measured Flow
Model Flow

Figure 3-5

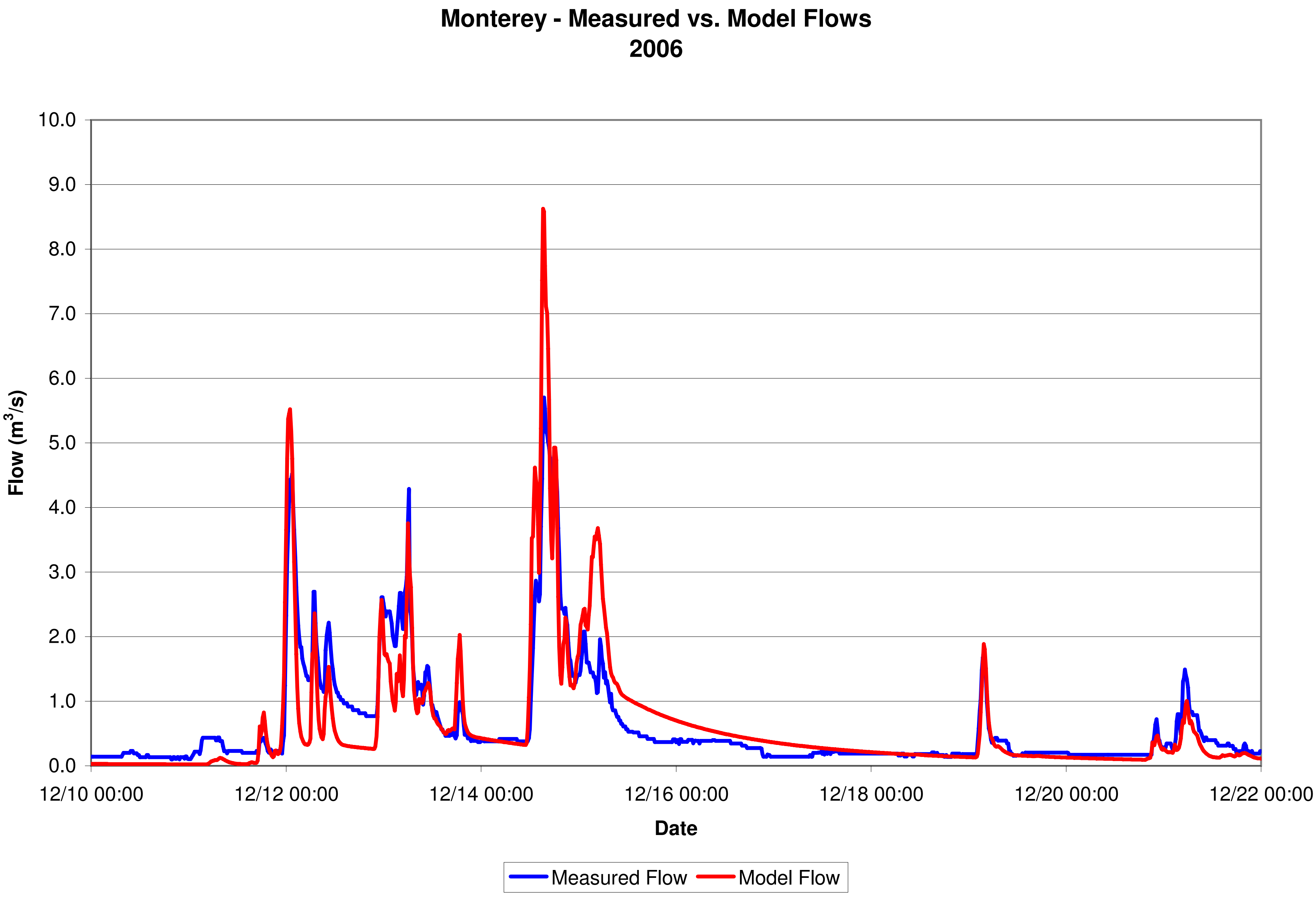
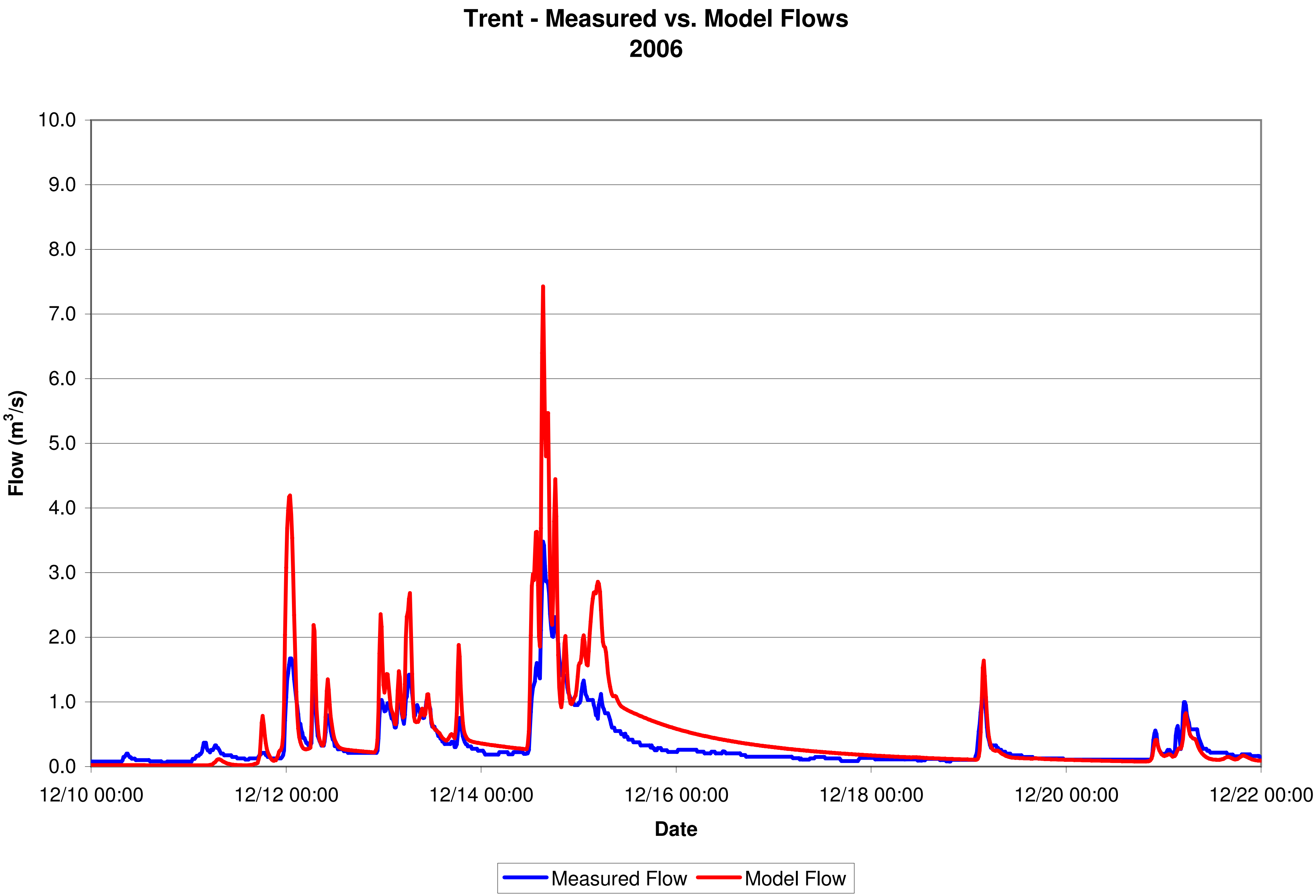

Monterey - Measured vs. Model Flows
2006
Flow (m³/s)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12/10 00:00
12/12 00:00
12/14 00:00
12/16 00:00
12/18 00:00
12/20 00:00
12/22 00:00
Date
Measured Flow
Model Flow

Figure 3-6



Trent - Measured vs. Model Flows
2006
Flow (m3/s)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12/10 00:00
12/12 00:00
12/14 00:00
12/16 00:00
12/18 00:00
12/20 00:00
12/22 00:00
Date
Measured Flow
Model Flow

Figure 3-7

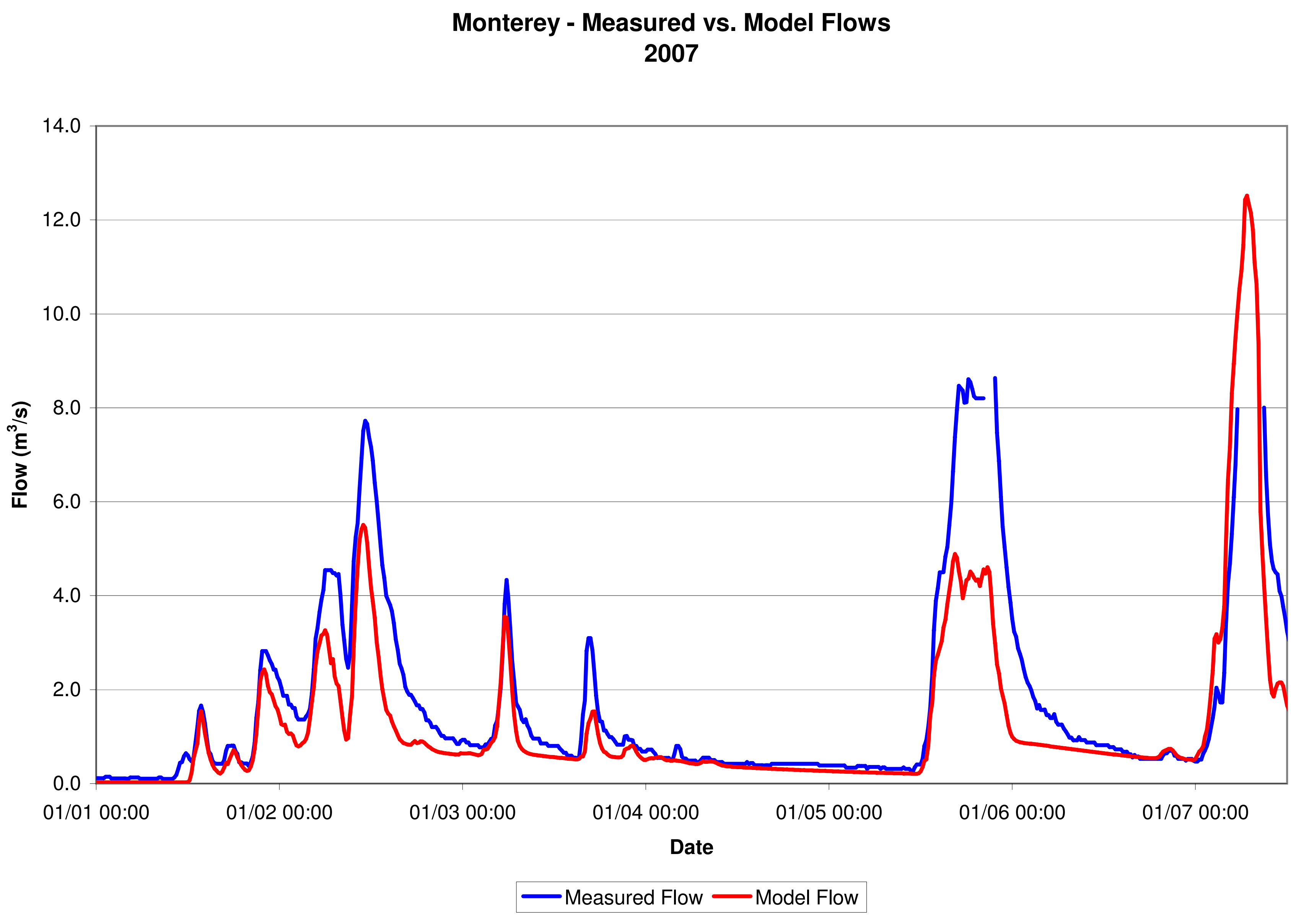

Monterey - Measured vs. Model Flows
2007
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Flow (m^3/s)
01/01 00:00
01/02 00:00
01/03 00:00
01/04 00:00
01/05 00:00
01/06 00:00
01/07 00:00
Date
Measured Flow
Model Flow

Figure 3-8

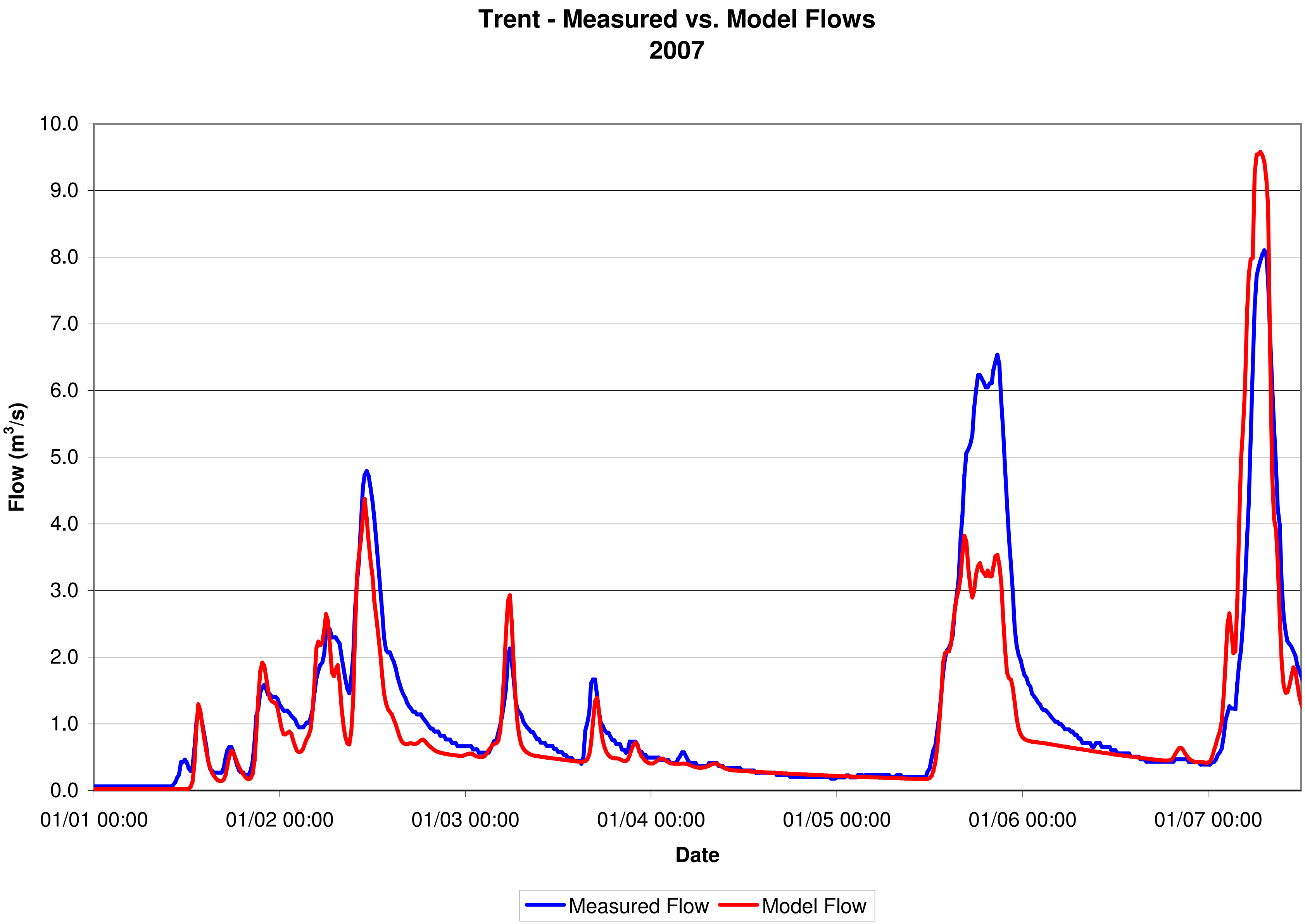

Trent - Measured vs. Model Flows
2007
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Flow (m³/s)
01/01 00:00
01/02 00:00
01/03 00:00
01/04 00:00
01/05 00:00
01/06 00:00
01/07 00:00
Date
Measured Flow
Model Flow

Figure 3-9

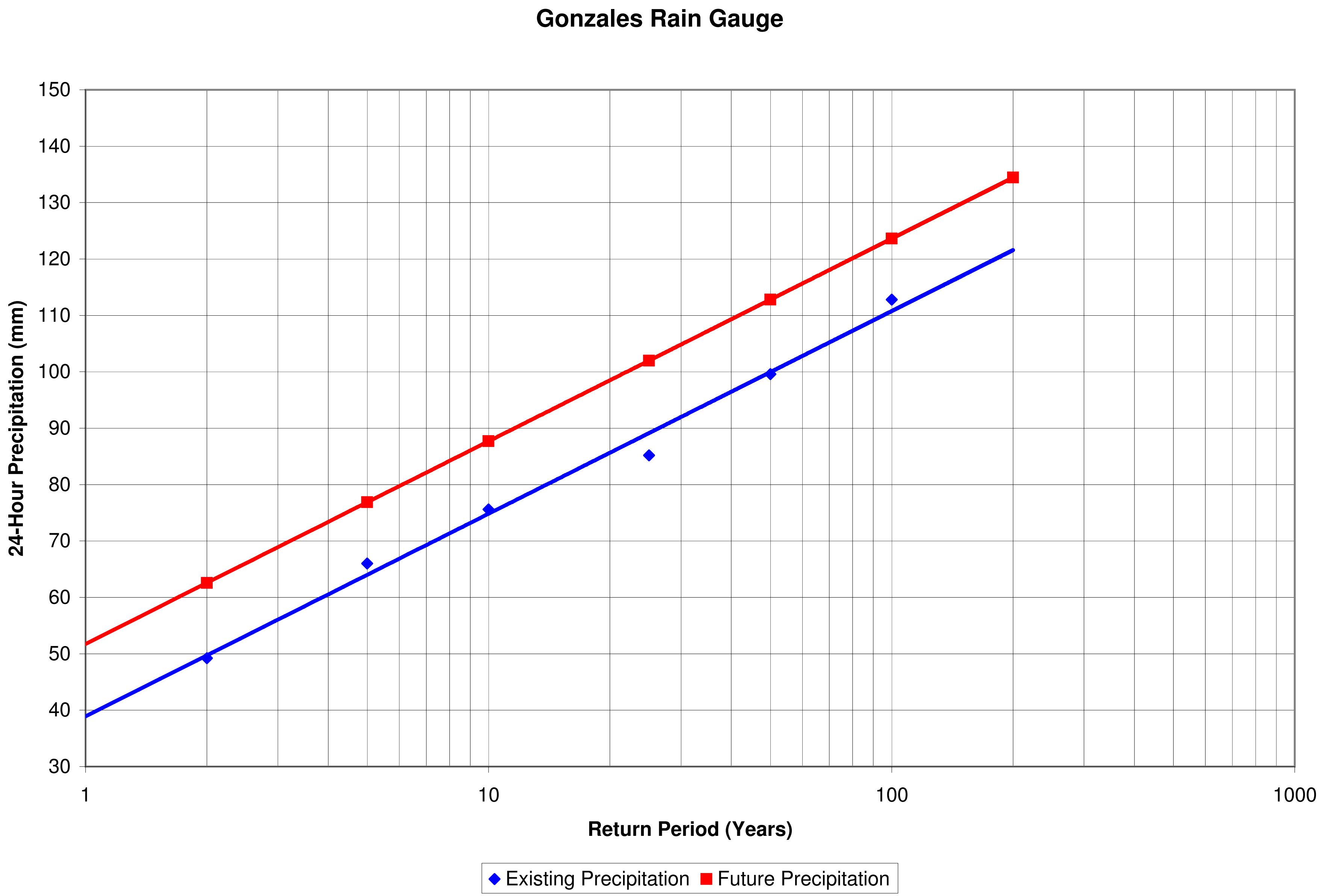

Gonzales Rain Gauge
150
140
130
120
110
100
90
80
70
60
50
40
30
24-Hour Precipitation (mm)
1
10
100
1000
Return Period (Years)
Existing Precipitation
Future Precipitation

Figure 3-10

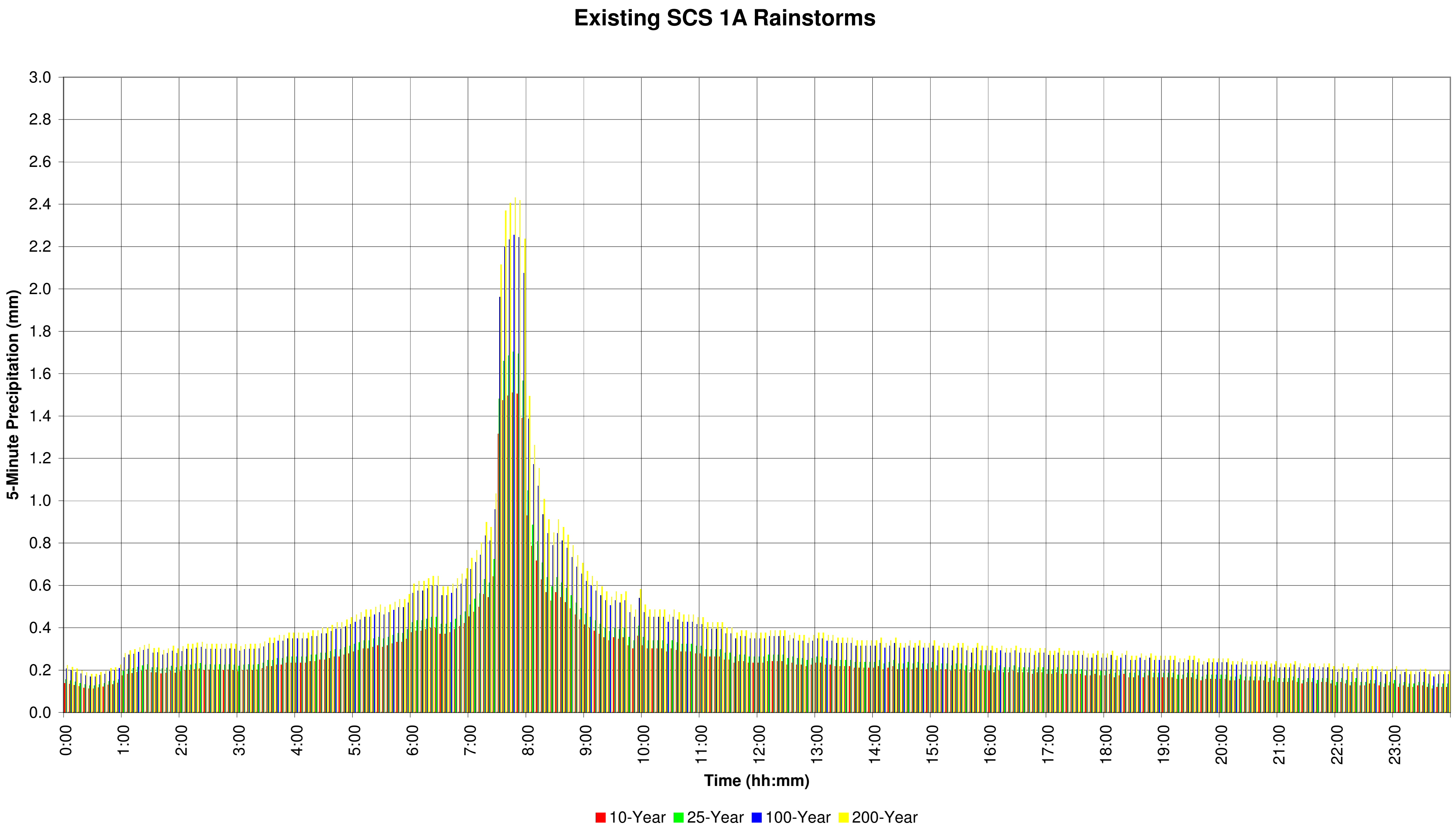

Existing SCS 1A Rainstorms
5-Minute Precipitation (mm)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time (hh:mm)
10-Year
25-Year
100-Year
200-Year

Figure 3-11

Future SCS 1A Rainstorms

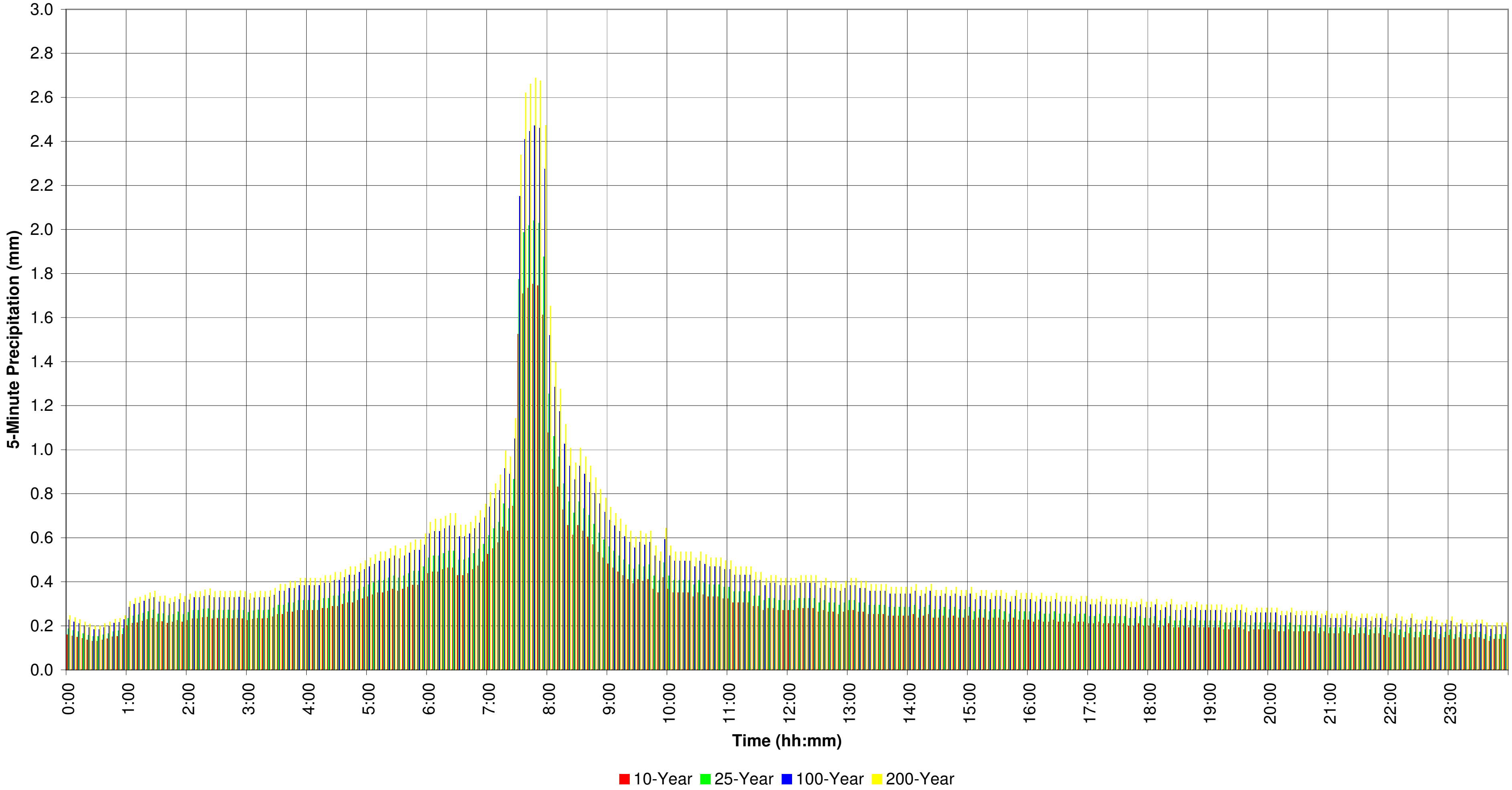
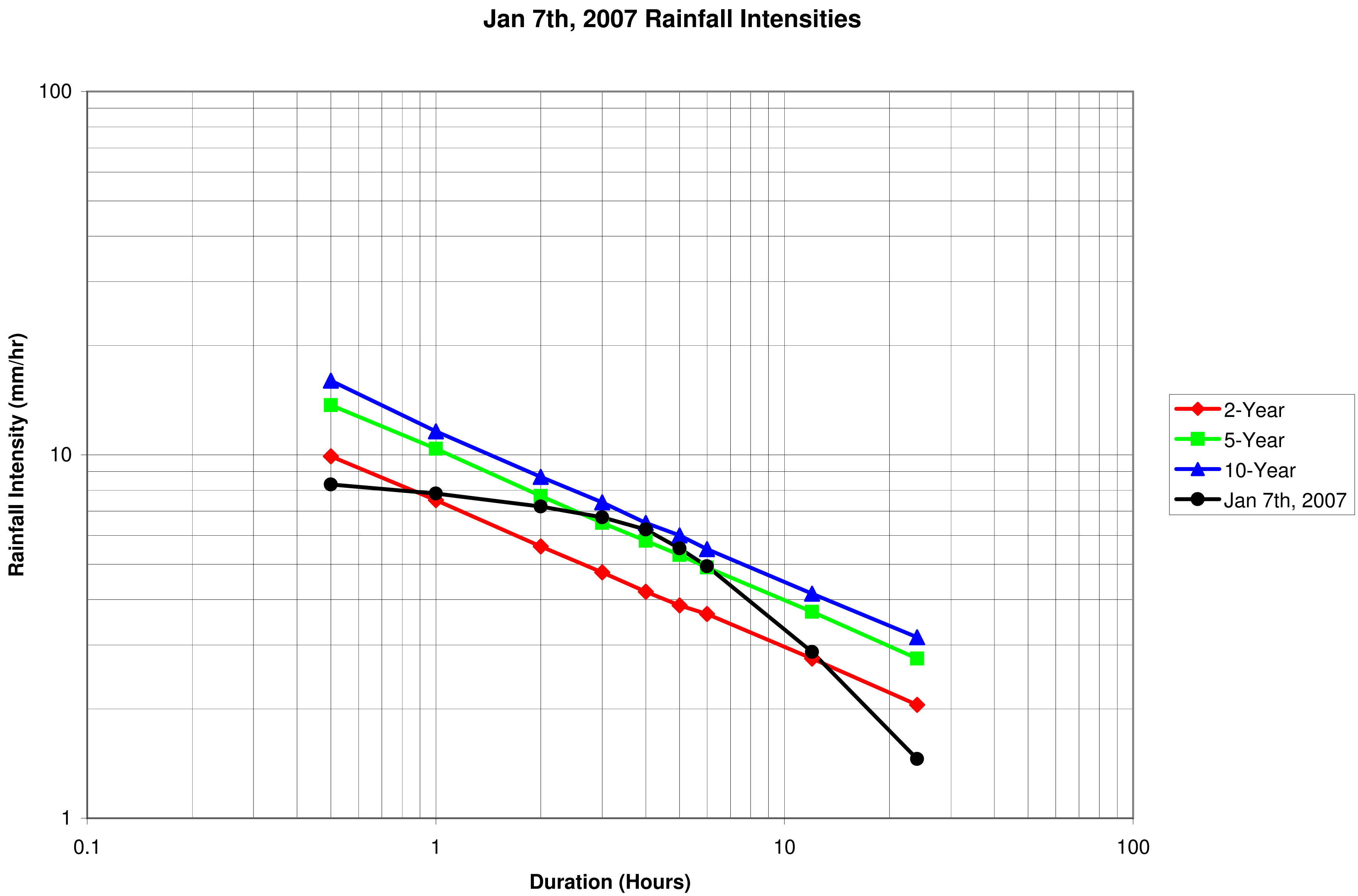


Figure 3-12



Jan 7th, 2007 Rainfall Intensities
100
10
1
0.1
1
10
100
Rainfall Intensity (mm/hr)
Duration (Hours)
2-Year
5-Year
10-Year
Jan 7th, 2007

Figure 3-13

Section 4

Model Scenarios

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4. MODEL SCENARIOS

4.1 INTRODUCTION

The hydraulic model has been run for seven scenarios for the 6-month, 2-year, 5-year, 10-year, 25-year, 100-year and 200-year return period storm events. The seven scenarios are as follows:

- Scenario 1 - Existing Land-Use, Existing Hydraulics;
- Scenario 2 - Future Land-Use, Existing Hydraulics;
- Scenario 3 - Existing Land-Use, Upgraded Hydraulics;
- Scenario 4 - Future Land-Use, Upgraded Hydraulics;
- Scenario 5 - Existing Land-Use, Upgraded Hydraulics and Daylighting;
- Scenario 6 - Future Land-Use, Upgraded Hydraulics and Daylighting; and
- Scenario 7 - Future Land-Use, Upgraded Hydraulics, Daylighting and Detention.

These model scenarios along with the results are described in detail below. All model scenarios were run using the SCS 1A rainfall distributions for the 6-month, 2-year, 5-year, 10-year, 25-year, 100-year, and 200-year return periods.

The purpose of the 6-month to 5-year return period scenarios are to provide information for the next phase of the ISMP (i.e., lower return periods that are important in habitat assessment). The results of these model runs are provided below and in Appendix F, however these results are not analyzed in this report.

The 10-year to 200-year return period scenarios were run to form the basis of the hydrotechnical evaluation. The results and analysis of these model runs are provided below.

4.2 SCENARIO 1 – EXISTING LAND-USE, EXISTING HYDRAULICS

DESCRIPTION

This scenario reflects existing land-use conditions and existing hydraulics.

RESULTS

The 15-minute peak flow rates (averaged over 15 minutes) at key locations along the creek and tributary are summarized in the following Table 4-1.

Table 4-1: Scenario 1 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	8.83	10.87	15.31[1]	16.64[1]	18.92[1]	22.74[1]	23.75[1]
32-31	Storm Drain at Trent Street	7.48	9.63	12.80	14.04[1]	16.72[1]	20.37[1]	21.40[1]
43-42	Storm Drain at Newton	7.39	9.90	15.07	17.65	18.50	20.03[1]	21.11[1]
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	5.40	7.26	10.62	14.22	16.53	27.95[1]	29.88[1]
70-69	Storm Drain at Knight	4.10	5.55	8.32	10.89	14.40[2]	21.37[2]	23.57[2]
100-52	Downstream End of Cedar Hill Tributary	1.12	1.52	2.67	3.38	4.15	5.07	5.30[1]

Notes:
1 - Includes overland flow.
2 - Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-1.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-2:

Table 4-2: Scenario 1 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	38
25-Year	72
100-Year	193
200-Year	297

Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.

The model indicates that sections of Bowker Creek with the most significant hydraulic limitations are summarized as follows:

Fireman's Park Storm Drain – The storm drain through Fireman's Park does not have adequate capacity to convey the 10-year storm event and overland flow occurs. This typically results in flooding of 1741 Monteith.

Trent Storm Drain and Upstream Channel – The storm drain from Trent to Fort does not have adequate capacity for the 10-year storm event and overland flow occurs. Furthermore, the properties upstream of this storm drain are relatively low and flooding occurs from Trent to upstream of Haultain.

Newton Storm Drain and Upstream Channel – The storm drain from Newton to Richmond does not have adequate capacity for the 100-year storm event and overland flow occurs. Furthermore, the properties near Pearl are relatively low and as a result of limited storm drain and channel capacity flooding occurs.

DISCUSSION

This model scenario shows that portions of the existing conveyance system have inadequate capacity and flooding occurs during the 10-year storm event. The current municipal standard for Bowker Creek is to have no flooding during the 25-year storm event, and therefore, substantial upgrades are required to meet this criteria.

4.3 SCENARIO 2 – 25-YEAR FUTURE LAND-USE, EXISTING HYDRAULICS

DESCRIPTION

This scenario reflects predicted climate change, future land-use conditions and existing hydraulics.

RESULTS

The 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-3.

Table 4-3: Scenario 2 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	10.85	15.21[1]	17.63[1]	20.30[1]	21.81[1]	23.87[1]	24.67[1]
32-31	Storm Drain at Trent Street	9.78	12.76	14.11	17.93[1]	19.60[1]	21.60[1]	22.62[1]
43-42	Storm Drain at Newton	10.17	15.07	18.17	18.74	19.24[1]	21.45[1]	23.26[1]
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	7.45	10.59	17.04	18.70	22.04[1]	32.45[1]	33.59[1]
70-69	Storm Drain at Knight	5.71	8.33	13.19	16.01[2]	19.43[2]	24.95[2]	27.22[2]
100-52	Downstream End of Cedar Hill Tributary	1.58	2.61	3.78	4.21	4.80	5.48[1]	6.24[1]

Notes:
1 - Includes overland flow
2 - Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-2.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-4.

Table 4-4: Scenario 2 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	53
25-Year	143
100-Year	301
200-Year	305

Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.

The model indicates that as a result of the predicted climate change and changes in land-use, flooding may increase.

DISCUSSION

With the predicted climate change and changes in land-use there will be greater pressure to increase the hydraulic capacity of Bowker Creek. In the future, flooding may occur more frequently and the flooding may be more significant. The current municipal standard for Bowker Creek is to have no flooding during the 25-year storm event, and therefore, significant hydraulics upgrades could be required. The extent of these upgrades is identified in the following scenarios.

4.4 SCENARIO 3 – EXISTING LAND-USE, UPGRADED HYDRAULICS

DESCRIPTION

This scenario reflects existing land-use conditions and upgraded hydraulics. The hydraulic capacity of the creek has been upgraded in the current state (i.e., open channels remain open and enclosed sections remain enclosed). The criteria used for the upgrades are to have no flooding of houses or buildings during the 25-year return period event. Contour information was used to determine when a house or building was impacted, as a survey of house minimum floor elevations was not undertaken.

For the extended enclosed sections, Gordon Head to Knight and North Dairy to Pearl, the upgrades were also based on maintaining a maximum water level at the obvert of the existing storm drains during the 25-year return period event.

The maximum water elevations (without flooding of buildings) are summarized in the following Table 4-5. These water levels were used to determine the required upgrades for all upgrade scenarios.

Table 4-5: Maximum Water Elevations Without Flooding

Node	Max Elev.	Node	Max Elev.	Node	Max Elev.	Node	Max Elev.
2	3.1	27	14.2	52	22.2	77	34.2
3	3.1	28	14.8	53	22.7	78	34.5
4	5.2	29	14.8	54	25.2	79	34.9
5	5.0	30	14.8	55	25.2	80	36.2
6	5.7	31	15.0	56	25.0	81	36.7
7	5.7	32	13.9	57	25.3	82	37.8
8	9.1	33	14.1	58	26.4	83	39.0
9	10.1	34	14.1	59	26.4	84	40.7
10	10.0	35	14.0	60	26.0	85	42.0
11	10.5	36	15.0	61	27.5	100	22.0
12	10.2	37	14.7	62	27.5	101	21.9
13	11.0	38	14.5	63	26.0	102	22.6
14	10.9	39	15.0	64	27.7	103	25.0

Node	Max Elev.	Node	Max Elev.	Node	Max Elev.	Node	Max Elev.
15	11.3	40	16.1	65	30.0	103	25.0
16	11.5	41	17.1	66	30.5	103	25.0
17	11.8	42	17.2	67	32.0	104	25.0
18	12.0	43	18.0	68	32.0	105	25.3
19	13.3	44	18.0	69	31.0	106	25.3
20	14.0	45	18.0	70	29.6	107	27.5
21	14.0	46	17.5	71	30.1	108	27.5
22	14.0	47	18.2	72	30.4	109	27.5
23	14.0	48	18.2	73	30.9	110	27.5
24	14.0	49	18.9	74	31.1	111	27.5
25	13.8	50	19.2	75	31.8	112	27.5
26	14.0	51	20.8	76	32.8	113	27.5

The hydraulic upgrades used for this scenario are summarized in the following Table 4-6.

Table 4-6: Scenario 3 - Hydraulic Upgrades

Link	Existing	Upgrade
4-3	3.0 x 1.8 Box	Upgrade to 7.0 x 1.8 Box.
10-7	1.7 x 1.7 Arch	Add 2.44 x 1.83 Box.
14-13	3.1 x 2.0 Box	Upgrade to 8.00 x 2.00 Box[1].
22-19	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.
23-22	2 - 2.4 x 2.4 Box	Upgrade to 8.00 x 2.40 Box. Lower by 0.43 m at upstream end and 0.32 m at downstream end.
24-23	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.
25-24	3.8 x 2.7 CSP Ellipse	Add 3.66 x 3.66 Box. Lower by 0.57 m at upstream end and 0.43 m at downstream end.
27-25	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.
28-27	3.6 x 3.3	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.
30-28	Open Channel (Rectangular)	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.
31-30	3.0 x 3.6 Arch	Add 3.66 x 3.66 Box. Lower by 1.16 m at upstream end and 0.92 m at downstream end.
32-31	2.4 x 2.4 Box	Add 3.66 x 3.66 Box. Lower by 1.36 m at upstream end and 1.16 m at downstream end.

38-32	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.
39-38	3.1 x 1.6 Box	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.
42-39	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.
43-42	2.4 x 2.4	Upgrade to 3.66 x 2.44 Box.
49-43	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes.
50-49	3.3 x 1.8	Add 2.44 x 1.52 Box.
64-62	Open Channel	Add 1.37 round (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.
71-69	1.8 Round	Upgrade to 3.10 x 1.83 Box.
74-71	1.8 x 1.5 Box	Upgrade to 2.44 x 1.52 Box.
75-74	1.8 x 1.5 Box	Upgrade to 3.66 x 1.52 Box.
76-75	1.8 x 1.5 Box	Upgrade to 3.10 x 1.52 Box.
80-76	1.8 x 1.2 Box	Upgrade to 2.44 x 1.22 Box.
81-80	2 – 0.9 Round	Upgrade to 2.44 x 1.22 Box.
84-81	1.05 Round	Upgrade to 1.22 Round.
85-84	0.6 Round	Upgrade to 1.07 Round.

Notes:
Manning's 'n' of 0.05 (i.e. clean bottom, brush banks) used for proposed open channels with 1.5:1 side slopes.
Manning's 'n' of 0.02 (i.e. mortared rock) used for proposed open channels with vertical sides.
1. Alternatively Haultain Road and the top of the culvert could be raised by approximately 1.0 m.

Table 4-6 above indicates that upgrades are required for all of the storm drains between Node 69 and Node 85. The majority of these upgrades however are not a significant increase in size. We have therefore investigated what volume of detention at UVic would be required in order to eliminate or reduce upgrades of this section of storm drains.

It was found that no volume of detention provided at UVic (Node 85) would eliminate the need for upgrades of the storm drains between Node 69 and 85. This was confirmed by running the model with the catchment contributing to Node 85 removed. The results of this model run indicate that some storm drains between Node 69 and 85 do not have adequate capacity and may surcharge during the 25-year storm event.

We also investigated the detention volume required at UVic (Node 85) in order to reduce the required upgrades of the storm drains between Node 69 and 85. With a detention volume of 6,000 m^3 at Node 85 for the 25-year storm event, the only require upgrades between Node 69 and 85 are as follows:

- Link 71-69, Upgrade to 3.10 x 1.83 Box; and
- Link 76-74, Upgrade to 3.10 x 1.52 Box.

With these upgrades and 6000 m^3 of detention at Node 85, there is still a small amount of surcharge at two locations between Node 69 and 85. At Node 74 there is 0.4 m of surcharge and at Node 81 there is 0.8 m of surcharge. These surcharge depths are below the ground surface.

RESULTS

The 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-7.

Table 4-7: Scenario 3 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	8.99	12.82	20.43	25.34	29.74	34.75	39.02[1]
32-31	Storm Drain at Trent Street	7.54	10.64	17.20	21.91	26.00	29.63	31.03
43-42	Storm Drain at Newton	7.34	10.3	16.58	20.60	24.83	29.20	29.09
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	5.35	7.51	11.88	15.23	17.78	20.52	26.44[1]
70-69	Storm Drain at Knight	4.12	5.72	9.19	10.81	13.66	15.02	24.03
100-52	Downstream End of Cedar Hill Tributary	1.12	1.52	2.63	3.49	4.18	4.64	5.29

Notes:
1. Includes overland flow
2. Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-3.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-8.

Table 4-8: Scenario 3 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	0
25-Year	0
100-Year	60
200-Year	76
Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.	

The upgrades designed to eliminate flooding for the 25-year event also significantly reduce the amount of flooding during the 100-year and 200-year events.

DISCUSSION

As summarized in Table 4-6, the required upgrades in order to have no flooding during the 25-year storm event are significant. The properties upstream of the Trent to Fort storm drain are relatively low. Therefore, the only reasonable method of meeting the criteria in this area is to lower the creek from Oak Bay High School to Haultain.

For some sections we have increased the hydraulic capacity of the storm drains rather than simply adding storm drains. This was done in areas where it was felt there is not adequate room for additional storm drains. However, either upgrading or the addition of storm drains is suitable as long as they have the same hydraulic capacity at the same elevation.

In comparing Table 4-7 with Table 4-3, the peak flows increase significantly as additional hydraulic capacity is provided. This is because the overland flooding and detention that occurs in the existing scenario, is reduced in this upgrade scenario.

For this scenario, detention at UVic can significantly reduce the extent of required upgrades (assuming a small amount of surcharge is acceptable) in the downstream storm drains (Nodes 69 to 85).

4.5 SCENARIO 4 – 25-YEAR FUTURE LAND-USE, UPGRADED HYDRAULICS

DESCRIPTION

This scenario reflects predicted climate change, future land-use conditions and upgraded hydraulics. The hydraulic upgrade criteria for this scenario are the same as for Scenario 3 (i.e. no flooding of buildings during the 25-year storm event). The hydraulic upgrades are summarized in the following Table 4-9.

Table 4-9: Scenario 4 - Hydraulic Upgrades

Link	Existing	Upgrade
4-3	3.0 x 1.8 Box	Upgrade to 7.0 x 1.8 Box.
10-7	1.7 x 1.7 Arch	Add 3.10 x 2.44 Box.
14-13	3.1 x 2.0 Box	Upgrade to 12.00 x 2.00 Box[1].
22-19	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.
23-22	2 - 2.4 x 2.4 Box	Upgrade to 10.00 x 2.40 Box. Lower by 0.43 m at upstream end and 0.32 m at downstream end.
24-23	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.
25-24	3.8 x 2.7 CSP Ellipse	Add 2 – 2.44 x 3.66 Box. Lower by 0.57 m at upstream end and 0.43 m at downstream end.
27-25	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.
28-27	3.6 x 3.3	Upgrade to 7.0 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.
30-28	Open Channel (Rectangular)	Widen to a base width of 6.0 m with vertical sides (only 7.0 m between property lines). Lower by 0.92 m at upstream end and 0.94 m at downstream end.
31-30	3.0 x 3.6 Arch	Upgrade to 2 - 3.66 x 3.66 Boxes. Lower by 1.16 m at upstream end and 0.92 m at downstream end.
32-31	2.4 x 2.4 Box	Upgrade to 2 - 3.66 x 3.66 Boxes. Lower by 1.36 m at upstream end and 1.16 m at downstream end.
38-32	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.
39-38	3.1 x 1.6 Box	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.
42-39	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.
43-42	2.4 x 2.4	Upgrade to 2 - 3.10 x 2.44 Boxes.
49-43	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes.
50-49	3.3 x 1.8	Add 3.66 x 1.83 Box.
52-50	2.4 x 2.4	Add 1.52 Round.
64-62	Open Channel	Add 1.83 x 1.52 box (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.
71-69	1.8 Round	Upgrade to 3.66 x 1.83 Box.
74-71	1.8 x 1.5 Box	Upgrade to 3.10 x 1.52 Box.
75-74	1.8 x 1.5 Box	Upgrade to 3.66 x 1.52 Box.
76-75	1.8 x 1.5 Box	Upgrade to 3.66 x 1.52 Box.
80-76	1.8 x 1.2 Box	Upgrade to 3.10 x 1.22 Box.
81-80	2 – 0.9 Round	Upgrade to 3.10 x 1.22 Box.

Link	Existing	Upgrade
84-81	1.05 Round	Upgrade to 1.83 x 1.22 Box.
85-84	0.6 Round	Upgrade to 1.37 Round.

Notes:
Manning's 'n' of 0.05 (i.e. clean bottom, brush banks) used for proposed open channels with 1.5:1 side slopes.
Manning's 'n' of 0.02 (i.e. mortared rock) used for proposed open channels with vertical sides.
1. Alternatively Haultain Road and the top of the culvert could be raised by approximately 1.2 m.

Similar to Scenario 3, we have investigated what volume of detention at UVic would be required in order to eliminate or reduce upgrades of the section of storm drains between Nodes 69 and 85.

As with Scenario 3, no volume of detention provided at UVic (Node 85) would eliminate the need for upgrades of the storm drains between Node 69 and 85.

We also investigated the detention volume required at UVic (Node 85) in order to reduce the required upgrades of the storm drains between Node 69 and 85. With a detention volume of 13,000 m^3 at Node 85 for the 25-year storm event, the upgrades upstream of Node 78 would not be required. The upgrades downstream of Node 78 would be the same as indicated in Table 4-9.

With these upgrades and 13,000 m^3 of detention at Node 85, there is some surcharge at two locations between Node 69 and 85. At Node 81 there is 1.4 m of surcharge and at Node 82 there is 0.7 m of surcharge. These surcharge depths are below the ground surface.

This detention volume of 13,000 m^3 is however greater than what has been identified as available at UVic (see Scenario 7).

RESULTS

The 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-10.

Table 4-10: Scenario 4 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	12.70	20.33	28.63	34.75	40.63	43.76	51.89
32-31	Storm Drain at Trent Street	10.76	17.17	24.58	29.63	34.54	37.59	38.63
43-42	Storm Drain at Newton	5.26	8.35	12.07	29.20	33.22	35.36	36.18
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	4.94	7.42	11.88	20.52	23.54	27.97[1]	28.58[1]
70-69	Storm Drain at Knight	5.87	9.13	12.99	15.02	18.08	21.09	28.55
100-52	Downstream End of Cedar Hill Tributary	1.58	2.62	4.01	4.64	5.24	5.50[1]	6.26[1]

Notes:
1. Includes overland flow.
2. Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-4.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-11.

Table 4-11: Scenario 4 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	0
25-Year	0
100-Year	72
200-Year	78

Note:
The above number of flooded houses or buildings does not include properties upstream of Knight Street.

DISCUSSION

In comparing Table 4-9 with Table 4-6, the required upgrades for Scenario 4 are greater than those of Scenario 3. This is the result of the increased flow rates for the future scenario, which can be seen by comparing Table 4-10 with Table 4-7.

For this scenario, detention at UVic can reduce the extent of required upgrades (assuming a some of surcharge is acceptable) in the downstream storm drains (Nodes 69 to 85). The flooding extents for Scenario 4 are illustrated on the attached Figure 4-4.

4.6 SCENARIO 5 – EXISTING LAND-USE, UPGRADED HYDRAULICS AND DAYLIGHTING

DESCRIPTION

This scenario reflects existing land-use conditions, upgraded hydraulics and daylighting of enclosed sections (except at road crossings). The hydraulic upgrade criteria for this scenario is the same as for Scenarios 3 and 4 (i.e., no flooding of buildings during the 25-year storm event).

The upgraded hydraulics and daylighted sections are summarized in the following Table 4-12.

Table 4-12: Scenario 5 - Upgraded Hydraulics and Daylighted Sections

Link	Existing	Upgrade
4-3	3.0 x 1.8 Box	Upgrade to 5.0 x 1.8 Box.
10-7	1.7 x 1.7 Arch	Open channel with a base width of 2.0 m and 1.5:1 side slopes.
14-13	3.1 x 2.0 Box	Upgrade to 8.00 x 2.00 Box[1].
22-19	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.
23-22	2 - 2.4 x 2.4 Box	Open channel with a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.32 m at downstream end.
24-23	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.
25-24	3.8 x 2.7 CSP Ellipse	Open channel with a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.57 m at upstream end and 0.43 m at downstream end.
27-25	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.
28-27	3.6 x 3.3	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.
30-28	Open Channel (Rectangular)	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.
31-30	3.0 x 3.6 Arch	Open channel with a base width of 4.0 m and vertical sides. Lower by 1.16 m at upstream end and 0.92 m at downstream end.
32-31	2.4 x 2.4 Box	Open channel with a base width of 4.0 m and vertical sides. Lower by 1.36 m at upstream end and 1.16 m at downstream end.

Link	Existing	Upgrade
38-32	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.
39-38	3.1 x 1.6 Box	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.
42-39	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.
43-42	2.4 x 2.4	Open channel with a base width of 4.0 m and vertical sides.
49-43	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes.
50-49	3.3 x 1.8	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
53-50	2.4 x 2.4	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
54-53	2.4 x 1.5	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
64-62	Open Channel	Add 1.37 Round (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.
71-69	1.8 Round	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
74-71	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
75-74	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
76-75	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
80-76	1.8 x 1.2 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
81-80	2 – 0.9 Round	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
84-81	1.05 Round	Open channel with a base width of 2.0 m and 1.5:1 side slopes.
85-84	0.6 Round	Upgrade to 1.07 Round

Notes:
Manning's 'n' of 0.05 (i.e. clean bottom, brush banks) used for proposed open channels with 1.5:1 side slopes.
Manning's 'n' of 0.02 (i.e. mortared rock) used for proposed open channels with vertical sides.
1. Alternatively Haultain Road and the top of the culvert could be raised by approximately 1.0 m.

RESULTS

The 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-13.

Table 4-13: Scenario 5 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	7.83	11.31	18.64	23.74	28.88	41.24	43.87
32-31	Storm Drain at Trent Street	6.47	9.29	15.64	20.12	24.91	35.12	37.89
43-42	Storm Drain at Newton	6.17	8.81	14.97	19.50	23.84	35.02	37.46
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	4.58	6.5	10.7	13.58	16.52	25.72	28.20
70-69	Storm Drain at Knight	3.62	5.09	8.36	10.79	13.18	19.26	21.22
100-52	Downstream End of Cedar Hill Tributary	1.12	1.52	2.69	3.51	4.39	5.67	5.90

Notes:
1. Includes overland flow
2. Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-5.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-14.

Table 4-14: Scenario 5 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	0
25-Year	0
100-Year	21
200-Year	35

Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.

DISCUSSION

Similar to Scenarios 3 and 4, the required upgrades in order to have no flooding during the 25-year storm event are significant. As with Scenarios 3 and 4, the upgrades assume lowering the creek from Oak Bay High School to Haultain.

The extent of flooding for the 100 and 200-year return periods for this scenario compared with Scenario 3 is decreased. This is because the capacity of an open channel significantly increases with depth, whereas the capacity of a surcharged storm drain only increases marginally with depth.

For the sections from Trent to Fort and from Newton to Richmond open channels were modelled with vertical sides. This was done because of the limited area available in these areas. However, open channels with flatter side slopes would also be acceptable as long as they have the same hydraulic capacity at the same elevation.

4.7 SCENARIO 6 – 25-YEAR FUTURE LAND-USE, UPGRADED HYDRAULICS AND DAYLIGHTING

DESCRIPTION

This scenario reflects future land-use conditions, upgraded hydraulics and daylighting of enclosed sections (except at road crossings). The hydraulic upgrade criteria for this scenario is the same as for Scenarios 3, 4 and 5 (i.e., no flooding of buildings during the 25-year storm event).

The upgraded hydraulics and daylighted sections are summarized in the following Table 4-15.

Table 4-15: Scenario 6 - Upgraded Hydraulics and Daylighted Sections

Link	Existing	Upgrade
4-3	3.0 x 1.8 Box	Upgrade to 7.0 x 1.8 Box.
10-7	1.7 x 1.7 Arch	Open channel with a base width of 2.0 m and 1.5:1 side slopes.
14-13	3.1 x 2.0 Box	Upgrade to 8.00 x 2.00 Box[1].
22-19	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.
23-22	2 - 2.4 x 2.4 Box	Open channel with a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.32 m at downstream end.
24-23	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.
25-24	3.8 x 2.7 CSP Ellipse	Open channel with a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.57 m at upstream end and 0.43 m at downstream end.
27-25	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.
28-27	3.6 x 3.3	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.
30-28	Open Channel (Rectangular)	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.

Link	Existing	Upgrade
31-30	3.0 x 3.6 Arch	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.16 m at upstream end and 0.92 m at downstream end.
32-31	2.4 x 2.4 Box	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.36 m at upstream end and 1.16 m at downstream end.
38-32	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.
39-38	3.1 x 1.6 Box	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.
42-39	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.
43-42	2.4 x 2.4	Open channel with a base width of 4.0 m and vertical sides.
49-43	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes.
50-49	3.3 x 1.8	Open channel with a base width of 5.0 m and 1.5:1 side slopes.
52-50	2.4 x 2.4	Open channel with a base width of 5.0 m and 1.5:1 side slopes.
53-52	2.4 x 2.4	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
54-53	2.4 x 1.5	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
64-62	Open Channel	Add 1.83 x 1.52 box (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.
71-69	1.8 Round	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
74-71	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
75-74	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
76-75	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
80-76	1.8 x 1.2 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
81-80	2 – 0.9 Round	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
84-81	1.05 Round	Open channel with a base width of 2.0 m and 1.5:1 side slopes.
85-84	0.6 Round	Upgrade to 1.37 Round

Notes:
Manning's 'n' of 0.05 (i.e. clean bottom, brush banks) used for proposed open channels with 1.5:1 side slopes.
Manning's 'n' of 0.02 (i.e. mortared rock) used for proposed open channels with vertical sides.
1. Alternatively Haultain Road and the top of the culvert could be raised by approximately 1.2 m.

RESULTS

The 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-16.

Table 4-16: Scenario 6 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	10.87	17.95	25.51	31.04	37.71	44.89	48.91
32-31	Storm Drain at Trent Street	9.08	15.09	21.93	27.01	32.52	38.74	42.13
43-42	Storm Drain at Newton	8.72	14.45	21.13	26.08	31.48	38.12	41.51
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	6.59	10.63	15.3	18.91	23.05	29.58	32.61
70-69	Storm Drain at Knight	5.22	8.31	12.03	14.43	17.45	22.24	24.77
100-52	Downstream End of Cedar Hill Tributary	1.58	2.61	4.02	4.65	5.30	5.81	6.15[1]

Notes:
1. Includes overland flow.
2. Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-6.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-17.

Table 4-17: Scenario 6 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	0
25-Year	0
100-Year	27
200-Year	44

Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.

DISCUSSION

In comparing Table 4-15 with Table 4-12, the required upgrades for Scenario 6 are greater than those of Scenario 5. This is the result of the increased flow rates for the future scenario, which can be seen by comparing Table 4-16 with Table 4-13.

4.8 SCENARIO 7 – 25-YEAR FUTURE LAND-USE, UPGRADED HYDRAULICS, DAYLIGHTING AND DETENTION

DESCRIPTION

This scenario reflects future land-use conditions, upgraded hydraulics, daylighting of enclosed sections (except at road crossings) and detention. The hydraulic upgrade criteria for this scenario is the same as for Scenarios 3, 4, 5, and 6 (i.e., no flooding of buildings during the 25-year storm event).

The detention facility locations were selected based on available land and suitable topography. The detention facilities used for this scenario are illustrated on Figure 4-7b. The detention was created in the model by modifying the channel sections to lower the floodplain to an elevation of 1.0 m above the channel invert. The exception is the detention provided at UVic, which has an area of 2,000 m^2 and the same invert as Node 85.

The detention volumes provided for the 6-month, 2-year and 5-year return periods were maximized by modelling control structures immediately downstream of the on line detention facilities (Nodes 39 and 43). This was not done at the lower detention facility (Node 35) because a reasonably sized control structure at this location would result in unacceptable water levels upstream during the 25-year return period event. The details of the control structures are summarized in the following Table 4-18.

Table 4-18: Scenario 7 – Detention Control Structures

Return Period	Node 39		Node 43	
	Lower Outlet	Upper Outlet	Lower Outlet	Upper Outlet
6-Month	Orifice Inv. 10.71 Area = 1.8 m^2	Weir Crest El. 13.9 Width = 15 m	Orifice Inv. 13.93 Area = 3.0 m^2	Weir Crest El. 16.3 Width = 15 m
2-Year	Orifice Inv. 10.71 Area = 4.0 m^2	Weir Crest El. 13.9 Width = 15 m	Orifice Inv. 13.93 Area = 9.0 m^2	Weir Crest El. 16.3 Width = 15 m
5-Year	Orifice Inv. 10.71 Area = 9.0 m^2	Weir Crest El. 13.9 Width = 15 m	See Note 1	See Note 1
Note: 1 – The detention upstream of this location is nearly optimized for the 5-year return period event without a control structure, therefore a control structure was not included in the model.				

The upgraded hydraulics and daylighted sections are summarized in the following Table 4-19.

Table 4-19: Scenario 7 - Upgraded Hydraulics and Daylighted Sections

Link	Existing	Upgrade
4-3	3.0 x 1.8 Box	Upgrade to 7.0 x 1.8 Box.
10-7	1.7 x 1.7 Arch	Open channel with a base width of 2.0 m and 1.5:1 side slopes.
14-13	3.1 x 2.0 Box	Upgrade to 8.00 x 2.00 Box[1].
22-19	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.
23-22	2 - 2.4 x 2.4 Box	Open channel with a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.32 m at downstream end.
24-23	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.
25-24	3.8 x 2.7 CSP Ellipse	Open channel with a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.57 m at upstream end and 0.43 m at downstream end.
27-25	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.
28-27	3.6 x 3.3	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.
30-28	Open Channel (Rectangular)	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.
31-30	3.0 x 3.6 Arch	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.16 m at upstream end and 0.92 m at downstream end.
32-31	2.4 x 2.4 Box	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.36 m at upstream end and 1.16 m at downstream end.
38-32	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.
39-38	3.1 x 1.6 Box	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.
42-39	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.
43-42	2.4 x 2.4	Open channel with a base width of 4.0 m and vertical sides.
46-43	Open Channel	Widen to a base width of 2.0 m and 1.5:1 side slopes.
49-46	Open Channel	Widen to a base width of 4.0 m and 1.5:1 side slopes.
50-49	3.3 x 1.8	Open channel with a base width of 5.0 m and 1.5:1 side slopes.
52-50	2.4 x 2.4	Open channel with a base width of 5.0 m and 1.5:1 side slopes.
53-52	2.4 x 2.4	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
54-53	2.4 x 1.5	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
64-62	Open Channel	Add 1.83 x 1.52 box (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.
71-69	1.8 Round	Open channel with a base width of 3.0 m and 1.5:1 side slopes.

Link	Existing	Upgrade
74-71	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
75-74	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
76-75	1.8 x 1.5 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
80-76	1.8 x 1.2 Box	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
81-80	2 – 0.9 Round	Open channel with a base width of 3.0 m and 1.5:1 side slopes.
84-81	1.05 Round	Open channel with a base width of 2.0 m and 1.5:1 side slopes.
85-84	0.6 Round	Upgrade to 1.37 Round.
Notes: Manning's 'n' of 0.05 (i.e. clean bottom, brush banks) used for proposed open channels with 1.5:1 side slopes. Manning's 'n' of 0.02 (i.e. mortared rock) used for proposed open channels with vertical sides. 1. Alternatively Haultain Road and the top of the culvert could be raised by approximately 1.2 m.		

RESULTS

The detention volumes provided at each of the sites are summarized in the following Table 4-20.

Table 4-20: Scenario 7 – Detention Volumes

Link or Node	Detention Volumes (m^3)						
	6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
37-34	3,700	6,600	9,700	12,500	14,800	18,600	20,600
42-39	9,500	10,200	11,300	12,000	15,300	20,500	23,000
49-43	8,900	10,200	11,500	14,100	17,100	21,000	23,000
Upstream of 85	1,500	1,900	2,300	2,500	2,980	4,100	4,800

The 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-21.

Table 4-21: Scenario 7 – 15-Minute Peak Flow Rates

Link	Location	15-Minute Peak Flow Rates (m^3/s)						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman's Park	7.34	12.83	20.47	27.56	33.32	41.16	45.15
32-31	Storm Drain at Trent Street	6.20	11.15	17.62	23.82	28.97	35.55	39.29
43-42	Storm Drain at Newton	7.10	12.00	19.60	24.60	30.08	37.55	41.08
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	6.36	10.01	14.62	18.13	21.93	28.17	31.03
70-69	Storm Drain at Knight	4.87	7.66	11.27	13.54	16.50	20.71	22.78
100-52	Downstream End of Cedar Hill Tributary	1.58	2.61	4.03	4.67	5.33	5.86	6.19[1]

Notes:
1 - Includes overland flow.
2 - Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The extent of flooding for the 10-year, 25-year, 100-year and 200-year return periods is illustrated on the attached Figure 4-7a.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for this scenario are summarized in the following Table 4-22.

Table 4-22: Scenario 7 – Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses or Buildings
10-Year	0
25-Year	0
100-Year	20
200-Year	36

Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.

DISCUSSION

In comparing the peak flows in Table 4-21 and Table 4-16 the peak flows decrease from 0% to 32%. The detention for Scenario 7 provides the greatest reduction in peak flows for the more frequent storms (6-month) and the least reduction in peak flows for the less frequent storms. For the 25-year return period (the design criteria event) the reduction in peak flows are minimal.

For the 6-month and 2-year return periods the reduction in peak flows is significant downstream of the larger detention facilities. These return periods are typically the management focus for environmental protection measures. Detention for these return periods may provide a significant environmental and erosion benefit and should therefore be considered as part of the ISMP.

The upgrades for this scenario are similar to those in Scenario 6, except the channel widths can be reduced through the areas of the proposed detention.

4.9 SCENARIO SUMMARY

REQUIRED UPGRADES

A summary of the hydraulic upgrades or daylighting for each scenario is summarized in the following Table 4-23.

Table 4-23: Summary of Hydraulic Upgrades

Link	Scenario 3 Ex. LU Up. Hyd.	Scenario 4 Fu. LU Up. Hyd.	Scenario 5 Ex. LU Daylight	Scenario 6 Fu. LU Daylight	Scenario 7 Fu. LU Day. & Det.
4-3	Up. 7.0x1.8	Up. 7.0x1.8	Up. 5.0x1.8	Up. 7.0x1.8	Up. 7.0x1.8
10-7	Add 2.4x1.8	Add 3.1x2.4	OC 2.0 BW	OC 2.0 BW	OC 2.0 BW
14-13	Up. 8.0x2.0	Up. 12.0x2.0	Up. 8.0x2.0	Up. 8.0x2.0	Up. 8.0x2.0
22-19	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]
23-22	Up. 8.0x2.4[1]	Up. 10.0x2.4[1]	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]
24-23	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]	OC 4.0 BW[1]
25-24	Add 3.7x3.7[1]	Ad.2-2.4x3.7[1]	OC 2.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]
27-25	OC 2.0 BW[1]	OC 4.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]
28-27	Up. 3.6x4.2[1]	Up. 7.0x4.2[1]	Up. 3.6x4.2[1]	Up. 3.6x4.2[1]	Up. 3.6x4.2[1]
30-28	OC Ex. BW[1/2]	OC 6.0 BW[1/2]	OC Ex. BW[1/2]	OC Ex. BW[1/2]	OC Ex. BW[1/2]
31-30	Add 3.7x3.7[1]	Up.2-3.7x3.7[1]	OC 4.0 BW[1/2]	OC 6.0 BW[1/2]	OC 6.0 BW[1/2]
32-31	Add 3.7x3.7[1]	Up.2-3.7x3.7[1]	OC 4.0 BW[1/2]	OC 6.0 BW[1/2]	OC 6.0 BW[1/2]
38-32	OC 2.0 BW[1]	OC 4.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]
39-38	Up. 4.0x3.6[1]	Up. 4.0x3.6[1]	Up. 4.0x3.6[1]	Up. 4.0x3.6[1]	Up. 4.0x3.6[1]
42-39	OC 2.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]	OC 2.0 BW[1]
43-42	Up. 3.7x2.4	Up. 2-3.1x2.4	OC 4.0 BW	OC 4.0 BW	OC 4.0 BW
46-43	OC 4.0 BW	OC 4.0 BW	OC 4.0 BW	OC 4.0 BW	OC 2.0 BW

Link	Scenario 3 Ex. LU Up. Hyd.	Scenario 4 Fu. LU Up. Hyd.	Scenario 5 Ex. LU Daylight	Scenario 6 Fu. LU Daylight	Scenario 7 Fu. LU Day. & Det.
49-46	OC 4.0 BW	OC 4.0 BW	OC 4.0 BW	OC 4.0 BW	OC 4.0 BW
50-49	Add 2.4x1.5	Add 3.7x1.8	OC 3.0 BW	OC 5.0 BW	OC 5.0 BW
52-50		Add 1.5 Dia.	OC 3.0 BW	OC 5.0 BW	OC 5.0 BW
53-52			OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
54-53			OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
64-62	Add 1.4 Dia.	Add 1.8x1.5	Add 1.4 Dia.	Add 1.8x1.5	Add 1.8x1.5
71-69	Up. 3.1x1.8	Up.3.7x1.8	OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
74-71	Up. 2.4x1.5	Up. 3.1x1.5	OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
75-74	Up. 3.7x1.5	Up. 3.7x1.5	OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
76-75	Up. 3.1x1.5	Up. 3.7x1.5	OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
80-76	Up. 2.4x1.2	Up. 3.1x1.2	OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
81-80	Up. 2.4x1.2	Up. 3.1x1.2	OC 3.0 BW	OC 3.0 BW	OC 3.0 BW
84-81	Up. 1.2 Dia.	Up. 1.8x1.2	OC 3.0 BW	OC 2.0 BW	OC 2.0 BW
85-84	Up. 1.1 Dia.	Up. 1.4 Dia.	Up. 1.1 Dia.	Up. 1.4 Dia.	Up. 1.4 Dia.

Notes:
Definitions: Ex. – Existing; Fu. – Future; LU – Land-use; Up. – Upgrade; Hyd. – Hydraulics; Add – Additional; OC – Open Channel; BW – Base Width; Dia. – Diameter.
1 - Includes lowering.
2 - Vertical sides of open channel.

RESULTS

The 6-month, 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-24.

Table 4-24: Summary of 6-Month Peak Flow Rates (m^3/s)

Link	Description	Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	Scen. 6	Scen. 7
10-9	Fireman's Park	8.83	10.85	8.99	12.70	7.83	10.87	7.34
32-31	Storm Drain at Trent Street	7.48	9.78	7.54	10.76	6.47	9.08	6.20
43-42	Storm Drain at Newton	7.39	10.17	7.34	5.26	6.17	8.72	7.10
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	5.40	7.45	5.35	4.94	4.58	6.59	6.36
70-69	Storm Drain at Knight	4.10	5.71	4.12	5.87	3.62	5.22	4.87
100-52	Downstream End of Cedar Hill Tributary	1.12	1.58	1.12	1.58	1.12	1.58	1.58

Notes:
Definitions: Scen. – Scenario.
1. Includes overland flow.
2. Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The 25-year, 15-minute peak flow rates at key locations along the creek and tributary are summarized in the following Table 4-25.

Table 4-25: Summary of 25-Year Peak Flow Rates (m^3/s)

Link	Description	Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	Scen. 6	Scen. 7
10-9	Fireman's Park	18.92[1]	21.81[1]	29.74	40.63	28.88	37.71	33.32
32-31	Storm Drain at Trent Street	16.72[1]	19.60[1]	26.00	34.54	24.91	32.52	28.97
43-42	Storm Drain at Newton	18.50	19.24[1]	24.83	33.22	23.84	31.48	30.08
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	16.53	22.04[1]	17.78	23.54	16.52	23.05	21.93
70-69	Storm Drain at Knight	14.40[2]	19.43[2]	13.66	18.08	13.18	17.45	16.50
100-52	Downstream End of Cedar Hill Tributary	4.15	4.80	4.18	5.24	4.39	5.30	5.33

Notes:
Definitions: Scen. – Scenario.
1. Includes overland flow.
2. Hydraulic grade line above ground elevation. Overland flow may occur. Overland flow routes are not included in this section of the model.

The approximate number of houses or buildings that may experience flooding as a result of water levels in Bowker Creek for the scenarios are summarized in the following Table

4-26. Since the existing municipal drainage criteria is the 25-year storm event, for Scenario 3-7, the hydraulic structures were increased until no houses were flooded during the 25-year event.

Table 4-26: Number of Flooded Houses or Buildings

Return Period	Number of Flooded Houses of Buildings						
	Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	Scen. 6	Scen. 7
10-Year	38	53	0	0	0	0	0
25-Year	72	143	0	0	0	0	0
100-Year	193	301	60	72	21	27	20
200-Year	297	305	76	78	35	44	36
Note: The above number of flooded houses or buildings does not include properties upstream of Knight Street.							

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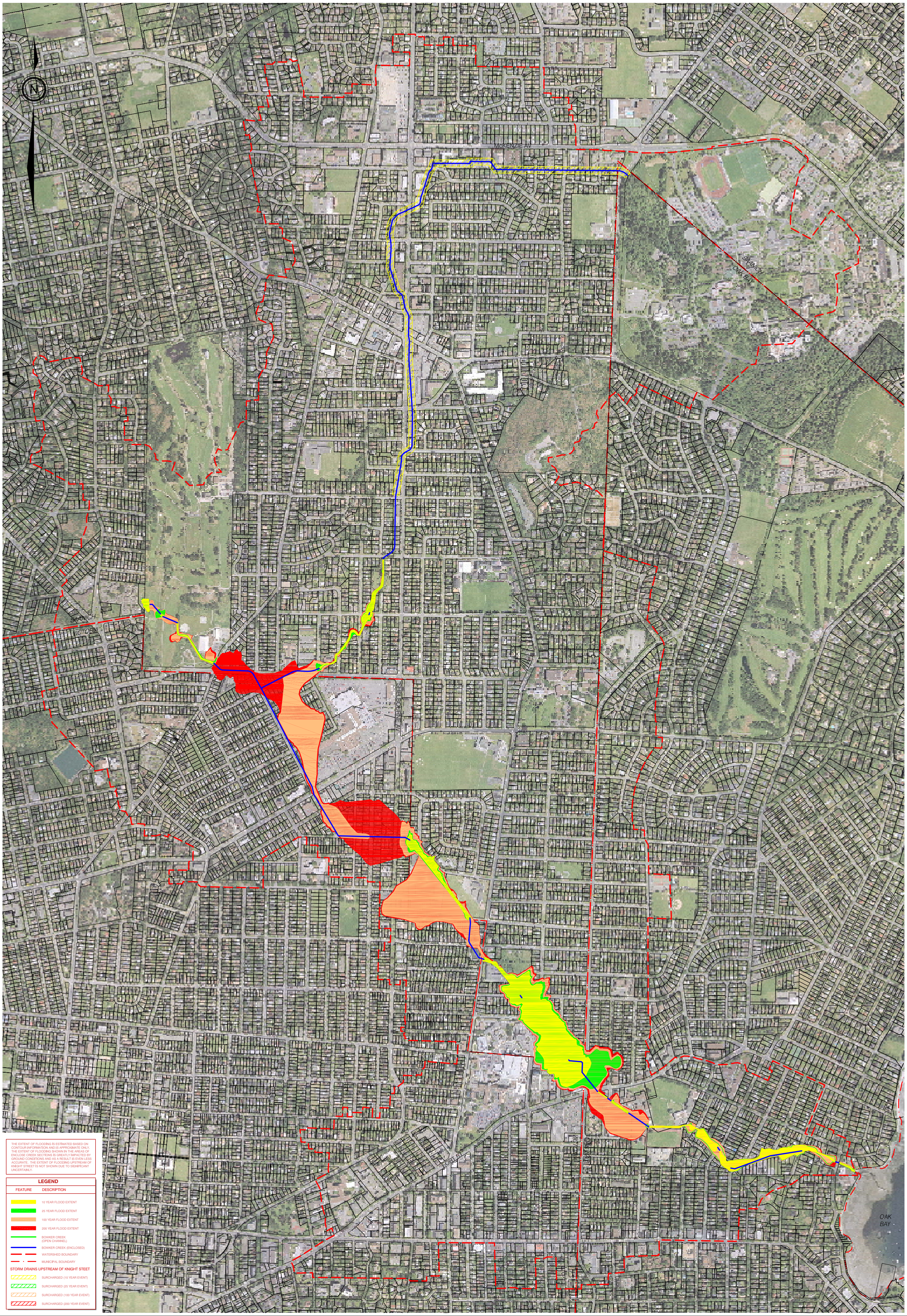

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CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

200 0 200
Scale in Metres 1:7500

BOWKER CREEK MASTER DRAINAGE PLAN
SCENARIO 1 - FLOODING EXTENTS

FIGURE 4-1

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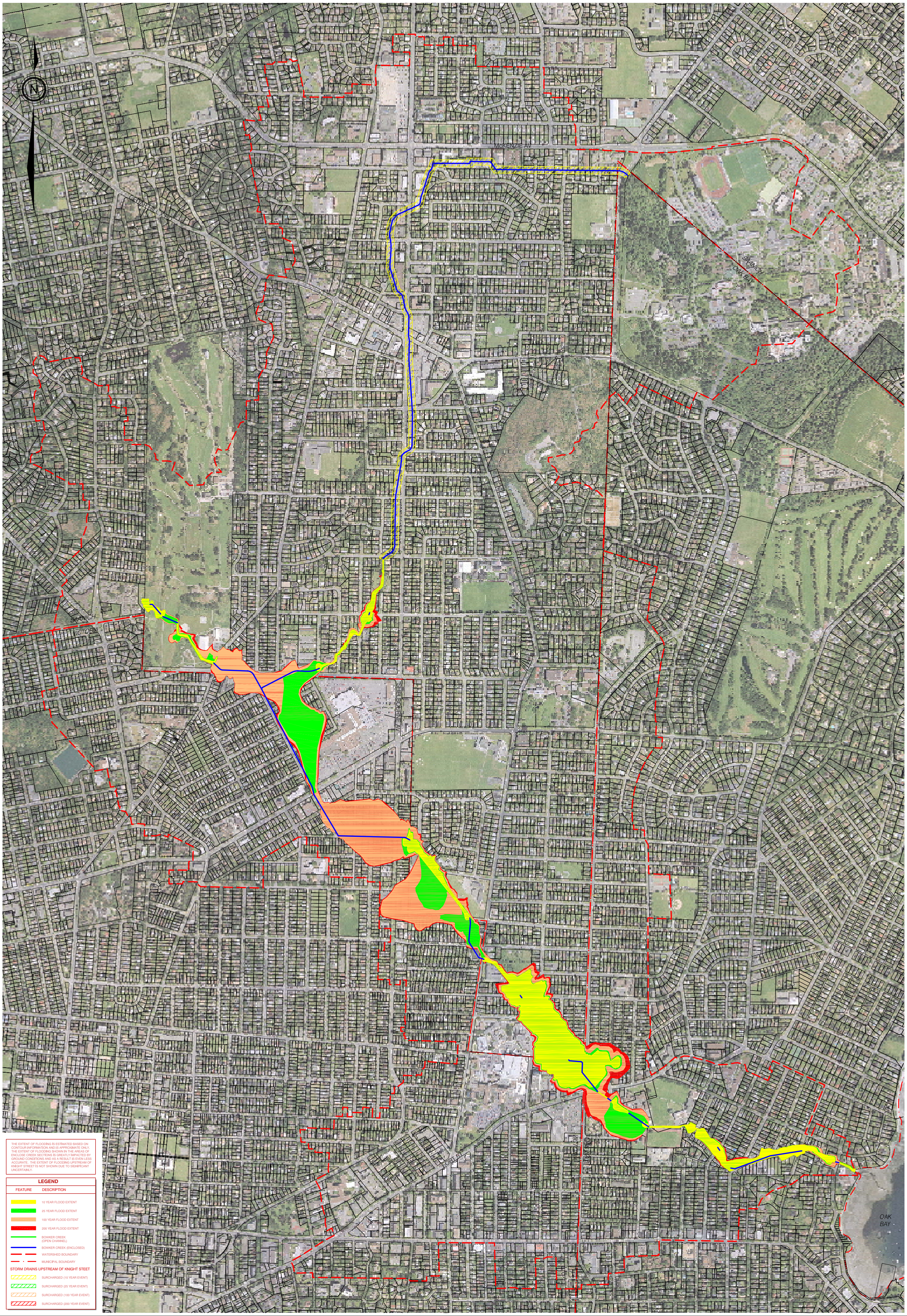

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CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

200 0 200
Scale in Metres 1:7500

BOWKER CREEK MASTER DRAINAGE PLAN
SCENARIO 2 - FLOODING EXTENTS

FIGURE 4-2

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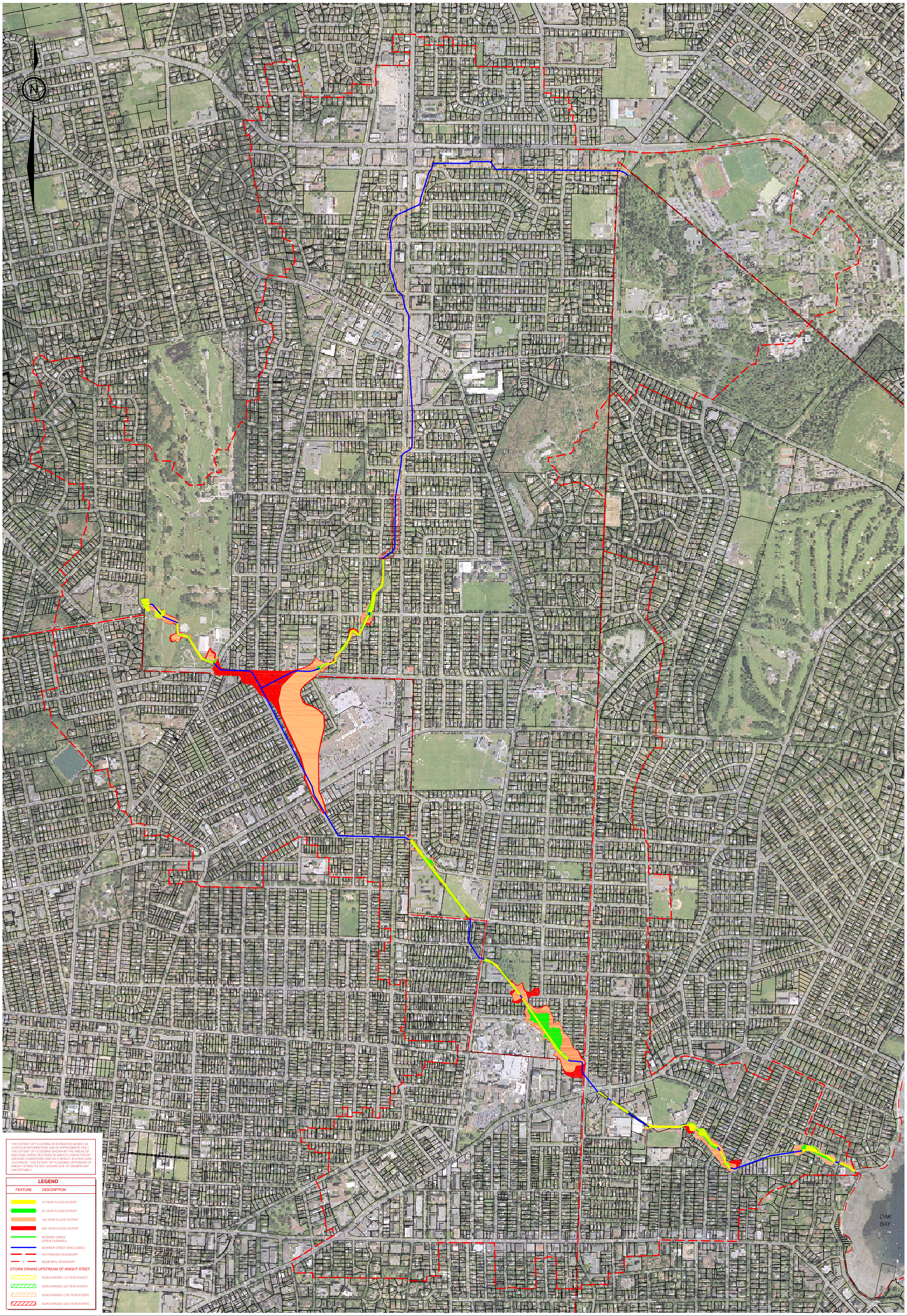

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200 0 200

Scale in Metres 1:7500

CAPITAL REGIONAL DISTRICT

BOWKER CREEK MASTER DRAINAGE PLAN

SCENARIO 3 - FLOODING EXTENTS

FIGURE 4-3

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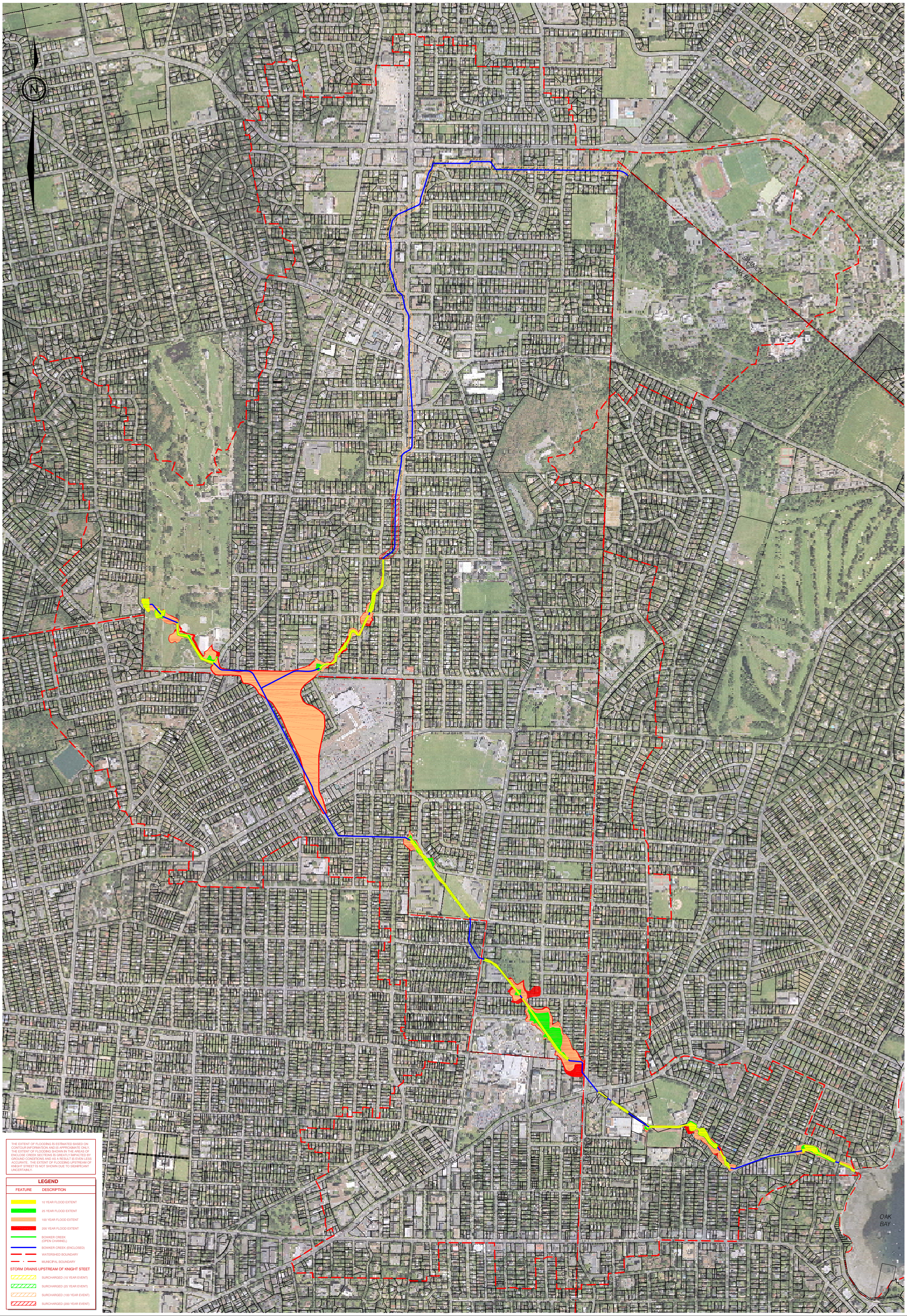

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Project No.	Date
283.288	MARCH 2007

200 0 200
Scale in Metres 1:7500

BOWKER CREEK MASTER DRAINAGE PLAN
SCENARIO 4 - FLOODING EXTENTS

FIGURE 4-4

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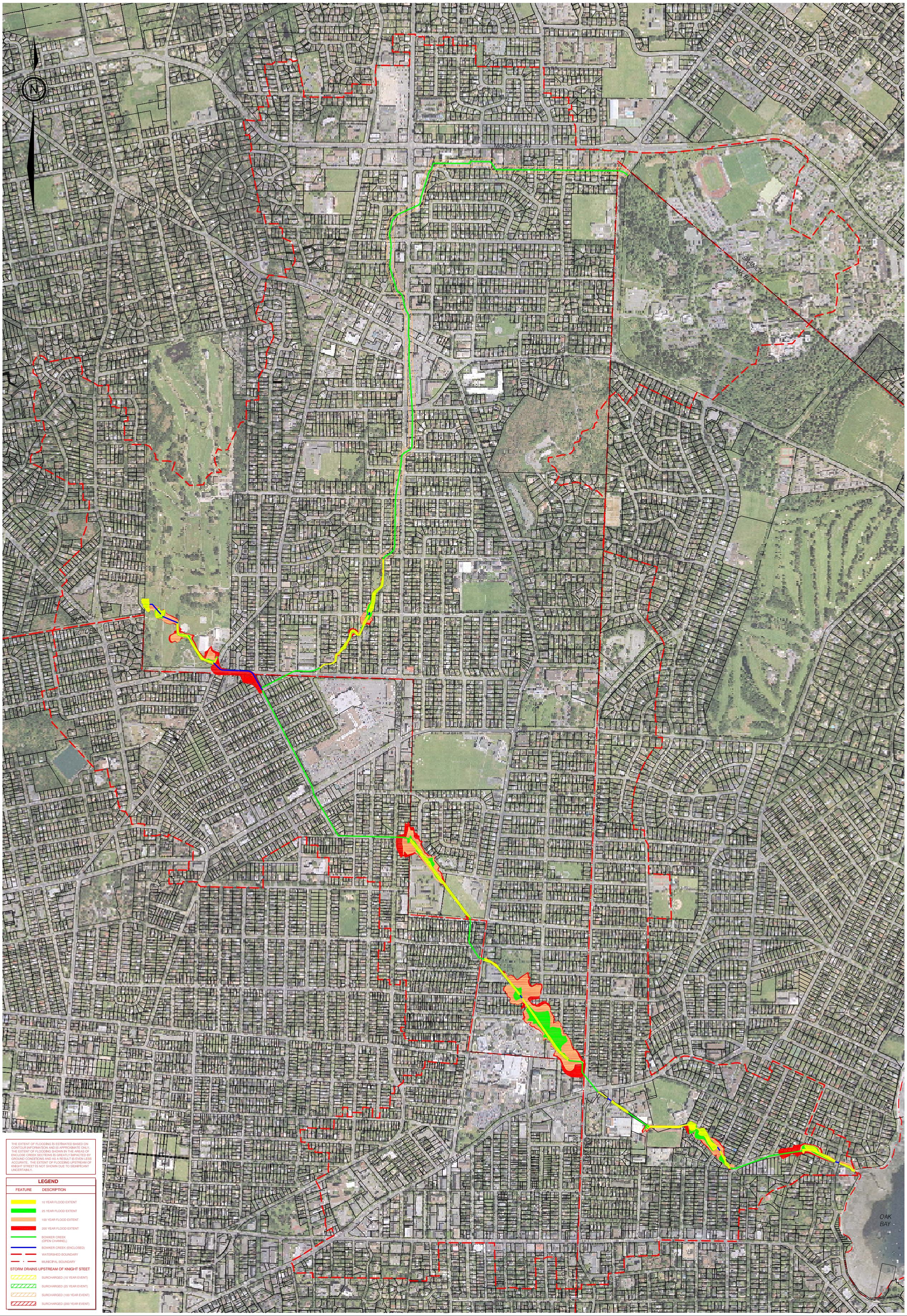
200 0 200
Scale in Metres 1:7500

CAPITAL REGIONAL DISTRICT

BOWKER CREEK MASTER DRAINAGE PLAN
SCENARIO 5 - FLOODING EXTENTS

FIGURE 4-5



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CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

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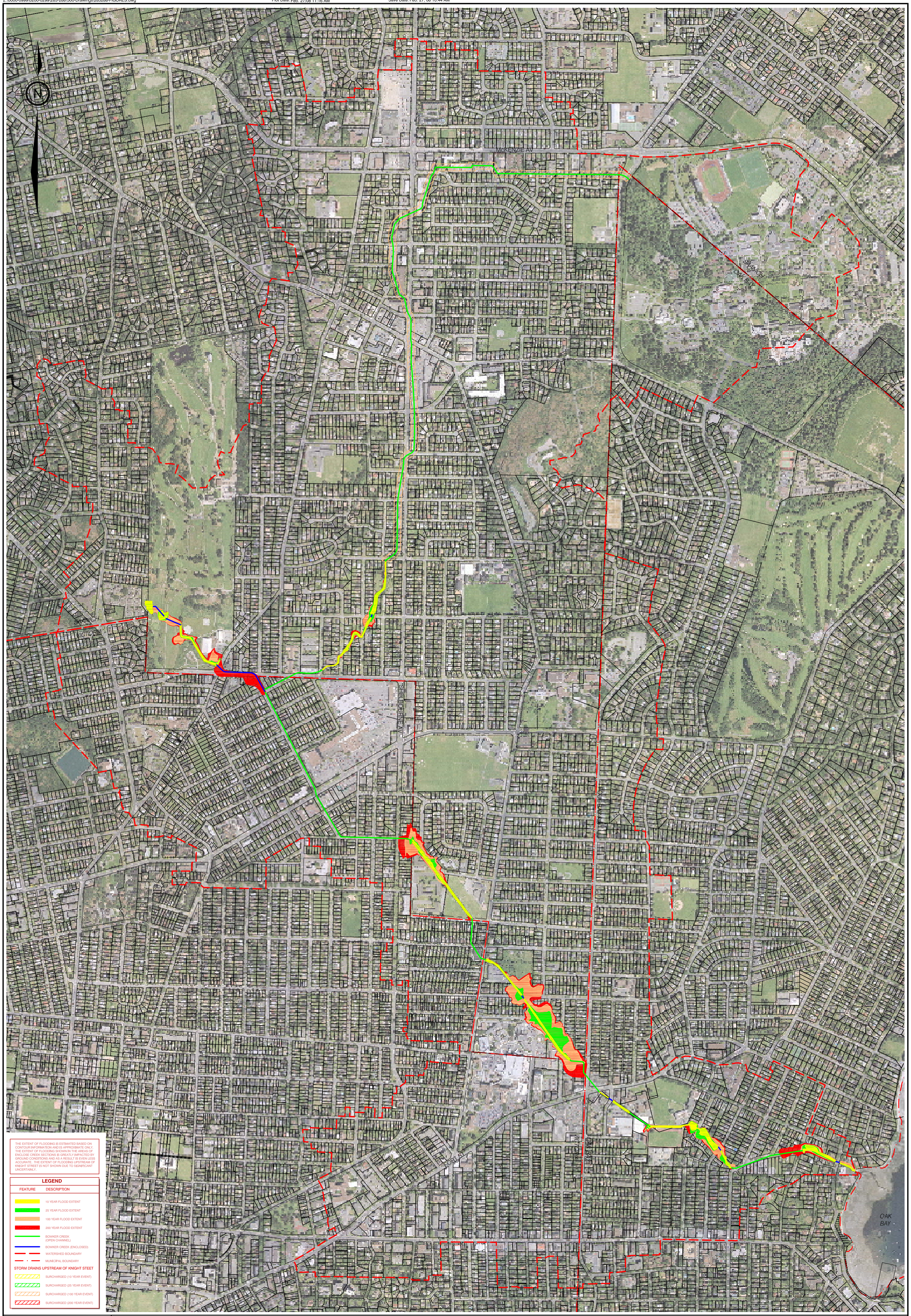
Scale in Metres 1:7500

BOWKER CREEK MASTER DRAINAGE PLAN
SCENARIO 6 - FLOODING EXTENTS

FIGURE 4-6

Z:\0000-0999\0200-0299\283-288\500-Drawings\283288-FIGURES.dwg Plot Date: Feb. 27/08 11:16 AM Save Date: Feb. 27, 08 10:44 AM



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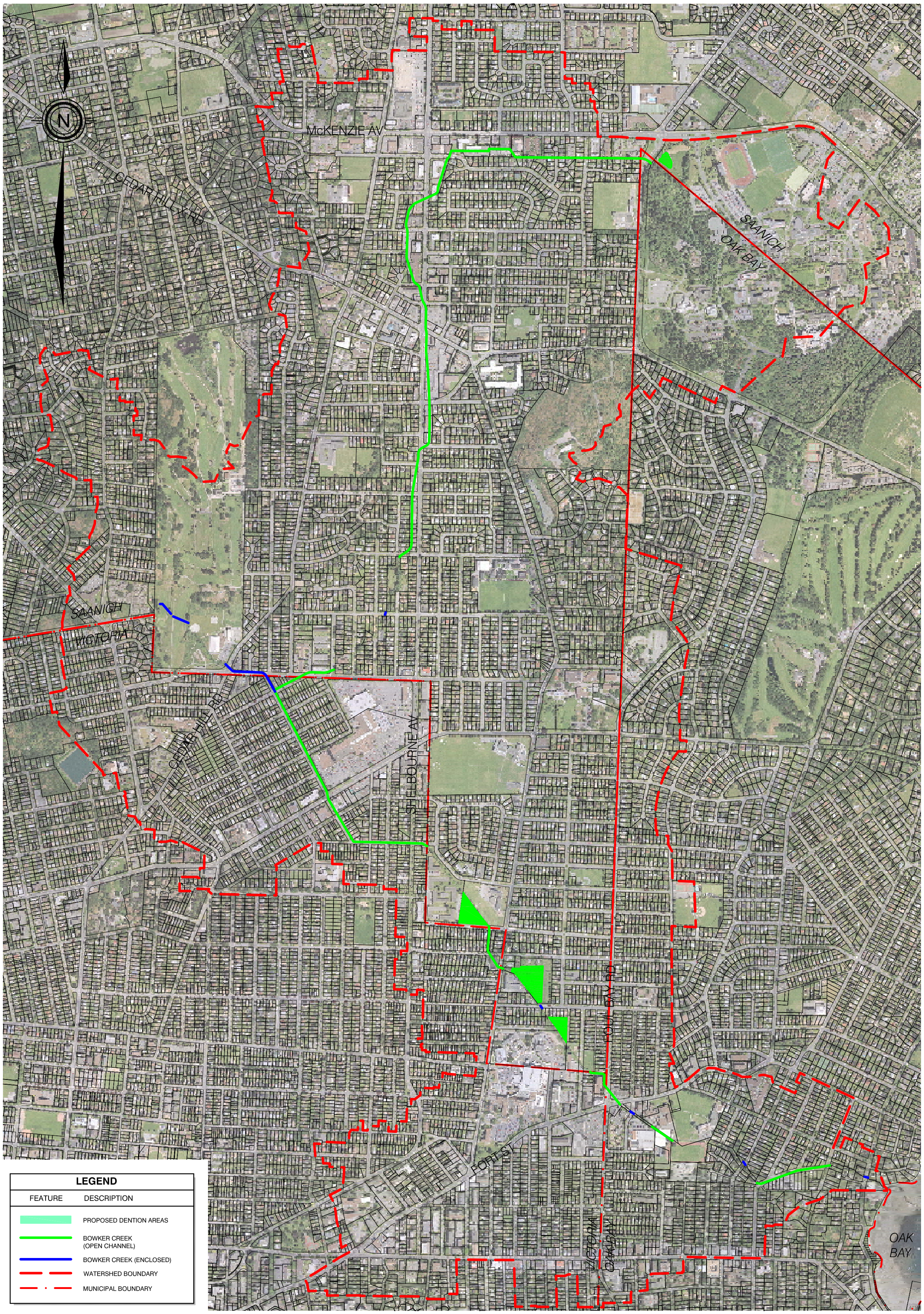
Project No.	Date
283.288	MARCH 2007

200 0 200
Scale in Metres 1:7500

BOWKER CREEK MASTER DRAINAGE PLAN
SCENARIO 7 - FLOODING EXTENTS

FIGURE 4-7A



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CAPITAL REGIONAL DISTRICT

Project No.	Date
283.288	MARCH 2007

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Scale in Metres 1:15000

BOWKER CREEK MASTER DRAINAGE PLAN
PROPOSED DETENTION

FIGURE 4-7B

Section 5

Evaluation of Alternatives

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5. EVALUATION OF ALTERNATIVES

5.1 INTRODUCTION

The Bowker Creek upgrade alternatives have been evaluated taking into account the following considerations:

HYDROTECHNICAL

There are sections of Bowker Creek that have limited capacity and as a result flooding has occurred. There has been documented flooding of houses in parts of the catchment for storms with less than a 10-year return period and this has been confirmed with model Scenario 1 - Existing Land-use, Existing Hydraulics. The required upgrades to ensure that Bowker Creek can pass a 25-year storm event are considered significant. There is a desire by residents and the municipalities to improve the hydraulic capacity of Bowker Creek. The alternatives for upgrades have been evaluated taking into account needed flooding improvements based on the level of service for flood protection being the 25-year storm event.

ENVIRONMENTAL/SOCIAL

Many of the goals of the BCWMP involve environmental and social issues for the Bowker Creek watershed such as; improve education, reduction in runoff, improve water quality, increase green space, expand public access, and increase biodiversity. Although studying these aspects in detail is not part of this MDP, evaluation of alternatives did take into consideration these aspects from previous studies.

COST

There are limited funds available for improvements to Bowker Creek and costs have been a key focus in evaluating alternatives. Both capital construction costs and property acquisition costs were identified as part of the cost evaluation. Since costs are substantial, the discussion should focus on how to balance the level of service of flood protection (i.e., public safety and risk management) vs. expenditures as part of a long-term capital program.

The following subsections describe the evaluation of alternatives with respect to the above considerations. However, this MDP report is the first phase of the ISMP and it does not consider the environmental and social issues in the detail. This will be done in the second phase of the ISMP. Priorities and recommendations made in this report are subject to change in the second and final phase of the ISMP.

The cost of doing nothing should also be considered carefully in weighing options since ongoing flooding repairs, private property damage claims and ongoing maintenance of existing aging infrastructure also have considerable cost associated with them.

5.2 HYDROTECHNICAL EVALUATION

The upgrades for Scenarios 3 to 7 have been selected based on having no flooding of buildings during the 25-year storm event. Therefore, the hydrotechnical benefits for each of these scenarios is similar for the 25-year return period. These upgrades also provide significant improvements during the 100 and 200-year storm event.

In reviewing Table 4-25 it is apparent that for the 100-year and 200-year return period events, the daylighting scenarios result in less flooding than the hydraulic improvement scenarios. This is because the hydraulic capacity of open channels increases significantly with depth because the area of flow becomes much greater. The hydraulic capacity of storm drains does not increase so significantly with depth because once surcharged the flow area does not increase.

The detention modelled in Scenario 7 (Future Land-Use, Upgraded Hydraulics, Daylighting and Detention) provides the greatest reduction in peak flows for the more frequent storms (6-month) and the least reduction in peak flows for the less frequent storms. The peak flows for Scenario 7 (with detention) relative to the peak flows for Scenario 6 Future Land-Use, Upgraded Hydraulics and Daylighting (without detention) are summarized in the following table.

Table 5-1: 15-Minute Peak Flows for Scenario 7 Relative to Scenario 6

Link	Location	15-Minute Peak Flows – Scenario 7 Relative to Scenario 6						
		6-Month	2-Year	5-Year	10-Year	25-Year	100-Year	200-Year
10-9	Fireman’s Park	68%	71%	80%	89%	88%	92%	92%
32-31	Storm Drain at Trent Street	68%	74%	80%	88%	89%	92%	93%
43-42	Storm Drain at Newton	81%	83%	93%	94%	96%	99%	99%
53-52	Immediately Upstream of Cedar Hill Tributary Confluence	97%	94%	96%	96%	95%	95%	95%
70-69	Storm Drain at Knight	93%	92%	94%	94%	95%	93%	92%
100-52	Downstream End of Cedar Hill Tributary	100%	100%	100%	100%	101%	101%	101%

For the 25-year return period (the design criteria event) the reduction in peak flows are minimal.

For the 6-month and 2-year return periods, the reduction in peak flows is significant downstream of the larger detention facilities. These return periods are typically the management focus for environmental protection measures. Detention for these return periods may provide significant environmental and erosion benefits and should therefore be considered as part of the ISMP.

For Scenario 4 (Future Land-Use, Upgraded Hydraulics), detention at UVic could reduce the required upgrades in the downstream storm drains. In order to provide the required volume, the detention pond would need to be larger than shown on Figure 2-3. This should be addressed as part of the ISMP.

From a hydrotechnical perspective, it is preferred to improve hydraulics through daylighting compared with upgrading or providing additional storm drains. The detention provides only a marginal reduction in flooding, but the reduction in peak flows during the more frequent return periods may be environmentally significant.

5.3 ENVIRONMENTAL/SOCIAL EVALUATION

Daylighting of Bowker Creek could provide an opportunity to add biodiversity to sections of the creek where it does not exist. Additionally, daylighting could allow for the removal of fish barriers. From an environmental perspective, improving hydraulic capacities by daylighting is preferred compared with adding or upgrading storm drains. Detention can provide reduction in the peak flow rates during frequently occurring storm events, which may provide further environmental benefits.

Daylighting could also provide an opportunity to incorporate a greenway along sections of the creek in areas where a trail system does not currently exist. Additionally, this could provide an opportunity to meet other goals of the BCWMP such as improving education, increasing green space and expanding public access.

It is apparent from reviewing the sections of Bowker Creek that are enclosed, that this was done to allow development. By enclosing these sections it has allowed for buildings, roads, parking areas and playing fields to be constructed above or near to the creek. Daylighting of these enclosed sections could impact these features. For example, through Fireman's Park, daylighting could likely result in the elimination of parking spaces, require the moving of playground apparatus and reduction of playing field areas.

From an environmental perspective, daylighting to improve hydraulic capacities is the preferred option. From a social perspective, the benefits of daylighting need to be evaluated in relation to conflicting current land-uses in order to select the methodology of providing hydraulic upgrades. This should be done as part of the second phase of the ISMP.

5.4 COST EVALUATION

Cost estimates have been prepared for each of the upgrade scenarios. These costs estimates are considered preliminary (Class 'D' level) due to limited information and that no design work was undertaken. The unit prices used reflect KWL's experience with similar work and therefore represent our best prediction of actual 2007 costs. Actual costs would depend on such things as market conditions, time of year, contractor's work loads, any perceived risk exposure associated with the work, and unknown conditions. The costs estimates are for design and construction of the works and do not include operation and maintenance costs.

The estimated design and construction costs for each upgrade scenario are summarized in the following Table 5-2. The distribution of costs shown in Table 5-2 is based on municipal boundaries and is for discussion purposes only. It does not account for possible cost sharing scenarios based on drainage area or other criteria (see Appendix D: Scenario Cost Estimates and Appendix E for cost sharing scenarios).

Table 5-2: Design and Construction Costs

Scenario	Oak Bay	Victoria	Saanich	Total
Scenario 3	$3.6 Million	$4.0 Million	$13.5 Million	$21.1 Million
Scenario 4	$5.7 Million	$8.8 Million	$16.5 Million	$30.9 Million
Scenario 5	$3.0 Million	$8.3 Million	$12.5 Million	$23.9 Million
Scenario 6	$3.1 Million	$9.4 Million	$12.7 Million	$25.1 Million
Scenario 7	$3.2 Million	$9.4 Million	$14.7 Million	$27.2 Million
Note: The distribution of costs shown in Table 5-2 are based on municipal boundaries and do not account for possible cost sharing scenarios based on drainage area or other criteria.				

It is estimated that the infrastructure cost to improve hydraulic capacities through daylighting is typically less expensive when compared with the cost of adding or upgrading storm drains (excluding property acquisitions costs). The daylighting costs assume the construction includes suitable native riparian plantings to the top of the banks (except for open channels with vertical walls). It is assumed that the land required for the daylighting could be at least partially obtained as a condition of rezoning for development. However, we have estimated the property purchase costs in order to provide information on what it may cost if this land was not obtained as a condition of development. In order to estimate the property purchase costs the following criteria was used:

- It was assumed that proposed storm drain upgrades or twinning can be installed within the existing road allowances and no property purchase is required.
- The property purchase widths for the open channel sections were the minimum possible (i.e. from top of bank to top of bank, at the side slopes identified).

- The land values are based on BC Assessment information and do not include improvement values (i.e. building).

The estimated property acquisition costs for each upgrade scenario are summarized in the following Table 5-3.

Table 5-3: Property Acquisition Costs

Scenario	Oak Bay	Victoria	Saanich	Total
Scenario 3	$0.3 Million	$0 Million	$0.2 Million	$0.5 Million
Scenario 4	$0.5 Million	$0 Million	$0.3 Million	$0.9 Million
Scenario 5	$0.8 Million	$3.9 Million	$9.8 Million	$14.4 Million
Scenario 6	$0.9 Million	$4.8 Million	$9.8 Million	$15.5 Million
Scenario 7	$0.9 Million	$4.8 Million	$13.5 Million	$19.3 Million

Notes:
1. The property acquisition costs above are based on BC Assessment land values for the minimum property required for open channel construction. In some cases, it appears that there is not sufficient room to construct the open channel without moving or removing existing houses/buildings. The costs above do not include the purchase of the entire property, which may be required.
2. The distribution of costs shown are based on municipal boundaries and does not account for possible cost sharing scenarios based on drainage area or other criteria.

The amount of property that may have to be acquired for each scenario, relative to the amount obtained as a result of development, could depend on a number of factors including the following:

- time frame for hydraulic upgrades;
- rate of development;
- size of development parcels (i.e. the larger the development the greater likelihood the land could be provided for the upgrades); and
- municipal policies and "density bonusing" for developments providing land for upgrades.

These factors and their affect on property acquisition costs should be investigated further as part of the second phase of the ISMP. Costs, including estimated property acquisition, are shown in Table 5-4.

Table 5-4: Capital Costs Including Estimated Property Acquisition

Scenario	Oak Bay	Victoria	Saanich	Total
Scenario 3	$ 3.9 Million	$4.0 Million	$13.7 Million	$21.6 Million
Scenario 4	$6.2 Million	$8.8 Million	$16.8 Million	$31.8 Million
Scenario 5	$3.8 Million	$12.2 Million	$22.3 Million	$38.3 Million
Scenario 6	$4.0 Million	$14.2 Million	$22.5 Million	$40.7 Million
Scenario 7	$4.1 Million	$14.2 Million	$28.2 Million	$46.5 Million

Notes:
1. The property acquisition costs above are based on BC Assessment land values for the minimum property required for open channel construction. In some cases, it appears that there is not sufficient room to construct the open channel without moving or removing existing houses/buildings. The costs above do not include the purchase of the entire property, which may be required.
2. The distribution of costs shown is based on municipal boundaries and does not account for possible cost sharing scenarios based on drainage area or other criteria.

5.5 OPTION COMPARISON

Considering hydrotechnical and environmental issues, the preferred method of improving creek hydraulics is to daylight the channel where possible. Considering design and construction costs (excluding property purchase), for most sections the preferred method of improving creek hydraulics is also to daylight. However, there are some reaches that this is not the case (i.e., not technically or practically feasible) as outlined below (assuming designed for future flow rates):

- Trent to Fort (Node 32-30) – it is assumed that daylighting this section will require near vertical walls due to limited space, which is estimated to cost more than storm drain hydraulic upgrades;

- Newton to Richmond (Node 43-42) – it is assumed that daylighting this section will require near vertical walls due to limited space, which is estimated to cost more than storm drain hydraulic upgrades; and

- Doncaster (Node 52-50) – the required hydraulic upgrade is relatively small with the addition of a 1.5 m diameter storm drain, which is estimated to be less expensive compared with daylighting.

For the Trent to Fort, Newton to Richmond and Doncaster reaches (which are estimated to cost more to daylight than to upgrade or add storm drains, not considering property acquisition), the second phase of the ISMP should compare the environmental benefits with costs.

If the land required for daylighting needs to be purchased, daylighting would typically be more expensive than culvert upgrading. At this stage, it is difficult to predict the amount of land required to be purchased. In some cases land required for daylighting may be obtained as a condition of development. A combination of property purchase and land acquired through rezoning during redevelopment may be the final solution. In some cases, the amount of property required for daylighting may render the rest of the lot unusable and could require full lot purchase. The ISMP should evaluate the property acquisition costs more extensively once overall priorities are set.

Section 6

Master Drainage Plan

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6. BOWKER CREEK MASTER DRAINAGE PLAN

6.1 INTRODUCTION

The following plan for hydrotechnical improvements to Bowker Creek has been developed based on the following information:

- This plan has been developed based on the required hydrotechnical improvements in order to meet the hydrotechnical criteria established.
- This plan has considered previously studied environmental and social information and made assumptions regarding these issues.

6.2 PLAN FOR IMPROVEMENTS

Improvements to Bowker Creek should be based on priorities ultimately set out in the ISMP and considering hydraulic constraints such as:

- Downstream improvements must proceed first.
- Problem flood areas should be given priority working downstream to upstream.
- Consideration should be given to a short-term lowering of the level of service for flood protection to less than the 25-year return period, where possible.
- From a hydrotechnical and environmental perspective daylighting is preferred over upgrading or adding storm drains.
- Improvements to Bowker Creek should consider future flow rates.
- Age of the infrastructure should be considered in determining priorities.

Since the eventual solution may be a combination of scenarios, likely Scenario 4 (Future Land-Use, Upgraded Hydraulics) and Scenario 6 (Future Land-Use, Upgraded Hydraulics and Daylighting), the Master Drainage Plan priorities are identified by location and to provide hydraulic conveyance capacity to the 25-year storm level of service. During the design stages it is likely that due to space limitations or environmental considerations these dimensions would be adjusted. Different open channel dimensions are acceptable as long as the hydraulic conveyance capacity is maintained. The open channels should be designed and maintained so that plant or tree growth will not limit hydraulic capacities in the future.

Priority locations for improvements and upgrades are as follows:

1. THE SITES OF HIGH EROSION

Address erosion areas identified as high in Table 2-3 and Figure 2-3 should be addressed. Erosion sites E2 to E8 would likely be addressed as part of future hydraulic upgrades. These sites should be investigated in detail to determine if they can wait for the hydraulic upgrade projects or if they should be addressed prior to these projects. Erosion sites E1, E9 to E14, and E15 should also be addressed.

2. BEACH DRIVE CULVERT (NODE 4 TO 3)

Upgrade the Beach Drive culvert to convey 37.8 m^3/s and a maximum upstream water elevation of 5.0 m. Alternatively, a bridge with similar hydraulic characteristics could be provided.

3. FIREMAN'S PARK STORM DRAIN (NODE 10 TO 7)

Upgrade the Fireman's Park storm drain to convey 37.7 m^3/s and a maximum upstream water elevation of approximately 10.0 m. The upgrade would likely be a combination of culvert upgrading and daylighting depending on how park uses are prioritized between playing fields and greenway space. This assumes the issues regarding land-use of Fireman's Park can be resolved as part of the second phase of the ISMP.

4. HAMPSHIRE ROAD CULVERT (NODE 14 TO 13)

Upgrade the Hampshire Road culvert to convey 37.0 m^3/s and a maximum upstream water elevation of 11.3 m. Alternatively, the road could be raised so the top of the culvert is above elevation 11.3 m and culvert upgraded to provide similar hydraulic characteristics.

5. TRENT STREET TO OAK BAY HIGH (NODE 32 TO 19)

Upgrade in order to convey flows in the range of 37.1 m^3/s at the lower end of this section (Node 20) and 32.5 m^3/s at the upper end of this section (Node 32). These flows are to be conveyed maintaining a maximum upstream water elevation (Upstream of Node 32) of 13.9 m.

6. HAULTAIN STREET TO TRENT STREET (NODE 39 TO 32)

Upgrade the Haultain Street culvert to convey 31.5 m^3/s and a maximum upstream water elevation of 15.0 m. The invert of this culvert is to be lowered by approximately 2.3 m.

7. ADJACENT TO BC HYDRO RESERVE LANDS (NODE 42 TO 39)

This section is to be re-graded to provide a transition between the lowered section of the creek (Nodes 39 to 19) and the existing invert. Potentially, the undeveloped BC Hydro Reserve Land could be used to meander the creek through this section as an environmental enhancement.

8. NEWTON STREET TO RICHMOND AVENUE (NODE 43 TO 42)

Upgrade the Newton Street to Richmond Avenue storm drain (Node 43 to 42) to convey 31.5 m^3/s and a maximum upstream water elevation (Node 43) of 17.0 m.

9. RICHMOND ELEMENTARY (NODE 49 TO 43)

Widen this open channel section to have a base width of 4.0 m and side slopes of 1.5 to 1.0. Potentially, the triangular piece of property to the west of the existing creek alignment could be used to meander the creek through this section.

10. NORTH DAIRY ROAD TO PEARL STREET (NODE 54 TO 49)

Upgrade the storm drain (Node 52 to 49) and (Node 54 to 52) in order to maintain future water levels at the obverts (top) of the existing storm drains. Assuming the existing storm drains are in good condition, the existing storm drain could be maintained as an overflow during extreme events.

11. MCRAE AVENUE TO WORDSWORTH STREET ROW (NODE 64 TO 62)

A high flow bypass is required around this section in order to maintain 25-year water levels below the properties at 1601 and 1607 McRae Avenue. It is estimated that these properties may experience flooding at an elevation of 26.0 m.

12. GORDON HEAD ROAD TO KNIGHT STREET (NODE 85 TO 69)

Upgrade (Node 81 to 69) and (Node 84 to 81) in order to maintain future water levels at the tops of the existing storm drains.

6.3 IMPROVEMENT PRIORITIES

In selecting the priorities for hydraulic improvements, the impact of hydraulic improvements on the downstream flow rates must be considered. In comparing the peak flow rates in Scenario 1 (no hydraulic improvements) with Scenario 3 (hydraulic improvements), it is apparent that the peak flow rates increase considerably downstream of the hydraulic improvements. This is a result of the considerable flooding and significant detention provided by the existing system because of the insufficient hydraulic capacities.

Therefore, if upgrades are made to the upstream system first (particularly if significant flooding is reduced), then the flooding downstream may become worse. As a result, in addition to the level of existing hydraulic deficiency, the hydraulic improvements have also been prioritized considering the impacts on the downstream system. In general, this means the priorities for hydraulic improvements go from downstream to upstream.

6.4 IMPLEMENTATION STRATEGY

The municipal drainage systems associated with Bowker Creek have been found to have considerable deficiencies and significant financial investments are required to reduce flooding risks. Based on the current level of service for no flooding during a 25-year storm event, 77% of the system requires upgrading. This section of the report suggests possible implementation strategies for the BCI that may distribute costs over a longer period or in some cases reduce the overall costs of upgrading. (See Appendix E for further details). Budget items suggested here are for example only and would be ultimately set by the cost-sharing arrangements determined by municipalities and subject to available funding.

DEVELOPMENT OF SHORT-TERM AND LONG-TERM CAPITAL PLANS

Development of short-term project priorities (once cost sharing arrangements have been determined) would identify priority projects over the near term (typically 5 years). This would identify top ranked projects, the timing, the funds required. Once a program is established, then a strategy to capitalize on grants and other funding initiatives could be determined, negotiating each municipality's responsibilities for upgrading costs. For example, the 5-year plan might target to spend $2.5M over five years.

Long-term capital plans (typically 5-15 years) could be based on secondary priorities and areas where a reduced level of service for flood protection may be possible in the near term as a way to manage the risk versus cost over the short to medium term. A 5-year to 15-year plan, for example, might spend $20M over 15 years.

REDEVELOPMENT PROPOSALS AND DEVELOPMENT COST CHARGES (DCC)

Some projects could be funded through DCCs applied to areas of redevelopment. Since the model analysis determined that there are effects on creek flows from densification and we anticipate higher flows over time from climate change, it may be deemed reasonable to set aside funding over time to finance upgrades into the future. The modelling identified that increases in flows were primarily due to anticipated climate change effects and flow increases due to future densification are relatively small. The percentage of DCCs associated with drainage could be re-evaluated to account for anticipated future flow increases and resulting costs for drainage upgrades.

REDUCTION IN LEVEL OF SERVICE (FLOOD PROTECTION) ANALYSIS

Presently, municipal policy requires stormwater infrastructure robust enough to ensure no flooding of buildings occurs during 25-year return period storm events. One way to risk manage the flooding could be reducing the target return period for no flooding of buildings in areas where the risk is acceptable in the short-term. An assessment of the Bowker Creek Watershed storm drain system to determine areas that could remain in their current state for the near-term with a service standard of less than the 25-year event could be one strategy to manage the flood risk. Comparing the 10-year results to the 25-year results could identify areas where critical upgrades may be deferred. This would be a temporary measure until financing for the required upgrades can be arranged.

CAPITAL FUNDING GRANTS

Funding programs should not be relied upon, but used where possible to accelerate or offset upgrade programs. The following is a summary of current available programs:

Current Programs

CANADA/BC MUNICIPAL RURAL INFRASTRUCTURE FUND

$102 million in senior government funding for capital projects.
Project cost is equally shared by applicant, province and federal government (1/3 each).

See website for more information: http://www.canadabcmrif.ca/

GAS TAX AGREEMENT

General Strategic Priorities Fund - $67.3 million in federal funding.
Innovations Fund - $31.8 million federal funding.
Grant funding is up to the lesser of 100% of the actual eligible project costs and 100% of the estimated eligible project costs.

See website for more information: http://www.civicnet.bc.ca/siteengine/ActivePage.asp?PageID=294

B.C. SPIRIT SQUARE PROGRAM

Up to $20 million to assist communities in creating or enhancing outdoor public meeting spaces.
Spirit Squares may take the shape of traditional town squares or community commons with design and location up to each community.
Province will provide 50 per cent of capital funding, up to a maximum of $500,000.

LOCAL MOTION FUND

$10 million per year for four years ($40 million in total) to help build bike paths, walkways, greenways, improved accessibility for persons with disabilities, and support programs to get kids playing in communities and parks.

Province will provide 50 per cent of capital funding, up to $1 million per year.

TOWNS FOR TOMORROW PROGRAM

$7 million a year for three years ($21 million in total) to support small towns' infrastructure priorities.

Province will fund 80 per cent of project cost and the municipalities fund the remaining 20 per cent, up to a maximum total value of $500,000.

GREEN CITIES AWARDS

Monetary Awards ($100,000+ each) to be given to communities encouraging physical activity, energy conservation, and environmental benefits.

Section 7

Summary and Recommendations

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7. SUMMARY AND RECOMMENDATIONS

7.1 SUMMARY OF FINDINGS

Bowker Creek lies within a 1,018 ha watershed located in the District of Saanich (Saanich), City of Victoria (Victoria) and District of Oak Bay (Oak Bay). With headwaters at the University of Victoria (UVic), Bowker Creek flows 7.9 km through storm drains, culverts and open channels to an ocean discharge in Oak Bay. Only 2.9 km (37 %) of Bowker Creek is open channel with the rest being enclosed within storm drains and culverts.

Surficial geology mapping obtained from the Geological Survey of Canada (GSC) indicates that the majority of the underlying soil within the catchment is clay. Clay soils have a low hydraulic conductivity. Source controls will not significantly reduce peak flow rates in Bowker Creek during extreme events (i.e. 10-year return period and greater).

Fifteen sites of high erosion were identified along the open channel sections of Bowker Creek.

Flooding has been observed on Bowker Creek with known hydraulic limitations at the Fireman's Park storm drain and the Trent Street to Fort Street storm drain.

It was found that the entire Bowker Creek watershed is about 50% impervious area. It is estimated that in 25-years the watershed would be about 56% impervious area.

Future model scenarios have included an increase in precipitation intensities to account for climate change.

An XP-SWMM hydrodynamic model was developed and can predict flow rates with a reasonable level of accuracy.

The hydraulic model has been run for seven scenarios for the 6-month, 2-year, 5-year, 10-year, 25-year, 100-year and 200-year return period storm events. The seven scenarios are as follows:

- Scenario 1 - Existing Land-use, Existing Hydraulics
- Scenario 2 - Future Land-use, Existing Hydraulics
- Scenario 3 - Existing Land-Use, Upgraded Hydraulics
- Scenario 4 - Future Land-Use, Upgraded Hydraulics
- Scenario 5 - Existing Land-Use, Upgraded Hydraulics and Daylighting
- Scenario 6 - Future Land-Use, Upgraded Hydraulics and Daylighting
- Scenario 7 - Future Land-Use, Upgraded Hydraulics, Daylighting and Detention.

From a hydrotechnical perspective, it is preferred to improve hydraulics through daylighting.

From an environmental perspective, daylighting to improve hydraulic capacities is the preferred option. From a social perspective, the benefits of daylighting need to be evaluated in relation to conflicting current land-uses and economic value of environmental values.

Since hydraulic upgrading of upstream reaches would worsen downstream flooding, the priorities for hydraulic improvements go from downstream to upstream.

It is estimated that the infrastructure costs to improve hydraulic capacities through daylighting is typically less expensive compared with the cost of adding or upgrading storm drains (excluding property purchase) however, property acquisition costs can change this relationship and must also be considered in decision-making. Future capital programs should include some available funds for property purchase not possible through rezoning for development.

The amount of property that would have to be acquired for daylighting would depend on a number of factors including timeframe for hydraulic upgrades, rate of development, size of development parcels, and municipal policies.

The cost of the upgrades is anticipated to be between $22,000,000 and $46,000,000 and would need to be implemented using a long-term strategy.

7.2 RECOMMENDATIONS

The Master Drainage Plan recommendations are as follows:

1. Present this information to municipal councils with the recommendation that the MDP be incorporated into the future ISMP and implemented as part of a long-term strategy.

2. Implement MDP priorities to the Bowker Creek system based on the findings outlined in the Master Drainage Plan and as amended by the environmental and social priorities from the future Bowker Creek ISMP. The MDP priorities are:

   - High Erosion Sites
   - Beach Drive Culvert
   - Fireman's Park Storm Drain
   - Hampshire Road Culvert
   - Trent Street to Oak Bay High

- Bee Street Culvert
- Fort Street to Bee Street
- Trent Street to Fort Street
- Haultain Street to Trent Street
- Haultain Street Culvert
- Richmond Avenue to Haultain Street
- Newton Street to Richmond Avenue
- Richmond Elementary
- North Dairy Road to Pearl Street
- McRae Avenue to Wordsworth Street
- Gordon Head Road to Knight Street.

These upgrade recommendations are a result of evaluating and prioritizing the hydrotechnical solutions based on drainage modelling results and current background information. However, prior to the completion of the ISMP, all solutions for Bowker Creek and watershed cannot be fully evaluated or prioritized.

3. Consider an implementation plan that develops short-term and long-term cost strategies that include external funding, reduction in levels of service (where possible) and development cost charges to fund future upgrades.

4. Continue with the completion of the Bowker Creek ISMP. Some specific issues the ISMP could impact the recommendation made above, include identifying the environmental benefits of detention, and opportunities for detention at UVic to reduce downstream hydraulic improvements.

5. Revisit future land-uses in 5 to 10 years to determine if the estimations outlined in this report are approximately correct.

6. Revisit the assumptions made regarding changes in precipitation intensities as a result of climate change as more becomes known, in particular for shorter durations.

7.3 REPORT SUBMISSION

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

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Project Manager

REFERENCES

[i] Bowker Creek Watershed Assessment, Reid Crowther & Partners Ltd. and SHIP Environmental Consultants Ltd., September 2000

[ii] Bowker Creek Watershed Management Plan, Westland Resource Group, January 2003

[iii] Surficial Geology, Victoria Sheet, Map 71A, Canada Department of Mines, Issued 1915

[iv] Regional Growth Strategy for the Capital Regional District, Regional Planning Services Capital Regional District, August 2003

[v] University of Victoria Campus Plan 2003, Adopted May 2003

[vi] Climate Change 2007: The Physical Science Basis, Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Corrections made as of February 5th, 2007.

[vii] Development of GVRD Precipitation Scenarios, Kerr Wood Leidal Associates, October 2002

[viii] Estimating Extremes in Transient Climate Change Simulations, Viatcheslav V. Kharin and Francis W. Zwiers, Canadian Centre for Climate Modelling and Analysis, Meteorological Service of Canada, Victoria, British Columbia, Canada, September 13, 2004

[ix] Changes in Temperature and Precipitation Extremes in the IPCC Ensemble of Global Coupled Model Simulations, Viatcheslav V. Kharin, Francis W. Zwiers, Xuebin Zhang.

Appendix A

Areas of High Erosion

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Bowker Creek Erosion Assessment
Areas of High Erosion

Indentifier	Location & Chainage	Description							Notes	Photo #
		Left Bank			Right Bank			Creek Bed		
		Slope	Material	Containment	Slope	Material	Containment			
E1	Downstream of Monteith Culvert, 0+000	N/A	Willow post technique, soil backfill		N/A	gravel size bed load		bed rock in channel	Existing willow post failing, scouring 1-2m behind willows	1-12
E2	Downstream of Haultain Culvert, 0+190 to 0+201				1 : 1	Terraced willow posts (4 terraces)		N/A		13
E3	Downstream of Haultain Culvert, 0+96 to 0+109	vertical erosion 2m high	clay							14
E4	Downstream of Richmond Rd, 0+150 to 0+165	N/A	0.6m top soil, then clay/silt layer		N/A	0.6m top soil, then clay/silt layer		N/A	recent activity on LB	15
E5	Downstream of Richmond Rd, 0+025									16
E6	Downstream of Pearl St. culvert, 0+245 to 0+410							clay/silt soil	RB slumping into channel at various points along this stretch	17-23
E7	Downstream of Pearl St. culvert, 0+195	1 : 1	blackberries	3	1 : 1	top soil on top of clay	3	clay/silt soil	Large scour holes, 1m & 2m deep created after fallen tree in channel	24
E8	Downstream of Pearl St. culvert, 0+50	1 : 1	blackberries	3	vertical	clay & soil	3	clay/silt soil	RB cut back to vertical, some minor slumping at bottom of slope	25,26
E9	Downstream of Knight Ave culvert, 0+434	0.25 : 1	sandy soil & blackberries	2	1 : 1	sandy soil	2.5	clay/silt soil	RB slumping into channel	27
E10	Downstream of Knight Ave culvert, 0+390	vertical	large boulder wall	2	vertical	rocks & soil	2.5	sandy, with bedrock	RB undercut significantly	28
E11	Downstream of Knight Ave culvert, 0+365	N/A	soil, with some grass	2	1 : 1	soil, grass & small roots	1.5	sandy clay	LB has 2m flat section to 1.8m almost vertical bank	29
E12	Downstream of Knight Ave culvert, 0+325	vertical	soil with roots and bushes	2	1 : 1	soil & black berries	2	clay/silt soil	LB eroding under roots	30
E13	Downstream of Knight Ave culvert, 0+265	1 : 1	Soil & grass, slumping	2	1 : 1	soil & black berries	2	concrete	Left bank is slumping into creek channel	31
E14	Downstream of Knight Ave culvert, 0+060	0.75 : 1	clay/soil	3	N/A	large rocks & clay	1	concrete	Slump was visible above rock/concrete wall at channel bottom	32
E15	Downstream 600mm culvert on Cedar Hill golf course 0+000	N/A	soil	2	N/A	soil	2	N/A	~ 4m x 6m scour hole, depth N/A	33, 34

Appendix A

Photo 1

Photo 2

Photo 3

Photo 4

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Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 13

Photo 14

Photo 15

Photo 16

Photo 17

Photo 18

Photo 19

Photo 20

Photo 21

Photo 22

Photo 23

Photo 24

Photo 25

Photo 26

Photo 27

Photo 28

Photo 29

Photo 30

Photo 31

Photo 32

Photo 32

Photo 33

Appendix B

Bowker Creek XP-SWMM Model Input

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Bowker Creek XP-SWMM Model Input

US Node	DS Node	Link Name	Length	US Invert	DS Invert	Slope	Section Number or Type	XP Section Type		Section Description	Overbanks from Contours (Looking DS) From CL: Left Station	Left Elevation	Section Elevation	Right Station	Right Elevation	Section Elevation	Walls Left	Walls Right	Channel Info (Looking DS): Photo (Week &#)	Photo (Week &#)	Left Bank	Right Bank	Channel Type (See 'Roughness') Left	Centre	Right	Manning's 'n' Left	Centre	Right
Bowker Creek																												
2	1	2-1	69.9	1.19	0.50	0.99	301	Natural	301	Open channel DS of Beach. Retaining walls both sides	-14.9	3.00	2.15	7.3	3.00	2.15	-14.9	7.3	2&33		-1.4	1.4	10	4	10	0.040	0.018	0.040
3	2	3-2	8.8	1.66	1.19	5.34	40	Natural	40	Open channel DS of Beach. Retaining wall left side	-10.4	3.00		9.0	5.00		-10.4	9	2&33		5.00	10.72	10	4	10	0.040	0.018	0.040
4	3	4-3	14.8	1.77	1.66	0.74	Box Culvert 3.05 x 1.82	Rectangular		Culvert under Beach									2&32	2&35			1	1	1	0.013	0.013	0.013
5	4	5-4	45.0	2.04	1.77	0.60	39	Natural	39	Open channel US of Beach. Retaining wall right side									2&34		8.36	15.07	13	8	13	0.070	0.035	0.070
6	5	6-5	87.2	2.38	2.04	0.38	38	Natural	38	Open channel DS of Monteith. Some sandbag armouring.	-20.0	5.50		15	5.5		-20.0	15.0	2&1	2&2	4.37	9.00	13	11	13	0.070	0.050	0.070
7	6	7-6	25.6	3.65	2.38	4.98	37	Natural	37	Open channel DS of Monteith	-28.6	6.50		23.7	7			23.7	2&3		12.40	20.27	12	11	13	0.050	0.050	0.070
8	7	8-7	137.5	4.46	3.65	0.59	Arch SD	Special		Lower Fireman Park storm drain									2&4				1	1	1	0.013	0.013	0.013
9	8	9-8	160.9	6.00	4.46	0.96	Arch SD	Special		Upper Fireman Park SD													1	1	1	0.013	0.013	0.013
10	9	10-9	17.2	6.17	6.00	0.96	Arch SD	Special		SD to Monterey									2&5				1	1	1	0.013	0.013	0.013
11	10	11-10	19.9	6.88	6.17	3.57	36	Natural	36	Approach to Fireman Park SD	-33.6	10.50		14.5	10.8		-33.6	14.5	2&5		0.00	8.80	2	2	2	0.015	0.015	0.015
12	11	12-11	29.7	7.04	6.88	0.54	35	Natural	35	Pond US of Monterey	-48.0	11.00		19.6	11		-48.0	19.6	2&6		5.22	14.94	12	5	12	0.050	0.020	0.050
13	12	13-12	44.9	8.1	7.61	1.09	34	Natural	34	Channel DS of Hampshire	-8.0	11.00		14.4	10.9		-8.0	14.4	2&21		4.56	8.17	13	5	13	0.070	0.020	0.070
14	13	14-13	15.3	8.18	8.1	0.52	Box Culvert	Rectangular		Culvert under Hampshire									2&19				1	1	1	0.013	0.013	0.013
15	14	15-14	79.4	8.70	8.18	0.66	33	Natural	33	Open Channel US of Hampshire	-15.5	11.00		24	11.2		-15.5	24.0	2&20		4.08	7.28	12	5	13	0.050	0.020	0.070
16	15	16-15	31.4	8.91	8.70	0.66	302	Natural	302	Widened reach DS of Armstrong							-21.0	17.0			19.00	29.01	12	5	12	0.050	0.020	0.050
17	16	17-16	20.5	9.03	8.91	0.60	32	Natural	32	Open channel at Armstrong	-18.0	12.00		22.8	12		-18.0	22.8	2&25		7.42	11.15	12	5	12	0.050	0.020	0.050
18	17	18-17	26.2	9.33	9.03	1.14	303	Natural	303	Open channel downstream of OBH Parking Lot							-16.5	28	2&26		14.50	28.51	12	5	12	0.050	0.020	0.050
19	18	19-18	41.6	9.75	9.33	1.02	304	Natural	304	Open channel downstream from OBH track							-33	23	2&23		31.35	34.66	6	5	6	0.030	0.020	0.030
20	19	20-19	61.4	9.98	9.75	0.36	31	Natural	31	Open channel adjacent to OBH track	-39.3	13.90		70	13.5		-39.3		2&24		7.23	17	6	18	6	0.030	0.045	0.030
21	20	21-20	70.3	10.20	9.98	0.31	30	Natural	30	Open channel adjacent to OBH track	-39.0	14.50		7.5	14				2&44		12.71	17.42	6	18	6	0.030	0.045	0.030
22	21	22-21	4.8	10.21	10.20	0.27	30	Natural	30	Open channel adjacent to OBH track	-39.0	14.50		7.5	14				2&44		12.71	17.42	6	18	6	0.030	0.045	0.030
23	22	23-22	6.2	10.29	10.21	1.29	2 Box Culverts	Rectangular		Culvert from OBH to OBH track									2&42	2&43			1	1	1	0.013	0.013	0.013
24	23	24-23	3.4	10.33	10.29	1.18	29	Natural	29	Open channel section downstream of tennis bubble culvert	-9.5	14.00		77	14		-9.5		2&42		4.11	8.09	6	18	6	0.030	0.045	0.030
25	24	25-24	94.2	10.56	10.33	0.24	CSP Ellipse	Special		Tennis bubble culvert							-24.0	-16.0	2&41				22	22	22	0.020	0.020	0.020
26	25	26-25	49.2	10.87	10.56	0.64	28	Natural	28	Open channel section upstream of tennis bubble culvert	-29.0	15.30		27	13		-29.0	27.0	2&40		7.98	17.98	17	19	17	0.018	0.060	0.018
27	26	27-26	43.8	11.07	10.87	0.45	27	Natural	27	Open channel downstream of Bee Street	-31.0	14.50		65	14.5		-31.0	65.0	2&40		4.45	12.58	17	19	17	0.018	0.060	0.018
28	27	28-27	17.3	11.04	11.07	-0.15	Box Culvert	Rectangular		Bee Street culvert									2&39				1	1	1	0.013	0.013	0.013
29	28	29-28	20.3	11.05	11.04	0.04	26	Natural	26	Open channel upstream of Bee Street	-8.0	14.88		11	14.94		-8.0	11.0	2&38		4.1	8.05	17	5	6	0.018	0.020	0.030
30	29	30-29	31.8	11.07	11.05	0.06	25	Natural	25	Open Channel downstream of Cadboro Bay Road	-9.0	15.06					-9.0	0.0	2&38		1.74	5.18	17	5	6	0.018	0.020	0.030
31	30	31-30	104.4	11.42	11.07	0.34	Arch SD	Special		Storm drain between Foul Bay Road and Cadboro Bay Road									2&37				1	1	1	0.013	0.013	0.013
32	31	32-31	105	11.72	11.42	0.29	Box Culvert	Rectangular		Storm drain between St. Patrick's School and Foul Bay Road									2&31				1	1	1	0.013	0.013	0.013
33	32	33-32	46.5	11.65	11.72	-0.16	24	Natural	24	Open channel adjacent to St. Patrick's School, storm drain to foot bridge	-63.0	15.00		30	14.19		-63.0	30.0	2&29		5.72	13.3	6	11	17	0.030	0.050	0.018
34	33	34-33	5	11.64	11.65	-0.16	23	Natural	23	Foot bridge, St. Patrick's School to field											7.67	16.85	6	11	6	0.030	0.050	0.030
35	34	35-34	116.2	11.77	11.64	0.11	23	Natural	23	Open channel upstream of St. Patrick's School foot bridge	-48.0	14.10		20	15		-48.0	20.0	2&30		7.67	16.85	6	11	6	0.030	0.050	0.030
36	35	36-35	69.3	11.44	11.77	-0.48	22	Natural	22	Open channel adjacent to Royal Jubilee Hospital	-49.0	14.00		62	15.5		-49.0	62.0	2&28		6.36	15.57	6	11	6	0.030	0.050	0.030
37	36	37-36	57.2	11.91	11.44	0.82	22	Natural	22	Open channel adjacent to Royal Jubilee Hospital	-49.0	14.0		62.0	15.5		-49.0	62.0	2&27		6.36	15.57	6	11	6	0.030	0.050	0.030
38	37	38-37	44.5	12.22	11.91	0.69	21	Natural	21	Open channel downstream of Haultain	-15.0	15.04		14	14.6		-15.0	14.0	1&41		1.93	7.35	10	19	12	0.040	0.060	0.050
39	38	39-38	12	13.05	12.22	6.92	Box Culvert	Rectangular		Culvert under Haultain Street									1&39	1&41			1	1	1	0.013	0.013	0.013
40	39	40-39	132.5	13.33	13.05	0.21	20	Natural	20	Open channel upstream of Haultain Street	-100.0	15.70		15	15		-100	15	1&38		3.51	9.86	12	19	12	0.050	0.060	0.050
41	40	41-40	57.9	13.73	13.33	0.70	19	Natural	19	Open channel adjacent to BC Hydro reserve lands	-130.0	18.00		20	17		-130	20	1&37		2.64	12.08	12	19	12	0.050	0.060	0.050
42	41	42-41	35	13.93	13.73	0.56	18	Natural	18	Open channel downstream of Richmond Avenue	-20.0	17.20					-20		1&36		5.33	18.31	12	11	12	0.050	0.050	0.050
43	42	43-42	205.5	14.31	13.93	0.18	Box Culvert	Rectangular		Storm drain from Newton Avenue to Richmond Avenue									1&34	1&35			1	1	1	0.013	0.013	0.013
44	43	44-43	100.2	14.6	14.31	0.29	16	Natural	16	Open channel upstream of Newton Avenue	-70.0	19.00		75	19		-70	75	1&26		1.14	12.3	6	19	6	0.030	0.060	0.030
45	44	45-44	5	14.60	14.60	-0.01	16	Natural	16	Richmond School foot bridge											1.14	12.3	6	19	6	0.030	0.060	0.030

Bowker Creek XP-SWMM Model Input

											Overbanks from Contours (Looking DS) From CL								Channel Info (Looking DS)									
											Left			Right			Walls		Photo (Week &#)	Photo (Week &#)			Channel Type (See 'Roughness')			Manning's 'n'		
US Node	DS Node	Link Name	Length	US Invert	DS Invert	Slope	Section Number or Type	XP Section Type		Section Description	Station	Elevation	Section Elevation	Station	Elevation	Section Elevation	Left	Right			Left Bank	Right Bank	Left	Centre	Right	Left	Centre	Right
46	45	46-45	109.1	14.70	14.60	0.10	15	Natural	15	Open channel downstream of Townley Avenue	-90.0	20.00		45	18		-90	45	1&27		8.31	17.3	6	19	6	0.030	0.060	0.030
47	46	47-46	124.1	15.10	14.70	0.32	14	Natural	14	Open channel adjacent to Townley Avenue	-37.0	19.00					-37		1&29		5.49	15.22	6	19	6	0.030	0.060	0.030
48	47	48-47	5	15.12	15.10	0.32	14	Natural	14	Foot bridgeat Townley Avenue											5.49	15.22	6	19	6	0.030	0.060	0.030
49	48	49-48	77.8	15.96	15.12	1.08	13	Natural	13	Open channel downstream of Pearl Avenue	-30.0	19		15	18.9		-30	15	1&30		5.8	15.38	6	19	6	0.030	0.060	0.030
50	49	50-49	309	16.81	15.96	0.27	Box Culvert 3.35 x 1.83	Rectangular		Storm drain along Pearl upstream to Doncaster									1&32				1	1	1	0.013	0.013	0.013
51	50	51-50	428.9	18.33	16.81	0.36	Box Culvert 2.44 x 2.44	Rectangular		Storm drain along Doncaster, Pearl to Edgeware													1	1	1	0.013	0.013	0.013
52	51	52-51	278.6	19.78	18.33	0.52	Box Culvert 2.44 x 2.44	Rectangular		Storm drain along Doncaster, Edgeware to Clawthorpe													1	1	1	0.013	0.013	0.013
53	52	53-52	116.9	20.26	19.78	0.41	Box Culvert 2.44 x 2.44	Rectangular		Storm drain along Clawthorpe, Doncaster to North Dairy													1	1	1	0.013	0.013	0.013
54	53	54-53	156.1	20.89	20.26	0.40	Box Culvert 2.44 x 1.52	Rectangular		Storm drain upstream of North Dairy									1&14				1	1	1	0.013	0.013	0.013
55	54	55-54	7.1	21.58	20.89	9.72	12	Natural	12	Approach to Storm Drain at Shelley				9.3	24.41			9.3	1&15		7.14	11.14	13	23	12	0.070	0.025	0.050
56	55	56-55	45.9	22.47	21.58	1.94	11	Natural	11	Open channel upstream of Shelley	-19.0	25.2		12	26		-19	12	1&17		4.57	7.45	13	23	12	0.070	0.025	0.050
57	56	57-56	28.4	22.68	22.47	0.74	10	Natural	10	Open channel upstream of Shelley	-7.0	25.5		9	25.5		-7	9	1&18		0.25	3.32	13	5	12	0.070	0.020	0.050
58	57	58-57	27.0	22.79	22.68	0.41	9	Natural	9	Open channel downstream of Keates	-29.5	27		14.1	26		-29.5	14.1	1&21		9.37	11.53	13	21	12	0.070	0.050	0.050
59	58	59-58	5.0	22.81	22.79	0.41	8	Natural	8	Keates foot bridge											6.7	11.84	13	11	13	0.070	0.050	0.070
60	59	60-59	92.9	23.30	22.81	0.52	8	Natural	8	Open channel upstream of Keates	-15.0	26		10	26.8		-15	10			6.7	11.84	13	11	13	0.070	0.050	0.070
61	60	61-60	52.9	23.57	23.30	0.52	7	Natural	7	Open channel downstream of Wordsworth	-5.6	26		15.3	27		-5.6	15.3	2&47		8.63	12.26	13	11	13	0.070	0.050	0.070
62	61	62-61	5	23.60	23.57	0.52	7	Natural	7	Wordsworth foot bridge											8.63	12.26	13	11	13	0.070	0.050	0.070
63	62	63-62	102.1	24.42	23.60	0.80	6	Natural	6	Open channel downstream of McRae	-6.6	26.85		4.7	26.9		-6.6	4.7	2&48	1&1	1.94	7.73	13	11	13	0.070	0.050	0.070
64	63	64-63	9.1	24.73	24.72	0.11	Box Culvert	Rectangular		Culvert under McRae									1&2	1&3			1	1	1	0.013	0.013	0.013
65	64	65-64	89.3	25.27	24.73	0.60	4	Natural	4	Open channel upstream of McRae	-16.6	29		20	30			20	1&4	1&6	4.33	10.88	13	11	13	0.070	0.050	0.070
66	65	66-65	39.2	25.54	25.27	0.69	3	Natural	3	Open channel through Browning Park	-24.0	30.3		29	30		-24	29	1&8		7.4	9.91	13	23	13	0.070	0.025	0.070
67	66	67-66	37	25.91	25.54	1.00	2	Natural	2	Open channel downstream of Browning Park foot bridge	-17.0	31		37	31				1&9	1&10	10.22	17.43	13	11	13	0.070	0.050	0.070
68	67	68-67	5	25.96	25.91	1.00	2	Natural	2	Browning Park foot bridge											10.22	17.43	13	11	13	0.070	0.050	0.070
69	68	69-68	81.2	26.49	25.96	0.65	1	Natural	1	Open channel of Knight Street							-8.87	11.27	1&11	1&12	4.99	12.02	13	11	13	0.070	0.050	0.070
70	69	70-69	296.3	27.81	26.35	0.49	Concrete 1.83	Circular		Storm drain, Derby to Knight													1	1	1	0.013	0.013	0.013
71	70	71-70	161.1	28.26	27.81	0.28	Wood Stave 1.83	Circular		Storm drain, North of Cedar Hill to Derby													1	1	1	0.013	0.013	0.013
72	71	72-71	64.5	28.88	28.57	0.48	Box Culvert 1.83 x 1.52	Rectangular		Storm drain, Donnelly to North of Cedar Hill													1	1	1	0.013	0.013	0.013
73	72	73-72	45.9	29.4	28.93	1.02	Box Culvert 1.83 x 1.52	Rectangular		Storm drain, Rowan to Donnelly													1	1	1	0.013	0.013	0.013
74	73	74-73	18.3	29.58	29.41	0.93	Box Culvert 2.44 x 1.52	Rectangular		Storm drain, at Rowan													1	1	1	0.013	0.013	0.013
75	74	75-74	114.8	30.25	29.79	0.40	Box Culvert 1.83 x 1.52	Rectangular		Storm drain, Pear to Rowan													1	1	1	0.013	0.013	0.013
76	75	76-75	302.6	31.28	30.25	0.34	Box Culvert 1.83 x 1.52	Rectangular		Storm drain, Cedar Hill X to Pear													1	1	1	0.013	0.013	0.013
77	76	77-76	331	32.95	31.28	0.50	Box Culvert 1.83 x 1.22	Rectangular		Storm drain, Earlston to Cedar Hill X													1	1	1	0.013	0.013	0.013
78	77	78-77	84	33.31	32.95	0.43	Box Culvert 1.83 x 1.22	Rectangular		Storm drain, Mortimer to Earlston													1	1	1	0.013	0.013	0.013
79	78	79-78	125.1	33.7	33.31	0.31	Box Culvert 1.83 x 1.22	Rectangular		Storm drain, upstream of Mortnimer													1	1	1	0.013	0.013	0.013
80	79	80-79	299.3	35.02	33.7	0.44	Box Culvert 1.83 x 1.22	Rectangular		Storm drain, Garnet to upstream of Mortnimer													1	1	1	0.013	0.013	0.013
81	80	81-80	393.9	35.76	35.36	0.10	Wood Stave 2 - 0.91	Circular		Storm drain, R/W along Garnet													1	1	1	0.013	0.013	0.013
82	81	82-81	121.9	36.87	35.76	0.91	Wood Stave 0.91	Circular		Storm drain, R/W along Garnet													1	1	1	0.013	0.013	0.013
83	82	83-82	176.3	37.96	36.87	0.62	Wood Stave 1.07	Circular		Storm drain, Ansell and downstream													1	1	1	0.013	0.013	0.013
84	83	84-83	224.3	39.64	37.96	0.75	Wood Stave 1.07	Circular		Storm drain, Gordon Head to Ansell													1	1	1	0.013	0.013	0.013
85	84	85-84	48.2	40	39.64	0.75	Wood Stave 0.61	Circular		Storm drain, across Gordon Head													1	1	1	0.013	0.013	0.013
Golf Course Tributary																												
100	52	100-52	70.3	20.27	20.21	0.09	Concrete 1.68	Circular		Storm drain on Doncaster, North Dairy to Clawthrope													1	1	1	0.013	0.013	0.013
101	100	101-100	156.3	20.96	20.4	0.36	Box Culvert 1.83 x 0.91	Rectangular		Storm drain, along North Dairy													1	1	1	0.013	0.013	0.013
102	101	102-101	22.6	21.37	21.3	0.31	Concrete 1.22	Circular		Storm drain across Cedar Hill													1	1	1	0.013	0.013	0.013
103	102	103-102	12.1	21.87	21.83	0.33	Concrete 0.76	Circular		Storm drain across Cedar Hill													1	1	1	0.013	0.013	0.013

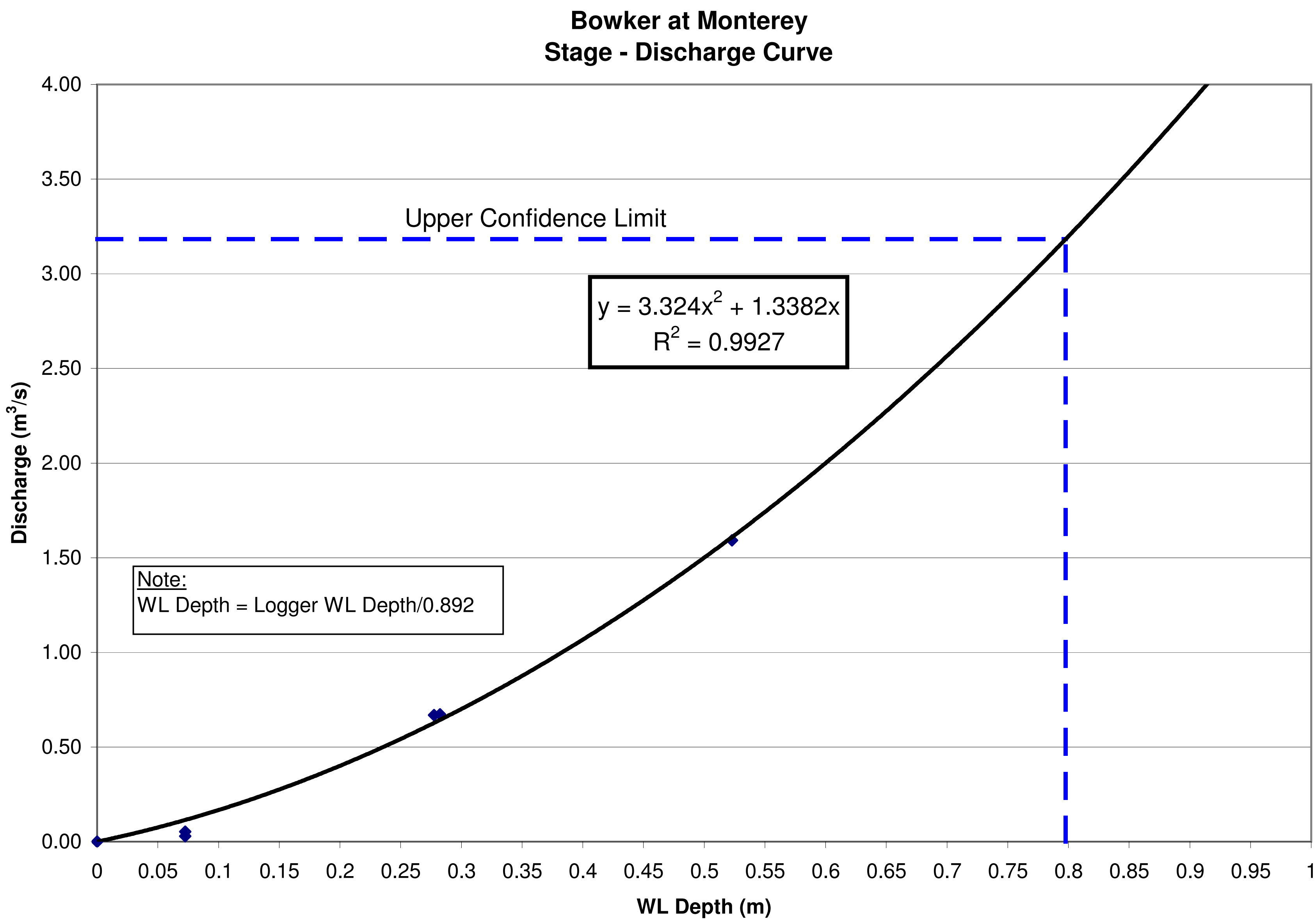
Bowker Creek XP-SWMM Model Input

														Overbanks from Contours (Looking DS) From CL									Channel Info (Looking DS)									
														Left			Right			Walls			Photo (Week &#)	Photo (Week &#)			Channel Type (See 'Roughness')			Manning's 'n'		
US Node	DS Node	Link Name	Length		US Invert	DS Invert	Slope		Section Number or Type	XP Section Type		Section Description		Station	Elevation	Section Elevation	Station	Elevation	Section Elevation	Left	Right				Left Bank	Right Bank	Left	Centre	Right	Left	Centre	Right
103	101	103-101	30.5		21.45	21.3	0.49		Concrete 1.22	Circular		Storm drain across Cedar Hill															1	1	1	0.013	0.013	0.013
103	52	103-52	240		24.9	22.6	0.96		306	Natural	306	Overland from Cedar Hill to Clawthorpe													-108	63	20	20	20	0.050	0.050	0.050
104	103	104-103	47.8		21.64	21.43	0.44		104	Natural	104	Open channel upstream of Cedar Hill Road											2&17		14.54	24.78	13	14	13	0.070	0.080	0.070
105	104	105-104	111.0		22.67	21.64	0.93		103	Natural	103	Open channel adjacent to Cedar Hil Recreation Centre		-30.0	25.2		20	26.2		-30			2&16	2&14	12.34	16.98	13	14	13	0.070	0.080	0.070
106	105	106-105	5.0		22.72	22.67	0.93		102	Natural	102	Foot bridge for trail around golf course											2&13		10.27	18.71	8	8	8	0.035	0.035	0.035
107	106	107-106	31.7		22.90	22.72	0.60		102	Natural	102	Open channel upstream of golf course trail foot bridge		-71.0	26		30	28					2&15		10.27	18.71	10	14	13	0.040	0.080	0.070
108	107	108-107	40		23.14	22.90	0.60		307	Natural	307	Swampy Area upstream of golf course trail foot bridge													-3.3	3.3	10	14	13	0.040	0.080	0.070
109	108	109-108	24.9		23.29	23.14	0.60		101	Natural	101	Open channel adjacent to ball diamond		-91.0	26		15	26.3					2&12		2.71	14.1	10	11	10	0.040	0.050	0.040
110	109	110-109	68.3		23.71	23.29	0.61		CSP 750mm	Circular		Culvert across the 16th Fairway															22	22	22	0.020	0.020	0.020
111	110	111-110	15		23.99	23.71	1.87		305	Natural	305	Open channel between 14th and 16th fairways													-3.3	3.3	6	11	6	0.030	0.050	0.030
112	111	112-111	54		24.25	23.99	0.48		CSP 750mm	Circular		Culvert across the 14th Fairway															22	22	22	0.020	0.020	0.020
113	112	113-112	10		24.4	24.28	1.20		Concrete 0.61	Circular		Outlet from 14th hole pond															1	1	1	0.013	0.013	0.013
Storm Drain From McKenzie																																
200	80	200-80	66.8		35.18	35.07	0.16		Concrete 1.22	Circular		Storm drain, McKenzie to Garnett															1	1	1	0.013	0.013	0.013
201	200	201-200	17.8		35.35	35.32	0.17		Concrete 2 - 0.91	Circular		Storm drain, scross Garnet															1	1	1	0.013	0.013	0.013

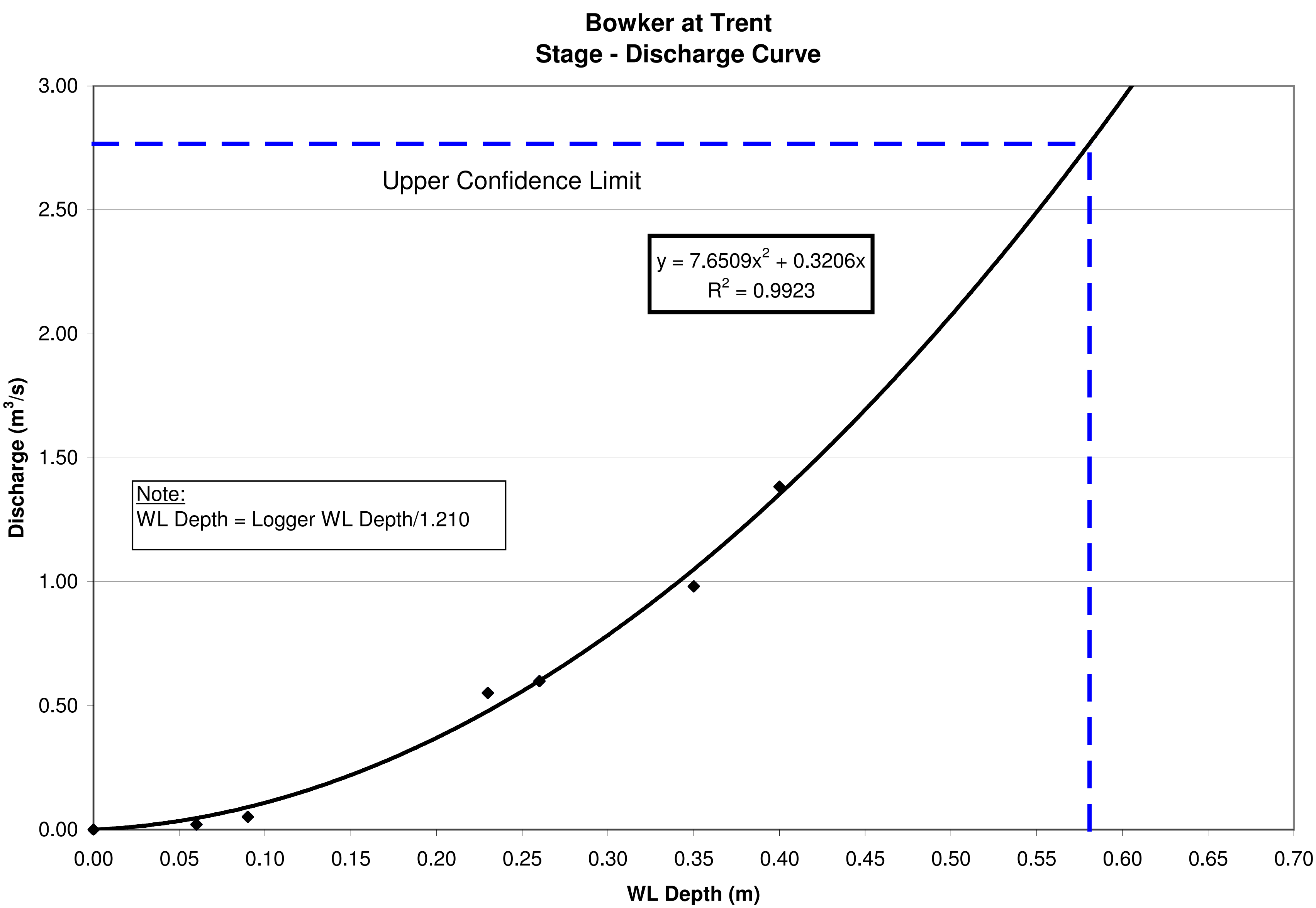
Appendix C

Monterey and Trent Stage Discharge Curves

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS



Bowker at Monterey
Stage - Discharge Curve
Upper Confidence Limit
y = 3.324x2 + 1.3382x
R2 = 0.9927
Note:
WL Depth = Logger WL Depth/0.892
Discharge (m3/s)
WL Depth (m)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1



Kerr Wood Leidal Associates Ltd.
283-288

Appendix C

Appendix D

Scenario Cost Estimates

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Scenario 3

Location (Model Nodes)	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Municipality
04-03	Upgrade to 7.0 x 1.8 Box	m	15	9,900	148,500	Oak Bay
10-07	Add 2.44 x 1.83 Box	m	316	2,300	726,800	
14-13	Upgrade to 8.00 x 2.00 Box[1]	m	15	11,000	165,000	
22-19	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.	m	137	2,600	356,200	
23-22	Upgrade to 8.00 x 2.40 Box. Lower by 0.43 m at upstream end and 0.32 m at downstream end.	m	6	15,300	91,800	
24-23	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.	m	3	2,600	7,800	
25-24	Add 3.66 x 3.66 Box. Lower by 0.57 m at upstream end and 0.43 m at downstream end.	m	94	5,400	507,600	
27-25	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.	m	93	2,300	213,900	
28-27	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.	m	17	10,500	178,500	
30-28	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.	m	52	2,000	104,000	
31-30	Add 3.66 x 3.66 Box. Lower by 1.16 m at upstream end and 0.92 m at downstream end.	m	104	5,400	561,600	Victoria
32-31	Add 3.66 x 3.66 Box. Lower by 1.36 m at upstream end and 1.16 m at downstream end.	m	105	5,400	567,000	
38-32	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.	m	339	2,300	779,700	Saanich
39-38	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.	m	12	11,300	135,600	
42-39	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.	m	225	2,300	517,500	
43-42	Upgrade to 3.66 x 2.44 Box.	m	206	4,500	927,000	Victoria
49-43	Widen to a base width of 4.0 m and 1.5:1 side slopes.	m	421	2,600	1,094,600	Saanich
50-49	Add 2.44 x 1.52 box.	m	309	2,200	679,800	Victoria
64-62	Add 1.37 round (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.	m	111	1,300	144,300	Saanich
71-69	Upgrade to 3.10 x 1.83 box	m	457	3,300	1,508,100	
74-71	Upgrade to 2.44 x 1.52 Box	m	129	2,400	309,600	
75-74	Upgrade to 3.66 x 1.52 Box	m	115	4,100	471,500	
76-75	Upgrade to 3.10 x 1.52 Box	m	303	3,200	969,600	
80-76	Upgrade to 2.44 x 1.22 Box	m	839	2,300	1,929,700	
81-80	Upgrade to 2.44 x 1.22 Box	m	394	2,300	906,200	
84-81	Upgrade to 1.22 Round	m	523	1,000	523,000	
85-84	Upgrade to 1.07 Round	m	48	900	43,200	
	SUBTOTAL				**14,568,100**	
	Engineering & Construction Management	15%			2,185,215	
	Contingencies	30%			4,370,430	
	TOTAL AMOUNT (excl. GST)				**21,100,000**	
	Oak Bay Total				3,625,145	
	Victoria Total				3,966,330	
	Saanich Total				13,532,270	

Scenario 4

Location (Model Nodes)	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
04-03	Upgrade to 7.0 x 1.8 Box	m	15	9,900	148,500	Oak Bay
10-07	Add 3.10 x 2.44 Box	m	316	3,800	1,200,800	
14-13	Upgrade to 12.00 x 2.00 Box[1]	m	15	16,100	241,500	
22-19	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.	m	137	2,600	356,200	
23-22	Upgrade to 10.00 x 2.40 Box. Lower by 0.43 m at upstream end and 0.32 m at downstream end.	m	6	18,700	112,200	
24-23	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.	m	3	2,600	7,800	
25-24	Add 2 – 2.44 x 3.66 Box. Lower by 0.57 m at upstream end and 0.43 m at downstream end.	m	94	10,500	987,000	
27-25	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.	m	93	2,600	241,800	
28-27	Upgrade to 7.0 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.	m	17	18,200	309,400	
30-28	Widen to a base width of 6.0 m with vertical sides (only 7.0 m between property lines). Lower by 0.92 m at upstream end and 0.94 m at downstream end.	m	52	6,500	338,000	
31-30	Upgrade to 2 - 3.66 x 3.66 Boxes. Lower by 1.16 m at upstream end and 0.92 m at downstream end.	m	104	10,500	1,092,000	Victoria
32-31	Upgrade to 2 - 3.66 x 3.66 Boxes. Lower by 1.36 m at upstream end and 1.16 m at downstream end.	m	105	10,500	1,102,500	
38-32	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.	m	339	2,600	881,400	Saanich
39-38	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.	m	12	11,300	135,600	
42-39	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.	m	225	2,300	517,500	
43-42	Upgrade to 2 - 3.10 x 2.44 Boxes.	m	206	7,200	1,483,200	Victoria
49-43	Widen to a base width of 4.0 m and 1.5:1 side slopes.	m	421	2,600	1,094,600	Saanich
50-49	Add 3.66 x 1.83 Box.	m	309	4,200	1,297,800	Victoria
52-50	Add 1.52 Round	m	708	1,500	1,062,000	
64-62	Add 1.83 x 1.52 box (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.	m	111	1,900	210,900	Saanich
71-69	Upgrade to 3.66 x 1.83 Box.	m	457	4,400	2,010,800	
74-71	Upgrade to 3.10 x 1.52 Box.	m	129	3,200	412,800	
75-74	Upgrade to 3.66 x 1.52 Box.	m	115	4,100	471,500	
76-75	Upgrade to 3.66 x 1.52 Box.	m	303	4,000	1,212,000	
80-76	Upgrade to 3.10 x 1.22 Box.	m	839	2,700	2,265,300	
81-80	Upgrade to 3.10 x 1.22 Box.	m	394	2,700	1,063,800	
84-81	Upgrade to 1.83 x 1.22 Box.	m	523	1,900	993,700	
85-84	Upgrade to 1.37 Round	m	48	1,600	76,800	
	SUBTOTAL				**21,327,400**	
	Engineering & Construction Management	15%			3,199,110	
	Contingencies	30%			6,398,220	
	TOTAL AMOUNT (excl. GST)				**30,900,000**	
	Oak Bay Total				5,717,640	
	Victoria Total				8,754,375	
	Saanich Total				16,452,715	

Scenario 5

Location (Model Nodes)	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
04-03	Upgrade to 5.0 x 1.8 Box	m	15	6,900	103,500	Oak Bay
10-07	Open channel with a base width of 2.0 m and 1.5:1 side slopes.	m	316	2,300	726,800	
14-13	Upgrade to 8.00 x 2.00 Box[1]	m	15	11,000	165,000	
22-19	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.	m	137	2,600	356,200	
23-22	Open channel with a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.32 m at downstream end.	m	6	2,600	15,600	
24-23	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.	m	3	2,600	7,800	
25-24	Open channel with a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.57 m at upstream end and 0.43 m at downstream end.	m	94	2,300	216,200	
27-25	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.	m	93	2,300	213,900	
28-27	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.	m	17	10,500	178,500	
30-28	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.	m	52	2,000	104,000	
31-30	Open channel with a base width of 4.0 m and vertical sides. Lower by 1.16 m at upstream end and 0.92 m at downstream end.	m	104	7,000	728,000	Victoria
32-31	Open channel with a base width of 4.0 m and vertical sides. Lower by 1.36 m at upstream end and 1.16 m at downstream end.	m	105	7,000	735,000	
38-32	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.	m	339	2,300	779,700	Saanich
39-38	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.	m	12	11,300	135,600	
42-39	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.	m	225	2,300	517,500	
43-42	Open channel with a base width of 4.0 m and vertical sides.	m	206	7,000	1,442,000	Victoria
49-43	Widen to a base width of 4.0 m and 1.5:1 side slopes.	m	421	2,600	1,094,600	Saanich
50-49	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	309	2,200	679,800	Victoria
53-50	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	824	2,200	1,812,800	
54-53	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	156	2,200	343,200	
64-62	Add 1.37 Round (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.	m	111	1,300	144,300	Saanich
71-69	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	457	2,200	1,005,400	
74-71	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	129	2,200	283,800	
75-74	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	115	2,200	253,000	
76-75	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	303	2,200	666,600	
80-76	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	839	2,200	1,845,800	
81-80	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	394	2,200	866,800	
84-81	Open channel with a base width of 2.0 m and 1.5:1 side slopes.	m	523	1,900	993,700	
85-84	Upgrade to 1.07 Round	m	48	900	43,200	
	SUBTOTAL				**16,458,300**	
	Engineering & Construction Management	15%			2,468,745	
	Contingencies	30%			4,937,490	
	TOTAL AMOUNT (excl. GST)				**23,900,000**	
	Oak Bay Total				3,026,875	
	Victoria Total				8,324,160	
	Saanich Total				12,513,500	

Scenario 6

Location (Model Nodes)	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
04-03	Upgrade to 7.0 x 1.8 Box	m	15	9,900	148,500	Oak Bay
10-07	Open channel with a base width of 2.0 m and 1.5:1 side slopes.	m	316	2,300	726,800	
14-13	Upgrade to 8.00 x 2.00 Box[1]	m	15	11,000	165,000	
22-19	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.	m	137	2,600	356,200	
23-22	Open channel with a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.32 m at downstream end.	m	6	2,600	15,600	
24-23	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.	m	3	2,600	7,800	
25-24	Open channel with a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.57 m at upstream end and 0.43 m at downstream end.	m	94	2,300	216,200	
27-25	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.	m	93	2,300	213,900	
28-27	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.	m	17	10,500	178,500	
30-28	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.	m	52	2,000	104,000	
31-30	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.16 m at upstream end and 0.92 m at downstream end.	m	104	8,000	832,000	Victoria
32-31	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.36 m at upstream end and 1.16 m at downstream end.	m	105	8,000	840,000	
38-32	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.	m	339	2,300	779,700	Saanich
39-38	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.	m	12	11,300	135,600	
42-39	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.	m	225	2,300	517,500	
43-42	Open channel with a base width of 4.0 m and vertical sides.	m	206	7,000	1,442,000	Victoria
49-43	Widen to a base width of 4.0 m and 1.5:1 side slopes.	m	421	2,600	1,094,600	Saanich
50-49	Open channel with a base width of 5.0 m and 1.5:1 side slopes.	m	309	2,700	834,300	Victoria
52-50	Open channel with a base width of 5.0 m and 1.5:1 side slopes.	m	708	2,700	1,911,600	
53-52	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	117	2,200	257,400	
54-53	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	156	2,200	343,200	
64-62	Add 1.83 x 1.52 box (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.	m	111	1,900	210,900	Saanich
71-69	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	457	2,200	1,005,400	
74-71	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	129	2,200	283,800	
75-74	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	115	2,200	253,000	
76-75	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	303	2,200	666,600	
80-76	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	839	2,200	1,845,800	
81-80	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	394	2,200	866,800	
84-81	Open channel with a base width of 2.0 m and 1.5:1 side slopes.	m	523	1,900	993,700	
85-84	Upgrade to 1.37 Round	m	48	1,600	76,800	
	SUBTOTAL				**17,323,200**	
	Engineering & Construction Management	15%			2,598,480	
	Contingencies	30%			5,196,960	
	TOTAL AMOUNT (excl. GST)				**25,100,000**	
	Oak Bay Total				3,092,125	
	Victoria Total				9,367,725	
	Saanich Total				12,658,790	

Scenario 7

Location (Model Nodes)	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
04-03	Upgrade to 7.0 x 1.8 Box	m	15	9,900	148,500	Oak Bay
10-07	Open channel with a base width of 2.0 m and 1.5:1 side slopes.	m	316	2,300	726,800	
14-13	Upgrade to 8.00 x 2.00 Box[1]	m	15	11,000	165,000	
22-19	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.32 m at upstream end and 0.00 m at downstream end.	m	137	2,600	356,200	
23-22	Open channel with a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.32 m at downstream end.	m	6	2,600	15,600	
24-23	Widen to a base width of 4.0 m and 1.5:1 side slopes. Lower by 0.43 m at upstream end and 0.43 m at downstream end.	m	3	2,600	7,800	
25-24	Open channel with a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.57 m at upstream end and 0.43 m at downstream end.	m	94	2,300	216,200	
27-25	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.99 m at upstream end and 0.57 m at downstream end.	m	93	2,300	213,900	
28-27	Upgrade to 3.6 x 4.2 Box. Lower by 0.94 m at upstream end and 0.99 m at downstream end.	m	17	10,500	178,500	
30-28	Lower by 0.92 m at upstream end and 0.94 m at downstream end with vertical sides to match existing.	m	52	2,000	104,000	
31-30	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.16 m at upstream end and 0.92 m at downstream end.	m	104	8,000	832,000	Victoria
32-31	Open channel with a base width of 6.0 m and vertical sides. Lower by 1.36 m at upstream end and 1.16 m at downstream end.	m	105	8,000	840,000	
38-32	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 1.52 m at upstream end and 1.36 m at downstream end.	m	339	2,300	779,700	Saanich
39-38	Upgrade to 4.00 x 3.60 box. Lower by 2.34 m at upstream end and 2.21 m at downstream end.	m	12	11,300	135,600	
42-39	Widen to a base width of 2.0 m and 1.5:1 side slopes. Lower by 0.00 m at upstream end and 2.34 m at downstream end.	m	225	2,300	517,500	
43-42	Open channel with a base width of 4.0 m and vertical sides.	m	206	7,000	1,442,000	Victoria
46-43	Widen to a base width of 2.0 m and 1.5:1 side slopes.	m	214	2,300	492,200	Saanich
49-46	Widen to a base width of 4.0 m and 1.5:1 side slopes.	m	207	2,600	538,200	
50-49	Open channel with a base width of 5.0 m and 1.5:1 side slopes.	m	309	2,700	834,300	Victoria
52-50	Open channel with a base width of 5.0 m and 1.5:1 side slopes.	m	708	2,700	1,911,600	
53-52	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	117	2,200	257,400	
54-53	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	156	2,200	343,200	
64-62	Add 1.83 x 1.52 box (bypass around section). Higher by 0.5 m at upstream end and 0.3 m at downstream end.	m	111	1,900	210,900	Saanich
71-69	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	457	2,200	1,005,400	
74-71	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	129	2,200	283,800	
75-74	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	115	2,200	253,000	
76-75	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	303	2,200	666,600	
80-76	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	839	2,200	1,845,800	
81-80	Open channel with a base width of 3.0 m and 1.5:1 side slopes.	m	394	2,200	866,800	
84-81	Open channel with a base width of 2.0 m and 1.5:1 side slopes.	m	523	1,900	993,700	
85-84	Upgrade to 1.37 Round	m	48	1,600	76,800	
85	Detention Pond Excavation	m^3	2,000	20	40,000	Oak Bay
	Landscaping and Planting	m^2	2,000	15	30,000	
46-43	Detention Pond Excavation	m^3	18,700	20	374,000	Saanich
	Landscaping and Planting	m^2	4,800	15	72,000	
41-39	Detention Pond Excavation	m^3	28,770	20	575,400	
	Landscaping and Planting	m^2	9,300	15	139,500	
37-35	Detention Pond Excavation	m^3	11,900	20	238,000	
	Landscaping and Planting	m^2	3,980	15	59,700	
	SUBTOTAL				**18,787,600**	
	Engineering & Construction Management	15%		6,321	2,818,140	
	Contingencies	30%			5,636,280	
	TOTAL AMOUNT (excl. GST)				**27,200,000**	
	Oak Bay Total				3,193,625	
	Victoria Total				9,367,725	
	Saanich Total				14,680,670	

Appendix E

GMF – Detailed Study Report Requirements

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GMF – DETAILED STUDY REPORT REQUIEMENTS

The Bowker Creek Master Drainage Plan was funded in part by the Green Municipal Fund (GMF). The Government of Canada established the GMF to, "stimulate investment in innovative municipal environmental projects that advance the progress of sustainable development in Canada's communities. The Fund supports partnerships, leveraging both public and private sector funding to encourage municipal actions to improve air, water and soil quality, and to reduce greenhouse gas emissions" (sustainable communities webpage: http://sustainablecommunities.fcm.ca/GMF/GMF_History.asp).

A requirement of the GMF is that two specific sections be included in the report. These sections are as follows:

- Financing and Implementation Plan for the Preferred Option(s), and;
- Expected Environmental Benefits of the Preferred Option(s).

These sections have been prepared in accordance with the *GMF Final Report Submission Requirements, Schedule D* and are outlined below.

FINANCING AND IMPLEMENTATION PLAN FOR THE PREFERRED OPTION

This section describes how the project could be financed and describes the political framework in which the project will take place.

DESCRIPTION OF HOW THE PROJECT COULD BE FINANCED

Construction of the preferred option could be financed by the municipalities (Oak Bay, Victoria, and Saanich). It is expected that each municipality would be responsible for funding the upgrades within their jurisdiction. This municipal funding will likely be provided through their infrastructure operations budgets.

Additionally, it is expected that grant applications will be made either by the CRD or the municipalities to assist in funding the construction projects. Some potential sources of funds include the following:

- Canada/BC Municipal Rural Infrastructure Fund;
- Gas Tax Agreement;
- BC Spirit Square Program;
- LocalMotion Fund, and;
- Green Cities Awards.

The potential economic benefits of the project include the following:

- job creation and economic spin-offs;
- reduction in flood damage and insurance claims, and;
- eliminate the need for some other municipal projects.

DESCRIPTION OF THE POLITICAL FRAMEWORK OF THE PROJECT

The targets for Bowker Creek are outlined in the Bowker Creek Watershed Management Plan. This plan was endorsed by the Bowker Creek Watershed Watershed Renewal Initiative (BCI) which includes representatives from the municipalities of Oak Bay, Victoria and Saanich, and the CRD.

The recommended option is similar to another project within the CRD that was completed in the recent past, Daylighting of Cecelia Creek.

Potential political barriers to the project include the following:

- funds;
- land availability, and
- change in land-use.

Methods to overcome these potential political barriers are as follows:

- council and public education to gain support for the project;
- completion of an Integrated Stormwater Management Plan (ISMP) to address land-use issues, and;
- lobbying of municipal councils to have local area plans modified to incorporate project land needs.

The proposed option for this project incorporates potential land-use changes within the watershed. Therefore, it will meet the long-term development and infrastructure requirements of the municipalities. This MDP along with the next phase of this project will form the ISMP. This ISMP will establish sustainability targets and methods to meet these targets.

EXPECTED ENVIRONMENTAL BENEFITS OF THE PREFERRED OPTION

This section describes the net environmental benefit of the project. This section will be explored in greater detail in the second phase of the ISMP.

SUMMARY OF THE STUDY GOALS AND COMPARISON OF THE STUDY OPTIONS

The goals of this study included the following:

- to document the existing hydraulic condition of Bowker Creek and the tributary from

Cedar Hill golf course;

- to develop a calibrated hydraulic/hydrologic model of Bowker Creek and the tributary from Cedar Hill Golf Course for existing and future conditions;
- to identify and prioritize the hydrotechnical drainage problems in the watershed;
- to evaluate the likely hydraulic impacts of further development and redevelopment;
- to identify and evaluate potential hydraulic improvements that are consistent with the goals and objectives of the BCWMP;
- to outline the benefits of the solutions;
- to provide capital cost estimates for the recommended solutions, and;
- to recommend solutions that will address the hydrotechnical problems.

The primary environmental benefit of the preferred option is it will provide an opportunity to add biodiversity to sections of the creek where it does not currently exist.

Secondary environmental benefits of the preferred option are as follows:

- allow for the removal of fish barriers;
- provide an opportunity to incorporate a greenway along the creek in areas where a trail system does not currently exist;
- improve public education and awareness;
- increase green space and expand public access.

DESCRIPTION OF PROJECT SYSTEM

The proposed option includes the following upgrades to the main elements of Bowker Creek:

Open Channels Upgrades

The total length of proposed open channel upgrade is approximately 6.1 km. It is anticipated that these open channels will typically include features to provide aquatic biodiversity. Riparian vegetation will also be included to provide shade and terrestrial habitat.

Culvert/Storm Drains Upgrades

The total length of proposed culvert or storm drain upgrades is approximately 200 m. The primary purpose of these features is to improve hydraulic capacities at roadway crossings.

DESCRIPTION OF BASELINE SYSTEM

The existing main elements of Bowker Creek are as follows:

Open Channels

The total length of existing open channels is 2.9 km, or 37% of the creek length.

Culvert/Storm Drains

The total length of existing culverts or storm drains is approximately 5.0 km. Most of these culverts and storm drains do not have adequate capacity to convey the design flow (25-year return period) and flooding will occur under this condition.

NET ENVIRONMENTAL BENEFIT OF THE PREFERRED OPTION

In addition to the hydraulic capacity improvements, the preferred option will also result in environmental benefit. These benefits include the following:

- The length of open channel section of Bowker Creek will increase from approximately 2.9 km to approximately 7.7 km. This will allow for the creation of aquatic and terrestrial habitat. Additionally, in some areas public greenways can be incorporated into the design of these open channel sections.

- The construction of open channels will allow for the removal of existing barriers to fish passage.

- The open channels will also assist in improving water quality by the removal of sediments and other pollutants. This will also improve the water quality in the receiving body of water, Oak Bay.

The five upgrade options investigated are summarized in the following table.

Table: Summary of Study Upgrade Options

Scenario	Description	Environmental Benefits
Scenario 3	Existing Land-Use, Upgraded Hydraulics	None
Scenario 4	Future Land-Use, Upgraded Hydraulics	None
Scenario 5	Existing Land-Use, Upgraded Hydraulics and Daylighting	▪ creation of aquatic habitat ▪ creation of terrestrial habitat ▪ public greenways ▪ removal of fish barriers ▪ water quality improvement
Scenario 6	Existing Land-Use, Upgraded Hydraulics and Daylighting	Same as 5
Scenario 7	Future Land-Use, Upgraded Hydraulics, Daylighting and Detention	Same as 5 and 6, plus: ▪ greater water quality improvement ▪ peak flow and erosion reduction
Note: - Scenario 6 is the recommended option.		

Appendix F

Terms of Reference

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CONSULTING ENGINEERS

Environmental Services

Capital Regional District
Scientific Programs

Bowker Creek Master Drainage Plan
Request for Proposal

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List of Appendices

1.0 Introduction

The purpose of this Request for Proposal (RFP) is to inform potential proponents of a business opportunity and to solicit proposals for the Bowker Creek Watershed Master Drainage Plan (MDP). The Capital Regional District (CRD) invites proposals from those firms selected for the shortlist in the Request for Qualifications process.

The Bowker Creek Urban Watershed Renewal Initiative (BCI) is a broad coalition of representatives from the community, government, business and institutions, working together to protect and enhance the overall health of the Bowker Creek watershed. The BCI was established following the completion of the Bowker Creek Watershed Management Plan (BCWMP) and its adoption by the member municipalities (Victoria, Saanich and Oak Bay) and the CRD in 2003. The plan was produced through a multi-stakeholder public consultation process. The BCI Steering committee is responsible for implementing the recommended actions from the BCWMP.

One of the key short-term priority actions of the BCI is the completion of an Integrated Stormwater Management Plan (ISMP) for the watershed. The ISMP will integrate hydrotechnical and environmental solutions and balance the issues of economy, protection of private property, existing and future development/redevelopment, protection of aquatic and riparian habitat and greenways/recreational opportunities. A number of issues are driving the need to complete an ISMP. These include:

- the risk of property damage and safety concerns due to flooding, particularly in the lower reaches of Bowker Creek
- the potential for opportunities associated with redevelopment throughout the watershed
- the ongoing loss of aquatic and riparian habitat
- the need for multi-jurisdictional decision-making within the watershed

The Bowker Creek ISMP will have two phases: **Phase 1 - Master Drainage Plan** and **Phase 2 - Environmental Plan.**

Phase 1 – The Master Drainage Plan will address the hydrological and engineering components of the ISMP, while incorporating existing ecological information. It will identify drainage solutions for the watershed and prioritize hydrological and stormwater problems and potential solutions. The MDP will integrate hydrotechnical drainage problems and water quality problems, and balance the issues of economy, operations and maintenance, protection of private property, existing and future development and redevelopment and protection of aquatic and riparian habitat. The MDP will also provide the estimated costs and the benefits for each solution identified and provide a plan for future capital works requirements. The solutions identified are to be consistent with the goals and objectives of the BCWMP.

Phase 2 – The Environmental Plan will assess riparian and in-stream habitat, water quality, the functional condition of the creek, and incorporate the recommendations from the MDP with the results and recommendations of the environmental and ecological assessments, and greenway and recreational planning.

Taking an integrated and comprehensive approach to stormwater management within the Bowker Creek watershed will provide solutions that will meet as many of the goals of the BCI as possible. The MDP is a joint project between the CRD, District of Saanich, City of Victoria and District of Oak Bay.

This Request for Proposal (RFP) identifies the requirements for **Phase 1 - Master Drainage Plan.**

1.1 Request for Proposal Terminology

Throughout this Request for Proposal, terminology is used as follows:

a) “Proponent” means an individual or a company that submits, or intends to submit, a proposal in response to this “Request for Proposal”;
b) “Consultant” means the successful Proponent to the Request for Proposal who enters into a written contract with the Capital Regional District;
c) “Division” or “SC” means CRD Scientific Programs on whose behalf this Request for Proposal is being issued;
d) “must”, “mandatory”, “shall” or “required” means a requirement that must be met in substantially unaltered form in order for the proposal to receive consideration;
e) “should” or “desirable” means a requirement having a significant degree of importance to the objectives of the Request for Proposal;
f) “CRD” means the Capital Regional District

2.0 Objectives

The MDP will provide the basis for making informed watershed management decisions. The overall objectives of the MDP are:

- document the existing hydraulic condition of Bowker Creek and the tributary from Cedar Hill golf course
- develop a calibrated hydraulic/hydrologic model of Bowker Creek and the tributary from Cedar Hill golf course for existing and future land use conditions
- identify and prioritize the hydrotechnical drainage problems in the watershed
- evaluate the likely impacts of further development and redevelopment (traditional and low impact development)
- identify and evaluate potential improvement solutions that are consistent with the goals and objectives of the BCWMP
- identify benefits of the solutions
- provide capital cost estimates for the recommended solutions
- recommend solutions that will address the hydrotechnical problems (e.g. flooding, aquatic ecosystem degradation)

3.0 Background

Previous reports, works and plans specific to the watershed (available upon request for RFQ applicants) include:

- Flood Flows in Bowker Creek – Haultain Street to the Oak Bay Recreation Centre (1984)
- Bowker Creek Watershed Assessment (2000)
- Bowker Creek Watershed Management Plan (2003)
- University of Victoria Integrated Stormwater Management Plan (2004)

Data collection has been initiated for the Bowker Creek MDP. Two continuous level sensors have been installed on the creek (Trent Street and Monterey Street) and four A/V meters were installed in the storm drain system for the winter of 2005/2006.

The stage-discharge relationship that will be used for the MDP has been completed for Bowker Creek at Trent Street and Monterey Avenue. This information will be available for the Request for Proposal (RFP) process.

3.1 Study Area

The Bowker Creek watershed is located in the CRD in the municipalities of Saanich, Victoria and Oak Bay (Figure 1). The catchment area is approximately 1,028 hectares. The main channel flows from the University of Victoria to Oak Bay, with a tributary coming from Cedar Hill golf course. Approximately 60% of the main channel is contained in underground pipes and approximately 30% of the watershed is impervious area.

Land use in the watershed is a mix of residential, commercial and institutional. The watershed is nearly built out with few open green spaces. The storm water collection system is a combination of road side ditches and storm sewers that flow into Bowker Creek. The open portions of Bowker Creek provide mostly unrealized but important habitat and recreational values.

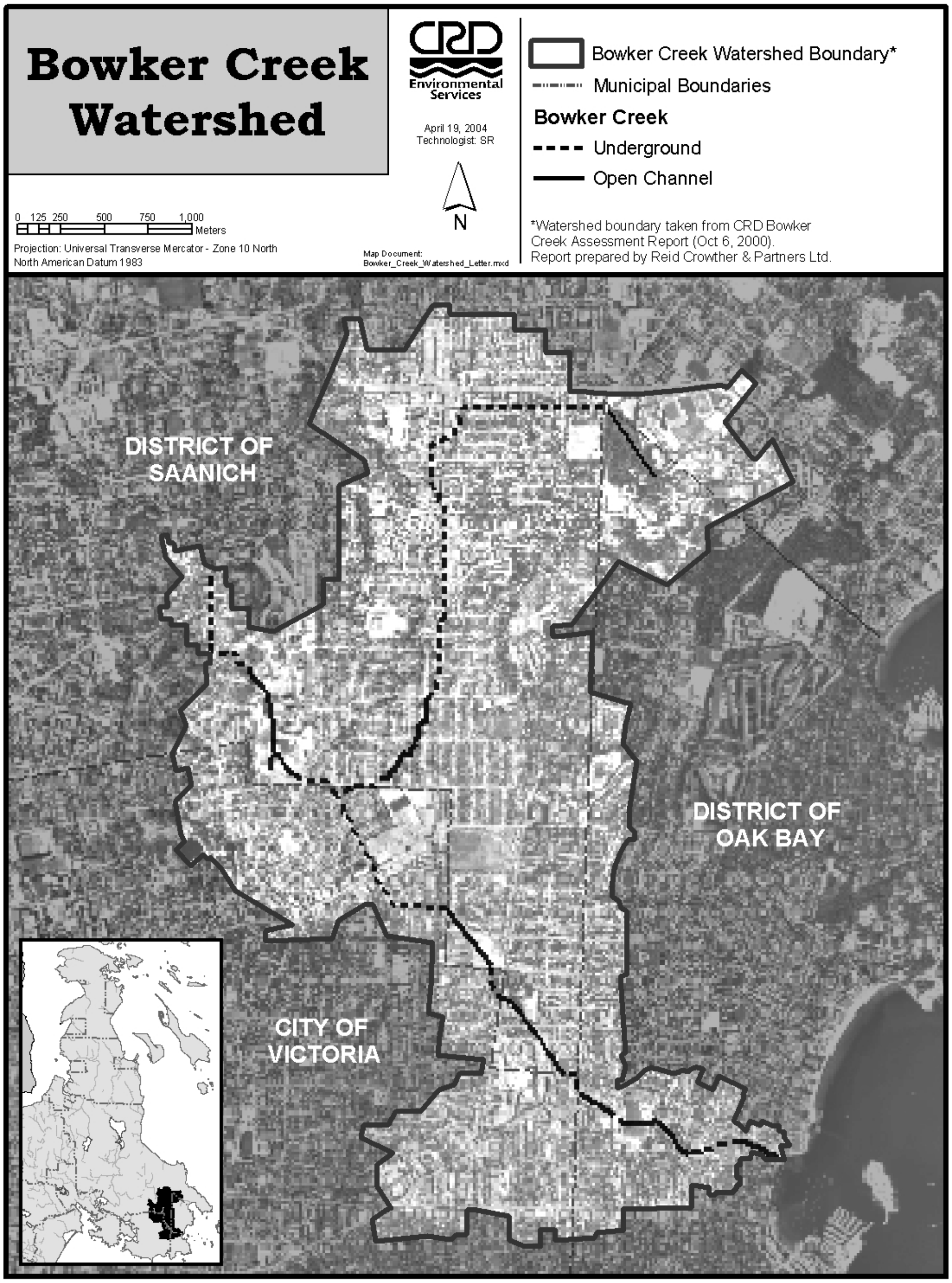

Figure 1. Map of Bowker Creek Watershed.

4.0 Terms of Reference

4.1 Scope of Work

Proposals must identify the methods to be used and develop a schedule to complete each of the following required project tasks. Modifications or additions to the task list proposed will be considered, subject to meeting the specified project objectives and evaluation criteria set out in this Request for Proposal. The following section identifies the tasks necessary to complete the MDP.

MDP STAGE 1

A. Project Initiation

1. Attend a project initiation meeting for the following purposes:
    - confirm project objectives;
    - establish lines of communication, and;
    - obtain background material;

B. Existing stormwater and watercourse system

1. Review existing studies including all planning, engineering and biological studies provided by the CRD, Saanich, Victoria and Oak Bay.
2. Using geographic information system (GIS) applications, compile existing digital mapping including watershed and sub-basin boundaries, land use, topography, hydrology, soils, surficial geology, storm drain infrastructure, etc., information as necessary (ArcView GIS compatible for future use).
3. Review existing water quality data.
4. Inventory and map (using a GIS application) significant features of Bowker Creek and Cedar Hill Golf Course tributary including culverts, headwalls, storm drains, and typical channel cross section survey information as required to prepare a hydrologic/hydraulic model.
5. Inventory and map (using a GIS application) existing erosion sites and evaluate general conditions of Bowker Creek and Cedar Hill Golf Course tributary features based on information provided and site inspection. Pipe inspection videos or other condition testing are not required.
6. Identify known flooding and erosion problems or issues of Bowker Creek and Cedar Hill Golf Course tributary through discussions with municipal engineering and operations staff, stakeholders, BCI Steering committee members, etc.

MDP STAGE 2

C. Land Use

1. Review zoning and other land use information and establish existing land use patterns within the watershed.
2. Review the CRD's Regional Growth Strategy, municipal official community plans (OCP), neighbourhood plans studies and other land use documentation. Work with the CRD to establish future land use patterns within the watershed based on the Regional Growth Strategy and other potential future land use conditions.
3. Calculate catchment runoff parameters for existing and future land use within the watershed.

D. Hydrologic and Hydraulic Analysis

1. Review rainfall, water level and runoff data provided in Section 4.4.2 of this document.
2. Develop a hydrologic/hydraulic model of Bowker Creek (upstream to McKenzie Avenue) and the Cedar Hill Golf Course tributary (upstream to the 14th hole pond) and floodplain. Modelling of the upland storm drainage system is not required.
3. Calibrate and verify the model.

4. Calculate flows, velocities, and water levels for various return periods (10-, 25-, 100-, and 200- year storms) for 7 different scenarios. The scenarios are to include the following:
   - existing land-use, existing creeks;
   - future land-use, existing creeks;
   - existing land-use, hydraulic upgrades*;
   - future land-use, hydraulic upgrades*;
   - existing land-use, daylighted and upgraded creeks;
   - future land-use, daylighted and upgraded creeks;
   - future land-use, daylighted and upgraded creeks, with proposed detention ponds if applicable;

   * hydraulic upgrades refers to increasing the hydraulic capacity of undersized pipes and culverts as determined by modelling while maintaining the current state of the creek. In this scenario, the adequately sized sections which are enclosed and the sections which are open channel, remain as they exist.

E. Evaluation of Issues, Potential Solutions and Recommendations

1. Identify and prioritize areas of flooding, erosion concerns and bank failure.
2. Determine potential flooding and erosion impacts of future development and re-development scenario.
3. Assess adequacy of existing drainage structures and channel capacities.
4. Evaluate modelling scenarios considering the BCWMP, capital costs (including property acquisition costs), community amenities.
5. Identify the highest priority land and/or right-of-way acquisitions required to address hydrotechnical goals.
6. Recommend solutions that will address the hydrotechnical problems in the watershed.
7. Identify how the MDP recommendations may integrate with other plans for the watershed such as plans for greenways and trail networks.
8. Prioritize solutions based on capital costs, flooding and erosion benefits. (Note: solutions may be re-prioritized as part of the ISMP).
9. Present results and findings at a workshop to be attended by the BCI Steering committee, CRD, municipalities and community groups.

F. Report Preparation and Submission

1. Prepare MDP Report. The report is to include the following:
   - summary of relevant background information;
   - outline the work and methodology undertaken;
   - results of the hydrologic/hydraulic modelling;
   - cost estimates for upgrades;
   - development and evaluation of scenarios, and;
   - conclusions and recommendations.
2. Make a presentation to the BCI Steering Committee and submit the report in draft format for review and comments.
3. Receive comments, finalize and submit MDP Report.

G. Terms of Reference Development for Phase 2 (Environmental Plan)

1. Develop terms of reference document for Phase 2 (Environmental Plan) of the ISMP;
2. Obtain input from BCI Steering committee and submit the ToR in draft format for review and comments;
3. Receive comments, finalize and submit ToR document.

H. Meetings

1. Attend meetings (as defined in the schedule) throughout the project and prepare minutes.
2. Present results, findings and recommendations at a workshop attended by the CRD, municipalities and community groups.

4.2 Schedule and Timeframe

This project has the following timeframe:

- Response to Request for Proposal due – noon, September 18, 2006
- Evaluation period – September 19 to 22, 2006
- Successful proponent awarded contract by CRD Board at October Board meeting – October 11, 2006
- Project initiation – October 20, 2006
- Initial project meeting with MDP Subcommittee – October 31, 2006, 9:00 a.m., CRD Offices, 625 Fisgard Street, Victoria, BC
- Provide draft report for review, March 15, 2007 (to comply with funding requirements)
- Oral presentation of the draft findings/recommendations to the BCI MDP subcommittee by March 31, 2007
- Present results, findings and recommendations from final report at a workshop attended by the BCI Steering committee, CRD, municipalities and community groups, April 15, 2007
- Project completion – May 31, 2007

4.3 Required Communications

The consultant is required to communicate and report on the project as detailed below:

- The consultant must communicate and report on project status to the project manager a minimum of *twice per month* for the duration of the project period either in person, by telephone or by e-mail to resolve issues as they arise. Close collaboration between the consultant and the project manager is expected and required throughout the project
- The consultant and the project manager will jointly determine any additional meetings and reporting requirements.
- Throughout the project, the consultant must notify the CRD project manager, or in their absence, the alternate CRD project manager, immediately of any circumstances which may arise to cause the project to fail to meet any deadline, or other deliverable as described in each stage of the contract or budget.
- The consultant will be required to attend an initial project meeting with the BCI MDP subcommittee to review the work plan and schedule for the project. Care should be taken to clearly outline when members will be required to review documents or be available for consultation.
- The consultant will be required to meet on a number of occasions the BCI MDP subcommittee at various stages of the project - most of which are identified in the Terms of Reference. Proposals must identify when, and with whom, the proponent plans to meet and also identify any charges for additional meetings or workshops that may be required.
- The consultant should ensure that meetings or draft deliverables requiring review by committee members are scheduled according to the meeting schedule in Section 4.2. Efforts should be made to allow more time for review where possible, particularly for large and detailed documents.
- The consultant must ensure that the final products can be supported and maintained by the CRD, which may require consultation with CRD IT and GIS staff. The CRD project manager will coordinate consultation between the consultant and CRD staff as required.

4.4 Project Management

4.4.1 Proponent Responsibilities

The consultant is expected to carry out all necessary project management to ensure the completion of the project tasks, required project communication and the successful provision of project deliverables within the timeframe for each stage of the project as identified in this RFP. In particular, the consultant is responsible for maintaining project costs within the negotiated contract budget. Finally, the consultant, working in cooperation with the CRD project manager, is responsible for maintaining creative control and overall project momentum and acceptable quality standards for all work produced.

If more than one company is involved with this submission, proponents must name the company that would be the prime consultant and those that would be the subconsultant(s). The prime consultant must be responsible for overall project coordination and management and for ensuring that all subconsultants abide by the Terms of Reference and requirements of the project.

4.4.2 CRD Scientific Programs Responsibilities

The Scientific Programs division is prepared to assist and support the consultant during the project as follows:

- Advise the consultant immediately of required changes to the scope of work for the project and facilitate the appropriate contract amendments as required.
- CRD and municipal staff will provide documents and materials as required throughout the duration of the project. Specifically:
  - Bowker Creek Watershed Management Plan
  - Bowker Creek Watershed Assessment Report
  - City of Victoria Stormwater Quality Management Plan, July 2002
  - University of Victoria ISMP
  - Previous studies – engineering and biological
  - Example terms of reference document for Phase 2 (Environmental Plan) of the ISMP (GVRD)
  - Subdivision bylaws
  - Land use planning documents including Official Community Plans and Neighbourhood Plans
  - Municipal engineering standards
  - Color Ortho Photos –100 mm per pixel quality from 2005
  - Mapping
    - digital topographic mapping with 1 m contours;
    - digital and hard copy schematics of storm drains;
    - digital (.dwg and .tif formats) and hard copies of as constructed drawings;
    - current land-use mapping in digital format for Saanich and Oak Bay;
    - current zoning mapping in digital format;
    - digital and hard copies of future development (Local Area Plans, Regional Growth Plan, Official Community Plans);
  - Water Level and Flow Monitoring Data
    - Technical Memorandum for Bowker Creek Stage-Discharge Relationship for Trent Street and Monterey Avenue
    - Trent Street and Monterey Avenue Level Sensors: flow data will be supplied as flow data logged at five minute intervals since summer 2005
    - Velocity area meter data: raw level and velocity data will be supplied for winter 2005/2006
    - Other data formats may be available upon request

- Rain Gauge Information
  - Victoria City Hall Rain Gauge – 5 minute data from 2003 (part) to present;
  - CRD Data;
- Survey Information
  - The municipalities and CRD will provide any current survey information.

- Provide information regarding the BCI, CRD and the project to date.
- Meet with the consultant on a regular or as-needed basis to ensure that decisions are made as necessary and that the project timelines can be met.
- Provide regular and ongoing professional and project guidance and advice on an as-needed basis in person or via telephone, fax or e-mail communications.
- Facilitate the organization of meetings between the consultant, CRD staff and MDP subcommittee, as required.
- Coordinate communication between the consultant, other CRD consultants and BCI Steering committee, as required.
- Provide information about the project to the public as requested.

4.5 Project Deliverables

The consultant must meet the following required performance standards and deliverables to be considered in compliance:

1. Attend an initial project meeting to review the project work plan and schedule, background materials, status of related projects, and to develop an initial project direction.
2. Submit all materials for copying and distribution no later than two weeks prior to scheduled meetings.
3. Submit eight (8) unbound copies of the draft report for review by the project manager, municipal engineers and BCI MDP subcommittee, which must include:
   - an executive summary;
   - a statement of purpose;
   - a description of the methodology or process followed; and,
   - a description of any analysis carried out and the findings, results and/or recommendation, drawing any conclusions as necessary, using graphics, charts, maps, and text as appropriate;
   - a summary of the proposed improvements, recommendations and cost estimates;
   - use the Greater Vancouver Regional District Integrated Stormwater Management Plan Terms of Reference Template as a reference and include Table of Contents items as appropriate.
4. Draft of the final report for review by the project manager, municipal engineers and BCI MDP subcommittee.
5. Oral presentation of the draft findings/recommendation to the BCI MDP subcommittee.
6. A final report with modifications requested by the CRD Project Manager, including:
   - one (1) unbound copy suitable for photocopying
   - 15 bound copies
   - electronic file versions of the materials obtained and submitted in accordance with the formats required by this RFP
   - an Executive Summary and selected text or graphics formatted for the CRD website
   - a PDF file version of all final reports and most documents must be supplied for the website, in accordance with required software and electronic formats
7. Present results, findings and recommendations at a workshop attended by the CRD, municipalities and community groups.

8. All materials, photos (or video) taken as part of the project and electronic files should be in a format consistent with CRD formats as required by this RFP; and
9. The return of any paper or electronic materials that have been loaned to the Consultant by the CRD. Note, the Consultant is required to comply with all licensing agreements that the CRD is party to for the use of map or other data.
10. Digital copies of the hydraulic and hydrologic models.
11. Digital files of all mapping, including the storm drain system and open channel, areas of concern, potential project locations, survey information and results from different modeling scenarios.
12. All spatially referenced data, GPS and GIS files must be provided in accordance with the format required by this RFP.

4.5.1 Software and Electronic Formats

- All **electronic files** submitted must also be saved and formatted in an appropriate choice from one of the following PC software:
  - MS Word 97 or higher
  - Microsoft Excel 97 or higher
  - Microsoft PowerPoint 97 or higher
  - Microsoft Access 97 or higher
  - Adobe PageMaker 7
  - Adobe Photoshop
  - Macromedia Fireworks
- All **PDF files and Adobe Acrobat documents** should be provided as follows:
  - <u>General requirements</u> – When creating Adobe Acrobat documents, the consultant shall provide two versions – one at print quality and the other optimized for posting to the web – and the original source file(s) and supporting graphics
  - <u>PDF for Print purposes</u> – The final PDF must be Acrobat 3 compatible, unless Acrobat 4, 5 or 6 features are used. If the PDF file is expected to be professionally printed, the consultant may need to communicate with the printer to choose the appropriate compression settings.
  - <u>PDF for the Web</u> - The final PDF must be Acrobat 3 compatible unless Acrobat 4, 5 or 6 features are used. The PDF must also be optimized and have thumbnails embedded. Creating a good quality PDF optimized and compressed for the web involves a trade-off between file size and image quality. The standard Acrobat screen optimized settings will produce a smaller file compared to one produced with the print or press settings, but image quality, particularly of maps and photographs, may be too poor. In the case of large files (> 1 MB), the consultant must split the complete document into files of less than 1 MB, unless this is impractical.
- All **graphics** should be supplied in their original native format (e.g., Photoshop, Corel, Illustrator, Fireworks) and in a format suitable for their end use. For example:
  - When creating <u>graphics for use in a web project</u>, the consultant must supply the native unflattened image file (e.g. Fireworks PNG or Photoshop PSD) and the optimized GIF or JPEG image for use in the web project. File names for the web must follow the 20.3 all lowercase standard using only letters, numbers and the underscore(as detailed in the Web Page Design Standards document).
  - When creating <u>images for a print publication</u> the consultant must supply the original artwork (e.g. Photoshop, Illustrator) and the exported flattened image for use in the publication (e.g. TIFF file). If the artwork uses photographs, supply high-quality digital images, Kodak PhotoCD files, or 8 x 10 glossy prints.

- When creating digital video, the consultant must supply video clips compressed in a format suitable for the project and the original raw files on a CD. Raw video files must include details of in and out points in an accompanying text document and precise and complete details of what compression technology was used to produce the final video clips. If the contractor has created video project files (e.g. in Final Cut Pro, Premiere, or After Effects) those must be included as well.

Note: If graphics use fonts that are not part of the CRD's corporate Adobe font set, then the contractor must supply a copy of the font file, or arrange with the CRD project manager to purchase a license for that particular font.

- An electronic copy of all data gathered by **global positioning system (GPS)** or Geographic Information System (GIS) files developed as a result of this project should be submitted as per the formats specified in British Columbia Standards, Specifications and Guidelines for Resource Surveys Using Global Positioning System (GPS) Technology; Release 3.0, March 2001

- An electronic copy of all **Geographic Information System (GIS) files** and associated data developed as a result of this project should be submitted in accordance with the following specifications:
  - File format: all GIS spatial data must be supplied either as:
    a) ESRI shapefile (shp) (as per specifications found at http://downloads.esri.com/support/whitepapers/other_/shapefile.pdf)
    b) ESRI Geodatabase format (as per specifications found at http://www.esri.com/software/arcgis/geodatabase.html)
  - Projected Co-ordinate System: NAD 83 UTM Zone 10N
  - Metadata Format: ESRI Standard for Digital Geospatial Metadata (based on US Federal Geographic Committee (FGDC) standard)
  - Addressing and Street Name Standards: use Canada Post Addressing Guide – PDF document of their standards is available at: http://www.canadapost.ca/offerings/address_management/pdf/addressing_guide-e.pdf
  - **Note: Any customized data model development must be reviewed and approved by the Senior GIS Administrator**

5.0 Proposal Preparation

This section defines the proposal preparation and submission procedures that are to be followed by all proponents. Proponents are cautioned to carefully read and follow the procedures required by this Request for Proposal, as any deviation from these requirements may be cause for rejection.

The proposal must be signed by the person(s) authorized to sign on behalf of the proponent to bind the proponent to statements made in response to this Request for Proposal.

5.1 General Information

5.1.1 Eligibility

Potential proponents are not eligible to submit a proposal if current, past or other interests, in the CRD's opinion, may result in a conflict of interest in connection with this project.

This is the first phase of what may prove to be a multi-phased project. The successful proponent for this phase may be permitted to bid on subsequent phases as long as, in the CRD's opinion, no conflict of interest would arise.

5.1.2 Proposal Confirmation

Proponents are to confirm in writing their intention with respect to participation in this RFP process. **Please complete the form at Appendix A and return it within five (5) working days** from receipt of this RFP.

Failure to complete this form will result in no further communications from the CRD regarding this RFP.

5.1.3 Registration with Workers' Compensation Board

Consultant and any approved subconsultants working on this project must be registered with the Workers' Compensation Board (WCB) and WCB coverage must be maintained for the duration of the contract. Prior to receiving any payment, the consultant may be required to submit a WCB Clearance Letter indicating that all WCB assessments have been paid.

5.1.4 Proponents' Expenses

Proponents are solely responsible for their own expenses in preparing, delivering or presenting a proposal and for subsequent negotiations with the CRD, if any.

5.1.5 Proponent Claims

The proponent shall have no claim against the CRD for anything arising from or in connection with the preparation and submission of a proposal, the review and negotiation process, the award or failure to award the work or any part of the work to any proponent, and the proponent releases the CRD from any and all claims, actions, suits, demands, liabilities and costs in connection with the foregoing.

5.1.6 Additional Information

Proposals may contain additional information. Alternative proposals must be submitted separately following the required format and will be evaluated on a best value to the CRD basis. An alternative proposal must have its own, clearly identified fee proposal envelope.

5.2 Proposal Timeframe and Schedule

This request for proposal has the following timeframe:

- Response to Request for Proposal due – noon, September 18, 2006
- Evaluation period – September 19 to 22, 2006
- Successful proponent awarded contract by CRD Board at October Board meeting – October 11, 2006
- Project initiation – October 20, 2006
- Initial project meeting with MDP subcommittee – October 31, 2006, 9:00 a.m., CRD Offices, 625 Fisgard Street, Victoria, BC
- Provide draft report for review, March 15, 2007 (to comply with funding requirements)
- Oral presentation of the draft findings/recommendation to the BCI MDP subcommittee, by March 31, 3007
- Present results, findings and recommendations from final report at a workshop attended by the BCI Steering committee, CRD, municipalities and community groups, April 15, 2007
- Project completion – May 31, 2007

5.3 Proposal Format

Evaluation of proposals is made easier when proponents respond in a similar manner. The following format and sequence for technical and fee proposals should be used to provide consistency in proponent response and to ensure that each proposal receives full consideration.

Proponents must ensure that the fee proposal is submitted in a separate, sealed envelope. All pages must be consecutively numbered.

The **technical proposal** should be submitted in the following format and sequence:

a) Title Page, showing Request for Proposal title, proponent's name and address, closing date and time, proponent's telephone number, and a contact name.
b) One page letter of introduction identifying the proponent and signed by the person or persons authorized to sign on behalf of, and bind the proponent to, statements made in the proposal.
c) Table of Contents including page numbers.
d) The body of the proposal that contains the methodology, solution or project plan and clearly indicates the proponents understanding of the project objectives and outcomes, the timelines, milestones and deliverables, etc.
e) Summarize the qualifications of key staff and how these staff will be organized and supervised on the project. If subconsultants are being used, include the same information for each of them.
f) A detailed work schedule and time allocation diagram.
g) Any additional information, brochures, etc. (may take the form of appendices).

The **fee proposal**, ***submitted in a separate sealed envelope***, should include the following:

a) Price details or pricing formulae
b) Include a payment schedule in accordance with major project milestones
c) Proposals submitted must clearly identify team members and their time allocation to the project and a clearly defined work schedule to demonstrate how the project will be conducted on time and within budget
   - specify budget allocation for each part of the project
   - an hourly fee structure for each team member
   - anticipated expenditures including travel costs
   - proponent shall quote a final lump sum price for all services requested or required under this RFP
   - must include all applicable taxes

5.4 Proposal Requirements

5.4.1 Basic Requirements

Proposals must identify the process, project work details and schedule to complete the project tasks identified in the Terms of Reference. Modifications or additions to the task list proposed will be considered, subject to meeting the specified project objectives and evaluation criteria set out in this RFP.

The following information is required (at a minimum) for each task:

- Responsible team member(s)
- Steps to complete the task
- Estimated Hours
- Estimated Fees
- Estimated Expenses

Additional information:

- Name and details of software and models to be used for the hydraulic and hydrological modelling
- Software to be used for GIS (e.g. ArcInfo 9.1)
- GPS hardware and software

5.4.2 Mandatory Requirements

This RFP contains mandatory requirements as identified in the mandatory criteria under the Proposal Evaluation and Procedures section. Proposals not meeting them, or not clearly demonstrating that they will meet them in a substantially unaltered form, will receive no further consideration in the evaluation process.

- The technical proposal **must meet all the requirements contained within the Request for Proposal**. Six copies of the technical proposal are required. The technical proposal must be clearly marked 'Technical Proposal'.
- The technical proposal must include a **detailed project work schedule and time allocation diagram** including who will do what, when (ensure that costs are not included here);
- A **fee proposal** detailing costs to complete each stage of the project must be submitted in a **separate sealed envelope** marked 'Fee Proposal'. Only one copy of the cost proposal is required.

5.5 Budget

5.5.1 Budget Allocation

A maximum budget of $135,000 is allocated in total for this project proposal including all fees, expenses, disbursements and applicable taxes (GST + PST). If the work outlined in the Terms of Reference cannot be completed within the available budget, the proponent may suggest options for changing the scope of the work. Proposal pricing must include all factors that will affect the cost of the proposal, including estimates of delivery, travel, support, cost savings in other areas and so forth.

Proponents shall provide a fee proposal of the actual cost to the CRD project manager of this work. Actual payment for services will be based on hours expended at the hourly rates provided in the proposal, plus expenses and taxes, up to the maximum budget amount of $135,000. If this amount appears inadequate, proponents should suggest ways to reduce costs to the budget amount.

Proponents must allow for the GST and all other taxes without exceeding the allotted budget. Proponents should indicate clearly the amount that is included in their budgets to meet the provisions of the GST tax and any other applicable taxes.

5.5.2 Firm Pricing

Proposals, including the proposed budget, must be open for acceptance for at least 90 days after the closing date. Upon acceptance, prices will be firm for the entire contract period unless otherwise specified. No additional costs will be considered or approved for work that is part of the contract.

6.0 Proposal Submission

6.1 Documents to Assist with Proposal Submission

The following documents are available to assist with the proposal submission from Sally McMurray (360-3046):

- Flood Flows in Bowker Creek – Haultain Street to the Oak Bay Recreation Centre (1984)
- Bowker Creek Watershed Assessment (2000)
- Bowker Creek Watershed Management Plan (2003)
- University of Victoria Integrated Stormwater Management Plan (2004)

6.2 Closing Date and Required Copies

Six bound complete copies of each proposal must be received by 12:00 noon on September 18, 2006 at:

Scientific Programs
Attention: Sally McMurray, Administrative Contracts Clerk
Capital Regional District
P.O. Box 1000
625 Fisgard Street
Victoria, British Columbia V8W 2S6
(use 625 Fisgard Street V8W 1R7 if sending by courier)
(250)360-3046

Proposals sent by facsimile or e-mail will not be accepted.

Proposals and their envelopes should be clearly marked with the name and address of the proponent and the Request for Proposal title. **Technical proposals must be clearly marked "Technical Proposal" and the fee proposal must be submitted in a separate, sealed envelope marked "Fee Proposal".**

Note regarding courier delivery: CRD has experienced delays in courier delivery from points off Vancouver Island. Proponents are responsible for ensuring that courier delivery occurs within the deadline regardless of the point of origin.

6.3 Completeness of Proposal

By submitting a proposal, the proponent warrants that all components required to deliver the services requested have been identified in the proposal or will be provided by the Consultant at no additional charge.

6.4 Late Proposals

Late proposals will not be accepted and will be returned to the proponent unopened. **Proponents are responsible for ensuring that courier delivery occurs within the deadline.**

6.5 Inquiries

Direct all inquiries related to this Request for Proposal to the CRD Project Manager or alternate project manager. Information obtained from any other source is not official and may be inaccurate. Inquiries and responses may be recorded and distributed to all proponents at the CRD's option.

<u>CRD Project Manager</u>
Lehna Malmkvist, Bowker Creek Initiative Coordinator, Environmental Services
Telephone: (250)360-3302
Fax: (250)360-3254
E-mail: lmalmkvist@crd.bc.ca

<u>Alternate CRD Project Manager</u>
Jody Watson, Harbours and Watersheds Coordinator, Environmental Services
Telephone: (250)360-3065
Fax: (250)360-3254
E-mail: jwatson@crd.bc.ca

6.6 Conflict of Interest

Any proponent, subconsultant or individual whose current or past corporate or other interests may, in the CRD's opinion, give rise to a conflict of interest in connection with this project will not be permitted. This includes, but is not limited to, any firm or individual involved in the preparation of proposals in response to the Request for Proposal.

7.0 Proposal Changes and Amendments

7.1 Notification of Changes to the RFP

All recipients of this Request for Proposal will be notified in writing by the CRD regarding any changes made to the Request for Proposal or any appendices or any change in the closing date or time. When these changes occur within five CRD business days of the close of the proposal, the proposal closing date may be extended to allow for a suitable number of bid preparation days between the closing date and the issuance of the change.

7.2 Changes to Proponent's Proposal

The proponent may change a previously submitted proposal by withdrawal, amendment or submission of a replacement if done prior to the RFP closing date and time. This information or request should be submitted in writing on company letterhead or equivalent and contain the signature of the individual submitting the original proposal.

The proponent may not change the wording of the proposal after the RFP closing date and no words or comments will be added to the general conditions or detailed specifications unless requested by the CRD for purposes of clarification.

7.3 Acceptance of Proposals

The CRD reserves the right to modify the terms of the Request for Proposal at any time at its sole discretion.

This Request for Proposal should not be construed as a contract to purchase goods or services. The CRD is not bound to accept the lowest priced or any proposal of those submitted. Proposals will be assessed in light of the Evaluative Criteria set out in the Proposal Evaluation Criteria and Procedures section.

Subsequent to the submission of proposals, interviews may be conducted with some of the proponents, but there will be no obligation to receive further information, whether written or oral, from any proponent.

The CRD will not be obligated in any manner to any proponent whatsoever until a written contract has been duly executed relating to an approved proposal.

8.0 Proposal Evaluation Criteria and Evaluation Procedures

8.1 Mandatory Criteria

Any proposal that does not meet the mandatory requirements or criteria will receive no further consideration during the evaluation process.

- The technical proposal **must meet all the requirements contained within the Request for Proposal**. Three copies of the technical proposal are required. The technical proposal must be clearly marked 'Technical Proposal'.
- The technical proposal must include a **detailed project work schedule and time allocation diagram** including who will do what, when (ensure that costs are not included here);

- A **fee proposal** detailing costs to complete each stage of the project must be submitted in a **separate sealed envelope** marked 'Fee Proposal'. Only one copy of the cost proposal is required.

8.2 Technical Evaluation Criteria

Proposals meeting the mandatory requirements will be further assessed against the weighted technical evaluation criteria contained in Appendix B. Care should be taken to ensure that sufficient information is provided so that an informed evaluation can be carried out in each of the areas where points are to be assigned.

8.3 Evaluation Procedures

Proposals will be evaluated according to the procedure set out below. Technical and mandatory evaluative criteria are set out in the previous section. Evaluation of the proposals will be undertaken by a committee formed by the CRD Environmental Services division and may include members with appropriate expertise from outside of the CRD.

The technical proposal shall be submitted in an envelope marked "Technical Proposal", and the fee proposal shall be submitted in a separate sealed envelope marked "Fee Proposal".

The technical proposals will be evaluated (including mandatory presentation and interview, if applicable) prior to the opening of fee proposals. The evaluation team will assess and score each technical proposal independently. Final scores for technical proposals will be the average of the individual scores as determined by the evaluation team members for each proposal. Proposals not meeting the mandatory requirements and criteria will not be evaluated further.

Both technical merit and cost will be awarded a maximum of 500 points each, for a total potential of 1000 evaluation points. Technical proposals (including reference check) will be opened and marked out of a total score of 500 points against an evaluation grid, before any fee proposals are opened. Each technical proposal will be evaluated on the basis of the firm's experience, competence of its personnel and acceptability of the method proposed in accordance with the weighted technical evaluative criteria in Appendix B.

A firm's technical proposal shall be deemed qualified only if it complies with all the requirements contained in the RFP.

Only those firms' proposals whose technical scores are within 15% of the proposal awarded the highest technical score will have fee proposals opened and evaluated. All other fee proposals will be returned unopened upon completion of successful contract negotiations with the preferred proponent. The only exception to this policy is when the proposal of the second-ranked proponent is more than 15% below the highest technical score and **still technically qualified**. In such a case, the second ranked firm would have its fee proposal opened to avoid a non-competitive situation. Proposals are technically qualified if they meet all requirements of the RFP and receive at least 350 technical points, or 70% of the total possible technical points.

The fee proposal can be awarded a maximum of 500 points. The fee proposal must specify the budget allocation for each part of the project, an hourly fee structure for each team member, and anticipated project expenditures including travel costs. Proponents shall quote a fixed lump sum price for all services requested or required under this Request for Proposal. Expenditures and disbursements shall be quoted separately as a fixed lump sum amount. Quoted prices shall be inclusive of all applicable provincial federal taxes. The final fee quotation shall be the sum of the cost of services, the cost of disbursements and applicable taxes.

The fee proposal with the lowest cost of fees will be awarded of 500 points, which will be added to the technical score, resulting in the proponent's total score. The percentage by which each of the remaining firms' proposed costs exceeds the cost of the lowest qualified proposal will be the percentage by which the 500 points is reduced, prior to adding it to the technical score resulting in each firm's total score.

For example, if the proposed cost of Firm A exceeds the lowest proposed cost of Firm B by 10%, Firm A's score will be calculated as 500 – (500 x .10) = 450; this value will be added to its technical score to determine Firm A's total score. The firm receiving the highest total score will be judged to have the best value to the CRD.

Where all other criteria (i.e., quality, service, performance) are equal, then consideration will be given to any Canadian or local content.

8.4 References

References of the proponent or proponents scoring highest will be checked and assessed against the technical criteria. The division will not enter into contract negotiations with any proponent whose references are found to be unsatisfactory. Providing the result of the reference check is satisfactory, the division's intent is to enter into contract negotiations with the proponent who has been deemed to have the best overall value. Subject to successful negotiation and execution of a contract, this proponent will provide the required goods or services.

9.0 Post Evaluation Procedures

9.1 Debriefing

Unsuccessful proponents may request a debriefing following execution of a contract with the successful proponent. Points awarded by the evaluation team for both technical and financial proposals will remain confidential and may not be divulged to any proponent. Proponents will be told where they ranked within the range of scores.

9.2 Negotiation Delay

If a written contract cannot be negotiated within 10 days of notification of the successful proponent, the CRD may, at its sole discretion at any time thereafter, terminate negotiations with that proponent and either negotiate a contract with the next qualified proponent or choose to terminate the Request for Proposal process and not enter into a contract with any of the proponents.

9.3 Privilege or Right to Cancel

Notwithstanding any custom or trade practice to the contrary, the CRD reserves the full right to, in its sole discretion and according to its own judgment of its best interests:

a) negotiate with one or more proponents;
b) reject any and all proposals submitted;
c) waive any technical or formal defect in a proposal and accept that proposal;
d) evaluate the proposals based on its perception of best value, not necessarily the lowest cost,
e) agree with any proponent on modifications or changes to the proposal; and
f) award the contract to other than the lowest bidder

10.0 Special Conditions and Constraints

10.1 Special Conditions

A payment holdback provision will be included in the final contract for each stage in the amount of 10% of the negotiated contract value, as an assurance of the final contract compliance to the satisfaction of the CRD or project manager.

10.2 Constraint

The contract award is subject to CRD Board approval.

11.0 Additional Terms and Clauses in an RFP

11.1 Charge Back for Report Editing

CRD Scientific Programs has very high standards for writing. The consultant must ensure that all reports (including draft reports) are well-organized, written and edited prior to submission. The CRD will include a provision in the final contract to charge back the cost of necessary editing of reports submitted, at a rate equivalent to the hourly rate for the consultant's project manager. Any such charges will be deducted from invoice amounts.

11.2 Maintaining Process Integrity

Neither the proponent nor any officer, employee or agent of the proponent shall discuss its proposal, the proposal of any other proponent, or the selection process with any elected officer of the CRD, nor otherwise attempt to influence the decision with respect to the proposal prior to the selection, if any, of a successful proponent. Any contravention of this restriction may result in the rejection of the proposal.

11.3 Subconsultants

Utilizing a subconsultant(s) -- who must be clearly identified -- is acceptable. This includes a joint submission by two proponents having no formal corporate links. However, in this case, one of these proponents must be prepared to take overall responsibility for successful provision of the goods or services and this must be defined in the proposal.

11.4 Definition of Contract

Notice in writing to a proponent of the acceptance of their proposal by the CRD and the subsequent full execution of a written contract will constitute a contract for the goods or services, and no proponent will acquire any legal or equitable rights or privileges relative to the goods or services until the occurrence of both such events.

11.5 Proposals as Part of Contract

Proposals may be negotiated with proponents and, if accepted, may form part of a contract.

11.6 Liability for Errors

While the CRD has made considerable effort to ensure accurate representation of information in this Request for Proposal, the information is supplied solely as a guideline for proponents. The CRD neither guarantees nor warrants the accuracy of the information nor claims that it is necessarily comprehensive or exhaustive. Nothing in this Request for Proposal is intended to relieve proponents from forming their own opinions and drawing their own conclusions respecting matters addressed in this Request for Proposal.

11.7 Acceptance of Terms

All the terms and conditions of this Request for Proposal are assumed to be accepted by the proponent and incorporated in his proposal.

11.8 Financial Stability

The successful proponent may be required to demonstrate financial security and be required to register to conduct business in British Columbia.

11.9 Ownership of Proposals and Freedom of Information

All documents, including proposals, submitted to the CRD become the property of the CRD for the term of proposal evaluation and are subject to disclosure under *the British Columbia Freedom* *of Information and Protection of Privacy Act*. By submitting a proposal, the proponent thereby agrees to public disclosure of its contents. Any information the proponent considers "personal information" because of its proprietary nature should be marked as "confidential" and will be subject to appropriate consideration as defined within the Act. All but a file copy of the winning proposal will destroyed. Proponents may include the following clause in their proposals:

(Company name) is supplying the proposal/tender in confidence and requests that the information contained in the proposal be kept confidential by the Capital Regional District and not be disclosed because it would reveal *(choose one or more of the reasons):*

1. trade secrets of a third party; or
2. commercial, financial, labour relations, scientific or technical information of a third party;

and because the disclosure of the information in the proposal would *(choose one or more of the reasons shown)*:

1. harm significantly the competitive position or interfere significantly with the negotiating position of the third party;
2. result in similar information no longer being supplied to the public body when it is in the public interest that similar information should continue to be supplied;
3. result in undue financial loss or gain to any person or organization; or
4. reveal information supplied to, or the report of, an arbitrator, mediator, labour relations officer or other person or body appointed to resolve or inquire into a labour relations dispute.

Please note that both conditions must apply*.*

11.10 Use of Request for Proposal

This document, or any portion thereof, shall be used for no purpose other than the submission of proposals.

11.11 Confidentiality of Information

Information pertaining to this competition or any Division information obtained by the proponent as a result of participation in this project is confidential, and must not be disclosed without the written authorization of the CRD.

12.0 Contract Clauses

12.1 Indemnity

The Consultant will indemnify and save harmless the CRD, its employees and agents from and against all claims, demands, losses, damages, costs and expenses made against or incurred, suffered or sustained by the CRD at any time or times (either before or after the expiration or sooner termination of this contract), where the same or any of them are based upon or arise out of or from anything done or omitted to be done by the consultant, or by any servant, employee, officer, director or subconsultant of the consultant pursuant to the contract.

12.2 Insurance (including Errors and Omissions)

The contract may contain a provision that the Consultant will without limiting its obligations or liabilities and at its own expense, provide and maintain throughout the contract term, Comprehensive General Liability in an amount not less than $1,000,000 inclusive per occurrence insuring against bodily injury, personal injury and property damage and including liability assumed under contract with insurers licensed in the province of British Columbia and in the forms and amounts acceptable to the CRD. The Consultant must also carry insurance covering error and omissions. All required insurance will be endorsed to provide the CRD with 30 days advance written notice of cancellation or material change. The consultant will, on demand, provide the CRD with evidence of the required insurance.

12.3 Funding

Notwithstanding any other provision of the Request for Proposal, the contract contemplated by this Request for Proposal and the financial obligations of the CRD pursuant to that contract are subject to:

- There being sufficient monies available in the appropriation, to enable the Division in any fiscal year or part thereof when the payment of money by the CRD to the Consultant falls due under the contract entered into pursuant to the Request for Proposal to make that payment.
- The CRD Board of Directors not having controlled or limited expenditure under any appropriation.

12.4 Contract Administration

The CRD project manager will be assigned by the CRD as the contract administrator to oversee the contract awarded to the successful proponent. In addition, the consultant will be expected to name a counterpart project manager. The consultant's project manager will be responsible for providing scheduled status reports to the CRD project manager or designate.

12.5 Compliance with Laws

The consultant will give all the notices and obtain all the licenses and permits required to perform the work. The consultant will comply with all the laws applicable to the work or performance of the contract.

12.6 Safety

Any equipment used in the performance of the contract must be certified by an accredited certification organization acceptable to the CRD. All costs of approval will be at the consultant's expense.

12.7 Software

The consultant is responsible for obtaining any required software and licences in order to complete the project.

12.8 Intellectual Property Rights

The CRD will be the owner of the intellectual property rights, including patent, copyright, trademark, industrial design and trade secrets in any product developed through a contract. Licensing and marketing rights to the developed product will not be granted in the contract.

12.9 Maintaining Consortia/Groups After Contract Awarded

The consultant is responsible for ensuring that any groups or consortia that formed to submit the successful proposal must remain together throughout the duration of the project.

APPENDIX A

CAPITAL REGIONAL DISTRICT
REQUEST FOR PROPOSAL
BOWKER CREEK MASTER DRAINAGE PLAN

RECEIPT CONFIRMATION FORM

Please complete this form and return it within five (5) working days from receipt to:

Sally McMurray/Administrative Contracts Clerk
Capital Regional District
P.O. Box 1000
625 Fisgard Street, Victoria, British Columbia V8W 2S6
(use 625 Fisgard Street V8W 1R7 if sending by courier)
Telephone: (250) 360-3046 / Fax: (250) 360-3270

Failure to return this form may result in no further communication regarding this Request for Proposal.

COMPANY: ______________________________

ADDRESS: ______________________________

____

CONTACT PERSON: ______________________________

PHONE: ______________ **FAX:** ______________

I have received a copy of the above-noted Request for Proposal, and (check one item):

☐ we will be submitting a proposal
☐ we will NOT be submitting a proposal

SIGNATURE: ____________________

TITLE: ____________________ DATE: ______________

APPENDIX B
EVALUATION OF TECHNICAL PROPOSAL

Project Name:____

Evaluator: ____

	POINTS	CONSULTANTS		
1. THE FIRM AND PERSONNEL (100)				
1.1 Project Manager/Director (65)				
• Experience with Master Drainage Plans and Integrated Stormwater Management Plans	25			
• Qualifications of Project Manager/Director	20			
• Local knowledge	20			
1.2 Project Team (85)				
• Experience with Master Drainage Plans and Integrated Stormwater Management Plans	20			
• Qualifications of team members (roles, time commitment and experience)	20			
• Local knowledge ○ particularly location of team members	15			
• Integrated project team (multi-disciplinary)	15			
• Additional specialized skills (e.g. RPBio, QEP, technical writing)	15			
TOTAL PERSONNEL	**150**			
Carried fwd.	150			

Brought fwd.				
3. THE METHOD (350)				
3.1 General approach (180)				
• Inventory of Bowker Creek features and erosion sites; identification of flooding problems	40			
• Land use analysis and approach to calculating runoff parameters	40			
• Developing hydraulic and hydrologic model, verification, calibration and scenarios	40			
• Process to identify and evaluate problems, solutions and recommendations	40			
• Development of ISMP Phase 2 Terms of Reference	20			
3.2 Proposed team organization	25			
3.3 Roles/responsibilities definition	25			
3.4 Work plan and proposed control of activities	20			
3.5 Understanding of project objectives	40			
3.6 Proposed level of effort	20			
3.7 Commitment to the terms and conditions of the RFP	20			
3.8 Commitment to delivery and schedule	20			
TOTAL METHOD	**350**			
TOTAL TECHNICAL COMPONENT*	**500**			
TOTAL FEE COMPONENT	**500**			
OVERALL PROPOSAL SCORE	**1000**			

***Minimum Score of 350 to be technically qualified.**

Additional Comments on Proposal Strengths and Weaknesses
(use additional sheet if required)