F I N A L   R E P O R T

CITY OF COQUITLAM
CITY OF PORT COQUITLAM

Hyde Creek Integrated Watershed Management Plan

ASSOCIATED ENGINEERING

April
2004

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering (B.C.) Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering (B.C.) Ltd. Information in this document is to be considered the intellectual property of Associated Engineering (B.C.) Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering (B.C.) Ltd. for the account of CITY OF COQUITLAM and CITY OF PORT COQUITLAM. The material in it reflects Associated Engineering (B.C.) Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering (B.C.) Ltd., accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

ASSOCIATED
ENGINEERING

Associated
Engineering
(B.C.) Ltd.

Suite 300
4940 Canada Way
Burnaby, B.C.
Canada
V5G 4M5

Tel. 604.293.1411
Fax 604.291.6163

www.ae.ca

April 19, 2004
File: 022313-5-1-010

Dana Soong, P.Eng.
City of Coquitlam
2647 Austin Avenue
2nd Floor
Coquitlam, B.C.
V3K 3S2

Re: HYDE CREEK IWMP FINAL REPORT

Dear Mr. Soong:

We are pleased to forward five copies of the Hyde Creek Integrated Watershed Management Plan final report.

We trust that this final report will meet your requirements. We have enjoyed working with you on this challenging and comprehensive assignment. Should you have any questions, please do not hesitate to contact the undersigned.

Respectfully submitted,

ASSOCIATED ENGINEERING (B.C.) LTD.

Prepared by:

Michael MacLatchy, Ph.D., P.Eng.
Water Resources Engineer

Reviewed by:

John van der Eerden, M.Eng., P.Eng.
Project Manager

MM/JV/lp

EXECUTIVE SUMMARY

The Hyde Creek Watershed study area encompasses the watersheds associated with Hyde, Watkins, West Smiling, Smiling and Burke Mountain Creeks as well as Cedar Drive Ditch (or Creek) in Port Coquitlam.

Above Victoria Drive, in the City of Coquitlam, the watershed has moderately steep slopes that become significantly steeper in the North East corner of the study area toward Pinecone Burke Mountain Park. Below Victoria Drive, within the City of Port Coquitlam, the terrain changes from gently sloping to nearly flat in the southern and eastern areas of Port Coquitlam's portion of the watershed.

Within the City of Coquitlam, the Hyde Creek and tributary watersheds are lightly developed at the present time, with dispersed homes and small subdivisions. The undeveloped areas have heavy forest cover. However, consistent with the Greater Vancouver Regional District's strategic plans, Coquitlam's Citywide Official Community Plan establishes a policy framework that will guide the development of a more urban community along the lower slopes of Burke Mountain and within those watersheds.

In contrast, Port Coquitlam has already developed in accordance with its Official Community Plan. It is predominately single family housing with associated schools, parks and green spaces. Some commercial developments, and areas of multi-family housing also exist; however, these land uses account for a relatively small proportion of the total area.

The Hyde Creek Integrated Watershed Management Plan (IWMP) was initiated to provide for the orderly and cost-effective development of the watershed while protecting environmental and community values. The Hyde Creek IWMP addresses the following issues:

- Flood protection and storm water management
- Stream corridor protection
- Water quality protection
- Erosion and sediment control
- Summer base flow protection
- No net loss of fish habitat on a watershed basis
- Maintaining existing watershed health

- Maintaining or improving productive capacity of fish habitats in the Hyde Creek watershed.

The drainage criteria used in the present study are derived from those put forward in both the GVRD Integrated Storm Water Management Planning Template (April 2002), and the Provincial Storm Water Planning Guidebook (March 2002). The criteria in these documents were modified during the course of the study to address the constraints encountered as the analysis progressed. In summary the adapted criteria are defined as:

Tier 1 - Small storms (up to twice per year Return Period): For these smaller storms, the intent is to strive to infiltrate as much of the rainfall volume as possible. Infiltration of small storms helps to preserve dry period base flows by recharging the water table, controls runoff and improves water quality by filtering contaminants through the soil horizon. After maximizing infiltration of rainfall, any runoff generated by Tier 1 storms should be routed through storm water quality ponds designed to settle sediment and improve water quality prior to discharging to the receiving watercourse.

Tier 2 - Intermediate Storms (2/year to 10-year return period): Flows should be detained or diverted to approximate the pre-development peak flow conditions in the natural water courses. This is accomplished through storm water diversions or storm water detention ponds. The minor storm water collection system would be designed to handle the 10-year event.

Tier 3 - Major Storm Events (up to 100-year return period): Watercourses and overland drainage routes, including major event diversions, that comprise the major drainage system, will be designed for the 100-year event. Culverts, bridges and diversion systems will be designed accordingly. The ability of existing stream crossings and other hydraulic structures to handle the 100-year event will be confirmed or recommendations made to increase capacity.

The objectives of the Hyde Creek IWMP were met by a system of 5 detention ponds, 9 water quality ponds and a high flow diversion that services most of the area to be developed. It is recommended that all ponds be configured as wet ponds to address water quality issues and improve their aesthetics. The 5 detention ponds are sized to attenuate the 10-year return period post-development peak flow to the 10-year pre-development peak flow. These facilities can provide multiple benefits, including peak flow attenuation, water quality improvement, erosion and sediment control and aesthetic appeal if designed as community amenities. The high flow diversion discharges to DeBoville Slough, where the Hyde Creek system drains under the natural regime.

The above measures only partially address the issue of maintaining summer base flows and protecting water quality. Numerous Best Management Practices (BMPs) or Low Impact Development (LID) measures can be applied to address these issues. Based on the soils information obtained for the watershed the Hyde Creek Integrated Watershed Management Plan recommends that the following BMPs be applied to new development within the watershed, unless local soil conditions warrant otherwise. Soil conditions in the watershed do not favour community-based infiltration facilities.

- Promote streets that drain to grass-lined swales, ditches or infiltration trenches.
- Provide grassed or other vegetated areas with a minimum of 300 mm of organic absorbent soil cover. This should include boulevards, developed park areas, and private property to the greatest extent possible.
- Utilize permeable (porous) paving in lightly travelled areas such as lanes, pathways and emergency accesses.
- Minimize the interception of subsurface flow by ditches, road cuts or the drainage system, except where necessary to address localized drainage problems.
- Minimize the disruption to, or removal of, the existing permeable soil layers, except where required for foundation or other construction considerations. Wholesale stripping of existing permeable soils should be avoided.
- Maximize infiltration of rainfall in areas where soil conditions are suitable by:
    - Disconnecting impervious surfaces such as parking lots and driveways.
    - Disconnecting roof leads.
    - Routing runoff from disconnected areas to on-site infiltration trenches or chambers.
    - Providing curb cuts to allow runoff from roads and parking areas to infiltrate to adjacent green spaces.
- Maximize on-site pervious areas through best management practices, including porous surfaces and landscaping.

Within currently developed areas BMPs can be retrofitted or applied as redevelopment occurs. As soils information is non-existent within the lowland Port Coquitlam portion of the study area, appropriate soils investigations should be undertaken prior to implementing any infiltration dependent BMPs. The following BMPs should be considered for retrofit to developed or re-developing areas:

- Promote streets that drain to grass-lined swales, ditches, or infiltration trenches.
- Provide grassed or other vegetated areas with a minimum of 300 mm of organic absorbent soil cover. This should include boulevards, developed park areas, and private property to the greatest extent possible.
- Utilize permeable (porous) paving in lightly travelled areas such as lanes, pathways and emergency accesses.
- Maximize infiltration of rainfall in areas where soil conditions are suitable by:
  - Disconnecting impervious surfaces such as parking lots and driveways.
  - Disconnecting roof leads.
  - Routing runoff from disconnected areas to on-site infiltration trenches or chambers.
  - Providing curb cuts to allow runoff from roads and parking areas to infiltrate adjacent green spaces.

The recommended infiltration target for development is to strive to infiltrate up to 45 mm of rainfall in 24 hours (50% of the MAR). However, fail safe measures, such as decants or overflows in infiltration chambers, should be employed to prevent flooding, property damage, and nuisance conditions when infiltration is limited by saturated ground conditions and the underlying impervious soils during the winter wet season.

The Hyde Creek Integrated Watershed Management Plan includes water quality ponds, detention ponds, the high flow diversion to DeBoville Slough and environmental enhancements or compensation. The estimated capital costs of these facilities are as follows:

	Diversion System	Tier 1 Water Quality Ponds	Tier 2 Detention Ponds
Construction Capital Cost	$6,205,000	$1,461,000	$1,916,000
25% E&C	$1,551,250	$365,250	$479,000
Item Subtotal	$7,756,250	$1,826,250	$2,395,000
Land or ROW Cost	$200,000	$4,203,500 (all ponds together)	
Subtotal[1]	**$7,960,000**	**$8,430,000 (all ponds together)**	
Total[1]	**$16,390,000**		

[1]Total rounded up to next ten thousand.

The estimated total capital cost to implement the storm water management component of the Hyde Creek Integrated Watershed Management Plan within the City of Coquitlam is $16,390,000. The estimated annual operations and maintenance cost for these facilities is $400,000, including monitoring programs.

In addition, the Hyde Creek Integrated Watershed Management Plan identified existing deficiencies in the watershed. These deficiencies include undersized culverts, fish passage concerns and erosion sites. These deficiencies should be addressed. The estimated cost of rectifying these deficiencies is broken down for the Cities of Coquitlam and Port Coquitlam in section 7.3. For the City of Coquitlam the estimated total cost to address these deficiencies is $1,438,000. The estimated cost to the City of Port Coquitlam to address its deficiencies in the Hyde Creek watershed is $1,775,000.

An environmental and flow monitoring program should be implemented to track impacts to the watershed as development progresses. Using an adaptive management approach, monitoring results can guide adjustments to recommended best management practices (BMP's), ponds and diversions in order to preserve overall watershed health and ensure no net loss of habitat at the watershed level.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PROJECT INITIATION

SECTION 1

1.1 INTRODUCTION

The study area encompasses the watersheds associated with Hyde, Watkins, West Smiling, Smiling and Burke Mountain Creeks as well as Cedar Drive Ditch (or Creek) in Port Coquitlam. Above Victoria Avenue, in the City of Coquitlam, the watershed has moderately steep slopes and become significantly steeper in the North East corner of the study area toward Pinecone Burke Mountain Park. Below Victoria Avenue, within the City of Port Coquitlam, the terrain changes from gently sloping to nearly flat in the southern and eastern areas of Port Coquitlam's portion of the watershed. Figure 1.1 provides a general plan of the study area.

Within the City of Coquitlam, the Hyde Creek and tributary watersheds are lightly developed at the present time, with dispersed homes and small subdivisions. The undeveloped areas have heavy forest cover. However, consistent with the Greater Vancouver Regional District's strategic plans, Coquitlam's Citywide Official Community Plan establishes a policy framework that will guide the development of a more urban community along the lower slopes of Burke Mountain and within those watersheds.

In contrast, Port Coquitlam has already developed in accordance with its Official Community Plan. It is predominately single family housing with associated schools, parks and green spaces. Some commercial developments, and areas of multi-family housing also exist; however, these land uses account for a relatively small proportion of the total area.

1.2 WATERSHED ISSUES AND GOALS

An initial meeting was held with the Advisory Committee for the Hyde Creek Integrated Watershed Management Plan on September 17, 2002. Input from the participants was solicited to determine the most important issues and objectives affecting the outcome of the IWMP. Catherine Berris Associates facilitated identification of the issues and goals for the Hyde Creek IWMP, and distilled the Advisory Committee's input down to the following items.

1.2.1 Watershed Issues

Several key issues were identified for the overall approach to be taken with the IWMP. Firstly it was stressed that the plan must find a balance between the social, economic and environmental issues that were at play in the watershed. Secondly, the most current and progressive planning concepts, such as sustainable development, should be incorporated into the final plan. Finally, the IWMP must incorporate both the objectives of the OCP and the realistic limitations as to what can be accomplished on a finite land base within the watershed.

As a whole the Advisory Committee identified several environmental, storm water management, cost and feasibility, and process issues of importance for the IWMP as follows:

Environmental

- Maintain or improve the ecological function of watercourses through restoration and enhancement.
- Protect habitat for red and blue listed species and maintain biodiversity.
- Address erosion control and soil stability.
- Preserve water quality and prevent pollution, particularly as they may affect environmental resources.
- Carefully plan stream crossings to minimize environmental impacts.
- Use greenways as an opportunity for environmental protection and integration with recreation.
- Maintain base flows.

Storm Water Management

- Ensure adequate flood control and protection of people and property (private and public), including downstream impacts.
- Consider reintroduction of water at low flows using wells.
- Consider diversion of high flows.
- Minimize effective impervious area (EIA).
- Consider groundwater recharge.

Feasibility - Costs and Practicality

- Ensure the plan is economically viable.
- Consider the need for funding of long term maintenance of facilities and capital projects.

Process

- Fully involve existing homeowners in Northeast Coquitlam and North Port Coquitlam and the broader public, which will encourage political acceptance.
- Base the plan on accurate information, including maps of types of watercourses, identification of wetlands, geotechnical information.
- Include provision for monitoring and evaluation, including adaptive management.
- Address education of city staff and the public within the plan.

1.3 WATERSHED OBJECTIVES

In considering the above identified issues, the Advisory Committee developed both general and specific objectives for the Hyde Creek IWMP.

The overall approach to be followed by the Hyde Creek IWMP should reflect a balance between the social, environmental and economic considerations that are at play in the watershed. Progressive planning concepts such as sustainable development and "smart growth" should be reflected in the final plan. The objectives of the OCP and neighbourhood planning processes should be integrated in the plan. Also, the plan should address the carrying capacity of the land base, and provide clarity and long-term viability for the future.

Specific objectives were identified within each of the broad categories of concerns for the watershed as follows:

Environmental

- Maintain or improve the ecological function of watercourses and wetlands through restoration and enhancement of fish and wildlife habitat.
- Protect habitat for red and blue listed fish, wildlife and plant species, and maintain or enhance biodiversity.
- Minimize erosion and soil instability.

- Improve water quality.
- Reduce downstream degradation.

Storm Water Management

- Maintain minimum base flows and the overall hydrology required to maintain or enhance fish and wildlife populations and habitat (also an environmental objective).
- Provide flood control for protection of people and property (private and public), including downstream impacts.
- Encourage progressive storm water management practices within development through guidelines, e.g., limitation of effective impervious area (EIA), infiltration of frequently occurring storms.

Ongoing Management

- Address long term maintenance needs and costs.
- Provide for monitoring and evaluation, with adaptive management recommendations.
- Include recommendations on education of city staff and the public.

Potential Tools for Accomplishing Objectives

- Determine stream setbacks.
- Plan stream crossings to minimize environmental impacts.
- Include greenways for environmental protection and recreation.
- Consider the reintroduction of water at low flows using wells if appropriate.
- Investigate applicability of diversion of peak flows.
- Investigate groundwater recharge.

In summary, the IWMP should provide for the orderly and cost-effective development of the watershed while protecting environmental and community values. Specific measures will be identified, evaluated and selected to achieve a balance of the objectives discussed above.

1.4 PERFORMANCE CRITERIA AND STRATEGIES

The most recent publicly available storm water guidelines and subdivision control bylaw for the City of Coquitlam requires that the piped system be designed to handle a ten-year return period storm. The City of Coquitlam recently revised its Stormwater Management

Policy and Design Manual, and Subdivision Control Bylaw; however, these had not been finalized during Phase I of the project, and were not available to the Hyde Creek IMWP project team. The City of Port Coquitlam also utilizes a ten-year return period design standard for their enclosed storm water systems.

The GVRD Integrated Storm Water Management Planning Template, and the Provincial Storm Water Planning guidebook utilize a tiered approach for handling of storm water. In the first tier, rainfall from small storms should be infiltrated and direct runoff minimized. In the second tier, intermediate size storms should be stored or detained so that the runoff hydrograph approximates that for natural (pre-development) conditions. For the third tier, encompassing very large storms, flows should be routed to protect life and property and minimize damage to watercourses.

The initial design parameters proposed for the Hyde Creek Integrated Watershed Management Plan were based on the GVRD and Provincial guidebooks discussed above. These initial design parameters adopted a more stringent approach than the guidebook required. The more stringent criterion was to ensure consistency with existing infrastructure and to provide the necessary level of flood control in downstream areas. Three tiers of storms were defined for use in developing the plan:

- **Tier 1:** For small storms, new development should strive to infiltrate 50% of the mean annual rainfall (MAR) event. This approximately translates into infiltrating up to 90% of the total annual rainfall. This requirement is primarily intended to preserve base flows in the natural watercourses.

- **Tier 2:** For intermediate storm events, from approximately the mean annual rainfall event up to the ten-year return period storm, flows should be detained to approximate the pre-development runoff conditions. The minor storm water collection system would be designed to handle the ten-year event.

- **Tier 3:** Watercourses and overland drainage routes, including major event diversions, that comprise the major drainage system, would be designed for the 100-year event. Culverts, bridges and diversion systems would be designed accordingly. The ability of existing stream crossings and other hydraulic structures to handle the 100-year event would be confirmed or recommendations made to increase capacity.

These parameters were used in the development and initial analysis of the three storm water management alternatives discussed in Section 4, Storm Water Management Alternatives, Identification and Evaluation. The details of these alternatives and the selection process is detailed in that section.

Subsequent analysis of the preferred alternative included modifications to the design parameters to ensure overall basin objectives are achieved. In order to balance the objectives, the design parameters described above were modified to change the role of Tier 1 storm water management and associated ponds. The revised design parameters are described below:

Tier 1 - Small storms (up to twice per year Return Period): For these smaller storms, the intent is to strive to infiltrate as much of the rainfall volume as possible. Infiltration of small storms helps to preserve dry period base flows by recharging the water table, controls runoff and improves water quality by filtering contaminants through the soil horizon. After maximizing infiltration of rainfall, any runoff generated by Tier 1 storms should be routed through storm water quality ponds designed to settle sediment and improve water quality prior to discharging to the receiving watercourse.

Tier 2 - Intermediate Storms (2/year to 10-year return period): Flows should be detained or diverted to approximate the pre-development peak flow conditions in the natural water courses. This is accomplished through storm water diversions or storm water detention ponds. The minor storm water collection system would be designed to handle the 10-year event.

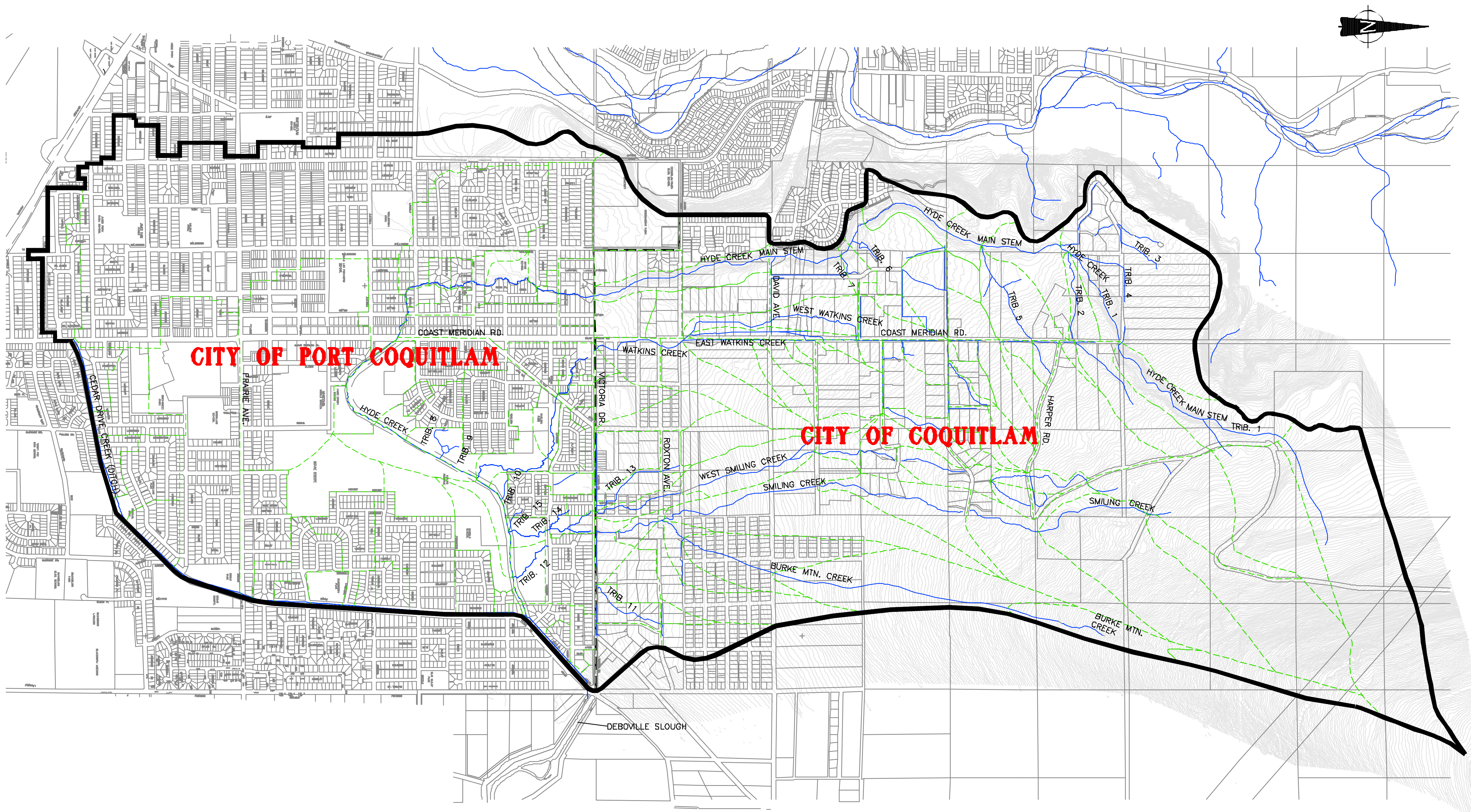
Tier 3 - Major Storm Events (up to 100-year return period): Watercourses and overland drainage routes, including major event diversions, that comprise the major drainage system, will be designed for the 100-year event. Culverts, bridges and diversion systems will be designed accordingly. The ability of existing stream crossings and other hydraulic structures to handle the 100-year event will be confirmed or recommendations made to increase capacity.

The final configuration of the preferred alternative, and the plan recommendations are based on these parameters, and are discussed fully in Sections 5 and 6.

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

LEGEND

- CATCHMENT BOUNDARY
- CITY BOUNDARY
- SUB-CATCHMENT BOUNDARY



NO.	DATE	ENG.	BY	SUBJECT
-	-	-	-	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 — 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:20000		
DRAWN	G.Q.		MAR. 2004
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

GENERAL WATERSHED MAP

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 1.1		

RECONNAISSANCE AND MONITORING

SECTION 2

2.1 FIELD INVESTIGATION

Both Associated Engineering and ECL Envirowest personnel participated in the field investigation of the watershed. Because of project scheduling considerations, the majority of the field investigation took place during August and September 2002. Anecdotal evidence indicated that this was one of the driest periods ever observed for the Hyde Creek Watershed. In order to observe hydraulic and environmental conditions during wet weather, a portion of the field investigation was delayed until the fall of 2002. Unfortunately, dry weather conditions persisted through October and the remaining field work was carried out before sustained wet weather, more typical of the fall and winter period, could set in.

A deficiency plan, Figures 2.1a to 2.1d, indicates the specific areas of concern that were identified as a result of the field investigation. Locations of concern for hydraulic and/or environmental reasons are identified on the figures. Each significant item is briefly described in the following table. Sites identified by Enkon Environmental as part of both the Lower and Upper Hyde Creek Village Neighbourhood Plan processes are incorporated here. Additional sites and information have been identified on the Sensitive Habitat Inventory Mapping (SHIM). This information is contained within Envirowest's report in Appendix A.

Table 2.1
Hydraulic and Environmental Locations of Interest Identified By Field Investigation

Locations of Interest	Watercourse	Description
C-1	Hyde Creek – Tributary 1	Perched 1000mm culvert.
C-2	Hyde Creek – Tributary 1	Perched 1000mm culvert.
C-3	Hyde Creek – Tributary 1	Perched 1500mm culvert.
C-4	Hyde Creek – Tributary 1	Culvert with unstable fill slopes.
C-5	Hyde Creek - Tributary 1	Culvert with suspect hydraulic capacity.
C-6	Hyde Creek - Tributary 3	Perched culvert.

Locations of Interest	Watercourse	Description
C-7	Hyde Creek - Tributary 2	Perched culvert @ Coast Meridian Road blocking fish access.
C-8	Hyde Creek - Tributary 5	Perched culvert @ Coast Meridian Road blocking fish access.
C-9	Burke Mountain Creek	Perched culvert on bike trail.
C-10	Smiling Creek	Collapsed log culvert and cribbing blocks flow and fish passage.
C-11	West Smiling Creek Tributary	Drop of 3m at culvert outlet.
C-12	Watkins Creek	Perched culvert @ Millard Avenue
C-13	Watkins Creek Tributary - Coast Meridian Ditch	Driveway culvert has suspect hydraulic capacity and may be structurally unsound.
C-14	Watkins Creek	David Avenue culvert is perched above stream bed, blocking fish passage to class A(P) habitat above.
C-15	Smiling Creek	Perched 900mm culvert
C-16	Watkins Creek Tributary - Coast Meridian Ditch	Driveway culvert with significant erosion on downstream side, approximately 1 m plunge. Unstable bank materials.
C-17	Smiling Creek	Drop of 1m at culvert outlet.
C-18	West Smiling Creek	Perched 1050mm wood stave pipe culvert.
E-1	Hyde Creek – Tributary 5	Bank erosion below Coast Meridian Road
E-2	Hyde Creek – main stem	Bank erosion
E-3	Hyde Creek – main stem	Bank erosion
E-4	Hyde Creek – main stem	Bank erosion on right bank
E-5	West Watkins Creek	Bank erosion and sloughing.
E-6	Smiling Creek	Bank erosion
H-1	Hyde Creek - main stem	During dry periods loss of base flow between Harper and Coast Meridian Streets as water infiltrates into gravelly substrate.
H-2	Hyde Creek - main stem	Log cabin located on overbank area in proximity to

Locations of Interest	Watercourse	Description
		creek. May impede conveyance during major events and be subject to damage.
H-3	Hyde Creek - Tributary 5	Woody debris blockage of channel, may prevent fish passage.
H-4	Hyde Creek – main stem	Frequent debris blockages in reach above David Avenue to vicinity of Coy Avenue.
H-5	Hyde Creek – Tributary No. 6	Existing storage pond with concrete wall and outlet wier. Steeply sloped channel and integrity concerns with impoundment
H-6	Hyde Creek – main stem	Localized steep drop in channel, greater than 20%.
H-7	Hyde Creek – main stem	Old log bridge and cribbing. Bridge opening constricts channel, and bridge collapse could create blockage
H-8	Hyde Creek – main stem	Loss of base flow from channel, Port Coquitlam from approximately Greenmount to Coast Meridian.
H-9	Hyde Creek – main stem	Channel constricted, with erosion undermining retaining wall. Retaining wall if it fails could block flow and lead to localized channel avulsion during major event.
H-10	Smiling Creek	Footbridge with minimal clearance to channel, could constrict flows during major event. Downstream of Baycrest Drive.
H-11	Hyde Creek – main stem	Debris jam at confluence with Smiling Creek, could lead to localized erosion or flooding problems.
M-1	West Smiling Creek	Failing retaining wall. If wall collapses into creek could block channel or result in large debris movement down channel.
M-2	Queenston Ave. Ditch	Undermining of concrete driveway slab with potential to block culvert inlet

Locations of Interest	Watercourse	Description
M-3	Hyde Creek – main stem	Invasive vegetation encroaching on creek channel, with potential to impede fish access and degrade riparian cover.
M-4	Hyde Creek – main stem	Trail in close proximity to creek channel, promotes human encroachment on sensitive reach.
M-5	Burke Mtn. Creek	Yard waste disposal into creek channel.

In addition to the specific locations at which issues were identified, general observations made during the field investigation of Burke Mountain Creek and Smiling Creek indicated that base flows are likely a problem on both of these watercourses. Also, significant stretches of both these creeks have poorly defined channels with the flow spreading out over the forest floor. This may indicate that flows on these creeks have been unable to cut proper channels due to the underlying soil stratum.

2.2 WATERSHED INVENTORY – DRAINAGE NETWORK CONDITIONS

The field reconnaissance attempted to locate and identify all major hydraulic features and record the significant characteristics of the watercourses. Additional data was compiled from previous reports, the concurrent work of consultants for the two neighbourhood plans, and record drawings. Similarly, the field investigation identified general environmental conditions and characteristics for the watershed. Detailed inventory information is provided in the relevant sections covering the stream classifications and setbacks, and data assembly for the hydraulic model, and are not contained here.

2.3 AREAS OF ENVIRONMENTAL SENSITIVITY

Historic and current development within the Hyde Creek watershed (primarily associated with the lower to mid reaches), have impacted salmon habitat through changes in water quality, water quantity, riparian and instream cover, stream habitat diversity, increased erosion and creation of barriers to fish movement. Areas of special concern within the watershed include critical fish habitat (i.e. spawning and rearing habitat and riparian habitat).

2.3.1 Spawning Habitat

A total of fifteen important areas of the Hyde Creek watershed have been identified as spawning and rearing habitat for salmonids. These are listed below; refer to Figure 2.2 for these locations.

1. **Hyde Creek Main stem Downstream of Coy Avenue -** Short sections of the channel are flat (approximately 3% gradient) where material has built up behind major debris jams.

2. **Hyde Creek Main stem Upstream of Tributary 4 -** Spawners were noted upstream of the confluence, this section of the main stem wouldn't be characterized as typical spawning habitat because substrates were comprised primarily of boulders and large cobbles. The channel gradient is 4 %. Spawners (coho salmon) were observed also upstream of the confluence with Hyde Creek Main stem Tributary 2.

3. **Hyde Creek Main stem Highland Drive Alignment -** Potential spawning habitat was identified within this section of the creek.

4. **Hyde Creek Main stem Between David and Mason Avenue -** Many juvenile salmonids were noted throughout this section, in pools and in areas with undercut banks. There is potential spawning habitat within this section of the creek.

5. **Hyde Creek Main stem Below Victoria Drive Right-of-Way** - This section of Hyde Creek contains potential spawning habitat. The creek is no longer confined within a ravine. Channel substrates throughout this reach area consist of boulders, cobbles, gravels and sands and the channel gradient is 2.5%.

6. **Hyde Creek Main stem Between Lincoln Avenue and Coast Meridian Road -** Over 20 dead spawners (chum salmon) were noted within this section of the creek during the November 25 survey. This confirms that it is an important section for spawning. Additionally, several redds were observed throughout this section.

7. **Hyde Creek between Coast Meridian Road and confluence with Cedar Creek -** There is high quality spawning habitat in Hyde Creek from Coast Meridian Road to the confluence with Cedar Creek in this section. The substrates are comprised of boulders (5 %), cobbles (5 %), gravels (65 %) and sands (25 %) and the existing channel morphology is run/riffle.

8. **Unnamed Tributary to Smiling Creek below Wedgewood St. -** One dead (spawned out) female coho salmon and one dead male coho were found and the channel exhibited good rearing/off-channel habitat for juvenile salmonids, and good spawning habitat;

9. **Watkins Creek Downstream of Coast Meridian Road -** There is good spawning habitat in the section of creek between Coast Meridian Road and Roxton Avenue with a channel morphology of run/riffle/drop pool. Many spawners (coho salmon) were observed immediately downstream of the Roxton Avenue culvert. Downstream of Roxton Avenue, there is spawning habitat potential until a 40 m section of channel lined with rip rap, just upstream of the next culvert. Downstream of this culvert substrates are composed of gravels and cobbles and from here to Victoria Drive is all potential spawning habitat;

10. **Watkins Creek at confluence with Hyde Creek -** During the November 25 survey, spawners (chum salmon) were noted within Watkins upstream of the confluence with Hyde Creek. Here the channel morphology is run/riffle/drop pool structure and the channel substrates are comprised of gravels (70%) and fines (30%);

11. **East Watkins Creek Upstream of the Confluence with Watkins Creek Main Stem -** (Up to the driveway culvert at 1288 Coast Meridian Road.) The substrates instream are dominated by gravels, and this channel section provides good spawning habitat. It is a good channel section for salmonid spawning;

12. **West Smiling Creek Upstream of Victoria Drive -** Spawning coho salmon were observed in the outlet pool and the downstream of the pool in during the November field visit. We observed good spawning habitat

downstream to the confluence with the main stem of Smiling Creek. The channel substrates are comprised of boulders (10%), cobbles (30%), gravels (40%) and sands (20%);

13. **Main stem Smiling Creek Downstream of Confluence with Burke Mountain Creek -** A small area that could potentially be used as spawning habitat (gravels) was noted within this section of the creek upstream of Victoria Drive. The area was 20 m long and had a 5 % gradient;

14. **East Smiling Creek Main stem at Lynwood Avenue Alignment -** Smiling Creek Main stem at Lynwood Avenue Alignment has been identified as excellent spawning habitat. Spawners (coho salmon) were observed building a redd from the bridge; and

15. **Smiling Creek at the Confluence with Hyde Creek -** From the upstream most debris jam north there is good spawning habitat and the channel gradient here is 1.5%.

2.3.2 Enhancement Opportunities

Many enhancement opportunities exist within the Hyde Creek watershed. Envirowest's report in Appendix A provides a detailed discussion, figures, and tables of deficiencies and enhancement opportunities within the watershed.

2.4 ENVIRONMENTAL MONITORING PROGRAMS

Two levels of monitoring are recommended to assess potential responses of the watershed area to land development activities. Watershed-level monitoring will assess long-term effects of urbanization while site-level monitoring will assess the efficiency (and guide the operational refinement) of individual storm water control features.

On a watershed level, monitoring is required to assess potential changes to overall watershed conditions. In the absence of mitigation works such as storm water detention ponds and other Best Management Practices (BMPs), land development results in notable adverse effects on runoff patterns and water quality. Even without direct modifications to riparian habitat, these changes can have both direct and indirect impacts on stream ecosystems and ultimately result in decreased production of salmonids. A series of watershed-level monitoring stations should be established and used to track potential long-term effects.

Variables that are most appropriate for such monitoring are water flows, water temperature, and benthic invertebrate community structure. Water quantity and temperature are recommended for monitoring as they are among the factors most directly affected by development, and can both be reliably measured on a continuous basis with affordable monitoring equipment. In addition, a single precipitation monitoring station would improve the value of stream flow data, and also allow tracking of climatic variability/changes. A monitoring protocol for these variables is described in Section 2.5. Benthic invertebrates are considered to be a good indicator of ecological health, as they tend to reflect general, longer-term water quality and habitat conditions. Protocols for invertebrate monitoring are described in Section 2.4.1.

Water quality and fish utilization are other parameters worthy of assessment. However, both are subject to relatively high degrees of variability and require intensive sampling frequencies in order to properly establish trends. Nonetheless, at the watershed scale, these parameters should also be included in the monitoring program. Suggested assessment protocols for water quality and fish usage are described in Sections 2.4.2 and 2.4.3, respectively.

Recommended monitoring sites are described below and shown on Figure 2.3. The highest priority has been attributed to sites where urbanization of the upstream catchment area has commenced (or is imminent) while the lowest priority has been assigned to sites where urbanization is not expected in the foreseeable future. The lower reaches of all creeks associated with the Hyde Creek watershed plan area have been, and will be, subjected to the greatest degree of urbanization, and are included in the watershed level monitoring program.

Site 1 – Cedar Creek at Cedar Drive. This site was chosen to sample water quality in Cedar ditch downstream of the junction with Hyde Creek.

Site 2 – Hyde Creek downstream of Tributary 12. This site is along the lower section of Hyde Creek and was chosen to sample water quality downstream of the junction of all tributaries to Hyde Creek.

Site 3 – Smiling Creek downstream of the confluence of West Smiling and Burke Mountain Creeks. The catchment upstream of this site is primarily forested habitat with very low-density rural/suburban development established on East Smiling Creek and proposed but not immediate low density housing for Burke Mountain Creek. Sampling of water quality for Smiling and Burke. This site provides water quality monitoring for Smiling and Burke Mountain Creek.

Site 4 – Baycrest Avenue just upstream of the confluence of Burke Mountain Creek and East Smiling Creek. Currently this location has no upstream development but moderate density is proposed in the foreseeable future. There are no potential spawning habitats; however, a portion of this catchment is comprised of high permeability soils. This site is included as it represents a catchment area of lower topographic relief section of Burke Mountain Creek.

Site 5 – West Smiling Creek on Victoria Drive at an existing water quality sampling site. This site was selected because the upper sections of West Smiling Creek have existing development and it will be a good reference site for downstream fisheries concerns involving spawning habitat in Hyde Creek.

Site 6 – Watkins Creek at Victoria Drive. This site was chosen because of the development proposed upstream of it and the impacts that this proposed development may have on fisheries values in Watkins and Hyde Creek.

Site 7 – Main stem of Hyde Creek near Birkshire Place. The site is intended to assess the long-term effects of the proposed development in the headwaters of Hyde Creek as well as assess the effectiveness of storm water control features that are proposed for the area. This section of Hyde Creek has a viable fish population and monitoring will assess the impacts to critical habitat within Hyde Creek.

Site 8 – Hyde Creek at Conifer Avenue in Pinecone-Burke Provincial Park. Since Hyde Creek flows may be reduced below this location, the intent of this station will be to assess the initial flow volumes for the watershed, act as a control, and monitor base line flows for downstream sections. It is situated in an area where development pressure is the least and it will be able to monitor existing conditions in the creek.

Site 9 – 200 – 300 metres downstream of the culverts at Victoria Drive on Deboville Slough. It is chosen to assess contaminant accumulation at the outlet from the watershed.

Site 10 – Outlet of Deboville Slough to the Pitt River. It has been chosen to assess the impacts that the slough and upper watersheds are having on contaminant loadings to the Pitt River and to monitor the levels from the Pitt River to the Slough via high tide fluctuations.

Prior to development monitoring should be established as early as possible to assess the baseline (pre-impact) conditions so that the effects of development, and the effectiveness of completed mitigation works, can be quantified. Monitoring programs should extend from pre-development through the period of complete build-out.

2.4.1 Benthic Invertebrate Sampling

Benthic invertebrates should be sampled at the ten watershed-level monitoring sites. Sampling techniques should follow standard procedures outlined by Environment Canada[1] and the United States Environmental Protection Agency[2]. Using Benthic Index of Biological Integrity (B-IBI)[3], (a stream-health grading system based on aquatic insects found at monitoring sites), a synthesis of diverse biological information that numerically depicts associations between human influence and biological attributes is used to indicate stream health. This method makes use of several biological attributes or 'metrics' that are indicative of changes in biological integrity caused by human activities. The multi-metric approach compares what is found at a monitoring site to what is expected using a regional baseline condition that reflects little or no human impact (Karr 1996). These multimetric indexes utilize a variety of measurements to assess the biological condition, or health, of streams.

[1] **Reynoldson, T.B., C. Logan, D. Milani, T. Pascoe and S.P. Thompson. 1998.** Protocols for reference condition databases: field sampling, sample, and data management of benthic community structure and environmental attributes in aquatic ecosystems. National Water Research Institute Report No. 98-129. NWRI, Environment Canada, Burlington, Ontario. 67p.

[2] **Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999.** Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water, Washington, D.C. 326p.

[3] http://www.clallam.net/streamkeepers/html/BIBI_whys___hows.htm

A standard Surber or Hess sampler should be used to conduct sampling within riffle habitats. Genus Level Taxonomic Identification should be used (10 metric BIBI). Surber samplers are restricted to depths less than 0.3 m and gravel/cobble substrates, and could therefore not be used on slow flowing deepwater channels with heavy instream vegetation and an absence of cobble or gravels. Sampling at lower gradient locations should be conducted using a dip net apparatus of similar dimensions and mesh size to the Surber sampler, pulled through the water and aquatic vegetation, over the same approximate area as that sampled by a Surber sampler. Samples should be rinsed from the net, transferred to sample jars, preserved with 10% formalin, and subsequently sorted and identified at a laboratory.

The 10 metric IBI method rates benthic taxa; they are grouped into categories: pollution intolerant, somewhat tolerant of pollution or pollution tolerant. A rapid bio-assessment of each sample would be completed following methods outlined in the Streamkeepers Handbook[4] and including the following calculations: total abundance and density of organisms; predominant taxon; pollution tolerance index; EPT index (*i.e.* total number of sensitive organisms from the orders *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies); EPT to total organism ratio; predominant taxon ratio; and site assessment rating.

2.4.2 Water Quality Sampling

Water quality should be sampled at the ten watershed-level monitoring sites. Water samples should be collected from the thalweg of the watercourse at each station in hand held bottles. The bottles would be transported to a certified laboratory in a cooler for analysis. Unstable parameters, such as water temperature, pH, conductivity and dissolved oxygen would be analysed in situ. Parameters that should be analysed by the laboratory include the following:

- pH
- conductivity
- total and dissolved metals

[4] **Taccogna, G. and K. Munro (eds.). 1995.** The Streamkeepers Handbook: a Practical Guide to Stream and Wetland Care. Salmonid Enhancement Program, Department of Fisheries and Oceans, Vancouver, B.C. 171p.

- total mineral oil and grease
- EPH (light and heavy extractable petroleum hydrocarbons)
- nitrate, nitrite and ammonia
- total phosphorous
- total Kjeldahl nitrogen
- suspended solids

Analysis of the water quality data would be conducted using criteria for the protection of aquatic life as outlined in the *British Columbia Approved Water Quality Guidelines*[5]. Where approved criteria do not exist, the natural range of the constituent in surface waters and working criteria for aquatic life would be reviewed in the Water Quality Sourcebook.[6]

2.4.3 Fish Sampling

Although subject to notable variations even in undeveloped watersheds, some measure of salmonid productivity is suggested as there is a public perception that fish presence is the ultimate indicator of stream health. Fish sampling procedures involve assessment of juvenile salmonid densities within a standardized sampling reach in proximity to the ten environmental monitoring sites.

At each site, a 50 m stream section including a variety of habitat types should be isolated with seine nets and all fish would be captured by seining and electro-shocking methods. All fish would be identified and enumerated; the fork-length of all salmonids would be measured. All fish should be returned unharmed to the stream. Findings would be reported as areal densities (fish per square metre) and linear densities (fish per linear metre). This sampling should be performed once per year in the late summer.

[5] British Columbia Ministry of Environment, Lands and Parks (MELP). 1998. British Columbia Approved Water Quality Guidelines (Criteria): 1998 Edition. Water Management Branch, Environment and Resource Management Department, MELP. 70p

[6] McNeely, R.N., V.P. Neimanis and L. Dwyer. 1979. Water Quality Sourcebook: A Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa, Ontario. 88p.

2.5 FLOW MONITORING PROGRAM

We investigated and identified likely locations for flow monitoring of watercourses within the Hyde Creek catchment. We considered the following factors when selecting locations for flow monitoring:

- Accessibility for City Works crews
- Suitable channel section
- Proximity to city boundary with Port Coquitlam
- Suitability of location to gauge overall response of catchment to storm events.

Preliminary selections were based on our earlier general reconnaissance, and available water course mapping from the City. Site visits were made to each of the recommended locations listed below, to confirm conditions and suitability of the site. All are near to roadways or rights of way, and are upstream of culverts, based on the assumption that a head-discharge relationship can be established with reasonable accuracy.

We recommended the following sites, as shown on Figure 2.3, for flow monitoring:

1. Hyde Creek @ culvert on right of way extending west from Victoria Drive.
2. Watkins Creek @ culvert on Roxton Avenue
3. Smiling Creek @ Victoria Drive

Site F1 offered the best location for gauging Hyde Creek flows. At this location the overall response of the entire catchment tributary to the main stem of Hyde Creek can be assessed. During the course of this study the City of Coquitlam installed portable flow monitoring equipment at this site. Initially, calibration at this site was difficult and useable data was not available until February 2003.

For Watkins Creek, Site F3 appeared to offer a reasonable location for flow measurement. The approach channel is relatively straight and the culvert under Roxton Avenue has a concrete headwall with approximately 60 degree wingwalls. However, the City was unable to carry out flow measurement on Watkins Creek.

Smiling Creek at Victoria Drive, Site F2, was the location recommended for gauging the combined Smiling Creek and Burke Mountain Creek discharge. The City of Coquitlam installed portable flow monitoring equipment on Smiling Creek at this location in late

2002. However, similar to the Hyde Creek flow monitoring site, useable data was not obtained until January 2003.

Both flow monitoring sites installed by the City of Coquitlam are temporary installations using portable equipment. We recommend that permanent flow monitoring stations be established in order to better assess impacts on the hydrology of the watershed due to development, and to evaluate the effectiveness of mitigation strategies.

Ideally, permanent installations would take the form of weirs (possibly concrete) with water level monitoring equipment. These installations would require a full hydraulic design, and Fisheries review for in-stream structures and in-stream construction restrictions. The long term data provided would establish base-line conditions in the watershed and allow for the ongoing monitoring of flow conditions and impacts as the watershed develops. Sites for permanent flow monitoring could differ from temporary installations as the permanent sites would be independent of the need to locate at channel sections or control points that would provide good head-discharge relationships.

Long term data analyses should include determination of the following:

- Mean annual flow and total runoff (yield);
- Mean monthly flow and total runoff (yield);
- Maximum instantaneous flows; and,
- Minimum instantaneous (and 7-day average) flows.

In combination with data from the GVRD rain gauge at Burke Mountain Fire Hall, additional analyses could include development of unit hydrographs (assessing the response of streamflow to a rainfall event of given quantity and duration) and by correlation with established rainfall monitoring stations, the affixing of statistical recurrence periods to storm/streamflow events.

For the purposes of the current Hyde Creek IWMP, it would also be beneficial to gauge the flow from an urbanized sub-catchment. However, the only fully urbanized catchments are located within the City of Port Coquitlam. The City of Port Coquitlam would therefore need to participate in the flow monitoring of one of its sub-catchments. Likely sites for flow monitoring could be identified for the City of Port Coquitlam, if desired.

If the City wishes to assess the impacts of development in the watershed, and the effectiveness of mitigation measures, then longer term monitoring will be essential. In this case, the installation of permanent flow monitoring sites should be undertaken.

2.6 STREAM CLASSIFICATION AND CORRIDOR SETBACK REQUIREMENTS

2.6.1 Fish Habitat Classification

Terrain Resource Inventory Mapping (1:20,000) and field surveys conducted on September 6th and 12th, 2002, October 15, 2002, and November 21st, 22nd, 25th, 2002 were used to classify streams. Envirowest's fisheries biologist walked all segments and tributaries of Hyde, Smiling, Watkins and Burke Mountain Creeks identifying areas of concern and assessing habitat and stream classification.

Based on historical information collected and the field sampling performed, watercourses within the study area were classified according to the definitions in the Fish Protection Act Streamside Protection Regulation (January 19, 2001) and the City of Port Coquitlam's Development Permit Area – Watercourse Protection XVI. The definitions of stream classifications follows, with the stream coding presented in Figure 2.4.

"**Fish Bearing Stream**" means a stream in which fish are present or potentially present if introduced barriers or obstructions are either removed or made passable for fish;

"**Non Fish Bearing Stream**" means a stream that
(i) is not inhabited by fish, and
(ii) provides water, food and nutrients to a downstream fish bearing stream or other water body;

"Non-Permanent Stream" means a stream that typically contains surface waters or flows for periods less than 6 months in duration;

"**Permanent Stream**" means a stream that typically contains continuous surface waters or flows for a period more than 6 months in duration;

"**Non-Habitat Streams/Ponds**" means a watercourse, pond or lake not regulated under the Fisheries Act or the Fish Protection Act-Streamside Protection Regulation.

2.6.2 Fish Habitat Assessment

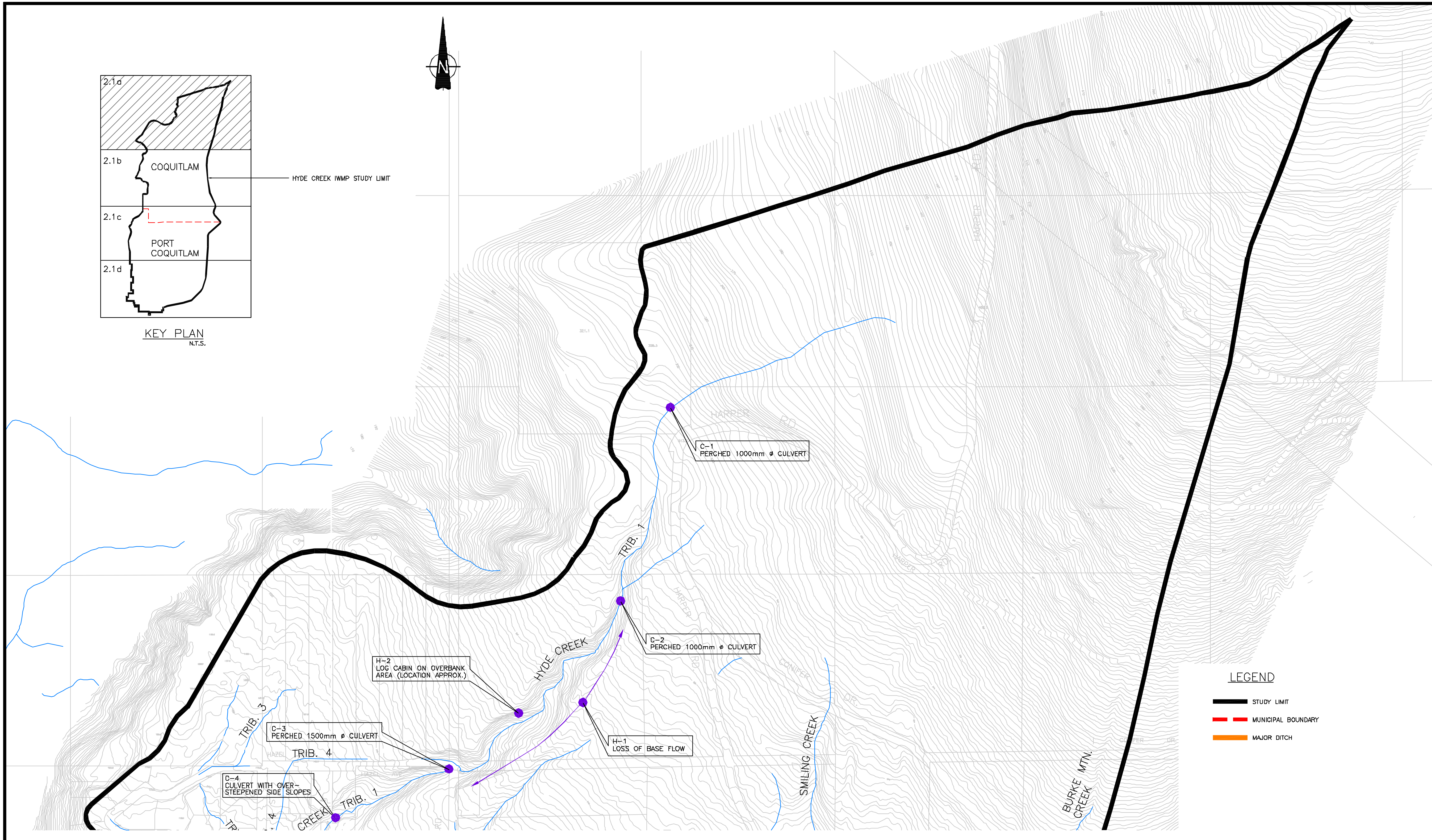
General descriptions of fish habitat were generated for the various branches and tributaries of all Creeks associated in the watershed area. The cited references in Section 2.0 of Envirowest's report and the field visits were the key source of habitat information. As a compliment to the secondary source compilation, fieldwork was undertaken to fill information gaps.

Anecdotal evidence indicated that 2002 was one of the driest periods ever observed for the Hyde Creek watershed. In order to observe the environmental conditions during wet weather, a portion of the field investigation was performed during November 2002.

2.6.3 Riparian Setbacks

Much of a developing watershed's capability to function as productive fish and wildlife habitat can be preserved through the protection of appropriately wide riparian corridors (DFO 1993). The general intent is to retain the watercourse and an adequate riparian buffer zone that will maintain its ecological integrity.

Development within the City of Coquitlam's portion of the Hyde Creek Watershed Study Area to date is predominantly rural and/or low density (City of Coquitlam); this type of land use has a low percentage of impervious cover (*ibid*). Riparian setbacks will also allow for the maintenance/maximization of pervious landscape immediately adjacent to watercourses within the watershed.



This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		NOV. 2002
DESIGNED	M.M./J.F.		NOV. 2002
CHECKED			
APPROVED			
DATE		INITIAL	

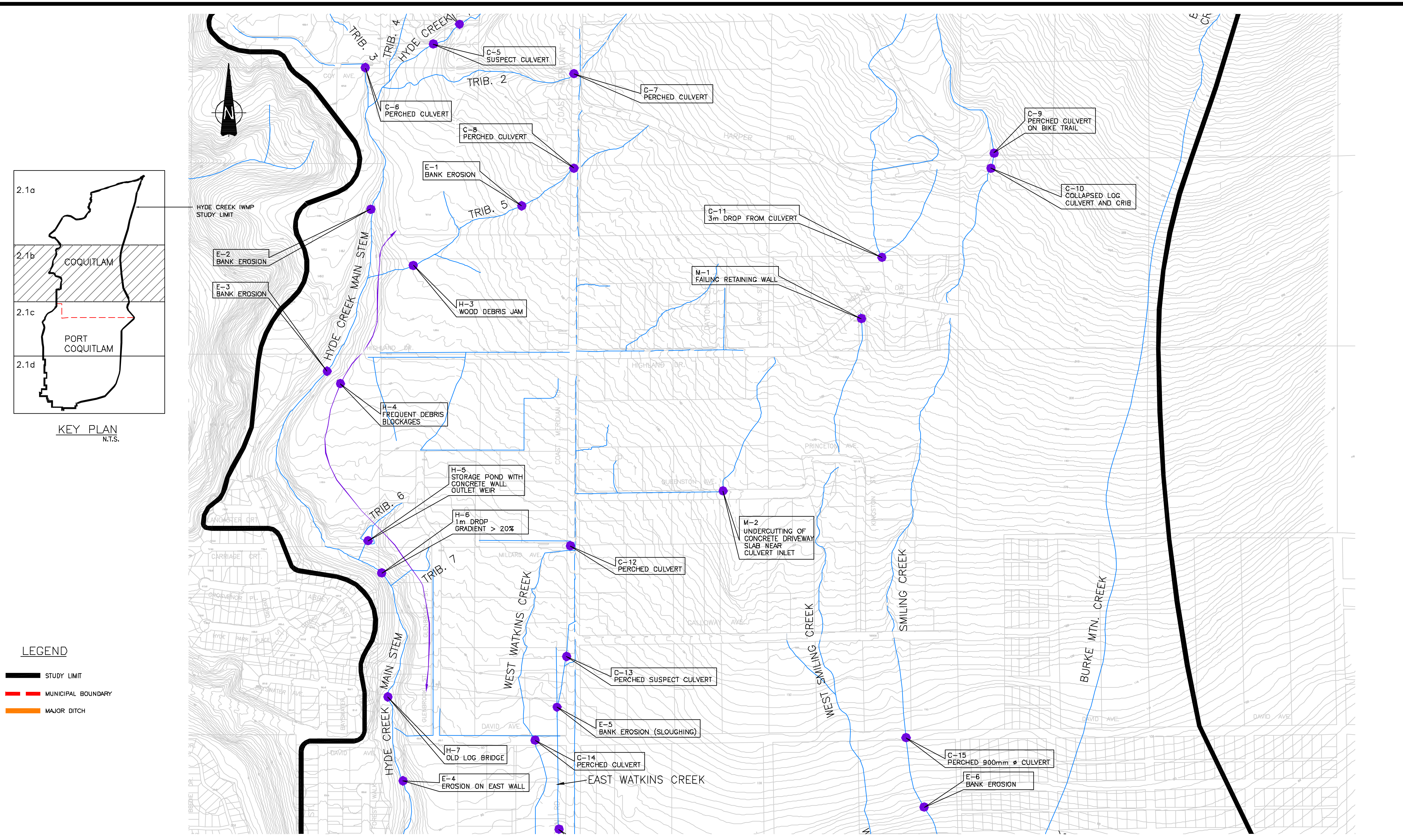
CITY OF COQUITLAM AND PORT COQUITLAM

WATERSHED DEFICIENCY PLAN

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.1a		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT
REVISIONS				

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 — 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		NOV. 2002
DESIGNED	M.M./J.F.		NOV. 2002
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND PORT COQUITLAM

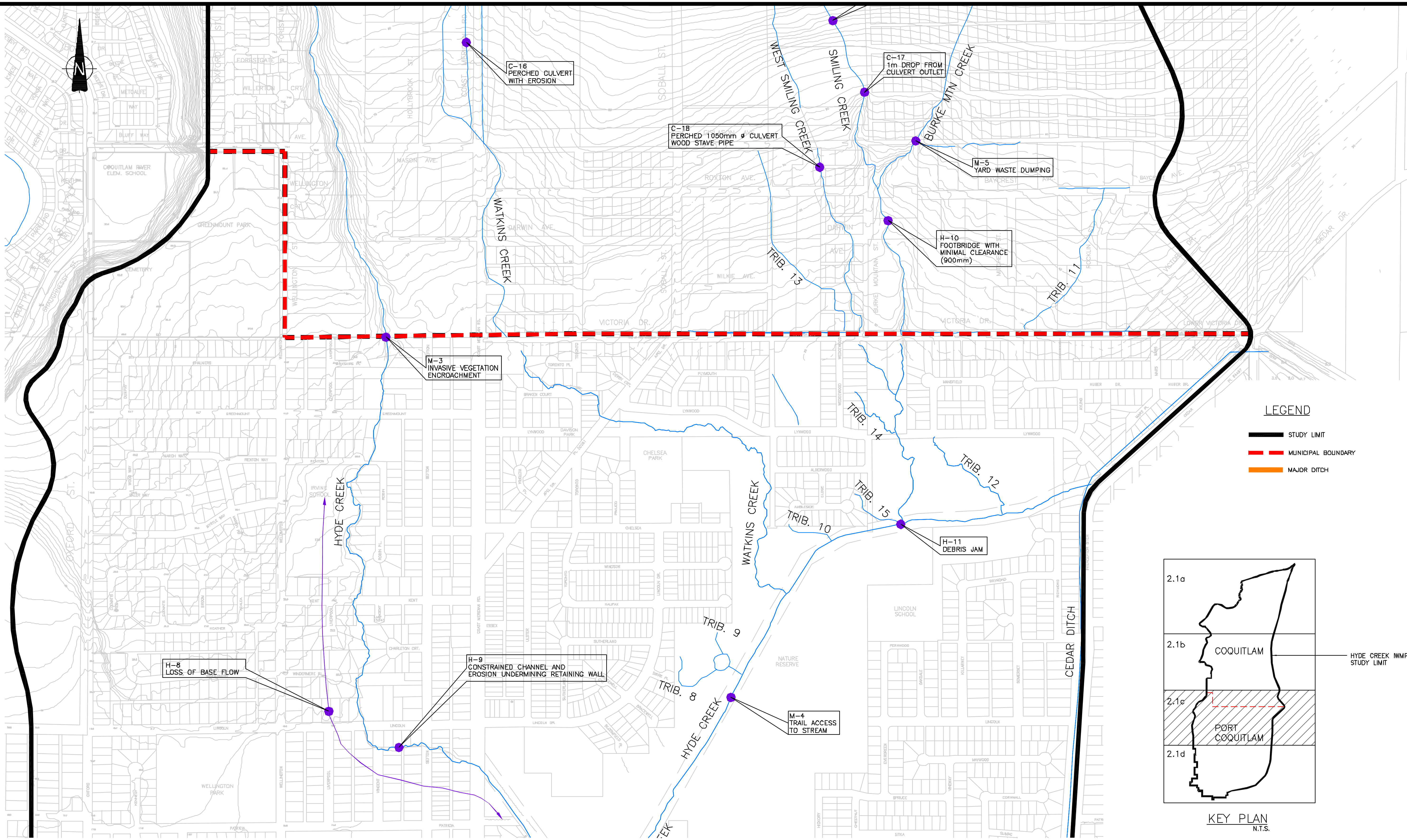
WATERSHED DEFICIENCY PLAN

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.1b		

Time: 13:14 Date: 2004/2/19 Xrefs: 2313r101, BASEPLAN
Plot Scale: 1=1 (Paper Space) AutoCAD File: G:\022313\CLIENDWG\FIGURE2.1.DWG (02)

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		NOV. 2002
DESIGNED	M.M./J.F.		NOV. 2002
CHECKED			
APPROVED			
DATE		INITIAL	

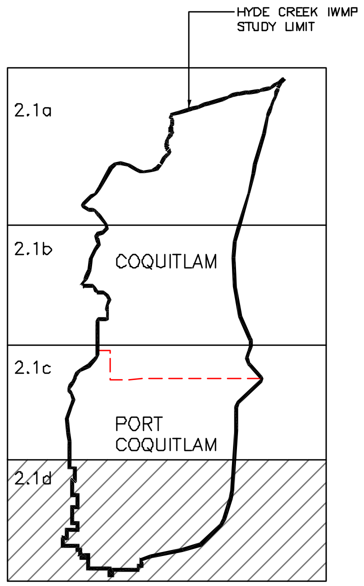
CITY OF COQUITLAM AND PORT COQUITLAM

WATERSHED DEFICIENCY PLAN

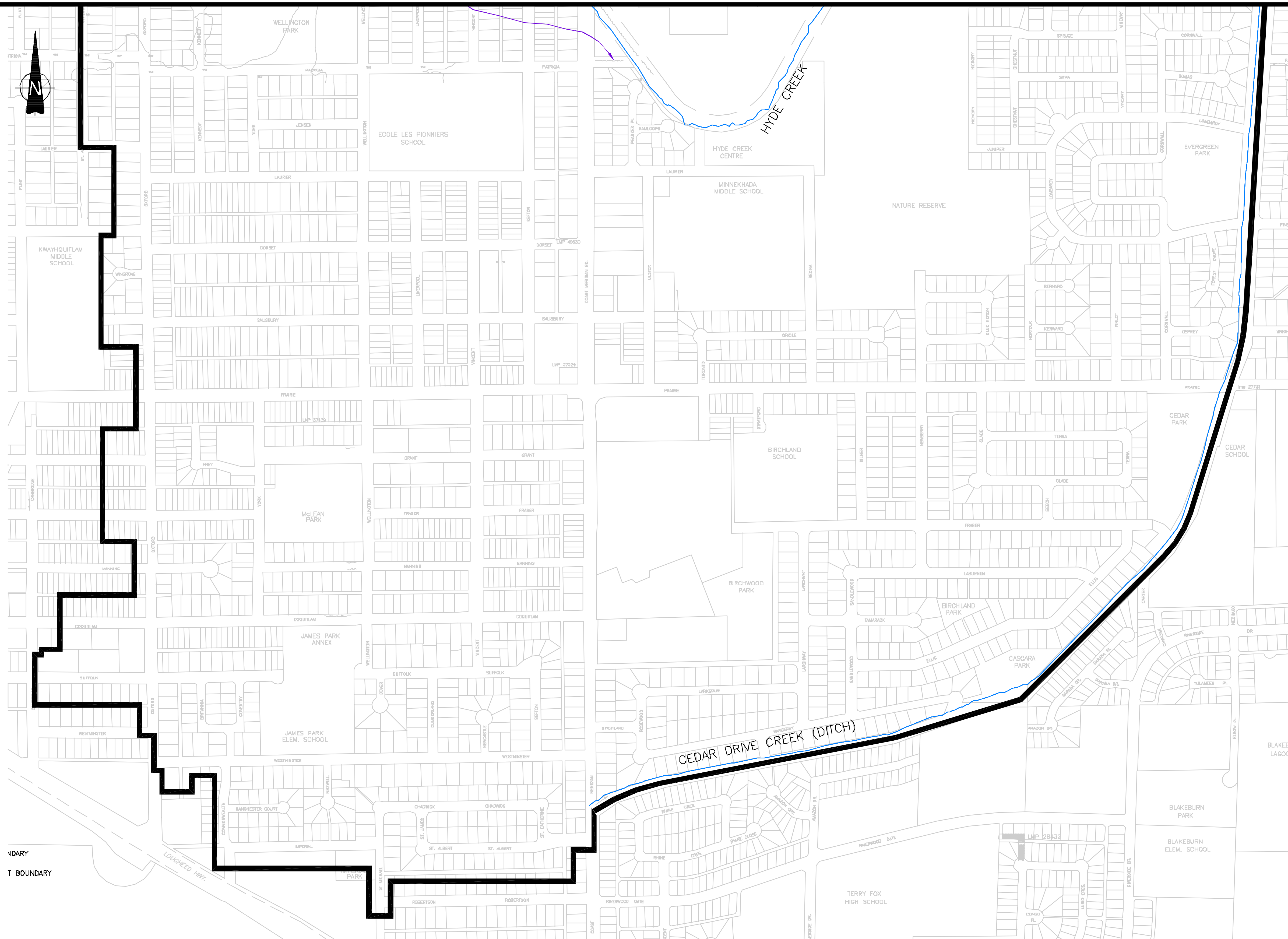
HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.1c		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



KEY PLAN
N.T.S.



NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		NOV. 2002
DESIGNED	J.F.		NOV. 2002
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND PORT COQUITLAM

WATERSHED DEFICIENCY PLAN

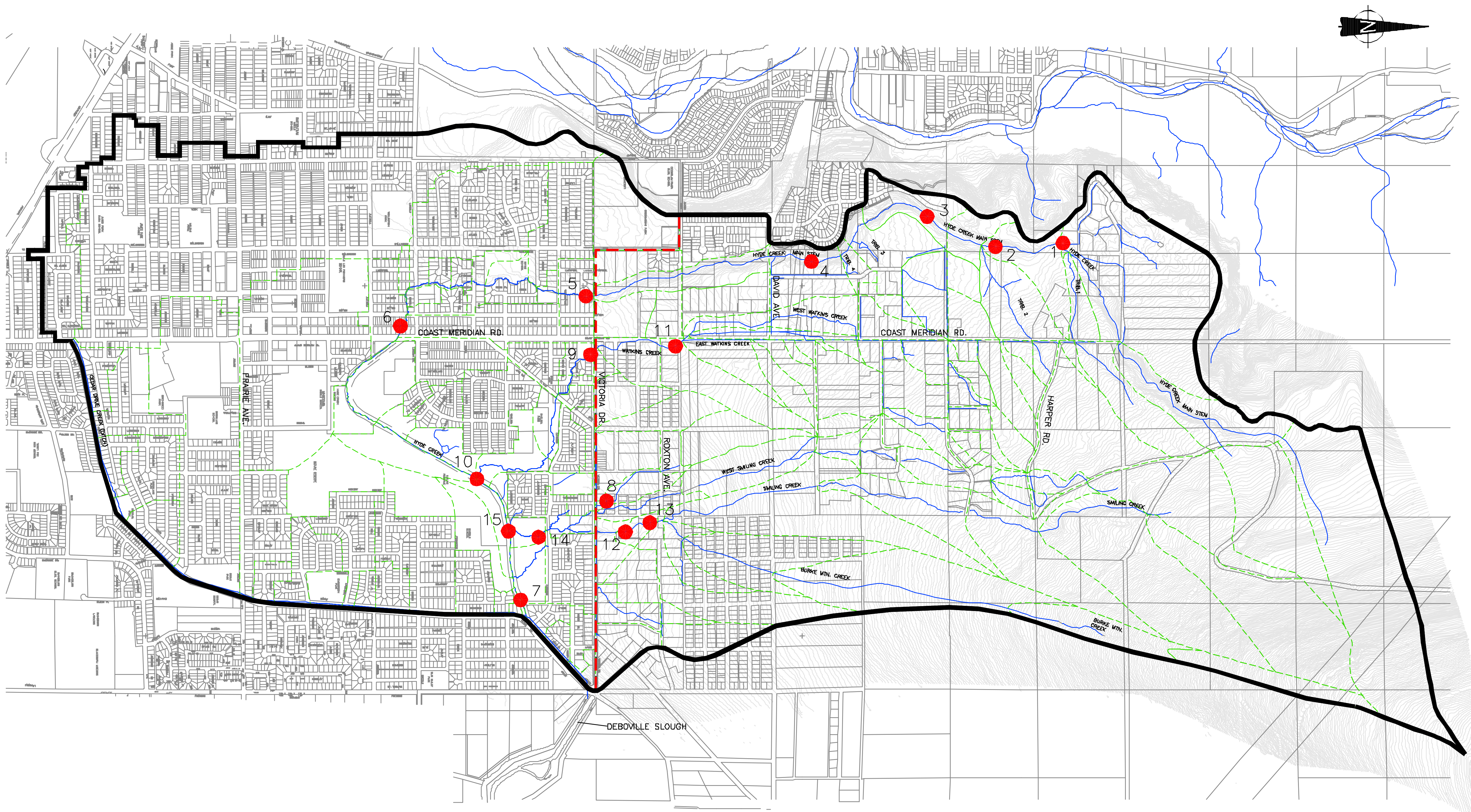
HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.1d		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

LEGEND

- CATCHMENT BOUNDARY
- CITY BOUNDARY
- SUB-CATCHMENT BOUNDARY
- SPAWNING OR REARING SITE



NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:20000		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

SPAWNING AND REARING HABITAT

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.2		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

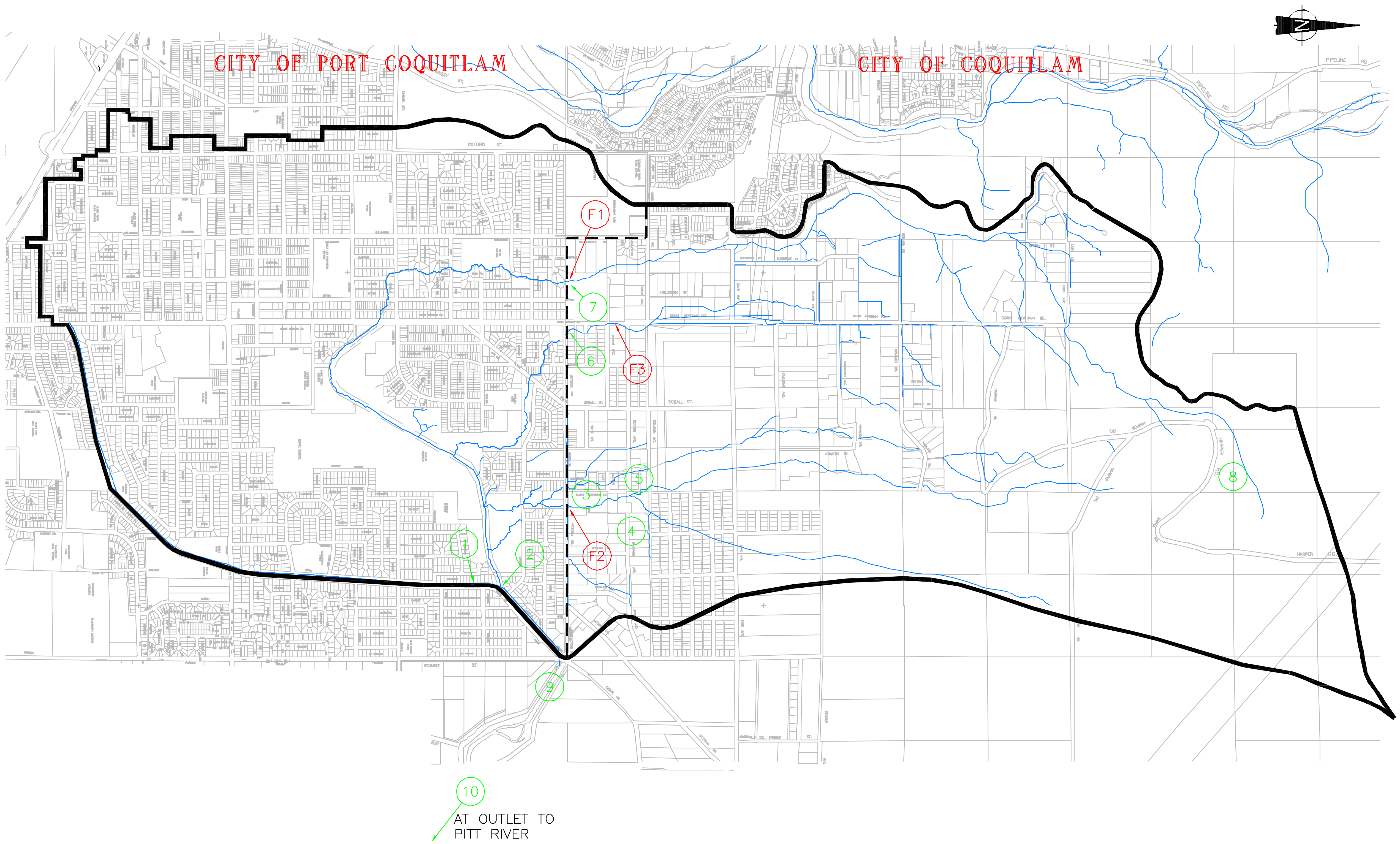
LEGEND

CATCHMENT BOUNDARY

CITY BOUNDARY

1 MONITORING

F1 FLOW MONITORING SITE



-	-	-	-	Description
NO.	DATE	ENG.	BY	SUBJECT
REVISIONS				

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:20000		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

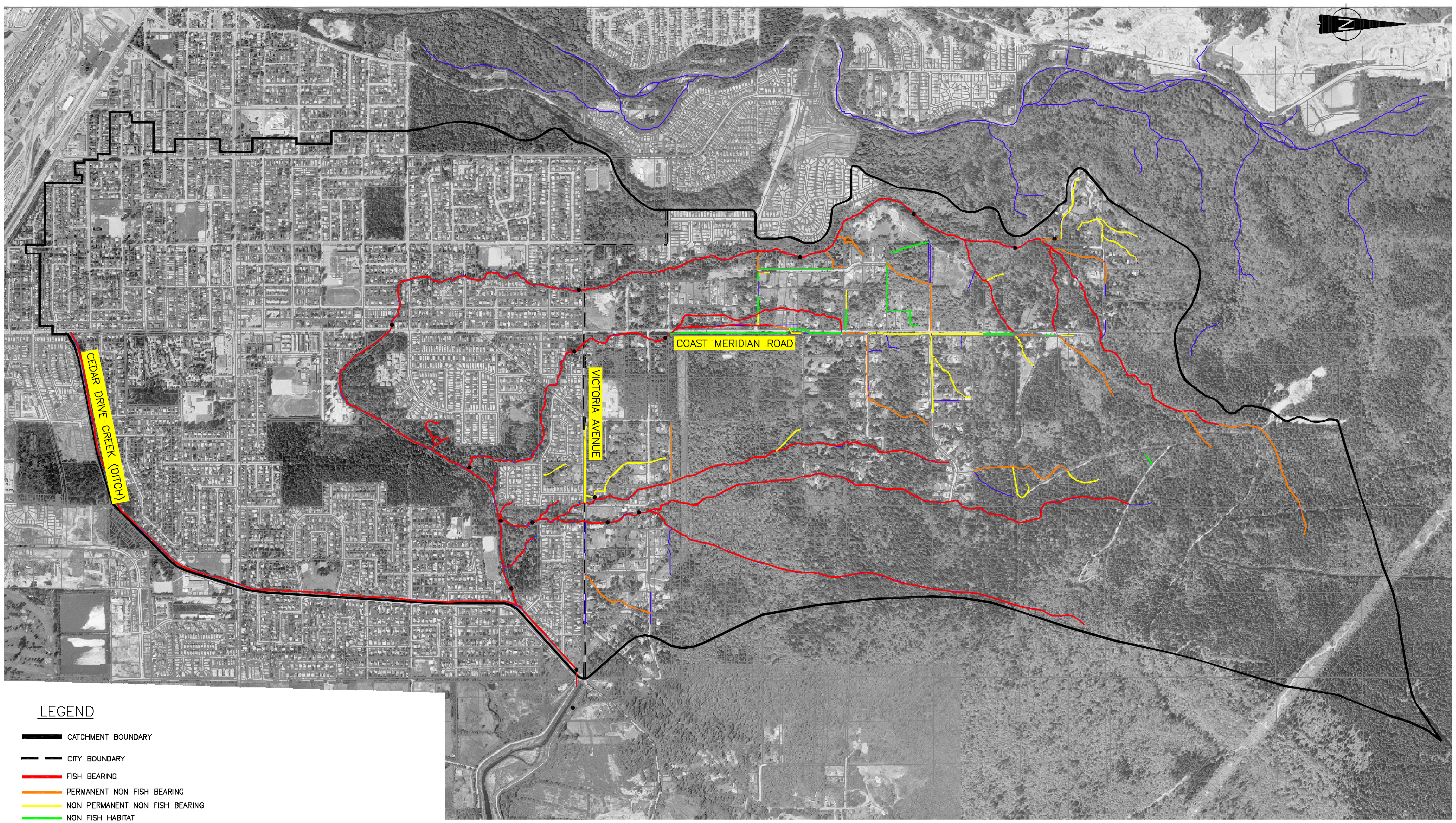
CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

ENVIRONMENTAL AND FLOW MONITORING SITES

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.3		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NOTE:
STREAM CLASSIFICATIONS ARE PRELIMINARY AND WILL BE REVIEWED IN DETAIL AT THE NEIGHBORHOOD PLANNING LEVEL.

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

PRELIMINARY
NOT FOR CONSTRUCTION

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:20000		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

PRELIMINARY STREAM CLASSIFICATIONS

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2.4		

Time: 11:42 Date: 2004/2/19 Plot Scale: 1=1 (Paper Space) AutoCAD File: Q:\022313\CURRENT\FIGURE2.4.DWG (GQ)
Xrefs: 2313r101, BASEPLAN

HYDROLOGIC MODEL

SECTION 3

3.1 BASE HYDROLOGIC MODEL

The base hydrologic model was developed using the Visual Hydro version of SWMM, by CAICE software. This model software allows fully dynamic hydraulic routing, extended period simulations and detailed graphical output of model results.

3.1.1 Sub-catchment Delineation and Characteristics

In the lesser developed portions of the watershed above Victoria Drive, sub-catchments were delineated on the basis of topographic information and drainage patterns. The outlet, or point of concentration, for each sub-catchment was defined by convenient drainage features such as culverts and stream confluences. Because of flow interception by constructed ditch and storm water drainage systems, sub-catchment boundaries tended to deviate from strictly topographic constraints. Figure 3.1a to 3.1d indicates the sub-catchments defined for the model.

Delineation of the sub-catchments revealed three locations where watercourses or enclosed storm water drainage systems originating above the boundary in Coquitlam are routed directly into Port Coquitlam's storm water drainage system and not into Hyde, Watkins or Smiling Creeks. The locations where Port Coquitlam receives storm water from Coquitlam are through Greenmount Park from the Oxford street area, from the vicinity of Soball Street above Victoria Drive, and the vicinity of Roxton Avenue above Victoria Drive.

Port Coquitlam's storm water drainage system plan indicates several locations where there are inlets of local drainage from park land to the storm water drainage system. While these areas are largely pervious with varying degrees of forest cover, during very large events the ground can reasonably be expected to become saturated and contribute runoff to the system.

In the more developed portions of the watershed sub-catchments were defined on the basis of the constructed storm sewer network and inlets for local drainage. Sub-catchment boundaries, tributary area and designation are also indicated on Figures 3.1a to 3.1d. Sub-catchment data is presented in Appendix C as Table C1.

Hydrologic parameters, such as impervious cover, characteristic widths of sub-catchments, and sub-catchment overland slope, were determined from topographic mapping and air photos provided by the Cities. Percentages of impervious cover used in the model varied depending upon the apparent extent of brush/trees, lawn area, building coverage and paved surfaces. Generally, for existing conditions in the upper, lightly developed and heavily forested, portions of the watershed values of between 2.5% and 7.5% were used depending upon the particular sub-catchment. Intermediate values ranging from 10 to 35% were applied for varying degrees of partial development or mixed land uses. Within the urbanized areas, impervious values of 40% to 50% were used for most sub-catchments, with higher values applied to sub-catchments that exhibited a high proportion of commercial or multi-family development.

General observations of existing land coverage/use were also made. These do not directly correlate to zoning, but reflect the actual condition of predominant vegetative cover and land use. Table C1 contains the various parameters applied to each sub-catchment, including land use, impervious values and overall slope.

Soil Properties

Soils mapping from both the Province and Agriculture Canada were used to assemble preliminary information on the soil properties in the watershed. This information indicates that a significant portion of the upper watershed is known to be, or thought to be, underlain with moderately well drained glacial deposits. Within the Port Coquitlam portion of the watershed the soils are unclassified. A soils map, incorporating previously known global information for the watershed, is provided as Figure 3.2.

Below approximately the 200 m contour, the soils in the watershed are predominantly Whatcom (W), Bose (BO), and Sunshine (SS) type soils. The provincial soils mapping classifies all three of these soils as being well drained or moderately well drained, with some subject to Telluric seepage. The soils descriptions note that these soils may become subject to temporarily perched water tables, with variable lateral (Telluric) seepage during and after prolonged heavy rains. Telluric seepage is groundwater flow moving through the soil roughly parallel with the ground surface above a restricting or confining layer.

Because of the slow infiltration into the confining layer (usually glacial till in the Hyde Creek watershed), Telluric seepage is an important component in flow routing, with the groundwater interflow close to the surface and subject to interception by ditches, roads and other excavations.

Above the 200 m contour, the soil structure becomes more complicated, with moderately well drained or better Buntzen (BZ), Cannell (CE), Eunice (EU), Hoover (HV), and Strachan (SN) soils. Less predominant, but indicated in some areas of the soils mapping are Burwell (BW), Steelhead (ST) and Whonnock (WH) soils that may have imperfect drainage, potentially perched water table and telluric seepage. The possible presence of these soils will dictate the need for specific soils investigations prior to the application of any LID principles in any of the affected sub-catchments.

Subsequent to the general soils investigation, Piteau Associates carried out a limited scope hydro-geological investigation of the watershed. Their report, included as Appendix B, indicates that the surficial soils below the approximate lower boundary of the development reserve are the most capable of infiltrating storm water. The major limiting factor is the depth and extent of these upper soils, with the result that groundwater storage is limited. During extended periods of wet weather the upper organic soil mantle will become saturated. The underlying soil stratum is impervious, with the result that the upper layer does not drain sufficiently in advance of the next rainfall. Instead, infiltration capacity is limited and groundwater travels down slope parallel to the impervious layer until intercepted by a ditch or creek, or it surfaces.

Piteau identified several possible infiltration measures that could be implemented at the site level. These measures would function primarily during drier periods when there is sufficient time for the upper soil layers to drain. Piteau recommends that infiltration only be considered when it can be dispersed over large areas, such as with individual lot systems, rather than concentrated community-based infiltration facilities.

Areas proposed for individual lot infiltration measures would require investigation to determine the suitability for storm water disposal. Subsurface infiltration trenches, detailed in the Piteau report could be used. Roof leaders and driveway drainage could be routed to the infiltration trench. During dryer periods the infiltration trenches would be able to infiltrate rainfall to the underlying permeable soils. During extended wet weather periods, when the permeable soils are saturated, a decant (high level outlet) would drain from the infiltration trench to the storm sewers. The water table should be maintained a minimum of 300 mm below landscaped surfaces, and 600 mm below driveways.

Infiltration measures along roads, such as perforated storm drains, or gravel infiltration trenches have a tendency to concentrate infiltration. Since groundwater recharge near ravine crests can have adverse impacts on slope stability, design of such measures will require a hydrogeological and geotechnical investigation.

Road cuts and service trenches will increase the degree of interception of the Telluric seepage, resulting in more rapid drainage of the upper soil layers. While this will aid in preventing surface ponding, it will be the detrimental to any flow attenuation and baseflow contribution that these layers provide.

Soil Parameters for Modelling

The majority of modelling effort is focussed around the winter wet weather period when wet antecedent conditions could be expected and even pervious surfaces may produce some surface runoff. Therefore, relatively low infiltration values were used for the pervious surfaces in the watershed. Table 3.1 indicates the Horton infiltration values applied to each major soil type in the model. The infiltration values used reflect the predominant soils type in each sub-catchment. In the case of sub-catchments that have forest as their predominant land use or cover, a slight increase in the infiltration parameter has been applied to reflect the greater interception and evapotranspiration provided by forest cover. Similarly, a penalty on the infiltration values is imposed for predominantly developed or disturbed land uses.

Table 3.1
Assumed Horton Infiltration Parameters for Major Soil Types, Existing Conditions

Soil Type/Land Use (from soil mapping)	Initial Infiltration Rate (mm/hr)	Final Infiltration Rate (mm/hr)	Decay Rate (1/s)
Developed Land - low or uncertain infiltration	6	3	0.0005
Forested land - low or uncertain infiltration	9	3	0.0001
Forested land - moderately well drained soils or better	12.5	6.25	0.00005
Developed land - moderately well drained soils or better	9	3	0.0005

These assumed infiltration values would not necessarily represent the infiltration capacity of the soils during lesser events, or summer storms, when the ground will not be saturated. LID principles are intended to infiltrate rainfall from smaller events, when saturated conditions are less prevalent and the infiltration capacities of the soils are not already fully utilized.

3.1.2 Hydraulic Model

The base model incorporated all of the significant drainage features identified in the field investigation and watershed inventory. Parameters such as channel width, and general channel cross-sections were recorded during the field investigations and used in the model development. Culvert and channel inverts in the upland section of the watershed, primarily above Victoria Drive, were estimated from topographic mapping, as was general channel slope. The major watercourses of Hyde Creek, Smiling Creek, West Smiling Creek, Watkins Creek, and Cedar Drive Creek/Ditch were included in the hydraulic model. Roadside ditches were included in the field investigation and in the model where they were important for routing flows and delineating drainage patterns and sub-catchments. Some minor drainage ditches and channels were not included in the hydraulic model.

While assembling the network inventory, it became apparent that there was no recorded information for the culverts on Cedar Drive Ditch. Instead, the culvert information necessary for this project was obtained through the field investigation.

Within developed areas of the watershed, record drawings were used to model the storm water drainage system. All sections of storm water drainage system composed of pipe larger than 450 mm diameter, or that intercepted flow from further upstream in the catchment, for example the flow from Coquitlam down through Greenmount Park to Port Coquitlam's storm water drainage system, were included in the model. Smaller diameter tributary sections of storm sewer were not included.

Comparison of field notes with record drawings and other data sources indicated some locales where information was out of date or inaccurate. Where this would impact upon model accuracy, further information was obtained from the respective cities to verify actual conditions, or additional field investigation was carried out.

Major watercourses, their associated hydraulic structures, and trunk storm sewers, are indicated on Figures 3.3a to 3.3e. Note that because of scale considerations, not all sections of enclosed storm sewer are indicated. Only major branches of storm sewer, greater than 450 mm in diameter, are included in the inventory. An inventory of all modelled watercourses, hydraulic structures and enclosed systems, corresponding to Figures 3.3a to 3.3e is included in Appendix D as Table D1.

3.1.3 Boundary Conditions

The outlet of the combined Hyde Creek and Cedar Drive Ditch is via DeBoville Slough to the Pitt River. As a result the outlet condition is influenced both by tidal fluctuations and freshet conditions on the Fraser River.

The City of Port Coquitlam carries out water level recording on both the upstream and downstream side of the Cedar Drive drainage pump station. From this data, suitable boundary conditions were developed for the model analysis. It was assumed that the appropriate boundary condition coinciding with the design storm events would be a one-year return period high water level. The boundary condition was modelled dynamically, with the diurnal variation of water level included. In the model, the peak water level was timed to occur approximately 1 hour after the peak rainfall intensity of the design storms.

The application of the synthetic design storm, coinciding with peak high water, and timed so that the highest water levels occur at approximately the time of concentration for the entire watershed, results in a conservative assessment of hydraulic conditions in those lowland portions of the watershed subject to backwater influence.

3.1.4 Model Calibration

The hydrologic/hydraulic model in Visual Hydro was calibrated with rainfall and flow monitoring data from the period of February 14th to March 24th, 2003. The winter period of 2002 to 2003 was unusual in that there was below average rainfall prior to mid-February. The flow monitoring data was provided by the City of Coquitlam for Hyde and Smiling Creeks. The flow monitoring sites were at the locations shown on Figure 2.3. No flow monitoring was attempted at the proposed Watkins Creek site. Rainfall data for the Burke Mountain Fire Hall gauge was obtained from the GVRD.

Antecedent conditions prior to the period used for model calibration were unusually dry, but this allowed the response of the watershed to rainfall after a dry period to be assessed. Further, a period of approximately seven days from March 15th to March 22, 2003, between significant storms, saw little rainfall and allowed the storm recession curves and return to baseflow conditions to be investigated.

The calibration analysis indicated that most model parameters were within a reasonable range. Minor adjustments were made to the Effective Impervious Areas (EIAs) of the existing condition model, and groundwater routing parameters were adjusted to better conform to the recession curve observed in the flow monitoring data. The calibration process indicated that the soil infiltration parameters employed in the model were reasonable.

Long term groundwater base flows were estimated for the currently undeveloped sub-catchments. The base flow rate was estimated from the lowest flows just prior to the storm event on February 14, 2003. Significant rainfall had not fallen on the catchment for two weeks prior to this event. This long term ground water baseflow equates to a flow rate of 0.20 L/s/ha, which has been applied as the groundwater base flow in the existing condition model.

Existing condition sub-catchment model data, as calibrated, is contained within Appendix C.

3.1.5 Rainfall Data

For our model analysis of the Hyde Creek Watershed, rainfall data from the GVRD rain gauge at the Burke Mountain Fire Hall (QT39) was utilized as the primary source. This rain gauge is located centrally within the study area, and should provide representative rainfall data.

Prior to selecting the Burke Mountain Fire Hall rain gauge, the GVRD rain gauge at the Port Coquitlam Pump Station (PQ38) and the Atmospheric Environment Service rain gauge at Pitt Polder were also investigated. Generally, though of shorter record, the Burke Mountain gauge exhibited higher rainfalls, reflecting its location in proximity to the mountain, and higher elevation. The other two gauges considered are located in predominantly flat areas.

In recognition of the varying elevations within the Hyde Creek watershed, rainfall data was developed for three different elevation bands. A multiplier was applied to the data for the upper two bands to reflect the increase in rainfall with elevation due to orographic effects. The first elevation band in the watershed, from 0 m to 175 m was given an elevation multiplier of 1.0. The second elevation band, from 175 m to 350 m was given a rainfall multiplier of 1.25. The third and highest elevation band, from 350 m to 600 m had a rainfall multiplier of 1.6 applied. The rainfall multipliers were developed from GVRD curves indicating the variation in annual rainfall (as yearly isohyets) with location, and elevation in the GVRD.

There is a distinct gradient of increasing rainfall from south to north within the GVRD, which becomes more pronounced with elevation gain in the North Shore Mountains, of which Burke Mountain is a continuation.

We utilized a synthetic design rainfall storm in our model analysis. The design storm incorporates all rainfall durations from 30 minutes to 24 hours, as obtained from the Intensity Duration Frequency (IDF) rainfall data.

The mean annual rainfall (MAR) as determined from the IDF information for the Burke Mountain rain gauge, was approximately 90 mm in 24 hour. Therefore, for the Hyde Creek watershed, Tier 1 storms would have rainfall depths less than 45 mm in 24 hours, or 50% of the MAR.

We carried out a statistical analysis of recorded rainfall data from the GVRD's Burke Mountain Fire Hall rain gauge for the period of 1997 to 2002 (inclusive). Our analysis indicated that 92% of the storms recorded during that 6 year period had total depths less than 50% of the MAR.

3.2 EXISTING CONDITIONS

We carried out a model analysis of the entire Hyde Creek Watershed under existing development conditions and the existing drainage system. Our initial model analysis primarily considered the ten-year return period event.

From our model analysis using the 10-year design storm, we identified culverts on the major creeks that appear to have inadequate capacity. These culverts are identified on Figures 3.3 a through e, and listed in Table 3.2. Table 3.2 presents the culvert ID, current culvert size, the current culvert capacity, the existing condition 10-year return period flow, and required size. This information can be used to upgrade the culverts on an interim basis until the storm water management plan presented in Section 5 is enacted and neighbourhood planning and development takes place.

The existing condition model analysis with the 10-year design storm also indicated that essentially all of the "lesser" culvert crossings are inadequate. These culverts include driveway culverts on ditches, and road culverts crossing secondary drainage routes. Our analysis indicates that overtopping is likely at these locations. We have not specifically identified these deficiencies, as they are numerous, and the local drainage system will be

Culvert ID	Municipality	Location	Post-Dev. 100-Year Peak Flow (m³/s)	Culvert Information: Existing Type	Existing Size (mm)	Existing Material	Required Type	Required Size (mm) H	Required Size (mm) V	Required Material	Comments
Burke Mountain Creek											
BRK-C10	Coquitlam		1.48	Circular Culvert	1200	Concrete					Existing culvert has sufficient capacity.
BRK-C20	Coquitlam		0.45	Circular Culvert	600	CSP					Existing culvert has sufficient capacity.
Hyde Creek											
HYD-C10,C20,C30	Port Coquitlam	Coast Meridian Road	15.92	Arch Culvert	2590H x 1880V	SPCSP	Arch Culvert	3730	2290	SPCSP	Existing culvert is undersized.
HYD-C40,C50	Port Coquitlam	Lincoln Avenue	15.71	Box Culvert	3100H x 1450V	Concrete	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.
HYD-C60,C70	Port Coquitlam	Kent Avenue	14.91	Box Culvert	3300H x 1050V	Concrete	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.
HYD-C80	Port Coquitlam	Greenmount Avenue	13.72	Box Culvert	3050H x 1050V	Concrete / Nat. Bottom	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.
HYD-C90	Coquitlam	Victoria Drive R/W	13.52	Box Culvert	2700H x 1600V	Concrete / Nat. Bottom	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.
HYD-C104	Coquitlam	Private Driveway	6.03	Circular Culvert	1500	CSP	Circular Culvert	2000		CSP	Existing culvert is undersized.
HYD-C106	Coquitlam	Private Driveway	6.06	Circular Culvert	2000	CSP					Existing culvert has sufficient capacity, stabilize fill slopes and extend
HYD-C110	Coquitlam	Coast Meridian Road	6.07	Circular Culvert	1500	SPCSP	Circular Culvert	2000		CSP	Existing culvert is undersized.
HYD-C120	Coquitlam	Harper Road	4.92	Circular Culvert	1000	CSP	Circular Culvert	1800		CSP	Existing culvert is undersized.
Smiling Creek											
SML-C10	Coquitlam	Victoria Drive	10.13	Box Culvert	2400H x 1200V	Concrete	Box Culvert	2400	2400	Concrete	Existing culvert is undersized.
SML-C50	Coquitlam		5.76	Twin Circ. Culverts	2 - 900	CSP	Twin Circ. Culverts	2000		CSP	Existing culverts are undersized. Could use 1 - 2000 mm CSP.
SML-C60	Coquitlam		4.88	Circular Culvert	1200	Concrete	Circular Culvert	1800		Concrete	Existing culvert is undersized.
SML-C70	Coquitlam	Galloway Avenue	5.07	Circular Culvert	1400	CSP	Circular Culvert	2000		CSP	Existing culvert is undersized.
SML-C80	Coquitlam	Highland Drive	5.10	Circular Culvert	1200	Concrete	Circular Culvert	1800		Concrete	Existing culvert is undersized.
SML-C100	Coquitlam		5.10	Circular Culvert	900	CSP	Circular Culvert	2000		CSP	Abandoned culvert - Remove
SML-C110	Coquitlam	Conifer Drive	2.89	Circular Culvert	1000	CSP	Circular Culvert	1600		CSP	Existing culvert is undersized.
West Smiling Creek											
UNN-C10	Coquitlam	Victoria Drive	1.91	Circular Culvert	900	CSP	Circular Culvert	1400		CSP	Existing culvert is undersized.
UNN-C15	Coquitlam	Gislason Avenue	1.98	Circular Culvert	900	CSP	Circular Culvert	1400		CSP	Existing culvert is undersized.
UNN-C18	Coquitlam	Galloway Avenue		Circular Culvert	750	Concrete					Existing culvert has sufficient capacity.
UNN-C20	Coquitlam	Galloway Avenue		Circular Culvert	800	CSP	Circular Culvert	1400		CSP	Existing culvert is undersized.
UNN-C30	Coquitlam	Princeton Avenue		Circular Culvert	900	Concrete					Existing culvert has sufficient capacity.
UNN-C50	Coquitlam	Highland Drive		Storm Sewer Outlet	450	Concrete	n/a	n/a		n/a	Storm sewer is undersized. Requires detailed analysis.
UNN-C60	Coquitlam	Highland Drive		Storm Sewer	450	Concrete	n/a	n/a		n/a	Storm sewer is undersized. Requires detailed analysis.
UNN-C70	Coquitlam	Highland Drive		Storm Sewer	450	Concrete	n/a	n/a		n/a	Storm sewer is undersized. Requires detailed analysis.
UNN-C80	Coquitlam	Highland Drive		Storm Sewer	450	Concrete	n/a	n/a		n/a	Storm sewer is undersized. Requires detailed analysis.
UNN-C90	Coquitlam	Highland Drive		Storm Sewer Inlet	450	Concrete	n/a	n/a		n/a	Storm sewer is undersized. Requires detailed analysis.
UNN-C100	Coquitlam	Harper Road	1.48	Circular Culvert	900	CSP	Circular Culvert	1200		CSP	Existing culvert is undersized.
UNN-C105	Coquitlam	Harper Road	1.24	Circular Culvert	600	CSP	Circular Culvert	1200		CSP	Existing culvert is undersized.
UNN-C110	Coquitlam	Highland Drive		Storm Sewer Inlet	450	Concrete	n/a	n/a		n/a	Storm sewer is undersized. Requires detailed analysis.
UNN-C120	Coquitlam	Harper Road	0.11	Circular Culvert	600	CSP					Existing culvert has sufficient capacity.
Watkins Creek											
WAT-C10	Port Coquitlam	Apel Drive	2.61	Box Culvert	1500H x 1500V	Concrete					Existing culvert has sufficient capacity.
WAT-C20	Coquitlam	Victoria Drive	1.78	Circular Culvert	1500	Riveted Steel					Existing culvert has sufficient capacity.
WAT-C30	Coquitlam		1.78	Circular Culvert	1500	CSP					Existing culvert has sufficient capacity.
WAT-C40	Coquitlam		1.78	Circular Culvert	1800	Steel					Existing culvert has sufficient capacity.
WAT-C50	Coquitlam		1.78	Circular Culvert	1600	Riveted Steel					Existing culvert has sufficient capacity.
WAT-C60	Coquitlam		1.79	Circular Culvert	1500	Woodstave					Existing culvert has sufficient capacity.
WAT-C70	Coquitlam	Roxton Avenue	1.79	Circular Culvert	2100	Riveted Steel					Existing culvert has sufficient capacity.
WAT-C80	Coquitlam	Coast Meridian Road	0.70	Circular Culvert	1500	Concrete					Existing culvert has sufficient capacity.
WAT-C90	Coquitlam	David Avenue	0.70	Circular Culvert	1000	CSP	Circular Culvert	1000		CSP	Existing culvert has sufficient capacity - fish access - provide fish ladder or regrade channel (Note may be replaced due to road reconstruction)
Cedar Drive Ditch											
CED-C10/C11	Port Coquitlam	Cedar Drive to DeBoville Slough		Arch Culvert	3890H x 2690V	SPCSP	Bridge				Existing arch culvert has excessive head loss, replace with bridge
CED-C50	Port Coquitlam	Lincoln Avenue		Box Culvert	2 x 2100H x 2100V	Concrete					Twin box culverts have sufficient capacity
CED-C60	Port Coquitlam	Lombardy Drive D/S		Box Culvert	2700H x 1700V	Concrete	Box Culvert	2400	3050	Concrete	Existing box culvert has excessive head loss, replace with larger
CED-C70	Port Coquitlam	Lombardy Drive U/S		Box Culvert	2750H x 1850V	Concrete	Box Culvert	2400	3050	Concrete	Existing box culvert has excessive head loss, replace with larger
CED-C80/C75	Port Coquitlam	Prairie Avenue		Box Culvert	2600H x 1200V	Concrete	Box Culvert	2400	3050	Concrete	Existing box culvert has excessive head loss, replace with larger

Table 3.2
Existing Condition Assessment of Major Culverts

Culvert ID (If Applicable)	City	Location	Post-Dev. 100-Year Peak Flow (m^3/s)	Culvert Information – Existing – Type	Existing – Size (mm)	Existing – Material	Required – Type	Required – Size (mm)		Required – Material	Comments
Burke Mountain Creek											
	Coquitlam										Yard waste/debris in channel - remove, install signage and leaflet area
Hyde Creek											
HAR-C20	Coquitlam	Harper Road	2.50	Circular Culvert	750	Concrete	Circular Culvert	1400		CSP	Perched culvert - regrade channel, or install concrete fish ladder
Not modelled	Coquitlam										Perched culvert - regrade channel, or install concrete fish ladder
CME-C320	Coquitlam	Coast Meridian	1.25	Circular Culvert	1000	CSP	Circular Culvert	1400		CSP	Perched culvert - regrade channel, or install concrete fish ladder
CME-C290	Coquitlam	Coast Meridian	1.26	Circular Culvert	1050/1400	Wood Stave/CSP	Circular Culvert	1400		CSP	Perched culvert - regrade channel, or install concrete fish ladder
	Coquitlam										Erosion control - rip-rap or bio-engineered bank protection
	Coquitlam	Main Stem									Erosion control - rip-rap or bio-engineered bank protection
	Coquitlam	Main Stem									Erosion control - rip-rap or bio-engineered bank protection
	Coquitlam										Erosion control - rip-rap or bio-engineered bank protection
	Coquitlam	Above Coast Meridian									Loss of base flow - supplement with wells or other supply
	Coquitlam										Debris Jams on Hyde Creek - remove only when they present a threat
	Coquitlam										Small dam and pond on private property - remove and reinstate channel
	Coquitlam										Sharp drop in channel - regrade
	Coquitlam										Old log bridge (possibly being used for trail access) - remove or replace
	Port Coquitlam										Loss of base flow - supplement with wells or other supply
	Port Coquitlam										Constrained channel and undermined retaining wall
	Port Coquitlam										Clear Debris Jam
	Port Coquitlam										Remove invasive vegetation
	Port Coquitlam										Fence off trail from creek
Smiling Creek											
	Coquitlam										Collapsed log crib bridge - Remove
	Coquitlam										Erosion control - rip-rap or bio-engineered bank protection
	Coquitlam										Low footbridge (private) - raise or remove
West Smiling Creek											
	Coquitlam										Failing retaining wall - reconstruct or remove
Watkins Creek											
CME-C120	Coquitlam			Circular Culvert	600	CSP	Circular Culvert	600		CSP	Existing culvert is perched, replace or otherwise provide fish access
CMW-C70	Coquitlam			Circular Culvert	600	Concrete	Circular Culvert	600		Concrete	Existing culvert has poor inlet conditions, structurally suspect, reconstruct
CMW-C30	Coquitlam			Circular Culvert	600	CSP	Circular Culvert	600		CSP	Existing culvert is perched with erosion occuring, replace
	Coquitlam										Erosion control - rip-rap or bio-engineered bank protection
	Coquitlam										

Table 3.2
Existing Condition Assessment of Major Culverts

substantially altered in function and configuration by the development process. We recommend that localized drainage system design and issues be addressed at the neighbourhood plan level.

We did not model the storm sewer collection system within Port Coquitlam in detail. Dayton & Knight's "North Side Storm Sewer Relief Project" report from July 2002, provided a detailed analysis and proposed solutions for the closed pipe storm water drainage systems within the Hyde Creek/Cedar Drive Ditch area. We do note that the 10-year return period storm that we investigated as a design event for the minor (piped) system indicated that there is surcharging of the few sections of storm sewer incorporated in our model. Realistically however, the high flows produced in our model would have difficulty entering the storm water drainage system due to the limited capacity of the inlets (such as catch basins). More likely these very high flows would in part be conveyed as overland flow on the road network to Cedar Drive Ditch.

For the above reasons, we limited our investigation of problems to Cedar Drive Ditch and the other creek channels within Port Coquitlam, as identified in Table 3.2 above. Table 3.3 presents hydraulic grade line results for Cedar Drive Ditch in Port Coquitlam. Functionally, Cedar Drive Ditch can be viewed as a lowland drainage channel. As such, culvert crossings with excessively high head losses (>0.10m) during a 10 year event are identified in bold face in Table 3.3, and culvert upgrades proposed to alleviate these head losses. Culvert improvements along the Cedar Drive Ditch would result in an overall improvement in hydraulic grade lines along this watercourse.

Table 3.3
Cedar Ditch Hydraulic Grade Lines Under Existing Conditions

Model Node ID	Location	Invert Elev. (m)	MAXIMUM WATER SURFACE ELEVATION (m) PRE-DEVELOPMENT (EXISTING) CONDITION HGLs				
			Q 1/2	Q2	Q5	Q10	Q100
CED-N5	Deboville Slough	0.89	2.80	2.80	2.80	2.80	2.80
CED-N10	Cedar Drive D/S	0.89	2.82	2.83	2.85	**2.85**	2.85
CED-N20	Cedar Drive U/S	0.89	3.12	3.34	3.47	**3.55**	3.79
CED-N30		0.90	3.37	3.64	3.78	3.86	4.10

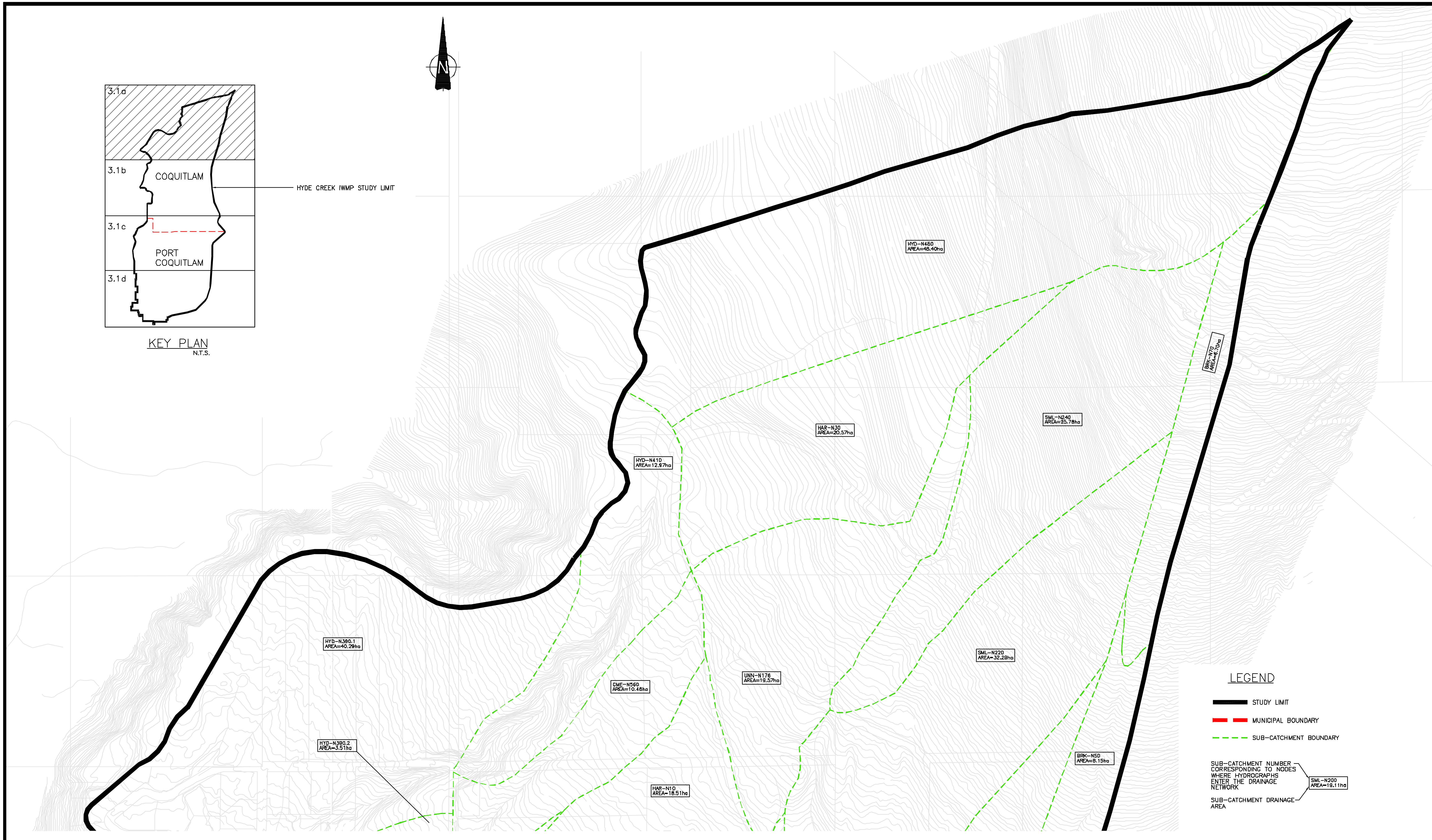
Model Node ID	Location	Invert Elev. (m)	MAXIMUM WATER SURFACE ELEVATION (m) PRE-DEVELOPMENT (EXISTING) CONDITION HGLs Q 1/2	Q2	Q5	Q10	Q100
CED-N40		0.92	3.70	4.02	4.17	4.27	4.51
CED-N50		0.93	3.78	4.11	4.27	4.37	4.62
CED-N60	Hyde Creek at Cedar Ditch	0.94	3.87	4.22	4.38	4.48	4.74
CED-N70	Pump Stn & Floodbox D/S	0.94	3.87	4.22	4.38	4.48	4.74
CED-N80		0.94	3.87	4.22	4.38	4.48	4.74
CED-N90	Pump Stn & Floodbox U/S	1.40	3.87	4.22	4.39	4.49	4.76
CED-N100		1.54	3.87	4.22	4.39	4.49	4.77
CED-N130		1.54	3.87	4.22	4.39	4.49	4.77
CED-N140		1.63	3.87	4.23	4.39	4.49	4.77
CED-N150		1.64	3.88	4.23	4.39	4.50	4.77
CED-N160		1.64	3.88	4.23	4.40	4.50	4.78
CED-N170		1.64	3.88	4.23	4.40	4.50	4.78
CED-N180	Lincoln Avenue D/S	1.65	3.89	4.24	4.40	4.50	4.78
CED-N190	Lincoln Avenue U/S	1.65	3.91	4.26	4.42	4.53	4.83
CED-N200		1.66	3.91	4.26	4.42	4.53	4.83
CED-N210		1.67	3.92	4.27	4.43	4.53	4.84
CED-N220	Lombardy Drive (N) D/S	1.68	3.93	4.27	4.44	**4.54**	4.85
CED-N230	Lombardy Drive (N) U/S	1.68	4.00	4.38	4.56	**4.68**	5.08
CED-N240	Lombardy Drive (S) D/S	1.92	4.01	4.39	4.57	4.69	5.09
CED-N250	Lombardy Drive (S) U/S	1.92	4.04	4.44	4.62	4.75	5.20
CED-N260		1.95	4.06	4.46	4.63	4.76	5.21
CED-N270	Prairie Avenue D/S	1.96	4.07	4.47	4.64	**4.77**	5.21
CED-N275		1.96	4.14	4.56	4.76	**4.91**	5.45
CED-N280	Prairie Avenue U/S	1.96	4.18	4.66	4.95	**5.16**	5.88
CED-N290		1.98	4.20	4.68	4.97	5.18	5.90
CED-N300		2.30	4.20	4.69	4.98	5.18	5.91
CED-N310		2.31	4.22	4.71	5.00	5.21	5.93
CED-N320		3.27	4.25	4.73	5.03	5.24	5.95
CED-N330		3.34	4.34	4.77	5.06	5.26	5.96
CED-N340		4.19	5.00	5.19	5.34	5.47	6.02

Our examination of the hydraulic grade lines presented in Table 3.2 revealed that the majority of the head losses experienced along the channel are concentrated at the culvert crossings. The long stretches of ditch with large cross-sections experience very minor head loss as compared to the culverts. Our analysis of existing conditions indicated head losses in excess of 10 cm for the 10-year rainfall event (combined with a one-year return period freshet water level) at three locations. These were:

- Cedar Drive Ditch/Hyde Creek culvert under Cedar Drive to DeBoville Slough headloss = 0.7 m.
- Lombardy Street Culvert headloss = 0.14 m.
- Prairie Avenue Culvert headloss = 0.39 m.

Of the three culverts, the crossing under Cedar Drive to Deboville slough exhibits the most serious head loss. Upgrading these culverts could provide significant water level improvements along Cedar Drive Ditch. Possible upgrades for these locations are discussed in Section 5.5.

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



Plot Scale: 1=1 (Paper Space) AutoCAD File: 022313\CURRENT\FIGURE3.1.DWG (GQ)

Time: 9:48 Date: 2003/7/23
Xrefs: 2313r101, BASEPLAN

NO.	DATE	ENG.	BY	SUBJECT
REVISIONS				

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

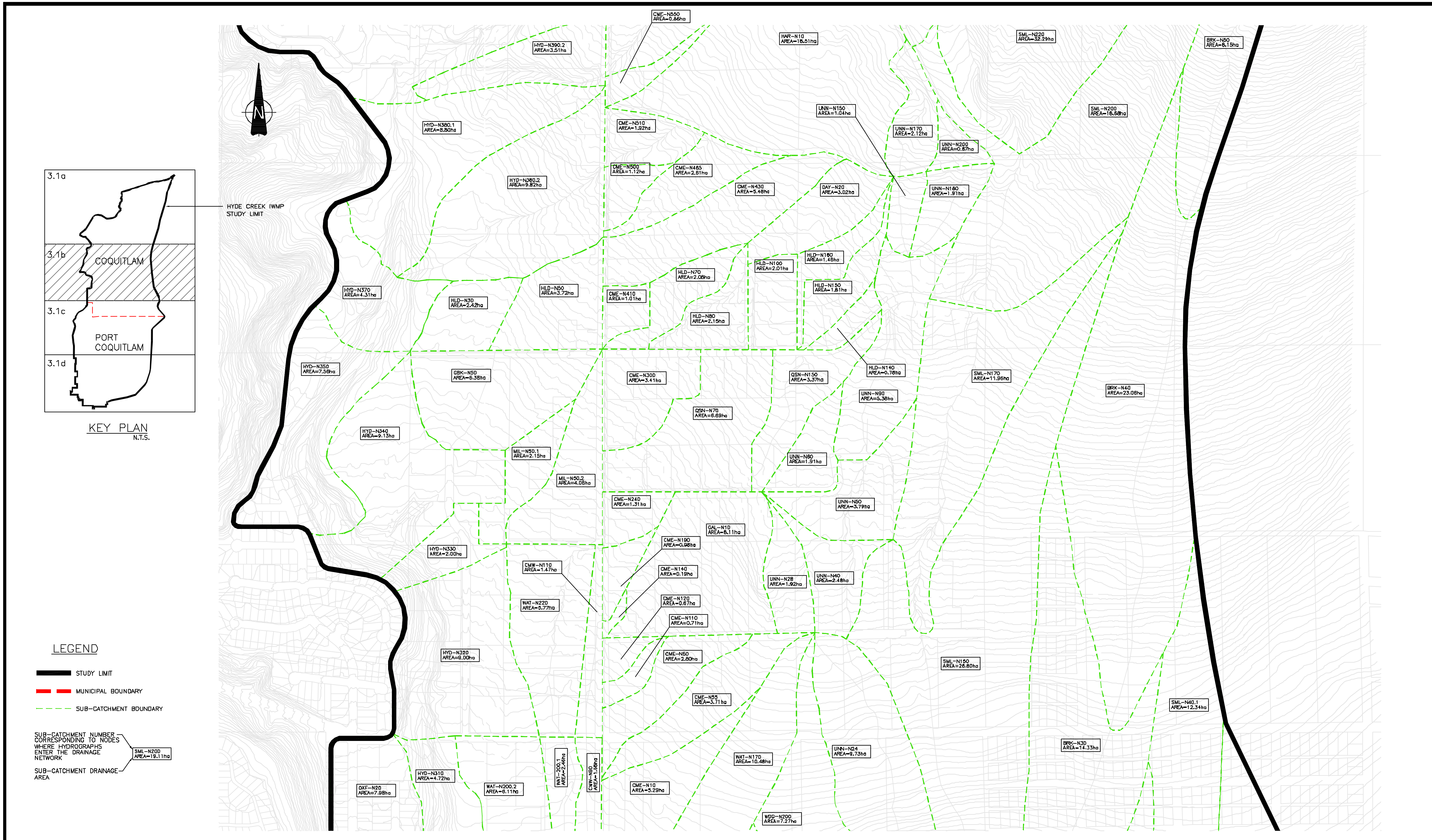
CITY OF COQUITLAM AND PORT COQUITLAM

SUB-CATCHMENT PLAN

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.1a		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

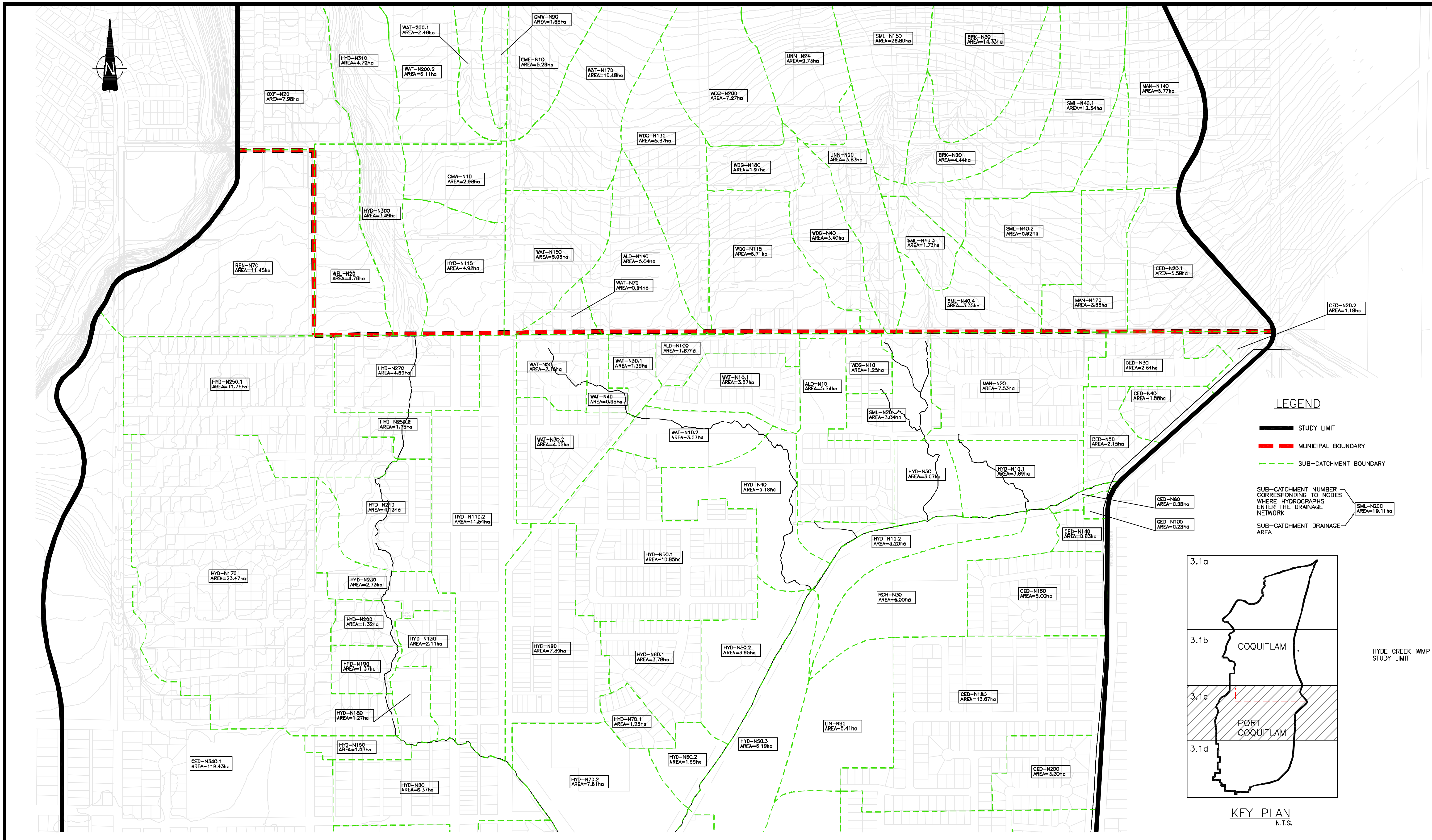
CITY OF COQUITLAM AND PORT COQUITLAM

SUB-CATCHMENT PLAN

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.1b		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT
REVISIONS				

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

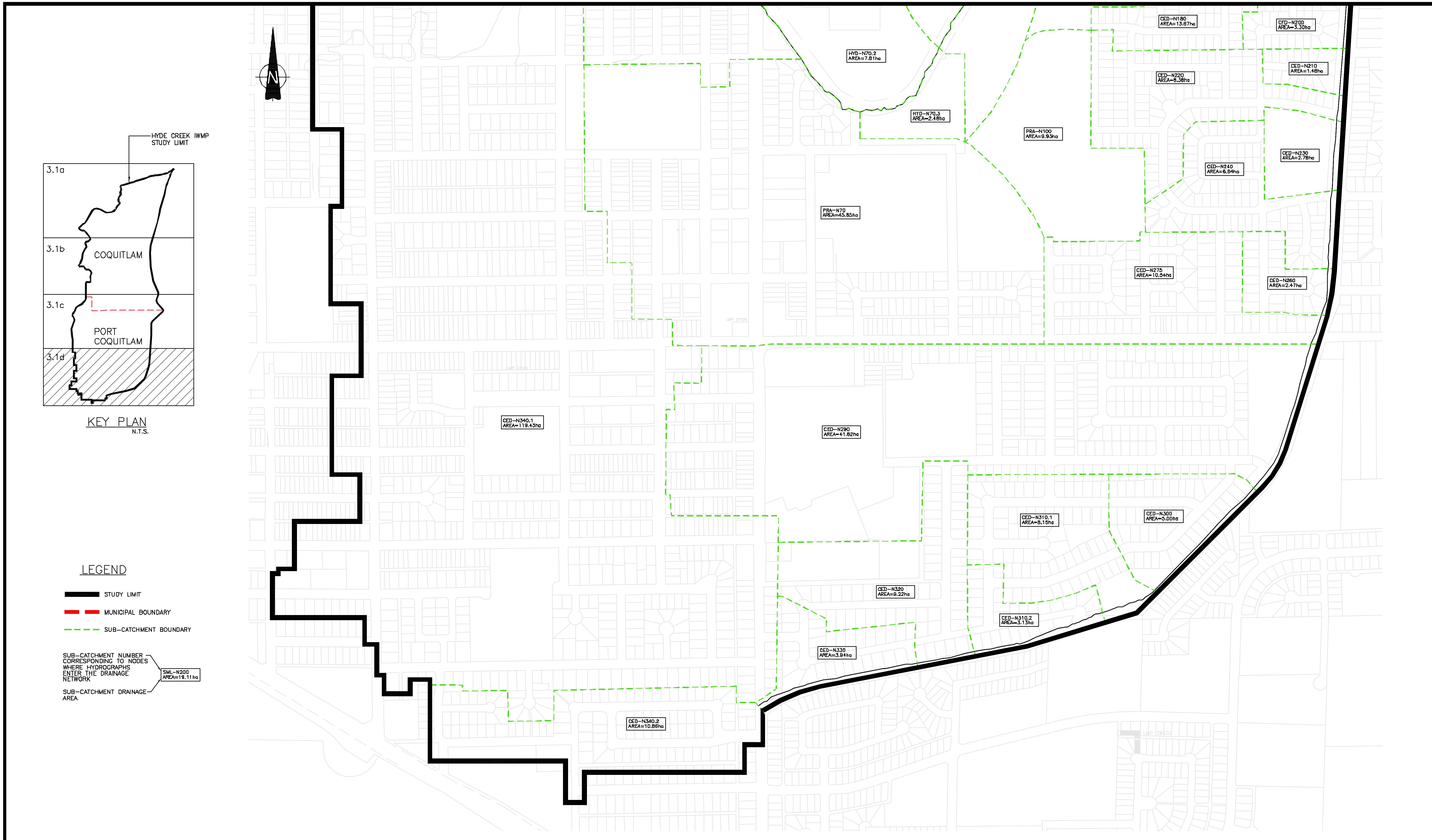
CITY OF COQUITLAM AND PORT COQUITLAM

SUB-CATCHMENT PLAN

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.1c		

This Drawing Is For The Use Of The Client And Project Indicated No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

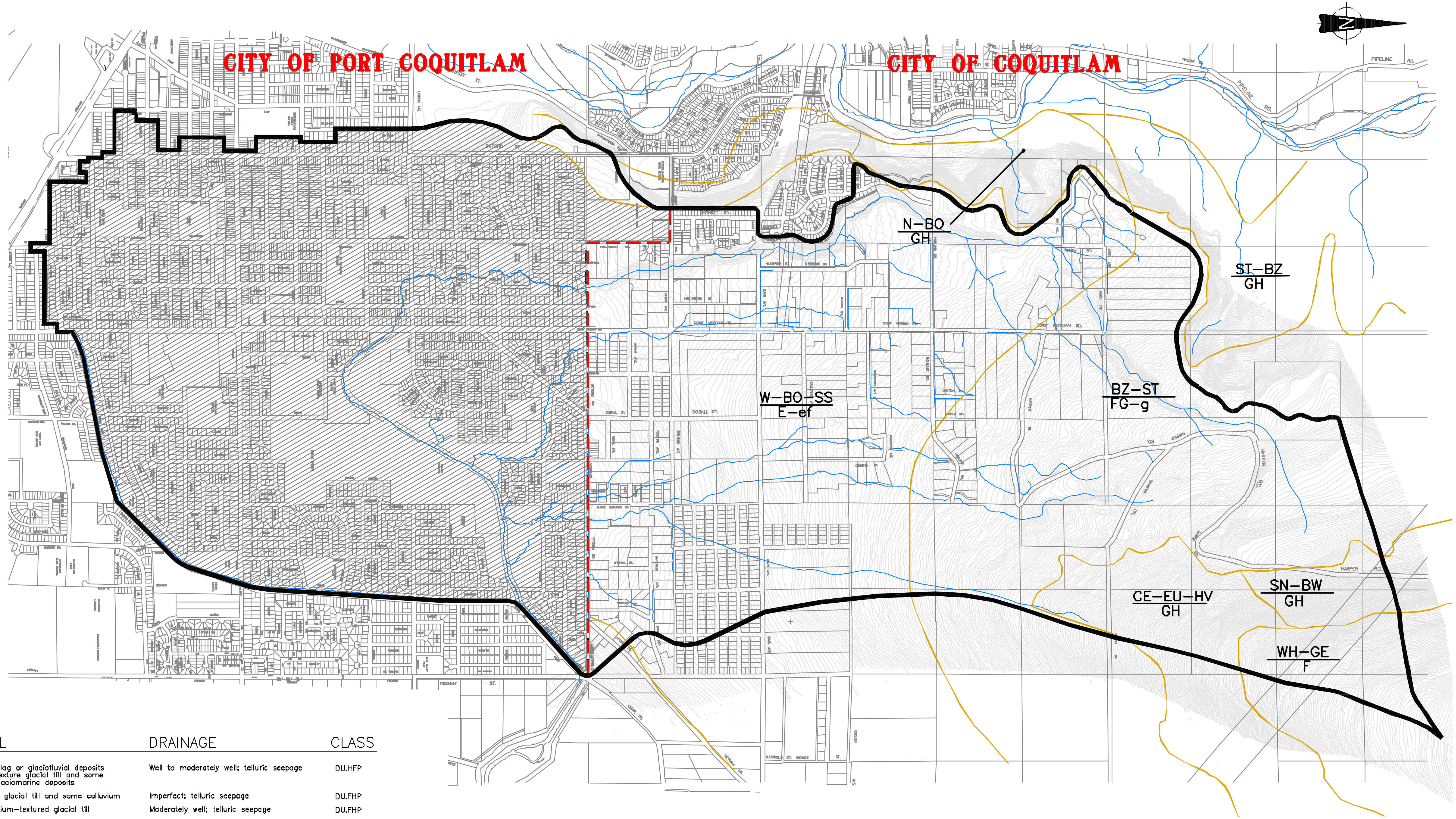
CITY OF COQUITLAM AND PORT COQUITLAM

SUB-CATCHMENT PLAN

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.1d		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



LEGEND

- CATCHMENT BOUNDARY
- CITY BOUNDARY
- SOIL TYPE DELINEATION LINE
- UNCLASSIFIED

EXAMPLE OF MAP SYMBOL

W-H-GE / F

SOIL SYMBOL (in order of dominance)

TOPOGRAPHICAL CLASS

TOPOGRAPHIC CLASSES

SIMPLE TOPOGRAPHY SINGLE SLOPES (REGULAR SLOPES)		COMPLEX TOPOGRAPHY MULTIPLE SLOPES (IRREGULAR SLOPES)	
C	gently sloping	a	nearly level
D	moderately sloping	b	gently undulating
E	strongly sloping	c	undulating
F	steeply sloping	d	gently rolling
G	very steeply sloping	e	moderately rolling
H	extremely sloping	f	strongly rolling
		g	very hilly

MAP SYMBOL	SOIL NAME	SOIL MATERIAL	DRAINAGE	CLASS
BO	BOSE	30 to 160cm of gravelly lag or glaciofluvial deposits over moderately coarse-texture glacial till and some moderately fine-texture glaciomarine deposits	Well to moderately well; telluric seepage	DU.HFP
BW	BURWELL	Moderately coarse-texture glacial till and some colluvium	Imperfect; telluric seepage	DU.FHP
BZ	BUNTZEN	Moderately coarse to medium-textured glacial till	Moderately well; telluric seepage	DU.FHP
CE	CANNELL	10 to 100 cm of moderately coarse-textured glacial till or colluvium over bedrock	Well to rapid	O.HFP1
EU	EUNICE	More than 10 cm of organic material over bedrock	Well to rapid	TY.FO
GE	GOLDEN EARS	Moderately coarse-textured glacial till	Moderately well	DU.FHP
HV	HOOVER	Moderately coarse-texture colluvium	Moderately well; telluric seepage	O.HFP
N	NICHOLSON	Moderately fine-texture glaciomarine deposits	Moderately well; telluric seepage	PZ.GL
SN	STRACHAN	Moderately coarse-textured galciall till and some colluvium	Moderately well; telluric seepage	DU.FHP
SS	SUNSHINE	Sandy littoral and glacial outwash deposits	Well to moderately well	O.HFP
ST	STEELHEAD	Moderately coarse-textured glaciall till	Imperfect; perched water table; telluric seepage	DU.FHP
W	WHATCOM	Moderately fine-texture glaciomarine deposits	Moderately well; telluric seepage	W.HFP
WH	WHONNOCK	Moderately coarse-texture galciall till	Imperfect; telluric seepage	DU.FHP

NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 — 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:20000		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

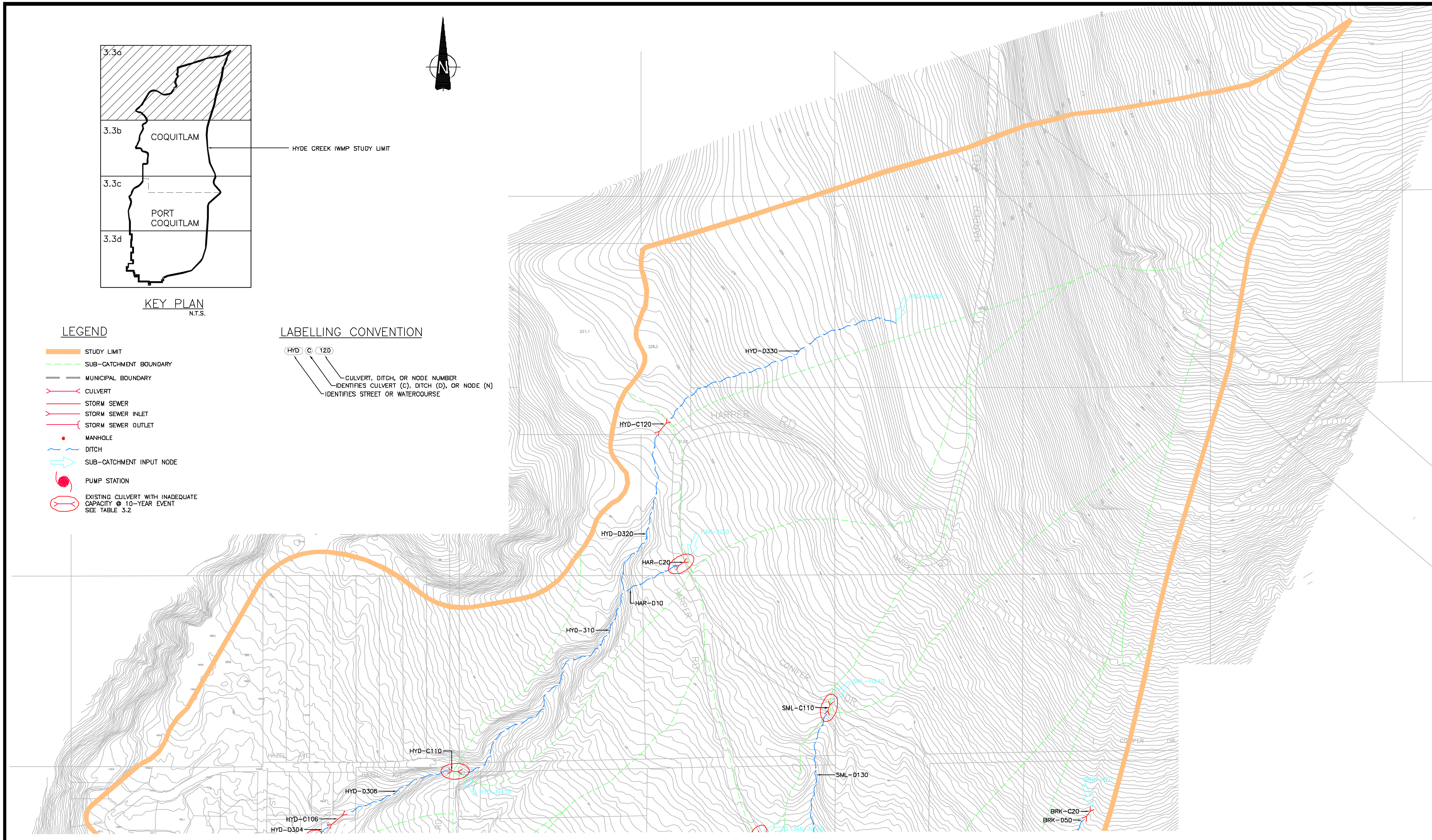
SURFICIAL SOILS MAP

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.2		

Plot Scale: 1=1 (Paper Space) AutoCAD File: Q:\022313\CURRENT\FIGURE3_2.DWG (02)
Time: 12:28 Date: 2004/7/19
Xrefs: 2313-101, BASEPLAN

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

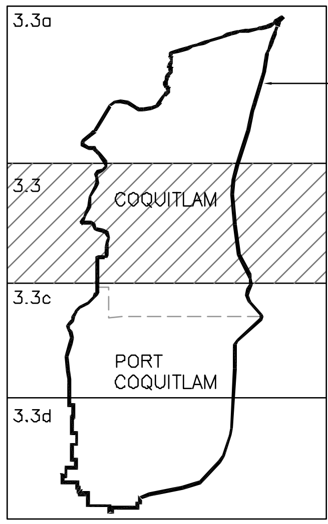
CITY OF COQUITLAM AND PORT COQUITLAM

EXISTING NETWORK INVENTORY

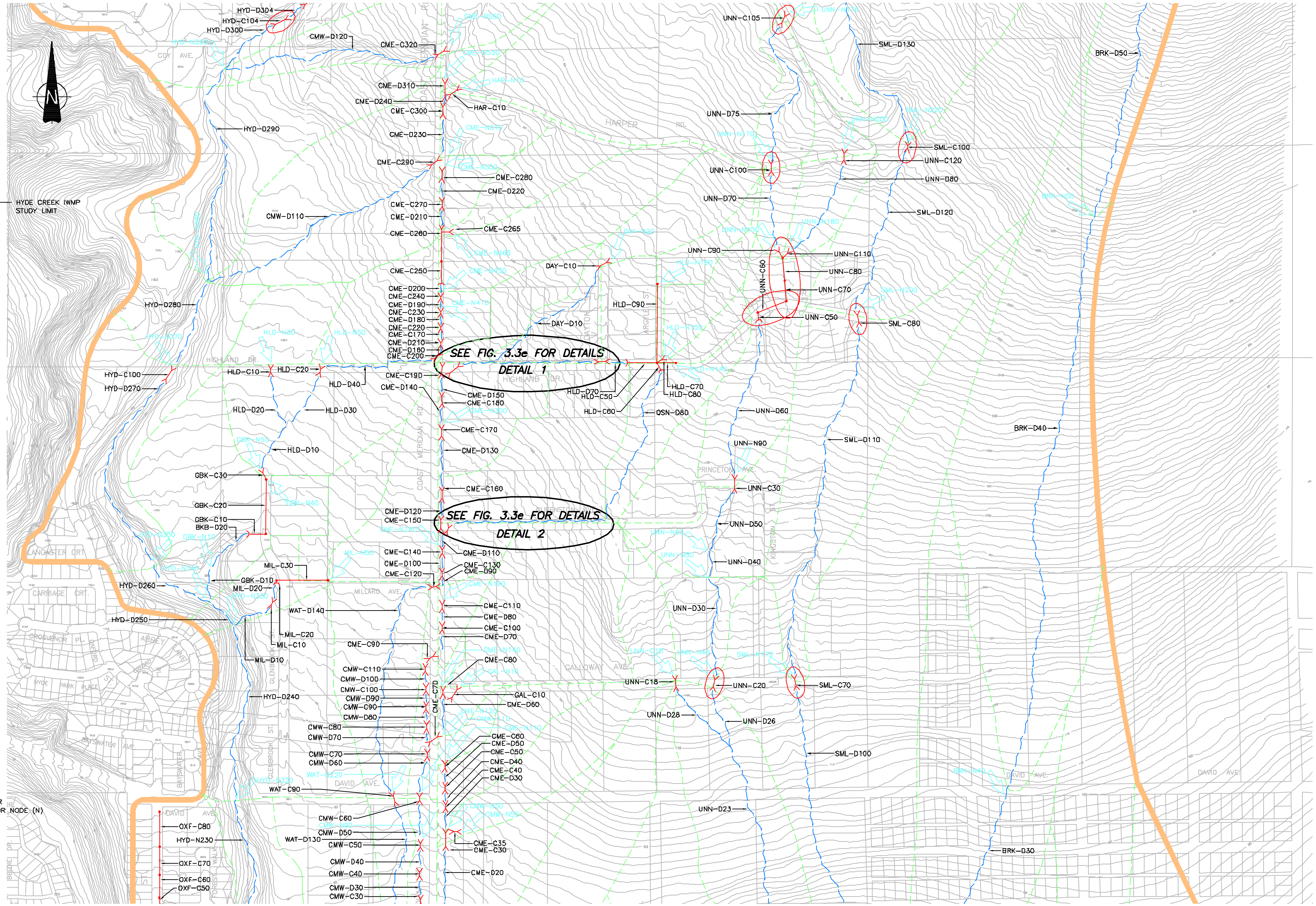
HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.3a		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



KEY PLAN
N.T.S.



LEGEND

- STUDY LIMIT
- SUB-CATCHMENT BOUNDARY
- MUNICIPAL BOUNDARY
- CULVERT
- STORM SEWER
- STORM SEWER INLET
- STORM SEWER OUTLET
- MANHOLE
- DITCH
- SUB-CATCHMENT INPUT NODE
- PUMP STATION
- EXISTING CULVERT WITH INADEQUATE CAPACITY @ 10-YEAR EVENT SEE TABLE 3.2

LABELLING CONVENTION

HYD C 120

- CULVERT, DITCH, OR NODE NUMBER
- IDENTIFIES CULVERT (C), DITCH (D), OR NODE (N)
- IDENTIFIES STREET OR WATERCOURSE

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND PORT COQUITLAM

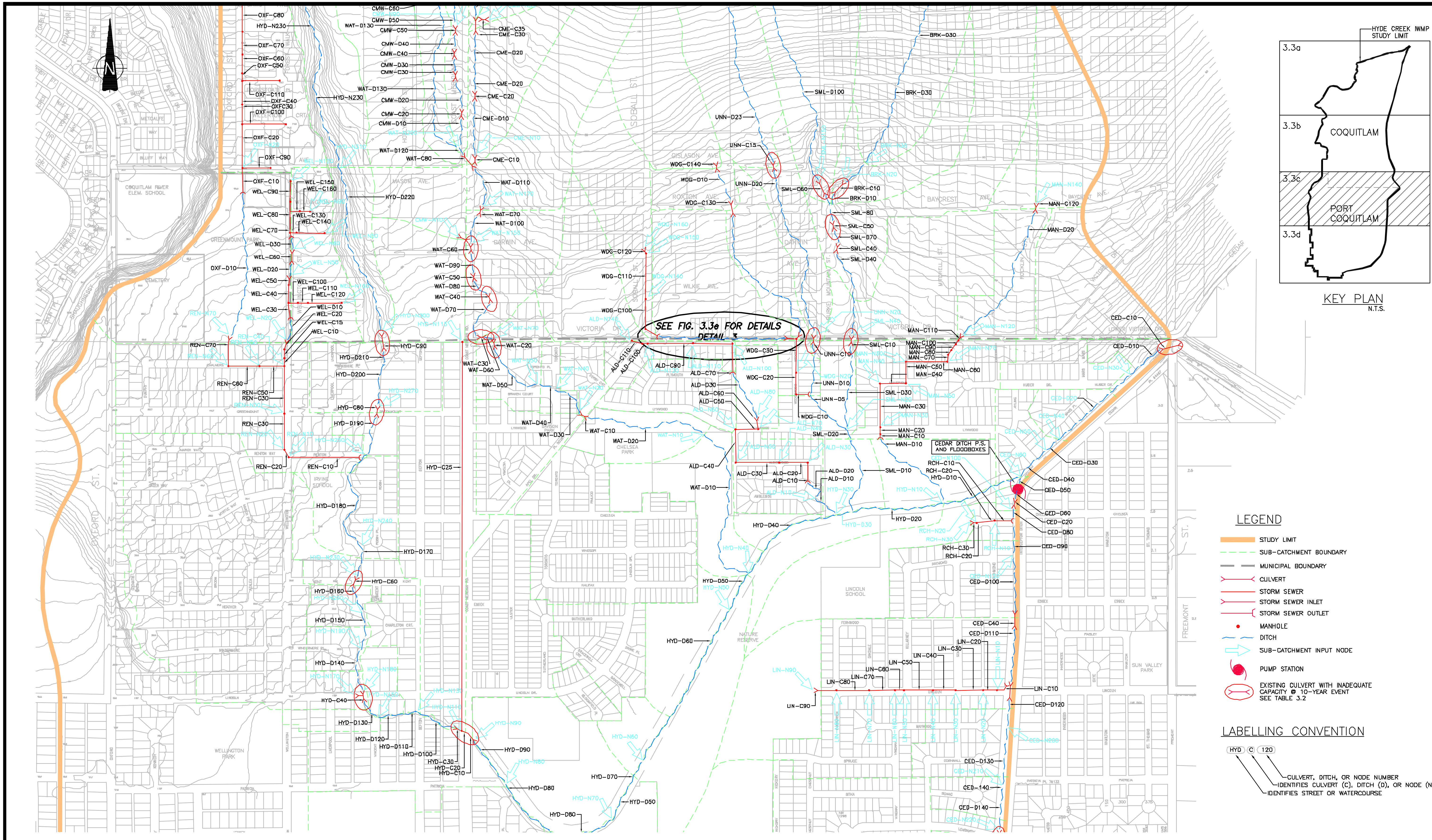
EXISTING NETWORK INVENTORY

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.3b		

Plot Scale: 1=1 (Paper Space) AutoCAD File: 022313\CURRENT\FIGURES\3.3.DWG (00)
Time: 8:59 Date: 2003/7/25
Xrefs: 2313r101, BASEPLAN

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT
REVISIONS				

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

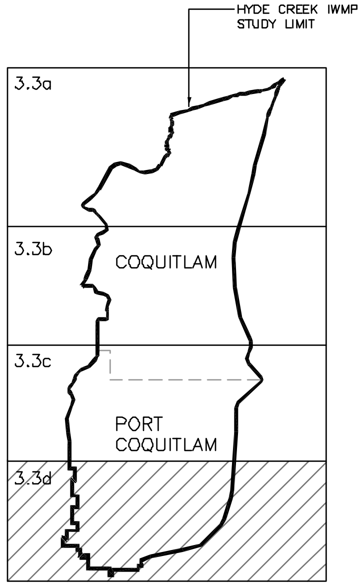
CITY OF COQUITLAM AND PORT COQUITLAM

EXISTING NETWORK INVENTORY

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.3c		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



KEY PLAN
N.T.S.

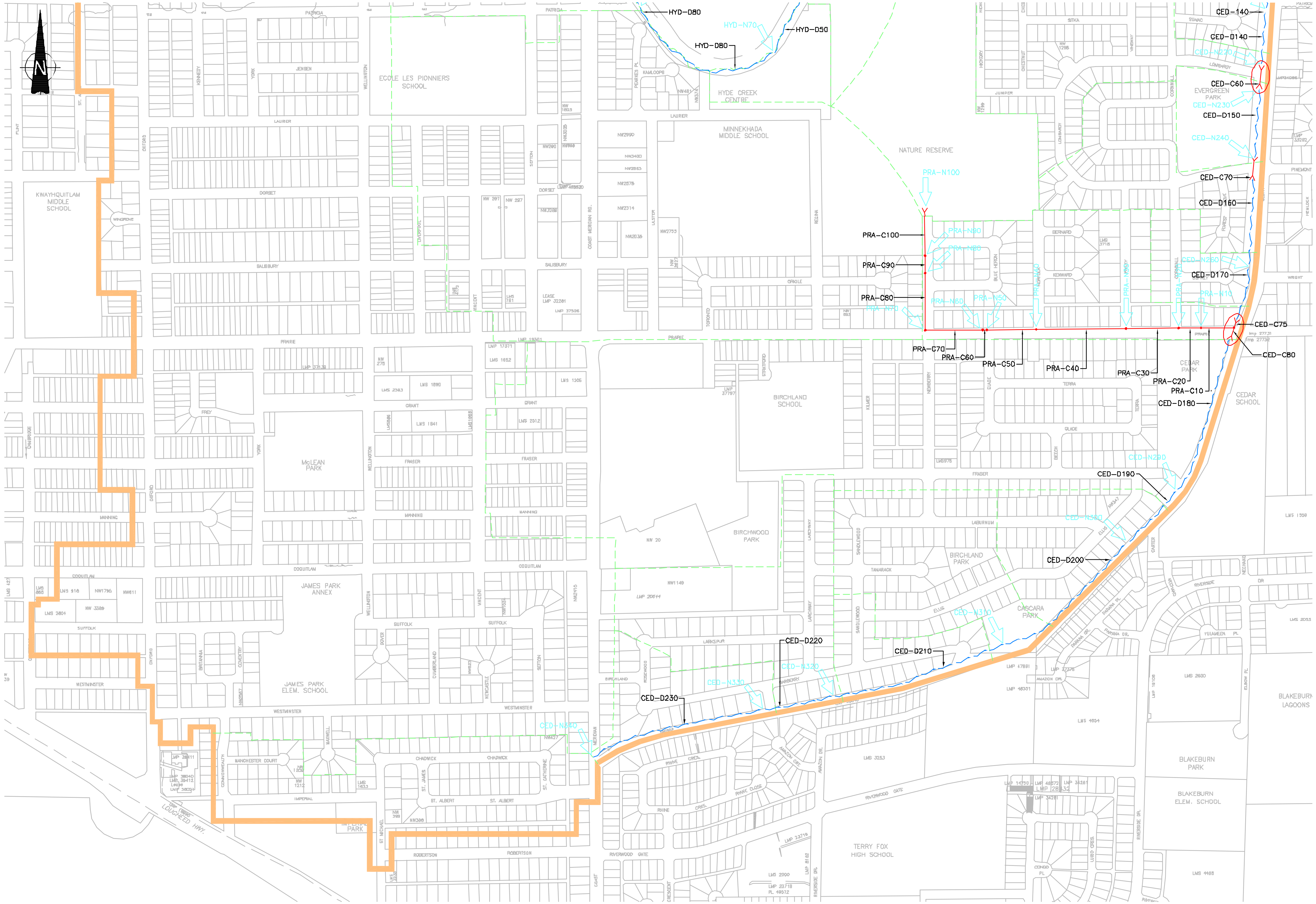
LEGEND

- STUDY LIMIT
- SUB-CATCHMENT BOUNDARY
- MUNICIPAL BOUNDARY
- CULVERT
- STORM SEWER
- STORM SEWER INLET
- STORM SEWER OUTLET
- MANHOLE
- DITCH
- SUB-CATCHMENT INPUT NODE
- PUMP STATION
- EXISTING CULVERT WITH INADEQUATE CAPACITY @ 10-YEAR EVENT SEE TABLE 3.2

LABELLING CONVENTION

HYD C 120

- CULVERT, DITCH, OR NODE NUMBER
- IDENTIFIES CULVERT (C), DITCH (D), OR NODE (N)
- IDENTIFIES STREET OR WATERCOURSE



NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		JULY 2003
DESIGNED	J.F.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND PORT COQUITLAM

EXISTING NETWORK INVENTORY

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.3d		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

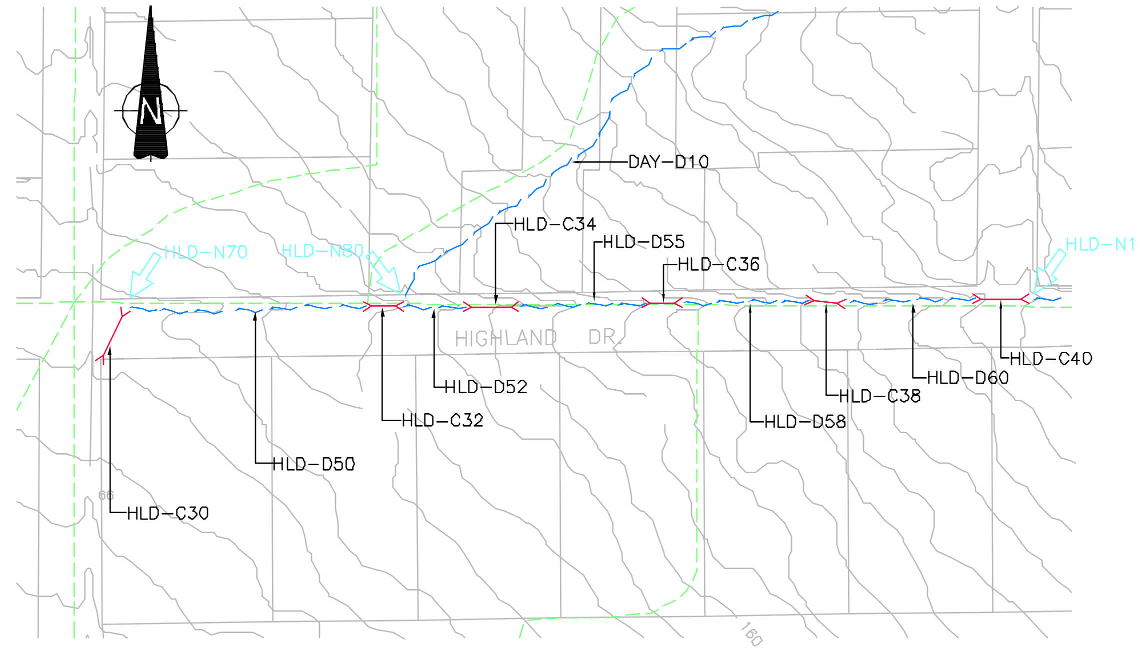
LEGEND

- SUB-CATCHMENT BOUNDARY
- MUNICIPAL BOUNDARY
- CULVERT
- STORM SEWER
- STORM SEWER INLET
- STORM SEWER OUTLET
- MANHOLE
- DITCH
- SUB-CATCHMENT INPUT NODE

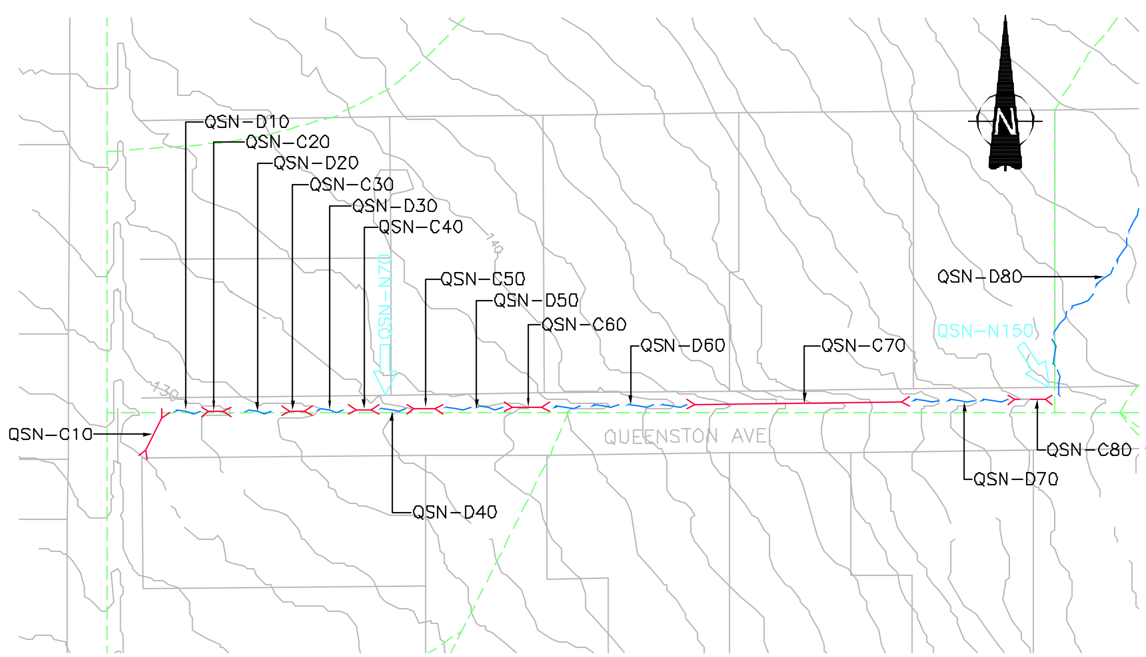
LABELLING CONVENTION

HYD C 120

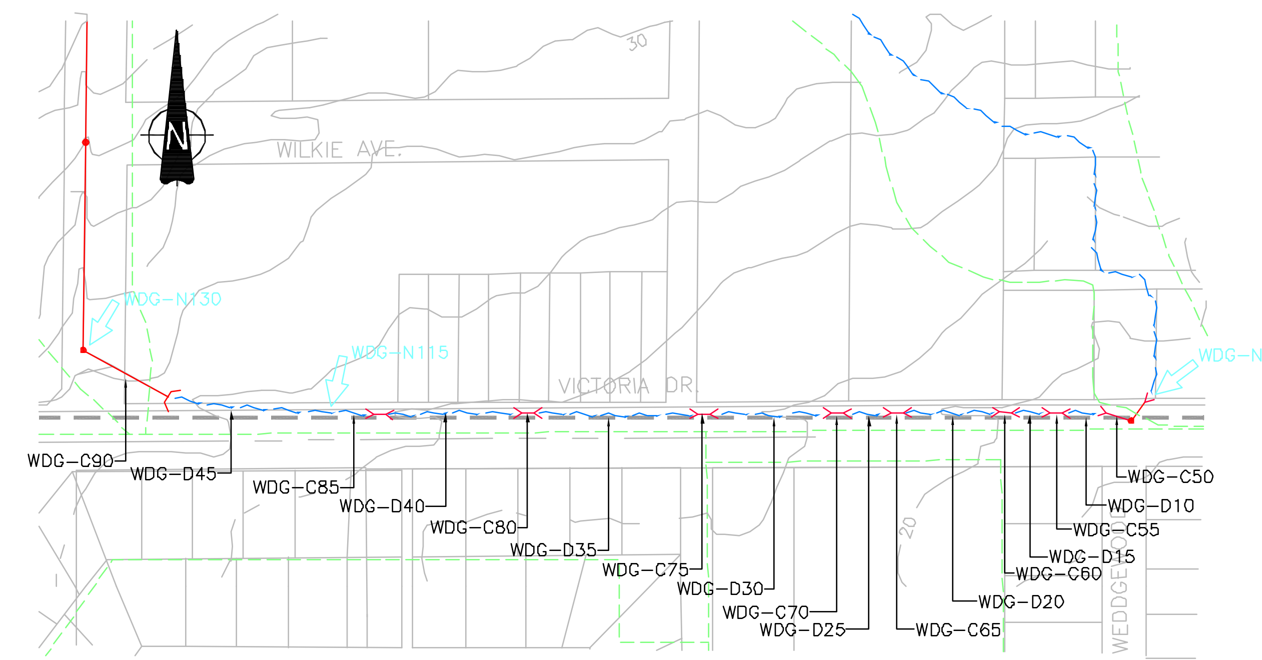
- CULVERT, DITCH, OR NODE NUMBER
- IDENTIFIES CULVERT (C), DITCH (D), OR NODE (N)
- IDENTIFIES STREET OR WATERCOURSE



DETAIL 1
SCALE 1:2500



DETAIL 2
SCALE 1:2500



DETAIL 3
SCALE 1:2500

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:7500		
DRAWN	G.Q.		NOV. 2002
DESIGNED	J.F.		NOV. 2002
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND PORT COQUITLAM

EXISTING NETWORK INVENTORY DETAILS

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3.3e		

STORM WATER MANAGEMENT ALTERNATIVES

SECTION 4

4.1 INTRODUCTION

This phase of the project identifies and evaluates alternatives to manage storm water, and protect environmental attributes in the Hyde Creek watershed.

4.2 POTENTIAL IMPACTS OF FUTURE DEVELOPMENT

Unmitigated, development in the Hyde Creek watershed will lead to changes in the hydrologic regime. Peak flows will increase as a result of an increase in impervious area and construction of conveyance systems which facilitate the rapid routing and concentration of storm water. As well as increased peak flows, the frequency of these large flows will increase. Local drainage channels and culverts could become undersized. Local flooding and damage may result.

Larger and more frequent peak flows will increase the rate of erosion at those sites already identified, and will likely result in more erosion sites becoming active. This material will be transported downstream, with increased deposition occurring in areas where gradients decrease and the flows no longer have the energy to transport the eroded material. This will become particularly evident in the stream reaches below Victoria Drive.

Similarly, increased frequency and magnitude of peak flows will result in a change in creek channel characteristics. In the upper portions of the watershed, at steeper gradients, the creek channels will tend to widen and cut deeper into its bed (degrade). In lower gradient reaches eroded material from upstream will be deposited, forcing the channel to widen to increase capacity.

Deposition will result in increased O&M costs involved in maintaining channels and culverts. If maintenance does not keep pace with increased deposition then channel capacity will be reduced. During large events, there will be an increased likelihood that a stream will flood adjacent property, or a channel avulsion (a spontaneous rerouting of flow) will occur.

Increased peak flows will also cause an increase in debris mobility and blockages of the stream channels and hydraulic structures. Large wood debris, that is mobilized from overbank areas by high flows, can cause local channel blockages. During very high flows, debris can be transported to more critical locations, such as culverts, where flooding and increased erosion or washouts could result.

Interception and routing of runoff that would normally infiltrate will result in base flows being reduced during dry, low flow periods. This will exacerbate base flow problems that exist in Hyde Creek within Port Coquitlam, and observed sites of low base flow higher in the watershed.

Changes in the hydrologic regime will also have environmental consequences. Low base flows obviously pose a threat to resident fish species. Spawning habitat may be damaged or destroyed by either erosion or deposition of material. Channel avulsions within flood plain areas, for example within the Hyde Creek ravine below David Avenue, could result in destruction of valuable habitat and trees, or undermine ravine slopes.

4.3 LOW IMPACT DEVELOPMENT

Low impact development (LID) is defined as land use and development standards and practices that reduce the impact of land development on the natural environment. The basic principles are to maximize infiltration by minimizing impervious surfaces, creating hydraulic disconnects, lengthening water flow paths, dispersing runoff, and providing water storage. This leads to conservation of natural features by reducing the harmful effects of high peak flows and by retaining summer base flows in creeks. LID practices are generally source control methods of handling water to approximate natural storage and infiltration functions to the degree possible.

Some benefits of LID include:

- Hydrological function of capturing runoff from frequently occurring, small rainfall events, allowing infiltration and more likely retention of summer base flows in creeks, and
- Reduction of pollutants reaching watercourses as a result of contaminated water passing through soils and plants.

Within the Hyde Creek watershed, two primary conditions exist with respect to the potential for implementation of LID. Most of the land area within the City of Port Coquitlam is already developed. The potential for implementing LID there is limited to redevelopment, upgrading or infill of already developed areas.

In the City of Coquitlam, the Official Community Plan for Northeast Coquitlam defines land uses that will result in major new development at densities that are much higher than those that exist. In July 2003, the City completed both a Subdivision Development Servicing Bylaw and a companion Stormwater Management Policy and Design Manual that provide guidelines related to the potential for LID. The Hyde Creek IWMP is also considering how LID methods could help to minimize the impacts of development on environmental resources.

4.3.1 LID Practices

The following are potential LID practices that could apply within the Hyde Creek watershed:

- Disconnected impervious surfaces (e.g., sidewalks and roof leaders drain to pervious landscape areas, not storm sewers),
- Minimize impervious surfaces (e.g., narrower roads, driveways and sidewalks, decks instead of patios, permeable porous paving, underground parking instead of surface impervious parking),
- Absorbent landscaping (e.g. 300 mm soil depth, increased planting areas, increased surface roughness through grading or planting, increased flow path through sheet flow, flattened swales, preservation of existing vegetation),
- Infiltration facilities (e.g., surface bioretention areas or rain gardens, subsurface channels or infiltration chambers, biofiltration swales in parking lots),
- Road side drainage swales or infiltration trenches,
- Roof-top storage (e.g., landscape “green” roofs, detention, storage for reuse),
- Rainwater reuse (e.g. rain barrels, cisterns, tanks in large buildings).

The use of LID can help to protect environmental resources primarily by helping to retain summer base flows in creeks. If implemented consistently over entire subwatersheds, they could also enable reduction in storm water infrastructure needs, e.g. smaller detention ponds and pipes.

4.3.2 LID Analysis Assumptions

The following sections analyze the proposed forms of development within Northeast Coquitlam and future redevelopment within Port Coquitlam. LID options and their potential effects on perviousness are identified. The following analysis is based on the general parameters discussed in the GVRD guidebook as they could be applied to the Hyde Creek Watershed.

Underlying Material

The potential LID applications are partially dependent on the underlying material. Where the porosity of the underlying material is minimal, there are more limits on LID methods. However, LID is not impossible in these areas. It can still be achieved by building up a permeable surface layer (similar to a natural forest) and by using grades to enable some infiltration.

The analysis addresses underlying material that is either permeable or impermeable. Although this represents the extreme conditions, in fact there are likely many areas with underlying materials that are somewhat permeable. In these areas, infiltration will be between the high and low values provided. Where the underlying material is somewhat permeable, slowing down runoff through measures such as deeper growing medium can make infiltration more likely by holding the water in place longer.

Effective Impervious Area (EIA)

EIA is used as an indicator of the relative amount of storm water flowing into the storm water pipe system. EIA is a physical measurement of impermeable surfaces (usually expressed as a percentage of a given land area) such as pavement and building roofs that are directly connected to the drainage system.

Infiltration Targets

Recent literature on storm water management provides two different methods for determining targets for infiltration. One is that the target storm to be infiltrated has 25 mm of rainfall in 24 hours. This statistic is based on the fact that a majority of the storms in southwest B.C. are under 25 mm. The other method states that

50% of the mean annual rainfall should be infiltrated, since 75% of storms are less than this amount. Therefore, for the purpose of the LID analysis, the target level of infiltration is 25 mm of rainfall and reflects the general approach in the GVRD guidebook.

Permeability

Permeability is not a black or white condition, as is often the interpretation from literature that discusses the extent of permeable vs. impermeable areas. For example, traditional asphalt is 100% impermeable when it is installed (ideally), but over time cracking and settling result in an impermeability of 90 to 95%. Gravel is usually considered pervious, but highly compacted gravel can be almost completely impervious. Landscaped areas are typically considered pervious; however, this is highly dependent on the depth and type of growing medium combined with the underlying material.

The average good quality landscape soil (imported growing medium) has a pore space of 25%. Therefore, 100 mm of growing medium would hold 25 mm of rainfall. However, if the ground was already saturated, there would be no ability to absorb more rain. In addition, landscape areas are often required to absorb water from adjacent surfaces as well, e.g. sidewalks or driveways. A 100 mm depth of dry growing medium could only absorb a 25 mm storm without any capacity to absorb water from surrounding areas. These conditions explain why the newer literature on low-impact development recommends a 300 mm depth of soil to enable infiltration. For the purpose of this analysis, it is assumed that 100 mm of soil will typically be saturated when the 25 mm storm occurs.
For the reasons described above, the following analysis provides different LID options for different underlying ground conditions, and calculations of imperviousness are adjusted based on estimates of the relative ability of each material or option to infiltrate the 25 mm storm.

Northeast Coquitlam Land Use

The conceptual plans prepared for the two neighbourhood plan areas (Upper Hyde Creek Village and Lower Hyde Creek Village) provide the best available basis for estimating the future form of development in Northeast Coquitlam. Statistics from these plans were therefore used as a baseline for estimating perviousness. It is understood that these plans are conceptual and that they have not been approved.

4.3.3 Roads - Coquitlam

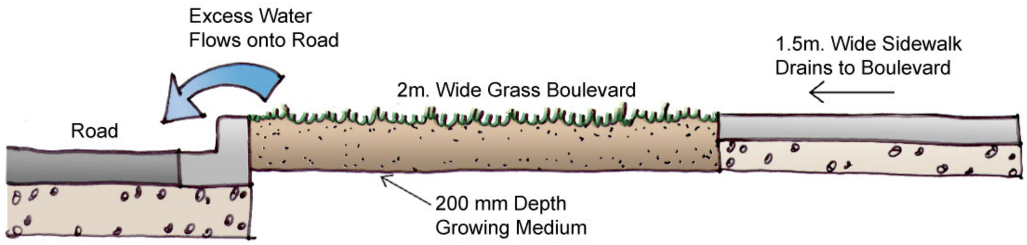
The total land area of road rights-of-way within the neighbourhood plan areas has been provided to the Hyde Creek IWMP team to assist in this analysis. New road cross-sections have been developed by the City of Coquitlam as part of their recent Subdivision Bylaw. At the time that this analysis was taking place they were not directly available to the IWMP team; instead, the City provided the percent of impervious area for each road type. The IWMP team was also provided with certain details of the road standards including configuration of curbs and gutters, grass boulevards with trees (with 100 mm of growing medium as the standard for grass areas), and disconnected sidewalks that drain into the boulevard. Based on the information provided, the following tables provide the extent and perviousness of the roads.

Lower Hyde Creek Village NP (Area 56.27 ha)				
	Area (ha) in NP (ROW)	**ROW % of NP Area**	**Impervious % of ROW**	**Pervious Area (ha)**
Local Roads	4.95	8.8%	50.3	2.46
Collectors	1.43	2.5%	56.5	0.62
Arterials	2.90	5.2%	59.6	1.17
Lanes	0.82	1.5%	65.0	0.29
Total	**10.11**	**18.0%**		**45.0%**

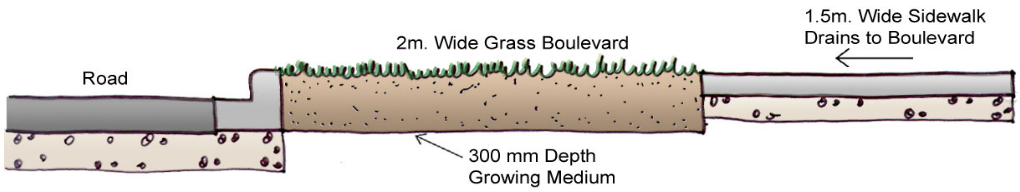
Upper Hyde Creek Village NP (Area 62.70 ha)				
	Area (ha) in NP (ROW)	**ROW % of NP Area**	**Impervious % of ROW**	**Pervious Area (ha)**
Local Roads	5.62	9.0%	50.3	2.79
Collectors	3.31	5.3%	56.5	1.44
Arterials	2.52	4.0%	59.6	1.02
Lanes	1.69	2.7%	65.0	0.59
Total	**13.14**	**21.0%**		**44.5%**

Using the average of the two neighbourhood plans, road rights-of-way occupy 19.5% (rounded to 20% for future reference) of the entire plan area. The stated average pervious area within these rights-of-way is 44.75% (rounded to 45%). However, with only 100 mm of growing medium in the boulevards and the sidewalk draining into this area as well, the boulevards are not likely to infiltrate 50% of the mean annual return period rainfall if the underlying soils are not at least moderately permeable.

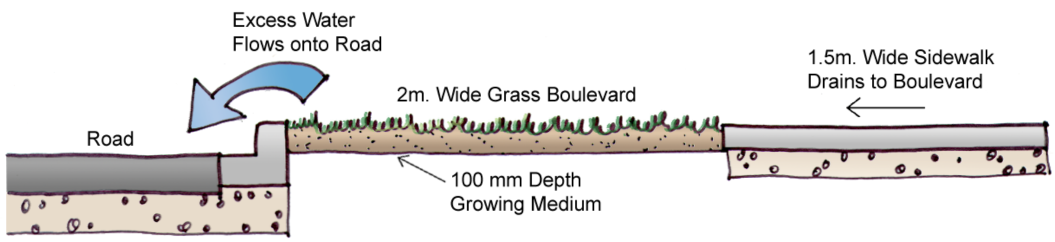
The following sketches illustrate a range of options with estimates of perviousness and effective impervious area. The estimates of EIA are based on a relatively impermeable underlying material.



Option 1: *Increase growing medium to 200 mm – Perviousness 75% of stated amount -* ***Estimated EIA 66%*** *(approx.)*

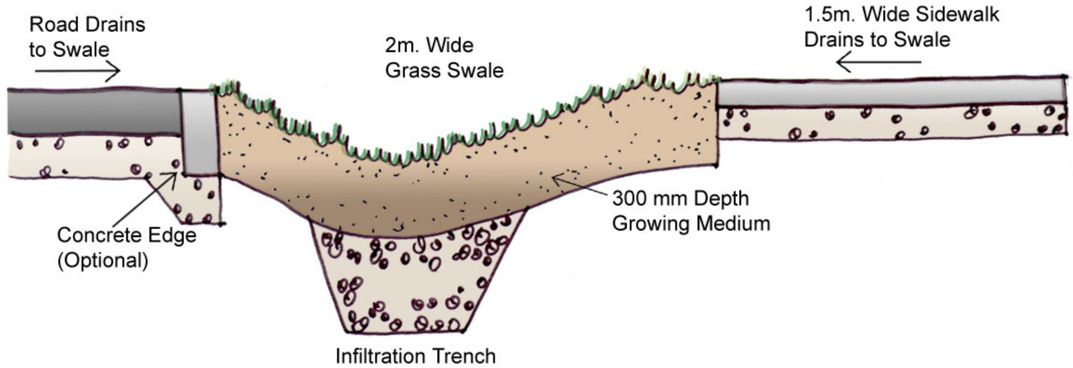


Option 2: *Increase growing medium to 300 mm – Perviousness at stated amount*

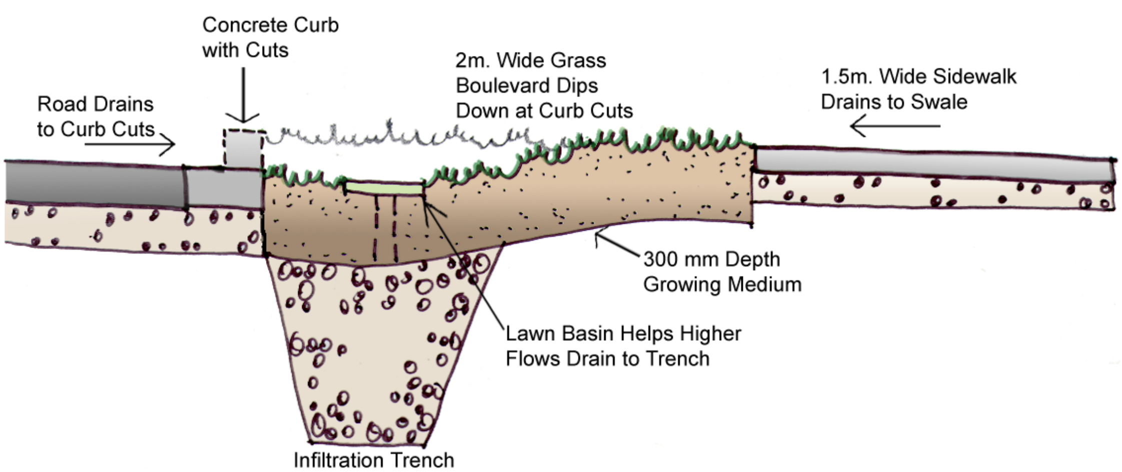


Existing Proposal *– Perviousness 50% of stated amount due to shallow soil depth -* ***Estimated EIA 77%*** *(approx.)*

The next option for reducing EIA within the road rights-of-way would be to infiltrate the water from local roads. Local roads occupy the largest land area of any of the road types, and since they are the smallest roads, they are typically the ones on which a less urban standard is more acceptable. There are two primary methods by which the water from these roads could be infiltrated: using roadside swales, or with curb cuts enabling the water to flow into an infiltration trench, as shown below.



Option 3: *Increase growing medium to 300 mm and infiltrate water from local roads with a swale and no curb. -* ***Estimated EIA 32%*** *(approx.)*



Option 4: *Increase growing medium to 300 mm and infiltrate water from local roads with a trench and curb cuts -* ***Estimated EIA 32%*** *(approx.)*

The advantage of Option 3 vs. Option 4 is that the positive drainage to the swale performs better. The disadvantage could be perceived to be a potential untidy appearance (the concrete edge can partially address this), and the fact that there is no barrier between vehicles and the swale. Option 4 retains the curb to address these considerations; however, more infrastructure is required to ensure that the water flows into the trench.

Option 5

A final option would be to make the lanes entirely pervious. There are several options for this including: gravel surface on permeable base, concrete for driving lanes with some form of permeable paving surrounding this, e.g., permeable asphalt, pave-el, reinforced grass. The additional overall reduction in impervious area from this option would be 6% for the entire right-of-way area.

4.3.4 Roads – Port Coquitlam

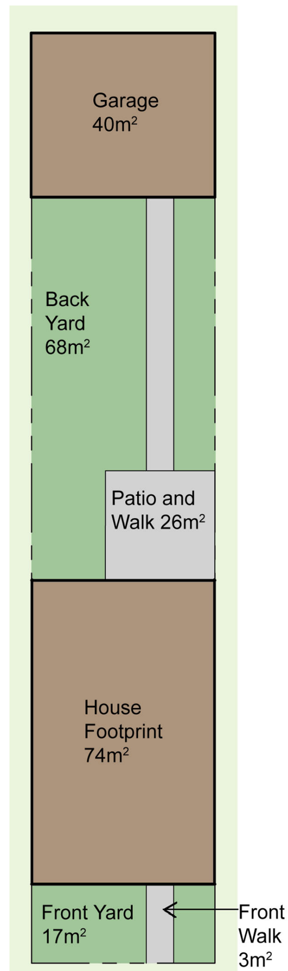
The roads in Port Coquitlam are fully developed. Most of them are based on traditional urban standards with curb and gutter. Some portions of the older neighbourhoods have local roads with swales. Given the age of some of the roads and likely pavement cracking, the existence of some swales, and well developed vegetation along many of the roads, the overall EIA of road rights-of-way in Port Coquitlam is estimated at 55%. This is considered unlikely to change.

4.3.5 Residential Development

The following sections review a range of residential densities and LID options that may apply in each condition. The sketches are conceptual, but they are representative of the range of densities proposed in the Northeast Coquitlam OCP and potential new development patterns in Port Coquitlam. Older Port Coquitlam neighbourhoods are addressed specifically.

Street-oriented Townhomes

Street-oriented townhomes are attached units on individual lots that are 6.7 by 34 m (see sketch). The lot has a small front yard and double car attached garage accessible from a rear lane. The sketch shows a typical extent of patio and walkways.



The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on typical development materials and assumptions.

Street-oriented Townhomes		
	Area (m2)	**% of Lot Area**
House Footprint	74	32.5%
Garage	40	17.5%
Patio and Walkways	29	12.7%
Total Impervious	**143**	**62.7%**
Back and Side Yards	68	29.8%
Front Yard	17	7.5%
Total Pervious	**85**	**37.3%**
Total	**228**	**100%**

Note: some patios and walkways may be disconnected, but many would likely drain to the street or tile drains surrounding houses.

The following table identifies a range of low impact development methods that could reduce the impervious area of the street-oriented townhomes.

Traditional and Low Impact Development Methods	**EIA (permeable underlying material)**	**EIA (impermeable underlying material)**
Traditional form of development with 100 mm depth growing medium in yard areas	63%	81% (permeability of yards reduced by 50% due to expected overflow)
Traditional form of development with 200 mm depth growing medium in yard areas	63%	73% (permeability of yards reduced by 25% due to expected overflow)
300 mm depth growing medium in yard areas	63%	63% (some overflow in saturated winter conditions could still occur)
ADD permeable patio and walkways	50%	50% (only with minimum 300 mm base for drainage)
ADD garage roof disconnected, e.g. holds water 25 mm deep for slow release; "green" roof minimum 100 mm deep; or roof drains to infiltration area – could include cistern.	Not practical# (unless lane is permeable yielding EIA 33%)	Not practical#

#With higher percentages of impervious lot coverage there is not likely to be sufficient area of permeable soils to accept runoff for infiltration from all impervious surfaces.

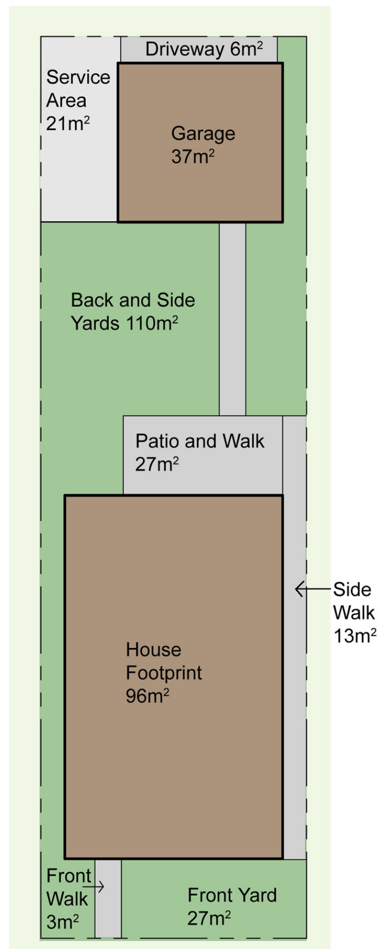
Note: the depth of growing medium is not a factor with a completely permeable subgrade since the water will all drain away. If the underlying material is somewhat permeable, the greater growing medium depths will encourage infiltration by retaining water until it can infiltrate.

Small Village Single Family

The small village single family lot is 10 by 34 m (see sketch). The lot has a small front yard and double car garage accessible from a rear lane. The sketch shows a typical extent of patio and walkways. A service area adjacent to the garage can be used as a maintenance area or parking for a boat, third vehicle or RV.

The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on typical development materials and assumptions.

Small Village Single Family		
	Area (m2)	**% of Lot Area**
House Footprint	96	28.2%
Garage	37	10.9%
Patio and Walkways	43	12.6%
Driveway	6	1.8%
Service Area	21	6.2%
Total Impervious	**203**	**59.7%**
Back and Side Yards	110	32.4%
Front Yard	27	7.9%
Total Pervious	**137**	40.3%
Total	**340**	**100%**



Note: some patios and walkways may be disconnected, but many would likely drain to the street or tile drains surrounding houses.

The following table identifies a range of low impact development methods that could reduce the impervious area of the small village single family lot.

Traditional and Low Impact Development Methods	**EIA (permeable underlying material)**	**EIA (impermeable underlying material)**
Traditional form of development with 100 mm depth growing medium in yard areas	60%	80% (permeability of yards reduced by 50% due to expected overflow)
Traditional form of development with 200 mm depth growing medium in yard areas	60%	70% (permeability of yards reduced by 25% due to expected overflow)
300 mm depth growing medium in yard areas	60%	60% (some overflow in saturated winter conditions could still occur)
ADD permeable patio, walkways, and service area	40%	40% (only with minimum 300 mm base for drainage)
ADD garage roof disconnected, e.g. holds water 25 mm deep for slow release; “green” roof minimum 100 mm deep; or roof drains to infiltration area – could include cistern.	30%	30%

Note: the depth of growing medium is not a factor with a completely permeable subgrade since the water will all drain away. If the underlying material is somewhat permeable, the greater growing medium depths will encourage infiltration.

Large Village Single Family

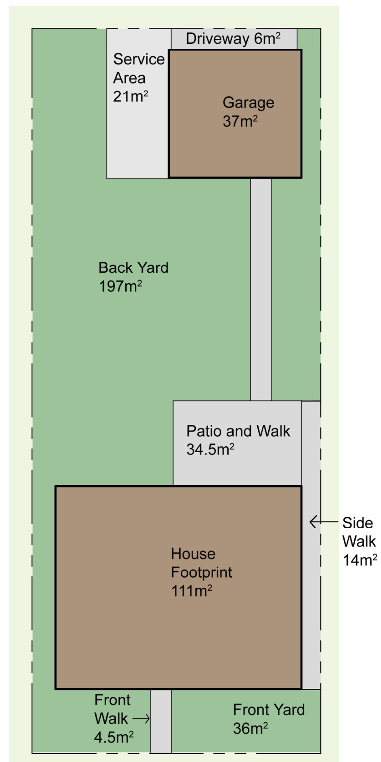
The large village single family lot is 13.5 by 34 m. The lot has a small front yard and double car garage accessible from a rear lane. The sketch shows a typical extent of patio and walkways. A service area adjacent to the garage can be used as a maintenance area or parking for a boat, third vehicle or RV.

The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on typical development materials and assumptions.

Large Village Single Family		
	Area (m2)	**% of Lot Area**
House Footprint	111	24.1%
Garage	37	8.0%
Patio and Walkways	53	11.5%
Driveway	6	1.3%
Service Area	20	4.3%
Total Impervious	**227**	**49.3%**
Back and Side Yards	197	42.8%
Front Yard	36	7.8%
Total Pervious	**233**	**50.7%**
Total	**460**	**100%**

Note: some patios, driveways and walkways may be disconnected, but many would likely drain to the street or tile drains surrounding houses.

The following table identifies a range of low impact development methods that could reduce the impervious area of the large village single family lot.



Traditional and Low Impact Development Methods	EIA (permeable underlying material)	EIA (impermeable underlying material)
Traditional form of development with 100 mm depth growing medium in yard areas	50%	75% (permeability of yards reduced by 50% due to expected overflow)
Traditional form of development with 200 mm depth growing medium in yard areas	50%	62% (permeability of yards reduced by 25% due to expected overflow)
300 mm depth growing medium in yard areas	50%	50% (some overflow in saturated winter conditions could still occur)
ADD permeable patio, walkways, and service area	35%	35% (only with minimum 300 mm base for drainage)
ADD garage roof disconnected, e.g. holds water 25 mm deep for slow release; "green" roof minimum 100 mm deep; or roof drains to infiltration area – could include cistern.	27%	27%
ADD house roof disconnected - drains to infiltration area	5%*	Not practical#

#With higher percentages of impervious lot coverage there is not likely to be sufficient area of permeable soils to accept runoff for infiltration from all impervious surfaces.

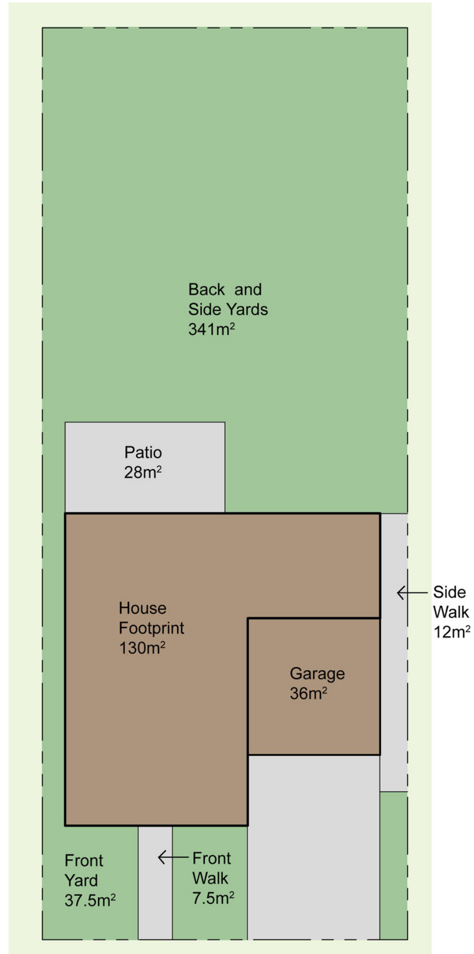
*Although the impermeability in this case would theoretically be 0%, in practice a nominal amount of water would likely drain off.

Note: the depth of growing medium is not a factor with a completely permeable subgrade since the water will all drain away. If the underlying material is somewhat permeable, the greater growing medium depths will encourage infiltration.

Large Single Family

The large single family lot is 16 by 40 m (see sketch). The lot has a larger front yard setback and double car garage accessible from the street and recessed from the façade of the house. The sketch shows a typical extent of patio and walkways.

The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on typical development materials and assumptions.



Large Single Family		
	Area (m2)	**% of Lot Area**
House Footprint	130	20.3%
Garage	36	5.6%
Patio and Walkways	48	7.5%
Driveway	48	7.5%
Total Impervious	**262**	**40.9%**
Back and Side Yards	341	53.3%
Front Yard	37	5.8%
Total Pervious	**378**	**59.1%**
Total	**640**	**100%**

Note: some patios, driveways and walkways may be disconnected, but many would likely drain to the street or tile drains surrounding houses.

The following table identifies a range of low impact development methods that could reduce the impervious area of the large single family lot.

Traditional and Low Impact Development Methods	EIA (permeable underlying material)	EIA (impermeable underlying material)
Traditional form of development with 100 mm depth growing medium in yard areas	40%	70% (permeability of yards reduced by 50% due to expected overflow)
Traditional form of development with 200 mm depth growing medium in yard areas	40%	65% (permeability of yards reduced by 25% due to expected overflow)
300 mm depth growing medium in yard areas	40%	40% (some overflow in saturated winter conditions could still occur)
ADD permeable patio and walkways	33%	33% (only with minimum 300 mm base for drainage)
ADD permeable driveway	25%	25% (only with minimum 300 mm base for drainage)
ADD house and garage roof disconnected - drains to infiltration area – could include cistern.	5%*	Not practical

Notes:

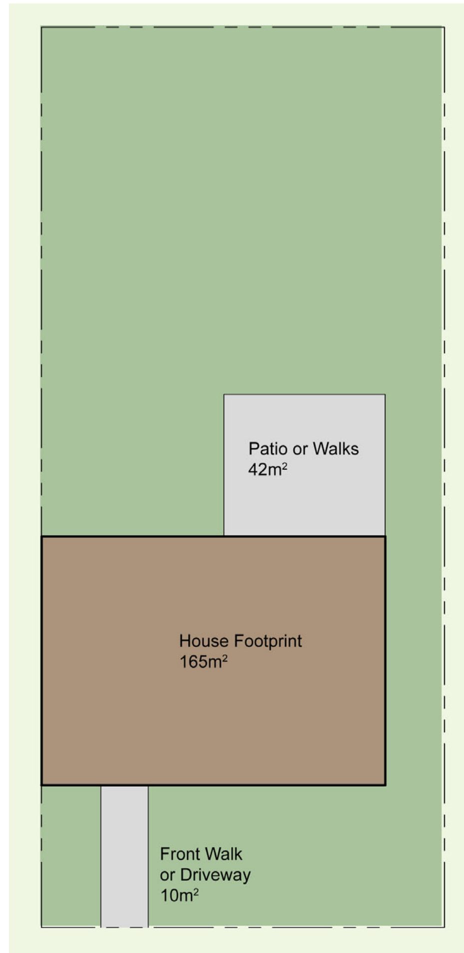
The depth of growing medium is not a factor with a completely permeable subgrade since the water will all drain away. If the underlying material is somewhat permeable, the greater growing medium depths will encourage infiltration.

*Although the impermeability in this case would theoretically be 0%, in practice a nominal amount of water would likely drain off.

Existing Port Coquitlam Neighbourhoods

Opportunities for low-impact development in Port Coquitlam may occur in new developments, which will likely be very similar to the housing densities described above. However, the areas proposed for redevelopment are limited.

There are older neighbourhoods in Port Coquitlam where densities will remain as they are. The primary opportunities for low impact development will be through upgrading or redevelopment of individual lots. This analysis is based on air photo interpretation of a "typical" existing lot in these neighbourhoods (see sketch). An average lot size is 17 by 38 m. Some homes have garages and others park on the street (therefore an average front walk or driveway is illustrated). Most of the lots have a high percentage of vegetative cover; an average amount of paving is shown in the rear of the lot.



The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on typical patterns of development in these neighbourhoods.

Older Port Coquitlam Neighbourhoods		
	Area (m2)	**% of Lot Area**
House Footprint	165	25.5%
Patio/Walkways/Driveway	52	8.0%
Total Impervious	**217**	**33.6%**
Back and Side Yards	339	52.5%
Front Yard	90	13.9%
Total Pervious	**429**	**66.4%**
Total	**646**	**100%**

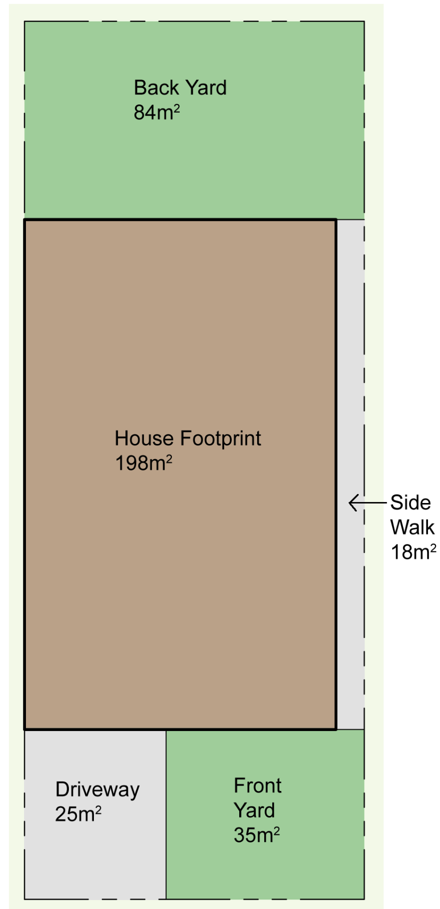
Note: some patios, driveways and walkways may be disconnected, but many would likely drain to the street or tile drains surrounding houses

The following table identifies a range of low impact development methods that could reduce the impervious area in the older single family lots.

Traditional and Low Impact Development Methods	EIA (permeable underlying material)	EIA (impermeable underlying material)
Existing form of development (extent of vegetation implies a fairly permeable surface in front and back yards)	33%	33%
ADD permeable patio, driveway and walkways	25%	25%
ADD house (and garage roof) disconnected - drains to infiltration area– could include cistern.	0%*	Not practical

#With higher percentages of impervious lot coverage there is not likely to be sufficient area of permeable soils to accept runoff for infiltration from all impervious surfaces.
*Although the impermeability in this case would theoretically be 0%, in practice a nominal amount of water would likely drain off.

Port Coquitlam Townhomes and Small Lot Residential



There are areas of newer development in Port Coquitlam of townhomes and small lot residential. There are also several blocks in Port Coquitlam where this type of development is anticipated in the OCP.

The form of development in this area is similar to the townhomes and small village single family uses in Coquitlam. In Port Coquitlam, some of these areas have lanes, and others do not. The example shown has no lane, illustrating a form of development different from the examples shown previously.

The analysis of this form of housing is based on air photo interpretation of a "typical" existing lot in these neighbourhoods (see sketch). An average lot size is 12 by 31 m. The homes appear to have garages since most have driveways. They may be duplexes due to the size of the building footprint. These lots have a low percentage of vegetative cover, with large building footprints in relation to the lot size.

The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on typical patterns of development in these neighbourhoods.

Port Coquitlam Townhomes and Small Lots		
	Area (m2)	**% of Lot Area**
House Footprint	198	55.0%
Patio/Walkways/Driveway	43	11.9%
Total Impervious	**241**	**66.9%**
Back and Side Yards	84	23.3%
Front Yard	35	9.7%
Total Pervious	**119**	**33.1%**
Total	**360**	**100%**

Note: some patios, driveways and walkways may be disconnected, but many would likely drain to the street or tile drains surrounding houses

The following table identifies a range of low impact development methods that could reduce the impervious area in the townhome/small lot area of Port Coquitlam. Disconnected roof leaders are not considered practical here due to the small lot sizes and existing level of development.

Traditional and Low Impact Development Methods	EIA (permeable underlying material)	EIA (impermeable underlying material)
Traditional form of development with 100 mm depth growing medium in yard areas	67%	83% (permeability of yards reduced by 50% due to expected overflow)
Traditional form of development with 200 mm depth growing medium in yard areas	67%	75% (permeability of yards reduced by 25% due to expected overflow)
300 mm depth growing medium in yard areas	67%	67% (some overflow in saturated winter conditions could still occur)
ADD permeable patio and walkways	55%	55% (only with minimum 300 mm base for drainage)

Notes:

The depth of growing medium is not a factor with a completely permeable subgrade since the water will all drain away. If the underlying material is somewhat permeable, the greater growing medium depths will encourage infiltration.

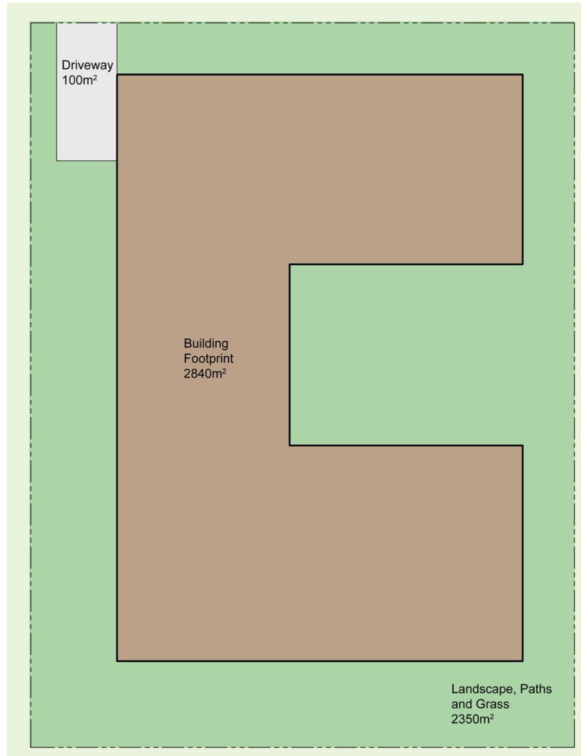
Village Medium Density – Coquitlam

A small portion of the watershed within Coquitlam is designated as village medium density. For the purpose of this planning exercise, it is assumed that the primary form of development in that area will be street-oriented townhomes.

Apartment – Port Coquitlam

A small portion of the watershed within Port Coquitlam is designated as apartment. A portion of this area already includes multi-family complexes. Several blocks of single family housing in the area will likely be converted to multi-family developments. Much of the existing apartment area includes lanes and a form of development similar to the townhome development proposed in Coquitlam. The EIAs for that use are therefore used in the analysis, with some benefits to be realized from low impact development in the areas that are not yet built to this density.

Village High Density



A small portion of the watershed within Coquitlam is designated as village high density. The specific form of development in that area has not yet been determined; however, it has been identified as being composed of stacked townhomes and residential apartments. For the purpose of this planning exercise, it is assumed that the form of development would be similar to the high density area near Coquitlam's city hall. Air photo interpretation was therefore used to determine a typical lot configuration (see sketch).

The example shown is a mid-rise apartment building with a two-lane driveway to underground parking. The building footprint is relatively large. It is assumed that the remainder of the site would be approximately 75% grass, 15% walkways and other forms of paving (e.g. plazas), and 10% planting beds. Much of the landscape area is over the parking garage, therefore it is assumed that the growing medium under grass is 100 mm with drain inlets to the storm sewer.

The following table identifies the components of the lot, with percent coverage, and summary of perviousness based on the example illustrated.

Village High Density		
	Area (m2)	**% of Lot Area**
Building Footprint	2840	53.7%
Driveway	100	1.9%
Walkways/Paving	352	6.7%
Total Impervious	**3292**	**62.2%**
Grass	1763	33.3%
Planting Beds	235	4.4%
Total Pervious	**1998**	**37.8%**
Total	**5290**	**100%**

The following table identifies a range of low impact development methods that could reduce the impervious area of the apartment form of development. In this situation, the permeability of the underlying material is not a consideration since almost the entire site area would be occupied by the structure (i.e. underground parking).

Traditional and Low Impact Development Methods	EIA
Traditional form of development with 100 mm depth growing medium in grass areas	79% (permeability of grass reduced by 50% due to expected overflow)
Traditional form of development with 200 mm depth growing medium in grass areas	71% (permeability of yards reduced by 25% due to expected overflow)
300 mm depth growing medium in grass areas	62% (some overflow in saturated winter conditions could still occur)
ADD permeable walkways and paved areas	56% (only with minimum 300 mm base for drainage)
ADD building roof holds water (.e.g. 25 mm deep) for slow release; or “green” roof minimum 100 mm deep; or roof drains to storage tanks for rainwater reuse	30% (theoretically lower, but that becomes expensive; estimate is therefore conservative)

Commercial

A small portion of the watershed within Port Coquitlam is already commercial development. This area is occupied by large buildings and parking lots. An EIA of 90% is assumed and considered unlikely to change.

Parks

Existing and proposed parks within the study area range from natural forested areas (e.g. Port Coquitlam Nature Area) to intensive parks containing play areas and sports fields. It is assumed that many of the parks in Northeast Coquitlam will be intensively developed, except for the linear park, since ESAs will provide the natural forested space and because the parks will be required to accommodate the active recreation needs of the future population. The estimated average EIA without low impact development is therefore 30%.

In Port Coquitlam, since so much of the park area is forested, the average existing EIA is estimated at 10%. Changes to the perviousness of existing parks are considered unlikely.

Schools

Elementary School

The following table provides a summary of lot coverage and permeability for a typical elementary school.

Elementary Schools		
	Area (m2)	**% of Lot Area**
School Footprint	7000	31.1%
Parking/Walks/Paving	1500	6.7%
Total Impervious	**8500**	**37.8%**
Play Fields	12000	53.3%
Play Area/Landscape	2000	8.9%
Total Pervious	**14000**	**62.2%**
Total	**22500**	**100%**

The following table identifies a range of low impact development methods that could reduce the impervious area. School sites provide an excellent opportunity to showcase low impact development. These methods are possible on any underlying material.

Traditional and Low Impact Development Methods	EIA (permeable underlying material)	EIA (impermeable underlying material)
Existing form of development (assuming that play fields are disconnected and built with proper drainage layers)	38%	38%
ADD disconnected paved areas – all drain to surrounding landscape (with proper drainage layers)	31%	31%
ADD disconnected school roof, e.g. holds water 25 mm deep for slow release; "green" roof minimum 100 mm deep; or roof drains to infiltration area	5%*	5%* (more difficult and expensive, but possible)

*Although the impermeability in this case would theoretically be 0%, in practice a nominal amount of water would likely drain off.

Secondary School

The following table provides a summary of lot coverage and permeability for a typical secondary school.

Secondary Schools		
	Area (m2)	**% of Lot Area**
School Footprint	22000	38.6%
Parking/Walks/Paving	4000	7.0%
Total Impervious	**26000**	**45.6%**
Play Fields	24000	42.1%
Play Area/Landscape	7000	12.3%
Total Pervious	**31000**	**54.4%**
Total	**57000**	**100%**

The following table identifies a range of low impact development methods that could reduce the impervious area. School sites provide an excellent opportunity to showcase low impact development.

Traditional and Low Impact Development Methods	EIA (permeable underlying material)	EIA (impermeable underlying material)
Existing form of development (assuming that play fields are disconnected and built with proper drainage layers to support irrigation)	45%	45%
ADD disconnected paved areas – all drain to surrounding landscape (with proper drainage layers)	39%	39%
ADD disconnected school roof, e.g. holds water 25 mm deep for slow release; "green" roof minimum 100 mm deep; or roof drains to infiltration area	5%*	5% (more difficult and expensive, but possible)

*Although the impermeability in this case would theoretically be 0%, in practice a nominal amount of water would likely drain off.

4.3.6 Watershed Analysis of Imperviousness

The existing and potential ranges in imperviousness described above were used within the Hyde Creek watershed to analyze the potential imperviousness over the entire watershed. To accomplish this, GIS maps of the Coquitlam and Port Coquitlam OCPs were used. Given that the analysis is based on numerous estimates and assumptions, it must be considered an indicator only and a tool for comparisons and analysis, not a precise estimate of imperviousness. The following were some of the assumptions made:

Coquitlam Assumptions

- The Development Reserve (DR) was included with Environmentally Sensitive Areas, since the DR is unlikely to be developed for many years.

- Parks include the Linear Park and Extensive Recreation areas, as well as proposed detention pond areas in the neighbourhood plans.
- Schools include existing and proposed schools, with 2.25 ha assumed for elementary schools, and 5.75 for secondary. The EIA for schools is an average of values for secondary and elementary schools. This category also includes the one small commercial and institutional parcel.
- Road rights-of-way were assumed to occupy 20% of proposed development areas.
- Densities for the Upper and Lower Neighbourhood Plans were taken from the draft plans.
- Suburban residential was based on the same EIAs as large single family.
- The remaining Village Low Density area was assumed to have slightly higher density than the average of the Upper and Lower Neighbourhood Plans.

Port Coquitlam Assumptions

- Parks include the Park Reserve and Special Study area.
- Road rights-of-way were assumed to occupy 20% of residential and commercial areas.
- The Commercial area includes Local Commercial.
- The area of compact housing west of Port Coquitlam Nature Area was included with the townhouse area, since its EIA is closer to that than to single family housing. Air photo analysis was used to determine that the existing EIA is 70%. The EIA of townhouse areas is considered unlikely to change.
- No low impact development options are proposed for existing roads, since it is considered highly unlikely that infrastructure would be redeveloped.
- Some low impact development may take place in the older single family neighbourhoods, but the overall impact will be small since it is assumed that a relatively small percent of homes will be upgraded or redeveloped to these guidelines.

Scenarios

Various scenarios were explored to determine the potential effect of low impact development on the watershed as a whole. The following is a description of the scenarios:

- **Scenario 1:** Development will proceed in a traditional manner with the road cross-sections proposed in Coquitlam, and no low impact development on private land.

- **Scenario 2:** Development and roads will be constructed with 300 mm growing medium in all boulevard and landscape areas.

- **Scenario 3:** In addition to the above, local roads in Coquitlam will be built with infiltration and all patios, walkways and driveways within developments and parks will be infiltrated through disconnection and/or pervious surfaces.

- **Scenario 4:** In addition to the above, lanes in Coquitlam will be pervious and roofs will be disconnected where practical.

- **Scenario 5:** In addition to the above, where there are underlying permeable soils (to be determined), infiltration will be maximized.

The estimated existing condition EIAs for the watershed are 6% in Coquitlam and in the range of 37% to 39% in Port Coquitlam. The overall average EIA for the watershed under existing conditions is approximately 20%.

Results

Tables 4.1 and 4.2 provide the detailed analysis of the scenarios for every land use type. Table 4.1 presents the data in relation to the watershed as a whole. Table 4.2 summarizes the EIA for the portion of the watershed within each municipality separately. These tables provide a tool that can be used to experiment with different combinations of low impact development methods.

Tables 4.3 and 4.4 summarize the EIA analysis for each scenario. Table 4.3 indicates the EIA within each municipality as a weighted average of the whole watershed. Table 4.4 indicates the EIA within each municipality separately, that is as a percentage of the watershed within each municipality separate from the whole.

Table 4.3
Percentage EIA Relative to the Watershed as a Whole

Municipality	Scenario 1 EIA (%)	Scenario 2 EIA (%)	Scenario 3 EIA (%)	Scenario 4 EIA (%)	Scenario 5 EIA (%)
Coquitlam	23.13	16.63	12.92	9.10	
Port Coquitlam	16.95	16.22	15.45	15.45	
Total	**40.1**	**32.9**	**28.4**	**24.6**	

Table 4.4
Percentage EIA For Each Municipality Separately

Municipality	Scenario 1 EIA (%)	Scenario 2 EIA (%)	Scenario 3 EIA (%)	Scenario 4 EIA (%)	Scenario 5 EIA (%)[1]
Coquitlam	40.98	29.47	22.88	16.25	
Port Coquitlam	39.10	37.25	35.47	35.47	
Total	**40.1**	**32.9**	**28.4**	**24.6**	

[1]Could not be estimated as EIA % for Scenario 5 is highly dependent on soil conditions.

Some of the observations and conclusions from this analysis are as follows:

- The estimated existing condition EIA's for the watershed are 6% in Coquitlam and in the range of 37% to 39% in Port Coquitlam. The overall average EIA for the watershed under existing conditions is approximately 20%.
- With traditional forms of development (including Coquitlam's road standards as proposed), the EIAs in Coquitlam and Port Coquitlam's portions of the watershed are very similar, at around 40%.
- A significant reduction in the EIA, to the benefit of the entire watershed, can be achieved in Coquitlam through implementation of low impact

Coquitlam	Total Area (ha)	Percent of Watershed	Scenario 1 EIA of land area (typ.)	Scenario 1 EIA of total watershed	Scenario 2 EIA of land area (typ.)	Scenario 2 EIA of total watershed	Scenario 3 EIA of land area (typ.)	Scenario 3 EIA of total watershed	Scenario 4 EIA of land area (typ.)	Scenario 4 EIA of total watershed	Scenario 5 EIA of land area (typ.)	Scenario 5 EIA of total watershed
ESAs	181.28	15.67%	1%	0.16%	1%	0.16%	1%	0.16%	1%	0.16%	1%	0.16%
Parks (existing and proposed)	153.91	13.30%	30%	3.99%	20%	2.66%	20%	2.66%	10%	1.33%	10%	1.33%
Schools (existing and proposed)	20.41	1.76%	41%	0.72%	41%	0.72%	35%	0.62%	1%	0.02%	1%	0.02%
Roads	66.60	5.76%	77%	4.43%	55%	3.17%	32%	1.84%	26%	1.50%	26%	1.50%
Upper Hyde Creek Village												
Street-oriented Townhome	2.02	0.17%	81%	0.14%	63%	0.11%	50%	0.09%	50%	0.09%	50%	0.09%
Small Village	5.74	0.50%	80%	0.40%	60%	0.30%	40%	0.20%	30%	0.15%	30%	0.15%
Large Village	13.95	1.21%	75%	0.90%	50%	0.60%	35%	0.42%	27%	0.33%	27%	0.33%
Large Single Family	7.61	0.66%	75%	0.49%	40%	0.26%	33%	0.22%	25%	0.16%	25%	0.16%
Estate Single Family	5.65	0.49%	75%	0.37%	40%	0.20%	33%	0.16%	25%	0.12%	25%	0.12%
Lower Hyde Creek Village												
Street-oriented Townhome	5.15	0.45%	47%	0.21%	63%	0.28%	50%	0.22%	50%	0.22%	50%	0.22%
Small Village	4.37	0.38%	45%	0.17%	60%	0.23%	40%	0.15%	30%	0.11%	30%	0.11%
Large Village	12.90	1.11%	55%	0.61%	50%	0.56%	35%	0.39%	27%	0.30%	27%	0.30%
Village Low Density Residential												
Street-oriented Townhome (20%)	15.71	1.36%	81%	1.10%	63%	0.86%	50%	0.68%	50%	0.68%	50%	0.68%
Small Village (20%)	15.71	1.36%	80%	1.09%	60%	0.81%	40%	0.54%	30%	0.41%	30%	0.41%
Large Village (40%)	31.42	2.72%	65%	1.76%	50%	1.36%	35%	0.95%	27%	0.73%	27%	0.73%
Large Single Family (12%)	9.43	0.81%	27%	0.22%	40%	0.33%	33%	0.27%	25%	0.20%	25%	0.20%
Estate Single Family (8%)	6.28	0.54%	15%	0.08%	40%	0.22%	33%	0.18%	25%	0.14%	25%	0.14%
Village Medium Density Residential	16.52	1.43%	81%	1.16%	63%	0.90%	50%	0.71%	50%	0.71%	50%	0.71%
Village High Density Residential	11.01	0.95%	79%	0.75%	62%	0.59%	56%	0.53%	30%	0.29%	60%	0.57%
Large Single Family	38.34	3.31%	75%	2.48%	40%	1.33%	33%	1.09%	25%	0.83%	25%	0.83%
Suburban Residential	29.17	2.52%	75%	1.89%	40%	1.01%	33%	0.83%	25%	0.63%	25%	0.63%
Total	**653.17**	**56.45%**		**23.13%**		**16.63%**		**12.92%**		**9.10%**		**N/A#**

Port Coquitlam	Total Area (ha)	Percent of Watershed	Scenario 1 EIA of land area (typ.)	Scenario 1 EIA of total watershed	Scenario 2 EIA of land area (typ.)	Scenario 2 EIA of total watershed	Scenario 3 EIA of land area (typ.)	Scenario 3 EIA of total watershed	Scenario 4 EIA of land area (typ.)	Scenario 4 EIA of total watershed	Scenario 5 EIA of land area (typ.)	Scenario 5 EIA of total watershed
Parks	91.00	7.86%	10%	0.79%	10%	0.79%	10%	0.79%	10%	0.79%	10%	0.79%
Schools	27.60	2.39%	41%	0.98%	42%	1.00%	41%	0.98%	41%	0.98%	41%	0.98%
Roads	77.08	6.66%	55%	3.66%	55%	3.66%	55%	3.66%	55%	3.66%	55%	3.66%
Townhouse (including small lot area)	30.28	2.62%	80%	2.09%	80%	2.09%	80%	2.09%	80%	2.09%	80%	2.09%
Commercial	7.15	0.62%	90%	0.56%	90%	0.56%	90%	0.56%	90%	0.56%	91%	0.56%
Apartment	28.25	2.44%	80%	1.95%	75%	1.83%	70%	1.71%	70%	1.71%	70%	1.71%
Residential	242.63	20.97%	33%	6.92%	30%	6.29%	27%	5.66%	27%	5.66%	27%	5.66%
Total	**504.00**	**43.55%**		**16.95%**		**16.22%**		**15.45%**		**15.45%**		**N/A#**

N:\022313\HYDGY\Report\April 04 Final\[Watershed3.xls]By Whole Watershed

 # Difficult to estimate as highly dependent on soils conditions

Table 4.1:
Detailed EIA Breakdown by Land Use Type for the Watershed as a Whole

Coquitlam	Total Area (ha)	Percent of Coq's Watershed	Scenario 1 EIA of land area (typ.)	Scenario 1 EIA of Coq's watershed	Scenario 2 EIA of land area (typ.)	Scenario 2 EIA of Coq's watershed	Scenario 3 EIA of land area (typ.)	Scenario 3 EIA of Coq's watershed	Scenario 4 EIA of land area (typ.)	Scenario 4 EIA of Coq's watershed	Scenario 5 EIA of land area (typ.)	Scenario 5 EIA of Coq's watershed
ESAs	181.28	27.75%	1%	0.28%	1%	0.28%	1%	0.28%	1%	0.28%	1%	0.28%
Parks (existing and proposed)	153.91	23.56%	30%	7.07%	20%	4.71%	20%	4.71%	10%	2.36%	10%	2.36%
Schools (existing and proposed)	20.41	3.12%	41%	1.28%	41%	1.28%	35%	1.09%	5%	0.16%	5%	0.16%
Roads	66.60	10.20%	77%	7.85%	55%	5.61%	32%	3.26%	26%	2.65%	26%	2.65%
Upper Hyde Creek Village												
Street-oriented Townhome	2.02	0.31%	81%	0.25%	63%	0.19%	50%	0.15%	50%	0.15%	50%	0.15%
Small Village	5.74	0.88%	80%	0.70%	60%	0.53%	40%	0.35%	30%	0.26%	30%	0.26%
Large Village	13.95	2.14%	75%	1.60%	50%	1.07%	35%	0.75%	27%	0.58%	27%	0.58%
Large Single Family	7.61	1.17%	75%	0.87%	40%	0.47%	33%	0.38%	25%	0.29%	25%	0.29%
Estate Single Family	5.65	0.87%	75%	0.65%	40%	0.35%	33%	0.29%	25%	0.22%	25%	0.22%
Lower Hyde Creek Village												
Street-oriented Townhome	5.15	0.79%	47%	0.37%	63%	0.50%	50%	0.39%	50%	0.39%	50%	0.39%
Small Village	4.37	0.67%	45%	0.30%	60%	0.40%	40%	0.27%	30%	0.20%	30%	0.20%
Large Village	12.90	1.97%	55%	1.09%	50%	0.99%	35%	0.69%	27%	0.53%	27%	0.53%
Village Low Density Residential												
Street-oriented Townhome (20%)	15.71	2.41%	81%	1.95%	63%	1.52%	50%	1.20%	50%	1.20%	50%	1.20%
Small Village (20%)	15.71	2.41%	80%	1.92%	60%	1.44%	40%	0.96%	30%	0.72%	30%	0.72%
Large Village (40%)	31.42	4.81%	65%	3.13%	50%	2.41%	35%	1.68%	27%	1.30%	27%	1.30%
Large Single Family (12%)	9.43	1.44%	27%	0.39%	40%	0.58%	33%	0.48%	25%	0.36%	25%	0.36%
Estate Single Family (8%)	6.28	0.96%	15%	0.14%	40%	0.38%	33%	0.32%	25%	0.24%	25%	0.24%
Village Medium Density Residential	16.52	2.53%	81%	2.05%	63%	1.59%	50%	1.26%	50%	1.26%	50%	1.26%
Village High Density Residential	11.01	1.69%	79%	1.33%	62%	1.05%	56%	0.94%	30%	0.51%	60%	1.01%
Large Single Family	38.34	5.87%	75%	4.40%	40%	2.35%	33%	1.94%	25%	1.47%	25%	1.47%
Suburban Residential	29.17	4.47%	75%	3.35%	40%	1.79%	33%	1.47%	25%	1.12%	25%	1.12%
Total	**653.17**	**100.00%**		**40.98%**		**29.47%**		**22.88%**		**16.25%**		**N/A#**

Port Coquitlam	Total Area (ha)	Percent of Watershed	Scenario 1 EIA of land area (typ.)	Scenario 1 EIA of POCO's watershed	Scenario 2 EIA of land area (typ.)	Scenario 2 EIA of POCO's watershed	Scenario 3 EIA of land area (typ.)	Scenario 3 EIA of POCO's watershed	Scenario 4 EIA of land area (typ.)	Scenario 4 EIA of POCO's watershed	Scenario 5 EIA of land area (typ.)	Scenario 5 EIA of POCO's watershed
Parks	91.00	18.06%	10%	1.81%	10%	1.81%	0.1	1.81%	10%	1.81%	10%	1.81%
Schools	27.60	5.48%	41%	2.25%	42%	2.30%	0.41	2.25%	41%	2.25%	41%	2.25%
Roads	77.08	15.29%	55%	8.41%	55%	8.41%	0.55	8.41%	55%	8.41%	55%	8.41%
Townhouse (including small lot area)	30.28	6.01%	83%	4.99%	80%	4.81%	0.8	4.81%	80%	4.81%	80%	4.81%
Commercial	7.15	1.42%	90%	1.28%	90%	1.28%	0.9	1.28%	90%	1.28%	91%	1.29%
Apartment	28.25	5.61%	80%	4.48%	75%	4.20%	0.7	3.92%	70%	3.92%	70%	3.92%
Residential	242.63	48.14%	33%	15.89%	30%	14.44%	0.27	13.00%	27%	13.00%	27%	13.00%
Total	**504.00**	**100.00%**		**39.10%**		**37.25%**		**35.47%**		**35.47%**		**N/A#**

N:\022313\HYDGY\Report\April 04 Final\[Watershed3.xls]By City

 # Difficult to estimate as highly dependent on soils conditions

Table 4.2
Detailed Breakdown of EIA by Land Use Type for Each City

development (a reduction from 40.1% overall under Scenario 1 to 24.6% under Scenario 4 (Table 4.3)).

- In the short term, minimal change to the EIA is possible in Port Coquitlam given that urban development with limited potential for reductions in impermeable surfaces already exists (only a 9% reduction under Scenario 4). Over time redevelopment or retrofitting of existing development within Port Coquitlam could gradually reduce overall EIAs.
- None of the scenarios result in an overall watershed EIA below 20%.This is achievable within the Coquitlam portion of the watershed when considered separately from the whole watershed (16.25% for Coquitlam under Scenario 4 of Table 4.4), but it would require significant LID measures.
- None of the LID scenarios by themselves will result in an overall watershed EIA below 10%, the threshold for impacts to the fisheries resource. In fact, the lowest EIA that can be achieved when considering LID measures alone is 24.6%, where the watershed can be expected to be degraded. However, the role of a stormwater diversion in mitigating peak flow increases and water quality ponds in addressing the water quality of direct runoff discharged to the creek system are not factored into this analysis.
- Without any reduction in EIAs within Port Coquitlam corresponding to Scenario 1, even with the full implementation of Scenario 4 within Coquitlam, the lowest overall EIA that can be achieved for the watershed is approximately 26.1%. This value represents Scenario 1 for Port Coquitlam from Table 4.3, a weighted EIA of 16.95%, combined with Scenario 4 for Coquitlam, a weighted EIA of 9.10%.
- With respect to the broad context of “sustainability”, population density needs to be considered in this analysis, since higher densities of “compact” development are generally more sustainable than a more sprawling form of development. Coquitlam has a significant opportunity to showcase how higher densities can be achieved with less environmental impact than lower densities and a traditional form of development. (In this regard, it would be useful for future analyses to incorporate calculations of EIA per housing unit.)

4.4 STORM WATER ROUTING ALTERNATIVES

Three conceptual storm water management alternatives were identified and considered for the watershed. These are described below and shown in Figures 4.1A to 4.1C. All of these options can be adapted, with minimal alterations, to employ Low Impact Development (LID) principles for the management of rainfall from frequently occurring small storms (Tier 1). In general, the successful application of LID strategies would reduce the size of, or possibly eliminate, some of the proposed storm water detention ponds. However, major storms govern the sizing of most components of the three alternatives and, therefore, they would not be affected to a great degree by LID.

All three alternatives would employ detention ponds. However, they are sized to different criteria depending upon the alternative. Common to all three is that the detention ponds would discharge attenuated flows to the natural watercourse system.

In the initial analysis of alternatives, all detention ponds were assumed to have 4:1 side slopes inside and outside, a crest width of 2 m and a total depth of 2.5 m with 2 m of live storage. With careful planning an site specific geotechnical investigations, infiltration facilities to return water to ground could be considered.

Alternative 1 – Tier 2 Detention Ponds

Under this alternative, as shown in Figure 4.1A, runoff from all storm events up to and including the 10-year event would be routed to and attenuated at the proposed storm water detention ponds. Therefore, all Tier 1 and Tier 2 storms would be accommodated at the detention ponds. If LID is applied to the Tier 1 storms then only the large storms of Tier 2 would be routed to the detention ponds. Because of the 10-year event upper threshold for the proposed detention ponds, the pond sizing would not be significantly reduced by the application of LID to the Tier 1 storms.

Without LID strategies, it is unlikely that the existing hydrological characteristics of the watershed could be replicated with ponds alone. Significant summer base flow augmentation would not be provided by detention ponds, as they would drain in a short period of time and have relatively limited capacity to infiltrate the captured volume of runoff. Even though detention ponds can limit peak flows during storms, they tend to release moderate flow rates for sustained periods.

Events larger than the 10-year return period, Tier 3 storms, would be routed to the natural watercourses via overflows in the detention ponds. These very large events would receive relatively little attenuation in the ponds.

Alternative 2 – High Flow Diversion to the Coquitlam River

This alternative would employ a diversion scheme to direct the runoff from the larger storms out of the upper watershed entirely. Effectively, all runoff greater than generated from a rainfall event corresponding to a storm occurring approximately twice per year, up to the 100-year return period storm is diverted out of the watershed and to the Coquitlam River (refer to Figure 4.1B). The storm water diversion main would follow the existing and proposed David Avenue alignment westward to the Coquitlam River. Only that portion of the watershed above the diversion is directly served by it.

The storm water detention ponds that are served by the diversion would be sized to receive and attenuate runoff from storms up to a twice per year storm (Tier 1). Since the available soils information indicates that the soils do not have capacity sufficient to infiltrate all Tier 1 storms, the detention ponds would handle any and all runoff produced by these smaller storms. From the detention ponds attenuated flows would be routed to the natural watercourse system. Flows from Tier 2 and Tier 3 storms would be routed past the detention ponds to the diversion system.

Detention ponds serving areas located south of (below) the diversion alignment would still be sized according to the Tier 2 criteria outlined for Alternative 1. However, many of these pond sizes would differ from those in Alternative 1, due to their reduced service areas.

The diversion would encounter several stream crossings along the David Avenue alignment. The most significant crossing would be that of the Hyde Creek main stem. The form that this proposed crossing of Hyde Creek could take is being determined as part of a separate study, by others. A diversion pipe could be incorporated into the proposed crossing with varying levels of difficulty and cost, depending on the final configuration selected.

Less challenging crossings would occur at West and East Watkins, West Smiling, Smiling and Burke Mountain Creeks. In most cases the creek ravines are not deep, and an inverted siphon crossing of the creek channel may be possible. In an inverted siphon the diversion main would drop underneath the existing creek channel.

Diverting large event storm water runoff to the Coquitlam River would ease the flows that must be routed via the natural watercourses within the Hyde Creek watershed, including the low gradient channels within Port Coquitlam. However, the Coquitlam River itself is subject to flooding concerns.

Currently, there are capacity concerns with the Coquitlam River. Sediment accumulation within the river has reduced the level of flood protection provided by the existing dyke system. Also, B.C. Hydro can release water with little or no warning to suit the operational and safety requirements of the Coquitlam Dam. The level of flood protection, and improvement strategies are currently under investigation by others. However, the impact of a storm water diversion on the Coquitlam River is not included in this work. Given that the Coquitlam River flood control works are currently operating at a reduced level of service, diversion of additional flows to the Coquitlam River, albeit a small amount, is not favourable. If this approach is pursued further, the impacts on the Coquitlam River should be investigated.

Alternative 3 – High Flow Diversion to Deboville Slough

The third alternative for storm water management was similar to Alternative 2, but differed in that the high flows would be diverted directly to Deboville Slough. This diversion scheme would result in high flows discharging to the same receiving water as they would reach under the natural regime.

This diversion alignment would start on the western side of the watershed and then run eastward to Coast Meridian, where it would then follow the B.C Hydro right-of-way down to the slough. Refer to Figure 4.1C for a conceptual plan of the diversion alignment.

As with Alternative 2, detention ponds not connected to the diversion would be sized to handle Tier 2 storms. These ponds are intended to provide flow attenuation for any runoff not controlled by LID strategies. Should soils investigations indicate that infiltration capacity is greater than assumed, then these ponds could be reduced in size or possibly eliminated.

Areas that are not serviced by the high flow diversions would require detention ponds that are sized for the larger Tier 2 storms, at a 10-year return period. The size of these ponds would not be as significantly affected by soil infiltration capacities, and hence their sizes would not be greatly reduced if soil infiltration capacity is proven to be greater than assumed.

Several stream crossings would be required for this diversion scheme. East and West Watkins, West Smiling, Smiling and Burke Mountain Creeks are encountered by the proposed diversion alignment. We anticipate that most, if not all, of these crossings could be accomplished with an inverted siphon arrangement, whereby the diversion pipe drops below the creek channel. If more deeply incised channels are encountered, then pipe bridges or other means would be required.

4.5 EVALUATION MATRIX

The following matrix (Table 4.5) was used to compare and evaluate the storm water management alternatives discussed above during the Advisory Committee meeting on January 21, 2003. The evaluation criteria are based generally on the project objectives, with emphasis on the criteria that may vary among options.

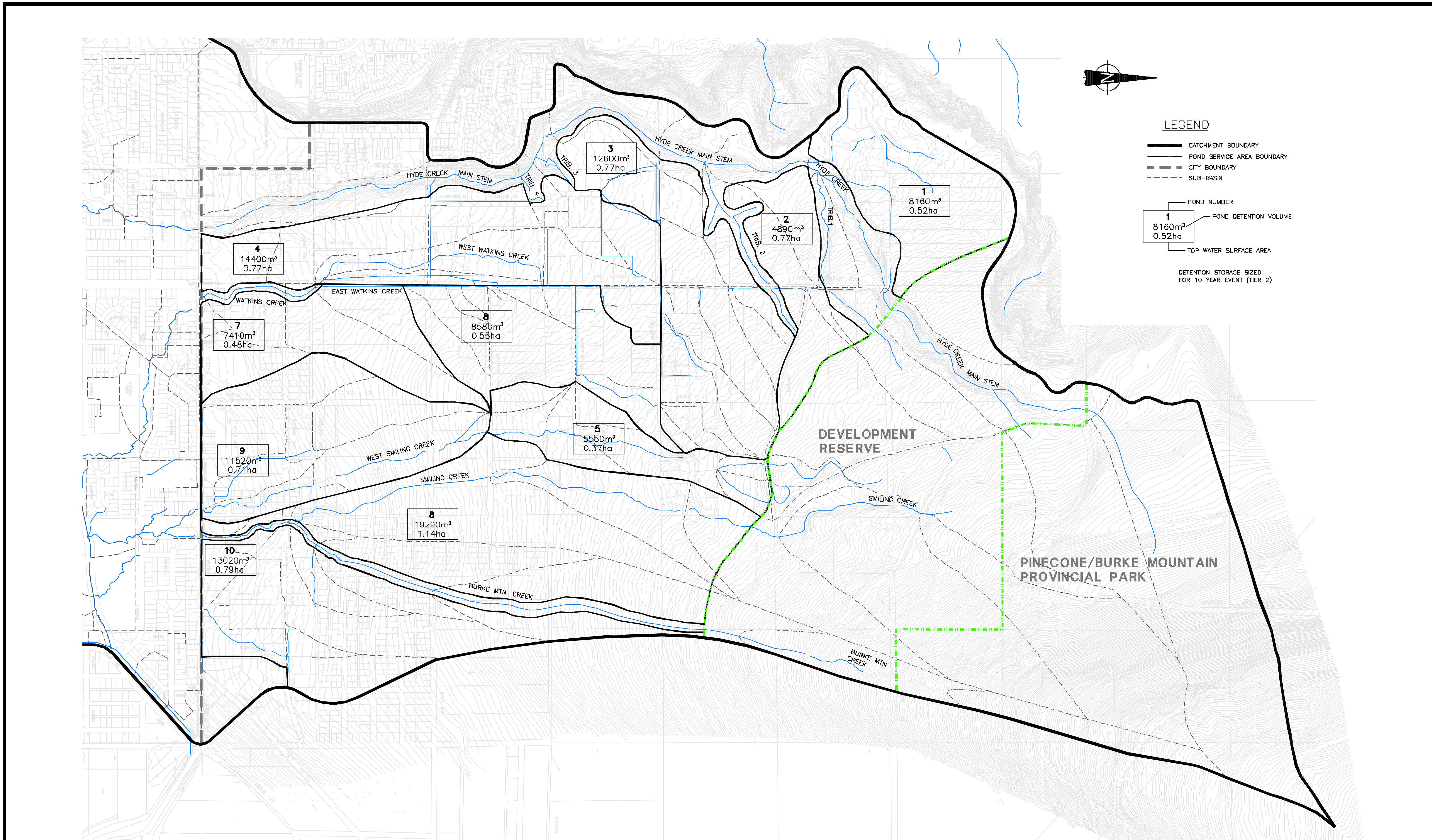
The approach used in the Advisory Committee meeting was to weight each criteria based on its perceived importance. Relative scores varying from 1 to 5 were given for each criteria according to how well each alternative dealt with that criteria. Assignment of weightings to each criteria, and the rating of each criteria was undertaken by the Hyde Creek Advisory Committee during the meeting on January 21, 2003.

The exercise of discussing the alternatives and filling out the evaluation matrix resulted in Alternative 3 having the highest ranking, and therefore being the preferred alternative. The preferred scenario, Alternative 3, is investigated further, and refined, in the following section.

Evaluation Criteria	Importance Factor (Weighting)	Alternative 1 Tier 2 Detention Ponds	Alternative 2 Diversion of Peak Flows to the Coquitlam River (Tier 1 ponds above diversion, Tier 2 below)	Alternative 3 Diversion of Peak Flows To DeBoville Slough (Tier 1 ponds above diversion, Tier 2 below)
Environmental				
Protect Fish Habitat through adequate riparian buffers	3	3	5	5
Maintain minimum summer base flows	4	1	1	1
Minimize degradation of fish habitat from high flows	4	3	4	4
Minimize negative impacts on water quality	4	4	3	3
Accommodate wildlife needs and enhance ecological function	2	3	2	2
Protect and enhance watercourse integrity (e.g., minimize crossings, support fish passage)	3	3	3	3
Average Weighted Score		**9.3**	**10.0**	**10.0**
Stormwater Management				
Minimize flooding and potential property and infrastructure damage	4	1	3	5
Achieve runoff control of Tier 1 storms per GVRD template	2	1	1	1
Achieve runoff control of Tier 2 storms per GVRD template	2	3	3	3
Achieve runoff control of Tier 3 storms per GVRD template	3	1	3	4
Minimize erosion and sedimentation	3	2	3	3
Promote groundwater recharge	1	1	1	1
Compatability with LID	2	3	3	3
Avoid transfer of flows across basins	3	4	1	3
Average Weighted Score		**5.0**	**6.0**	**8.1**
Land Use Planning				
Comply with OCP objectivesa	4	1	2	3
Provide opportunities for outdoor nature-oriented recreation	2	4	3	2
Ease of Implementation	2	4	2	1
Average Weighted Score		**6.7**	**6.0**	**6.0**
Cost				
Minimize costs of new infrastructure	3	4	2	3
Minimize ongoing operations and maintenance costs	1	4	3	3
Cost of land	3	1	3	4
Average Weighted Score		**6.3**	**6.0**	**8.0**
Grand Total		**27.3**	**28.0**	**32.1**

TABLE 4.5
EVALUATION MATRIX

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:12500		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

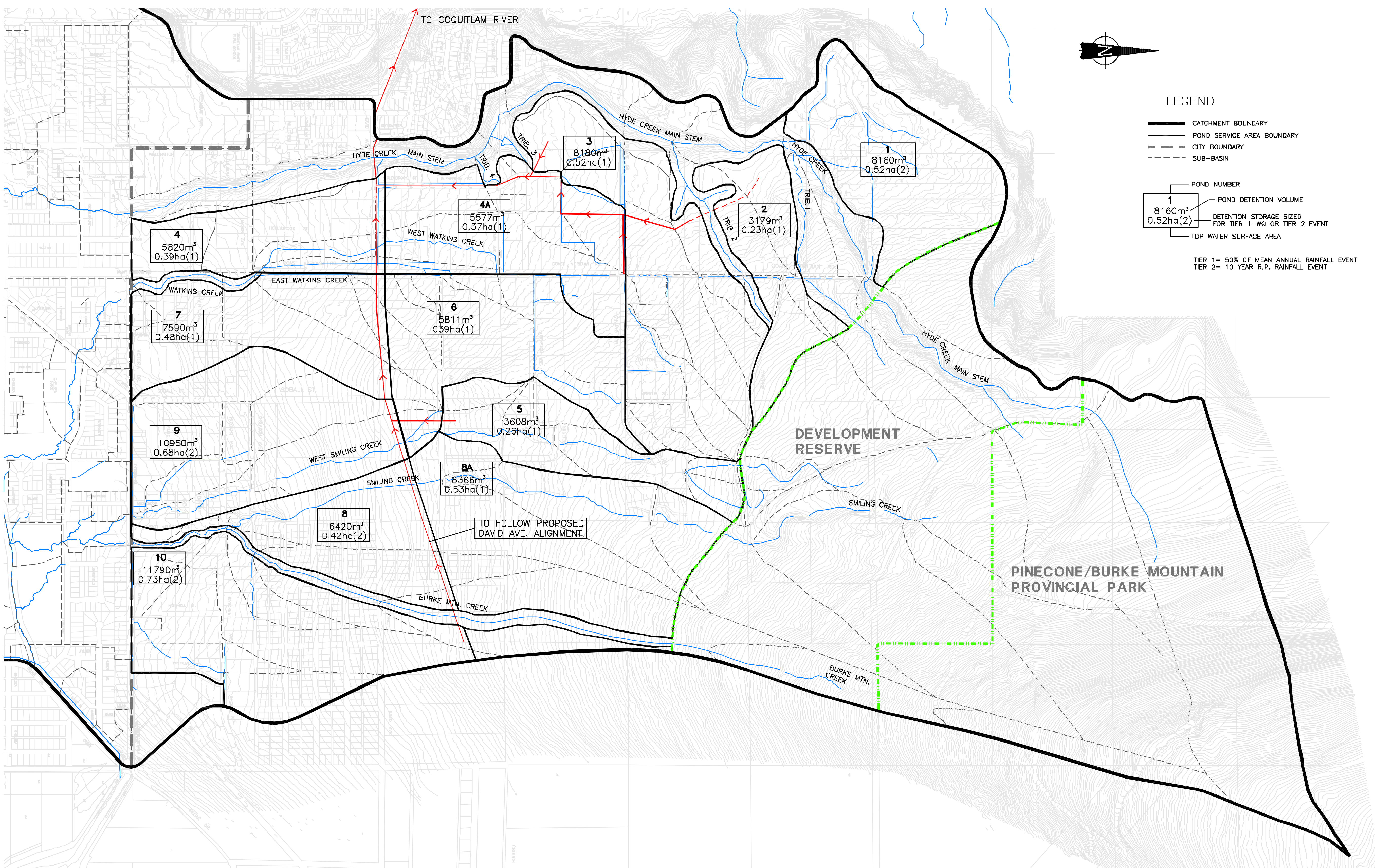
CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

ALTERNATIVE 1
TIER 2 DETENTION PONDS

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4.1A		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 — 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:12500		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

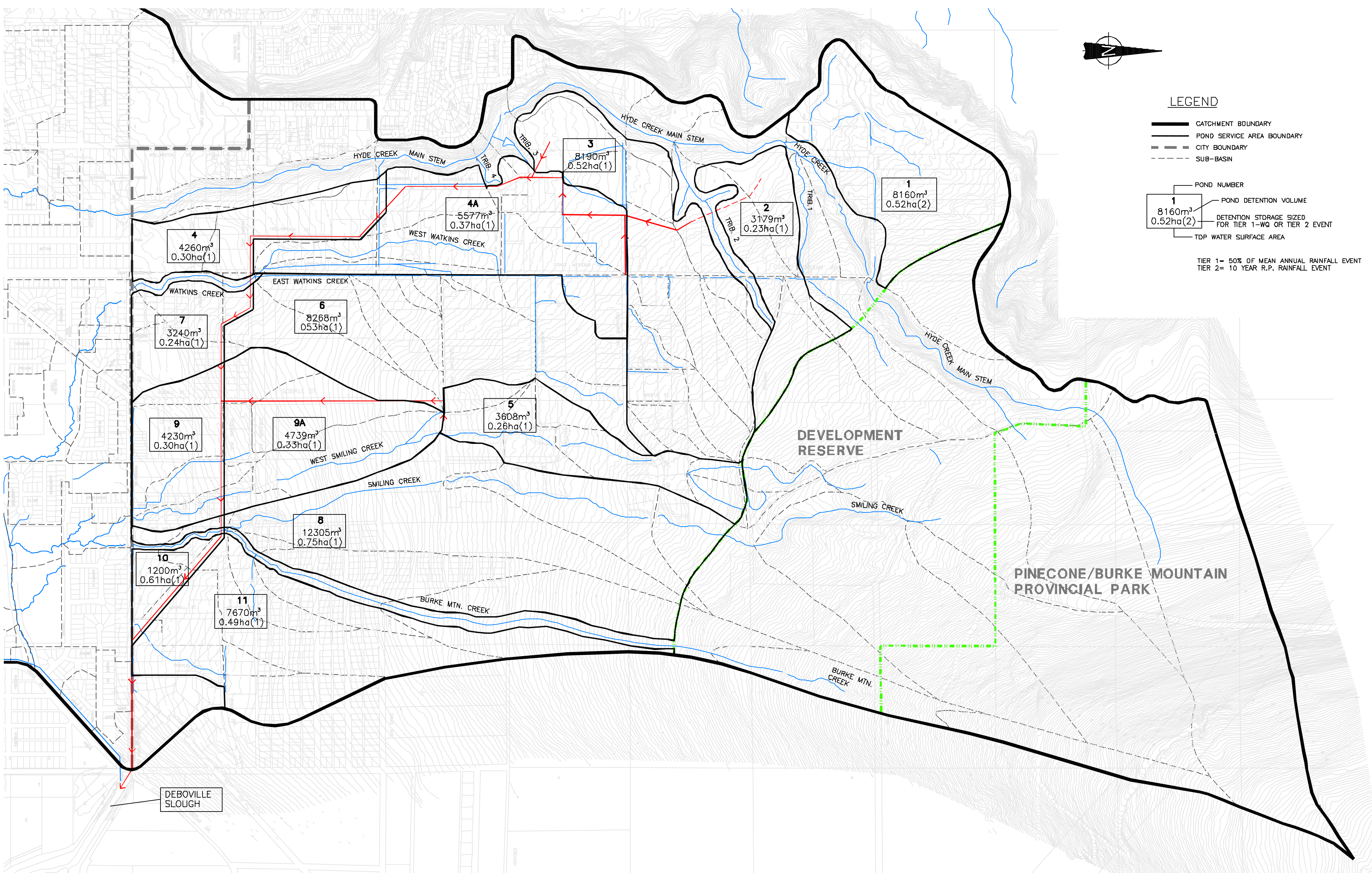
CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

ALTERNATIVE 2
HIGH FLOW DIVERSION TO COQUITLAM RIVER
TIER 1 & 2 DETENTION PONDS

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4.1B		

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 — 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:12500		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

ALTERNATIVE 3
HIGH FLOW DIVERSION TO DEBOVILLE SLOUGH
TIER 1 & 2 DETENTION PONDS

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4.1C		

DEVELOPMENT OF PREFERRED ALTERNATIVE

SECTION 5

5.1 INTRODUCTION

The selected alternative from Section 4, Alternative 3, was refined through a detailed model analysis. This allowed the details of the proposed storm water management system, such as pipe diameters, detention pond sizes and flow routing to be established. Flow hydrographs were used to investigate the effectiveness of the proposed storm water management measures in preventing flooding problems and maintaining a flow regime approximating current conditions.

Flow monitoring data from Hyde and Smiling Creeks became available for the period of mid-March to mid-February, 2003 prior to the final model analysis discussed here. Through this data, a degree of calibration of the hydrologic model was achieved. Also, Piteau Associates completed a hydro-geological assessment of the Hyde Creek watershed and provided a draft report, which allowed the consideration of LID measures with greater certainty, and improved estimates of infiltration capacity in the soils of the watershed.

During the course of the present study, several alignment options were considered. Pending the outcome of a detailed alignment assessment and associated geotechnical investigation of subsurface conditions on Victoria Drive, an alignment that roughly follows the B.C. Hydro right-of-way is the preferred routing for the peak flow diversion. Alternative 3, as discussed in this section, reflects this proposed routing.

Elimination of the proposed water quality ponds in areas serviced by the high flow diversion was assessed. Possible elimination of the ponds would assume that since high flows enter the diversion, attenuation of the remaining flows would not be necessary prior to routing to the creek system. However, the role of the water quality ponds is not to attenuate flows but to address water quality issues on runoff generated by Tier 1 storms and first flush flows generated by larger storms and not routed to the diversion. As these flows will primarily originate on impervious surfaces directly connected to the storm sewer system, and not mitigated by LID measures, it is essential to address sediment and other water quality issues with these flows prior to discharge.

5.2 FLOW ROUTING

As discussed in Section 1.5, the original design parameters used early in the development and analysis of the alternatives for the Hyde Creek Watershed were modified to ensure overall basin objectives are achieved. In order to balance the objectives, the design parameters used for Tier 1 storm water management and associated ponds were modified.

As with the original Alternative 3, the flow routing scheme divides the watershed into two categories of service area. The majority of the watershed is serviced by a diversion system that handles all flows from storms greater than the 2/year event (Tier 1) up to the 100-year return period event (Tier 2 & 3).

Under the revised routing scheme, the ponds associated with the diversion are intended to provide sediment settling and some water quality treatment for the runoff from smaller (Tier 1) storms and are designated Tier 1-WQ. These Tier 1-WQ ponds do not play a significant role in storm water detention or attenuation of peak flows. Flows from the Tier 1-WQ ponds continue to be routed to the existing creek system, to provide intermediate flows during rainfall events.

As envisioned, the storm water quality ponds (Tier 1-WQ) will handle all runoff up to the twice per year (2/yr) pre-development flow. For intermediate storms, those between the 2/yr event and the 5-year event, all flows equal to the corresponding pre-development flow will be routed to the creek. The difference between the pre- and post-development flows will be routed to the diversion. Peak flows equal to the 2/yr pre-development flow will be routed through the water quality pond, with the remaining pre-development flow up to the 5-year pre-development flow routed directly to the creek via a bypass structure. The higher pre-development flows bypass the water quality ponds to avoid re-suspension of accumulated sediments and damage to the plant assemblage. Figure 5.1 provides a schematic representation of the routing for the Tier 1-WQ water quality ponds.

Example: The pre-development 2/yr flow from a diversion serviced sub-catchment is 0.5 m^3/s, the pre-development 5-year peak flow is 0.7 m^3/s, and the post-development 5-year flow is 1.1 m^3/s. The peak flow routed through the water quality pond for the 5-year event is 0.5 m^3/s, with 0.2 m^3/s (0.7 m^3/s- 0.5 m^3/s) routed directly to the creek, and the difference between the pre- and post-development flows, 0.4 m^3/s routed to the diversion.

For events greater than the 5-year event, the entire flow in excess of the 5 year pre-development peak flow would be routed to the proposed diversion system. The creek would only receive peak flows equal to the 5-year pre-development flow rate. Flow control structures upstream of each water quality pond would determine the appropriate split in the flow.

The water quality ponds have been sized to settle the coarse silt fraction down to a size of 62 microns at a peak flow rate corresponding to the 2/yr peak flow. At lower peak flow rates finer sediment sizes would be settled more effectively. Also, the first flush from larger events would be routed to the water quality ponds and then to the creek. Excessively large flows originating within the diversion serviced area, those greater than the 5-year pre-development flow, will not enter the creek system within the watershed.

The sizing criteria used for the Tier 1-WQ ponds are that they have sufficient surface area and volume to settle particles as small as 62 microns under a peak design flow rate equal to the pre-development 2/year event. Other contaminants (metals and organics) that tend to adsorb to sediment particles will be settled with those particles in the water quality ponds. Removal of dissolved contaminants, such as nutrients, will be limited and will likely only occur at lower flow rates during dryer periods.

In those areas of the watershed that are not serviced by the diversion, all Tier 1 and Tier 2 flows are routed to detention ponds. These ponds are designed to attenuate the post-development peak flows to the corresponding pre-development peak flows for all storms up to the 10-year return period. Flows in excess of those from the 10-year rainfall event will be bypassed around the Tier 2 detention ponds. Figure 5.1 also indicates the flow routing for the Tier 2 detention ponds.

As envisioned, both the Tier 1-WQ and Tier 2 ponds are configured as wet ponds. Aquatic vegetation and a small pool will be maintained at the bottom of the ponds at all times. These features will provide additional water quality benefits during dryer periods of the year.

5.3 STORM WATER MANAGEMENT COMPONENTS

The intensive model analysis of Alternative 3 yielded more refined design values for pond sizing, diversion system components, and flow rates and hydrographs. Figure 5.2

presents a conceptual plan of the “finalized” storm water management system for Alternative 3.

The diversion system is sized for flows up to the post-development 100-year return period event. Diverted flows are routed to DeBoville slough where they are discharged in the vicinity of Cedar Creek and Victoria Drive. Diversion pipe diameter, lengths, slopes and 100-year design flows are indicated in Table 5.1 and correspond to pipes shown on Figure 5.2.

Pond sizes, in terms of total active volume and top water surface area are also indicated on Figure 5.2. The estimated footprint of the pond, and representation of the pond top water surface are indicated schematically on Figure 5.2. Design peak inflow and peak outflow, and total active volumes for both the Tier 1-WQ and Tier 2 ponds are provided in Table 5.2. Note that the Tier 1-WQ ponds are not intended to provide flow detention and attenuation.

5.4 INTEGRATED STORM WATER MANAGEMENT

The analysis of low impact development measures and resulting EIAs in Section 4.3 considered only the role of LID in reducing effective impervious area in the watershed. For example, the estimated overall EIA for the watershed if Scenario 4 is implemented in Coquitlam while retaining existing development in Port Coquitlam is approximately 24.6%. This EIA value is high enough to indicate that potential degradation of the watershed may occur. However, the results of that analysis did not consider the additional benefits provided by the other components of the storm water management plan discussed in this chapter.

The hydrogeological assessment carried out in support of the Hyde Creek Integrated Watershed Management Plan provided an understanding of the infiltration capacity of the existing soils. A thin (1 to 2 meter) mantle of pervious surficial soils overlays most of the watershed currently subject to development. Once this thin pervious soil layer becomes saturated during extended wet weather, surface ponding takes place, and subsurface flow parallel to the underlying impermeable till layer occurs. Creek ravines, road cuts and ditches intercept the lateral seepage and produce channelized surface flow. Therefore, the ability to infiltrate rainfall on a sustained basis in the watershed is limited by the surficial soil structure.

Pipe Section No.	Diameter (mm)	Length (m)	Slope (%)	100 Year Peak Flow (m^3/s)
DIV-C10	2100	30	7.03%	15.38
DIV-C20	2100	280	8.21%	15.40
DIV-C30	2100	200	8.00%	15.41
DIV-C35	2100	80	6.25%	15.40
DIV-C40	2100	120	1.25%	14.11
DIV-C50	2100	250	2.00%	14.13
DIV-C55	2100	140	1.07%	14.15
DIV-C60	1500	400	4.00%	9.60
DIV-C70	1050	540	10.70%	1.60
DIV-C75	1050	50	0.40%	1.60
DIV-C80	1500	90	5.56%	6.15
DIV-C90	1500	410	2.20%	4.70
DIV-C100	1500	200	0.88%	4.72
DIV-C110	1200	140	2.68%	4.72
DIV-C120	900	300	5.17%	2.61
DIV-C130	900	80	3.75%	2.61
DIV-C140	900	40	5.00%	2.61
DIV-C150	600	130	3.08%	0.87
DIV-C160	900	100	6.00%	1.76
DIV-C170	900	120	5.00%	1.76
DIV-C180	900	200	6.50%	1.76
DIV-C190	600	200	6.00%	0.73
DIV-C200	900	180	8.22%	1.02
DIV-C210	900	60	0.33%	1.03
DIV-C220	900	200	0.50%	1.03

· Final\[Diversion Details.xls]Diversion Flow Summary

POND NO. / Regime / Service Area (ha) / Active Volume (m^3)	Flow Parameter	POST-DEVELOPMENT CONDITION PEAK FLOW RATES				
		$Q_{1/2}$ (m^3/s)	Q_2 (m^3/s)	Q_5 (m^3/s)	Q_{10} (m^3/s)	Q_{100} (m^3/s)
POND #1						
Tier 2	Peak Inflow	1.85	2.35	2.75	3.01	3.86
27.2 ha	Peak Flow from Pond to Hyde Creek	0.31	0.61	1.78	2.72	2.72
8160 m^3	Peak Flow Bypassing Pond	0.00	0.00	0.00	0.00	1.08
	Total Peak Flow to Hyde Creek	0.31	0.61	1.78	2.72	3.80
POND #2						
Tier 1	Peak Inflow	1.55	1.98	2.17	2.29	2.64
16.3 ha	Peak Flow from Pond to Hyde Creek	0.67	0.84	0.84	0.84	0.84
513 m^3	Peak Flow Bypassing Pond to Hyde Creek	0.00	0.38	0.75	0.75	0.75
	Total Peak Flow to Hyde Creek	0.67	1.25	1.61	1.61	1.61
	Peak Flow to Diversion	0.88	0.76	0.58	0.70	1.05
POND #3						
Tier 1	Peak Inflow	0.69	0.88	1.04	1.14	1.48
21 ha	Peak Flow from Pond to Hyde Creek	0.23	0.29	0.29	0.29	0.29
155 m^3	Peak Flow Bypassing Pond	0.00	0.16	0.32	0.32	0.32
	Total Peak Flow to Hyde Creek	0.23	0.45	0.62	0.62	0.61
	Peak Flow to Diversion	0.46	0.44	0.43	0.54	0.87
POND #4						
Tier 1	Peak Inflow	0.85	1.01	1.13	1.21	1.47
21 ha	Peak Flow from Pond	0.33	0.41	0.41	0.41	0.41
173 m^3	Peak Flow Bypassing Pond	0.00	0.15	0.32	0.32	0.32
	Total Peak Flow to Hyde Creek	0.14	0.24	0.31	0.31	0.31
	Total Peak Flow to Watkins Creek	0.19	0.33	0.42	0.42	0.42
	Peak Flow to Diversion	0.52	0.45	0.40	0.48	0.74
POND #5						
Tier 1	Peak Inflow	1.56	1.99	2.33	2.63	3.45
28.9 ha	Peak Flow from Pond	0.51	0.64	0.64	0.64	0.64
412 m^3	Peak Flow Bypassing Pond	0.00	0.32	0.66	0.66	0.66
	Total Peak Flow to Hyde Creek	0.35	0.67	0.91	0.91	0.91
	Total Peak Flow to Watkins Creek	0.15	0.29	0.39	0.39	0.39
	Peak Flow to Diversion	1.05	1.03	1.03	1.33	2.16
POND #6						
Tier 2	Peak Inflow	0.72	0.96	1.14	1.27	1.68
19.1 ha	Peak Flow from Pond	0.02	0.11	0.23	0.43	0.43
5742 m^3	Peak Flow Bypassing Pond	0.00	0.00	0.00	0.00	1.23
	Total Peak Flow to Hyde Creek	0.00	0.06	0.11	0.22	0.83
	Total Peak Flow to Watkins Creek	0.01	0.06	0.11	0.22	0.83
POND #7						
Tier 1	Peak Inflow	1.96	2.56	2.93	3.14	3.74
18.5 ha	Peak Flow from Pond to West Smiling Creek	0.97	1.22	1.22	1.22	1.22
761 m^3	Peak Flow Bypassing Pond	0.00	0.41	0.91	0.91	0.91
	Total Peak Flow to West Smiling Creek	0.97	1.65	2.14	2.15	2.16
	Peak Flow to Diversion	0.99	0.94	0.81	1.02	1.61
POND #8						
Tier 1	Peak Inflow	1.24	1.59	1.88	2.08	2.72
35.6 ha	Peak Flow from Pond to Watkins Creek	0.44	0.55	0.55	0.55	0.55
320 m^3	Peak Flow Bypassing Pond	0.00	0.37	0.71	0.71	0.71
	Total Peak Flow to Watkins Creek	0.44	0.93	1.27	1.27	1.26
	Peak Flow to Diversion	0.80	0.68	0.63	0.84	1.47
POND #9						
Tier 2	Peak Inflow	0.85	1.12	1.34	1.49	2.01
17.7 ha	Peak Flow from Pond	0.12	0.17	0.46	0.81	0.81
5310 m^3	Peak Flow Bypassing Pond	0.00	0.00	0.00	0.00	1.17
	Total Peak Flow to Hyde Creek	0.02	0.04	0.18	0.34	0.92
	Total Peak Flow to Watkins Creek	0.10	0.13	0.28	0.47	1.05

POND NO. / Regime / Service Area (ha) / Active Volume (m^3)	Flow Parameter	POST-DEVELOPMENT CONDITION PEAK FLOW RATES				
		$Q_{1/2}$ (m^3/s)	Q_2 (m^3/s)	Q_5 (m^3/s)	Q_{10} (m^3/s)	Q_{100} (m^3/s)
POND #10						
Tier 1	Peak Inflow	1.41	1.92	2.31	2.57	3.38
24.8 ha	Peak Flow from Pond to Smiling Creek	0.60	0.75	0.75	0.75	0.75
533 m^3	Peak Flow Bypassing Pond to West Smiling Creek	0.00	0.36	0.72	0.72	0.72
	Total Peak Flow to Smiling Creek	0.27	0.51	0.68	0.68	0.67
	Total Peak Flow to West Smiling Creek	0.33	0.61	0.82	0.82	0.81
	Peak Flow to Diversion	0.81	0.82	0.84	1.10	1.91
POND #11						
Tier 2	Peak Inflow	0.75	1.13	1.42	1.61	2.19
23.7 ha	Peak Flow from Pond to Smiling Creek	0.10	0.11	0.15	0.24	0.24
7101 m^3	Peak Flow Bypassing Pond	0.00	0.00	0.00	0.00	0.73
	Total Peak Flow to Smiling Creek	0.10	0.11	0.15	0.24	0.97
POND #12						
Tier 1	Peak Inflow	3.07	4.09	4.89	5.44	7.16
47.5 ha	Peak Flow from Pond to Smiling Creek	1.26	1.57	1.57	1.57	1.57
1148 m^3	Peak Flow Bypassing Pond	0.00	0.73	1.55	1.55	1.55
	Total Peak Flow to Smiling Creek	1.26	2.04	2.58	2.57	2.55
	Peak Flow to Diversion	1.81	2.06	2.35	2.90	4.63
POND #13						
Tier 1	Peak Inflow	1.12	1.43	1.67	1.84	2.36
26.3 ha	Peak Flow from Pond to Hyde Creek	0.41	0.52	0.52	0.52	0.52
297 m^3	Peak Flow Bypassing Pond to Smiling Creek	0.00	0.22	0.48	0.48	0.48
	Total Peak Flow to Hyde Creek	0.08	0.16	0.22	0.22	0.22
	Total Peak Flow to Smiling Creek	0.33	0.58	0.78	0.78	0.78
	Peak Flow to Diversion	0.70	0.69	0.68	1.15	1.36
POND #14						
Tier 2	Peak Inflow	1.21	1.53	1.92	2.07	2.52
17.1 ha	Peak Flow from Pond to Smiling Creek	0.44	0.53	1.42	1.98	1.98
2750 m^3	Peak Flow Bypassing Pond to Hyde Creek	0.00	0.00	0.00	0.00	0.54
	Total Peak Flow to Smiling Creek	0.35	0.40	0.91	1.14	1.41
	Total Peak Flow to Hyde Creek	0.10	0.12	0.51	0.84	1.11

N:\022313\HYDGY\Report\April 04 Final\[Pond Flow Summary - Report.xls]Flow Summary

Even with LID implemented to the level discussed under Scenario 4 in the previous chapter, direct surface runoff will occur from those impervious surfaces directly connected to the storm drainage system. Also, persistent wet weather will result in runoff from disconnected impervious surfaces and pervious surfaces as the surficial soils become saturated. Surface runoff, particularly from roads and parking lots, may potentially mobilize and transport fine sediments and other contaminants.

In order to maintain the health of the creek system, small return period (approximately 1 to 2 year return period) peak channel forming flows to the creeks must be maintained at a level similar to that under the existing hydrologic regime. This requires that some of the surface runoff be directed to the creek system. The proposed water quality ponds address the issue of contaminants mobilized from impervious surfaces during wet weather and provide a degree of treatment prior to discharge to the creek system. First flush mobilization of contaminants during these and larger events will also be handled through the proposed storm water quality ponds prior to the diversion becoming active. This will prevent the bulk of first flush contaminants from being routed directly to DeBoville Slough via the proposed peak flow storm water diversion and also help to protect water quality in the slough.

The proposed peak flow diversion also offers a benefit above and beyond that provided by LID reductions in EIA. Once implemented and properly adjusted, the peak flow diversion will ensure that the creek system is not subjected to peak flows greater than it currently experiences. In actual practice, to control erosion and deposition processes, and to protect Port Coquitlam from flooding risks, the diversion system should be adjusted to slightly reduce peak flows from those that would currently occur. The increased flow generated by developed conditions in the watershed is diverted away from the creek system and routed to the slough. Even under conditions where LID measures may become saturated by persistent wet weather or heavy rainfall, the diversion will prevent peak flows in the creek system from exceeding those that would have occurred under the pre-development (existing) hydrologic conditions. Therefore, in terms of peak flows discharged to the creek system, the EIA tributary to the creeks will be maintained at approximately current levels. The additional EIA that results from development in the watershed will not contribute to the creek system, but will contribute to the slough.

Implementation of multiple BMPs to manage stormwater and protect stream corridors from peak flows and damage will be more successful than dependence on one type of approach. LID measures will be most successful at addressing both runoff and water quality issues, and protecting stream base flows, during periods of intermittent or lesser rainfall when the surficial soils have a chance to regenerate their infiltration capacity. When LID measures become overwhelmed by persistent or heavy rainfall, the water quality ponds will continue to protect the water quality of discharges to the creek system, while the diversion system prevents excessively high peak flows from damaging creek channels or producing downstream flooding. Through the combined interaction of the proposed BMPs, the EIA of the watershed is further reduced from that indicated for LID alone, in terms of influence on the creek system.

5.5 FLOW HYDROGRAPHS

As an indication of the effectiveness of the proposed storm water management plan, we plotted flow hydrographs for 2-year, 5-year, 10-year and 100-year return period rainfall events for several locations in the watershed. Most of these locations are located in proximity to the Coquitlam/Port Coquitlam border, and indicate the effect on trans-boundary flows. The locations for which hydrographs are provided are:

- Hyde Creek at Victoria Drive - Figures 5.3A to 5.3D
- Cedar Ditch above DeBoville Slough (with the post-development diversion hydrograph superimposed) - Figures 5.4A to 5.4D
- Hyde Creek above Cedar Ditch (with the post-development diversion hydrograph superimposed) - Figures 5.5A to 5.5D
- Smiling Creek above Hyde Creek (includes West Smiling and Burke Mountain Creeks) - Figures 5.6A to 5.6D
- Watkins Creek above Hyde Creek - Figures 5.7A to 5.7D

We plotted pre-development and post-development hydrographs for each location. Comparison of the two indicates the benefit that the storm water management plan provides. For all locations, the post-development hydrograph, with the storm water management plan in place, results in a reduction in peak flows. This becomes most evident for the larger events, where the diversion plays an increasingly larger role in routing peak flows.

Considering Hyde Creek @ Victoria Drive, we observe that the 2/yr post-development peak flow is slightly lower, approximately 2.1 m^3/s, than the 2/yr pre-development (existing condition) peak flow due to the benefit provided by the diversion and Tier 2 ponds. For larger events, we see that the difference between the peak pre- and post-development flows increase. For the 10-year rainfall event the post-development flow, with the storm water management plan, is 0.2 m^3/s lower than the peak pre-development flow. For the 100 year event the difference is approximately 2.0 m^3/s. All other locations exhibit a similar (positive) impact of the storm water management plan on the post-development condition.

As indicated by the modelled flow hydrographs, the proposed storm water management plan reduces post-development peak flows on the creek system from those that currently occur. Watercourses in both Coquitlam and Port Coquitlam are protected from increased peak flows that may result in flooding or erosion. In addition, some improvement (reduction) in peak flows is evident with the storm water management plans. These improvements in peak flows will help alleviate existing conveyance and erosion problems, particularly in Port Coquitlam.

5.6 CEDAR DRIVE DITCH HYDRAULIC GRADE LINES

From the model analysis, we determined the impacts on the hydraulic grade line (HGL) and the potential for flooding on Cedar Drive Ditch. In Table 5.3, both pre-development and post-development water levels are presented for the Cedar Drive Ditch. Under all storm conditions, there is a slight improvement in water levels on the Cedar Drive Ditch with the storm water management plan implemented in the watershed above Victoria Drive.

The proposed diversion of peak storm water flows from certain sub-catchments along Prairie Avenue to the Blakeburn Lagoons was not investigated in the model analysis. More detailed information, including survey of the Cedar Drive Ditch, the existing storm water systems in the affected sub-catchments, and water level data for the lagoons would be required to investigate the proposed diversion within the model. The available elevation for driving the diversion is very limited, and a highly accurate model would be required to confirm the hydraulic conditions. If hydraulically feasible to divert water from the storm sewer sub-catchments to the Blakeburn Lagoons it would likely provide some benefit to water levels on the Cedar Drive Ditch during high flow events.

Previously, in Section 3.3, we identified three culverts on Cedar Drive Ditch which have inadequate capacity and are experiencing head losses greater than 10 cm for the 10-year design flow. We have identified conceptual upgrades or replacements for these culverts.

Model Node ID	Location	Invert Elev. (m)	MAXIMUM WATER SURFACE ELEVATION (m)										Culvert Improvements	
			PRE-DEVELOPMENT (EXISTING) CONDITION HGLs					POST-DEVELOPMENT CONDITION HGLs					PRE-DEVELOPMENT CONDITION HGLs	
			Q 1/2	Q2	Q5	Q10	Q100	Q 1/2	Q2	Q5	Q10	Q100	Q10 HGL	HGL Reduction
CED-N5	Deboville Slough	0.89	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	**2.80**	2.80	2.80	0.00
CED-N10	Cedar Drive D/S	0.89	2.82	2.83	2.85	2.85	2.85	2.80	2.80	2.80	**2.80**	2.80	2.87	-0.02
CED-N20	Cedar Drive U/S	0.89	3.12	3.34	3.47	3.55	3.79	3.10	3.24	3.34	**3.41**	3.65	2.94	0.61
CED-N30		0.90	3.37	3.64	3.78	3.86	4.10	3.34	3.51	3.64	**3.72**	3.96	3.56	0.30
CED-N40		0.92	3.70	4.02	4.17	4.27	4.51	3.66	3.87	4.02	**4.11**	4.37	4.14	0.13
CED-N50		0.93	3.78	4.11	4.27	4.37	4.62	3.74	3.96	4.11	**4.20**	4.47	4.26	0.11
CED-N60	Hyde Creek at Cedar Ditch	0.94	3.87	4.22	4.38	4.48	4.74	3.82	4.05	4.21	**4.31**	4.59	4.40	0.08
CED-N70	Pump Stn & Floodbox D/S	0.94	3.87	4.22	4.38	4.48	4.74	3.82	4.05	4.21	**4.31**	4.59	4.40	0.08
CED-N80		0.94	3.87	4.22	4.38	4.48	4.74	3.82	4.05	4.21	**4.31**	4.59	4.40	0.08
CED-N90	Pump Stn & Floodbox U/S	1.40	3.87	4.22	4.39	4.49	4.76	3.84	4.07	4.23	**4.33**	4.62	4.42	0.07
CED-N100		1.54	3.87	4.22	4.39	4.49	4.77	3.84	4.07	4.24	**4.33**	4.63	4.42	0.07
CED-N130		1.54	3.87	4.22	4.39	4.49	4.77	3.84	4.07	4.24	**4.33**	4.63	4.42	0.07
CED-N140		1.63	3.87	4.23	4.39	4.49	4.77	3.84	4.08	4.24	**4.33**	4.63	4.43	0.07
CED-N150		1.64	3.88	4.23	4.39	4.50	4.77	3.85	4.08	4.24	**4.34**	4.63	4.43	0.07
CED-N160		1.64	3.88	4.23	4.40	4.50	4.78	3.86	4.09	4.25	**4.35**	4.64	4.44	0.06
CED-N170		1.64	3.88	4.23	4.40	4.50	4.78	3.86	4.09	4.25	**4.35**	4.64	4.44	0.06
CED-N180	Lincoln Avenue D/S	1.65	3.89	4.24	4.40	4.50	4.78	3.87	4.10	4.26	**4.35**	4.65	4.44	0.06
CED-N190	Lincoln Avenue U/S	1.65	3.91	4.26	4.42	4.53	4.83	3.90	4.13	4.29	**4.39**	4.71	4.48	0.05
CED-N200		1.66	3.91	4.26	4.42	4.53	4.83	3.91	4.14	4.29	**4.39**	4.71	4.48	0.05
CED-N210		1.67	3.92	4.27	4.43	4.53	4.84	3.92	4.15	4.30	**4.40**	4.72	4.49	0.04
CED-N220	Lombardy Drive (N) D/S	1.68	3.93	4.27	4.44	4.54	4.85	3.93	4.16	4.31	**4.41**	4.73	4.50	0.04
CED-N230	Lombardy Drive (N) U/S	1.68	4.00	4.38	4.56	4.68	5.08	4.05	4.32	4.49	**4.61**	5.01	4.55	0.13
CED-N240	Lombardy Drive (S) D/S	1.92	4.01	4.39	4.57	4.69	5.09	4.06	4.34	4.50	**4.62**	5.02	4.56	0.13
CED-N250	Lombardy Drive (S) U/S	1.92	4.04	4.44	4.62	4.75	5.20	4.11	4.42	4.59	**4.71**	5.16	4.67	0.09
CED-N260		1.95	4.06	4.46	4.63	4.76	5.21	4.14	4.44	4.60	**4.73**	5.17	4.68	0.08
CED-N270	Prairie Avenue D/S	1.96	4.07	4.47	4.64	4.77	5.21	4.15	4.45	4.61	**4.73**	5.18	4.70	0.07
CED-N275		1.96	4.14	4.56	4.76	4.91	5.45	4.27	4.59	4.78	**4.93**	5.46	4.73	0.18
CED-N280	Prairie Avenue U/S	1.96	4.18	4.66	4.95	5.16	5.88	4.34	4.74	5.04	**5.25**	5.98	4.75	0.40
CED-N290		1.98	4.20	4.68	4.97	5.18	5.90	4.36	4.76	5.07	**5.28**	6.00	4.80	0.38
CED-N300		2.30	4.20	4.69	4.98	5.18	5.91	4.36	4.77	5.08	**5.29**	6.01	4.81	0.37
CED-N310		2.31	4.22	4.71	5.00	5.21	5.93	4.38	4.80	5.11	**5.31**	6.03	4.87	0.34
CED-N320		3.27	4.25	4.73	5.03	5.24	5.95	4.41	4.84	5.14	**5.35**	6.05	4.94	0.30
CED-N330		3.34	4.34	4.77	5.06	5.26	5.96	4.46	4.88	5.18	**5.37**	6.07	5.02	0.24
CED-N340		4.19	5.00	5.19	5.34	5.47	6.02	5.05	5.24	5.42	**5.56**	6.12	5.43	0.04

N:\022313\HYDGY\Report\April 04 Final\[Cedar Ditch HGL Summary.xls]Cedar HGL Summary

Table 5.3
Cedar Drive Ditch
Hydraulic Grade Lines

The resulting hydraulic grade lines for the 10-year storm only are indicated in Table 5.3 for comparison.

The three proposed culvert upgrades are:

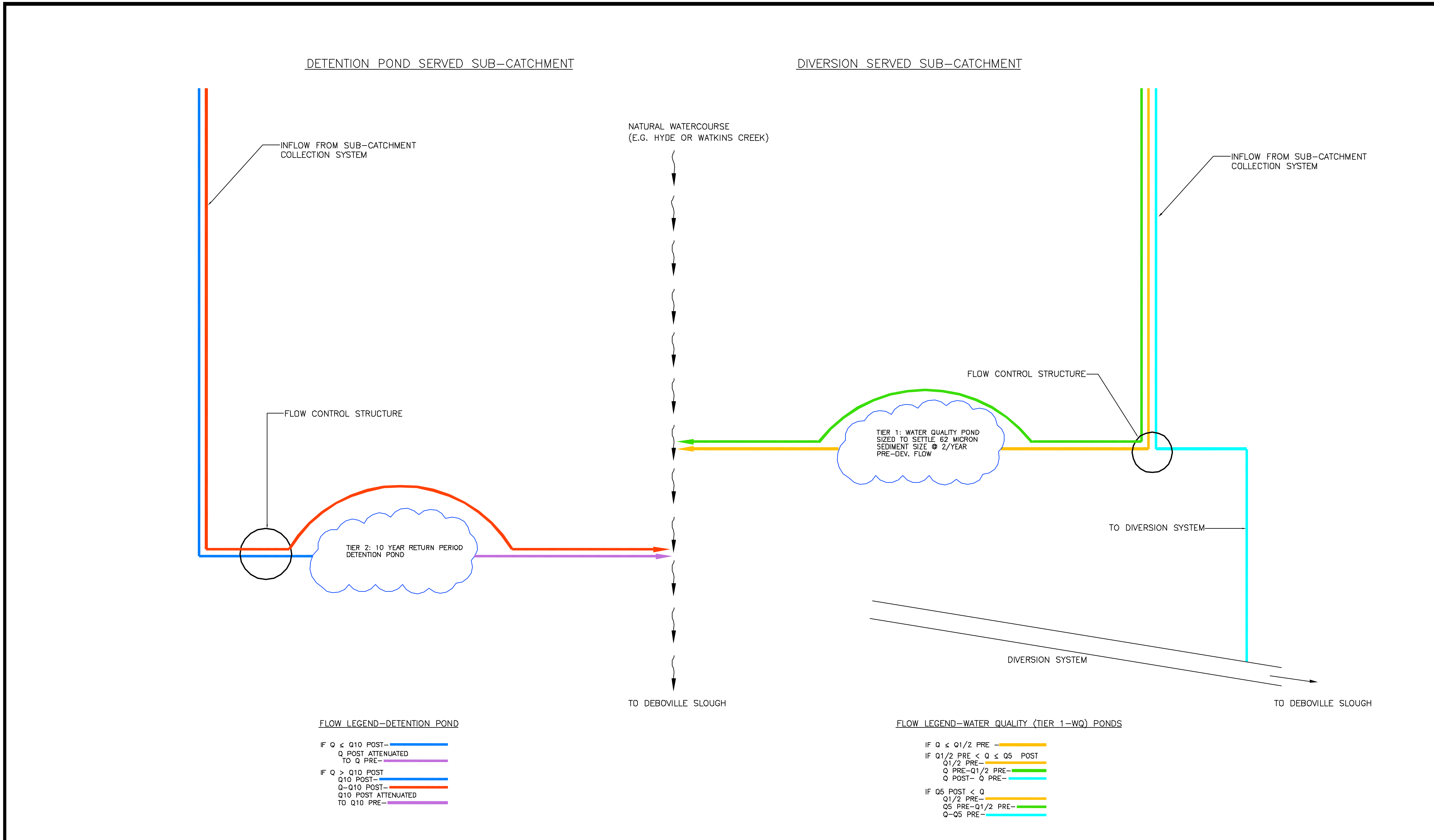
- Cedar Drive Ditch/Hyde Creek crossing Cedar Drive to DeBoville Slough: replace existing arch culverts with free span concrete slab bridge. While upgrading this crossing with a free span bridge would be more expensive, there would be a reduction in head loss through the structure of up to 0.6 m, depending upon the conditions. A reduction in hydraulic grade line at this location would provide a positive benefit (0.08 m reduction) at the Cedar Drive Drainage Pump Station and flood box.

- Prairie Avenue: replace existing culvert with larger 3.05 m wide by 2.4 m high concrete box culvert. The head loss would be reduced by up to 0.4 m.

- Lombardy Street: replace existing culverts with larger 3.05 m wide by 2.4 m high concrete box culvert. The head loss at this crossing would be reduced by up to 0.1 m.

As evident in comparing the hydraulic grade lines in Table 5.3, the combined effect of these improvements is to lower the water levels ranging from to 0.2 to 0.4 m in the upstream reaches (above Prairie Avenue) of Cedar Drive Ditch during the 10-year return period storm. Similar benefits would be apparent during larger flow events, for example the 100-year return period event.

The downstream condition used for the investigation of water levels on the Cedar Drive Ditch corresponded to approximately a one-year return period freshet water level. When higher downstream water levels occur, the benefit of these improvements is not as apparent, as the water levels would tend to be dominated by the downstream condition, and less affected by channel hydraulics. These improvements provide some benefit, but a wider range of flow conditions, including downstream water levels should be investigated to confirm the range of conditions under which they are effective.



This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties

Plot Scale: 1=1 (Paper Space) AutoCAD File: 022313\CURRENT\FIGURE5.1.DWG (GQ)
Date: 2003/9/29 Time: 15:30

NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

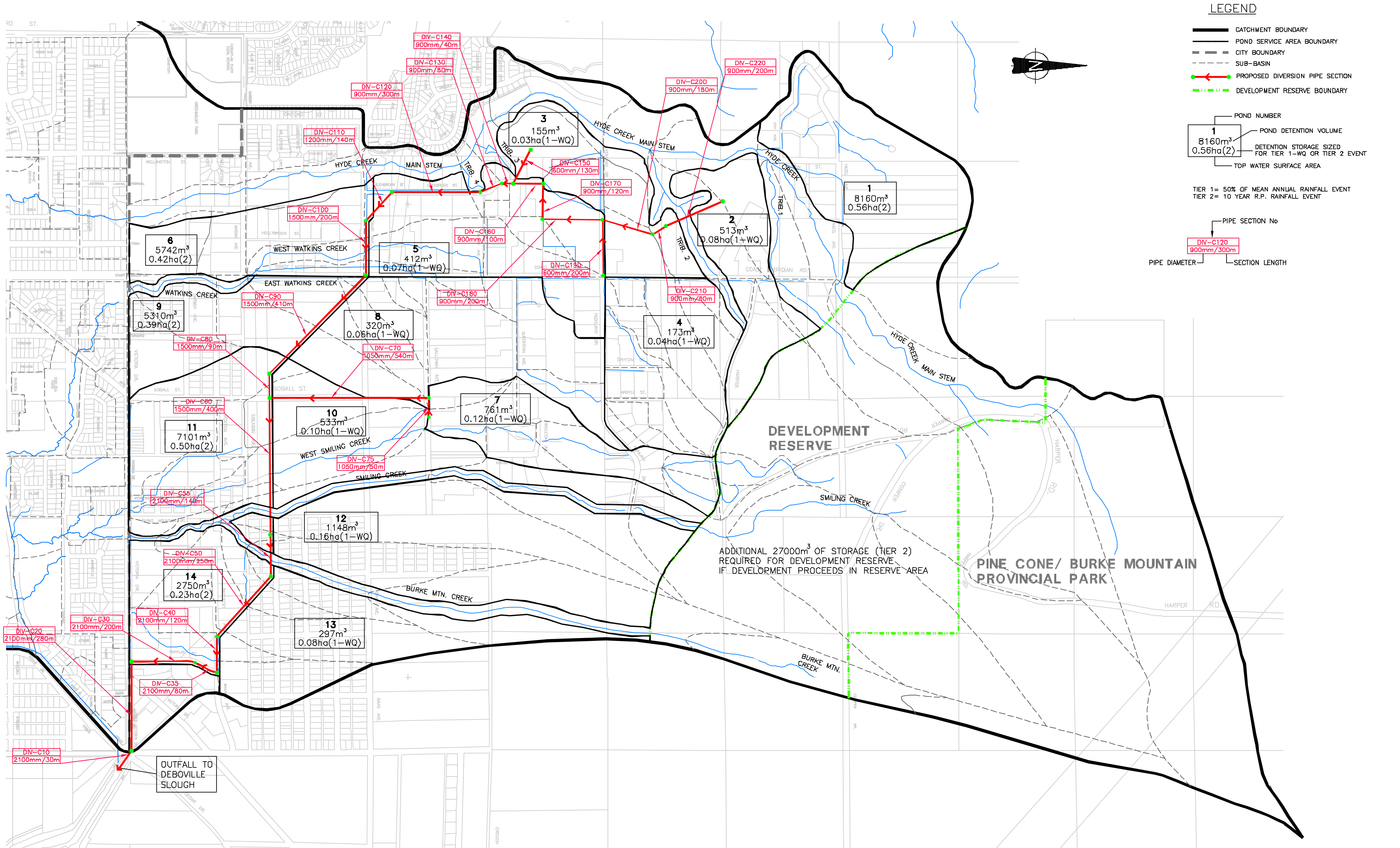
PROJECT No.	022313		
SCALE	N.T.S.		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

FLOW ROUTING AND SCHEMATIC

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 5.1		



This Drawing Is For The Use Of The Client And Project Indicated No Representations Of Any Kind Are Made To Other Parties

NO.	DATE	ENG.	BY	SUBJECT
–	–	–	–	Description

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

ASSOCIATED ENGINEERING

PROJECT No.	022313		
SCALE	1:12500		
DRAWN	G.Q.		JULY 2003
DESIGNED	M.M.		
CHECKED			
APPROVED			
DATE		INITIAL	

CITY OF COQUITLAM AND
CITY OF PORT COQUITLAM

RECOMMENDED STORM WATER MANAGEMENT PLAN

HYDE CREEK
INTEGRATED WATERSHED
MANAGEMENT PLAN

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 5.2		

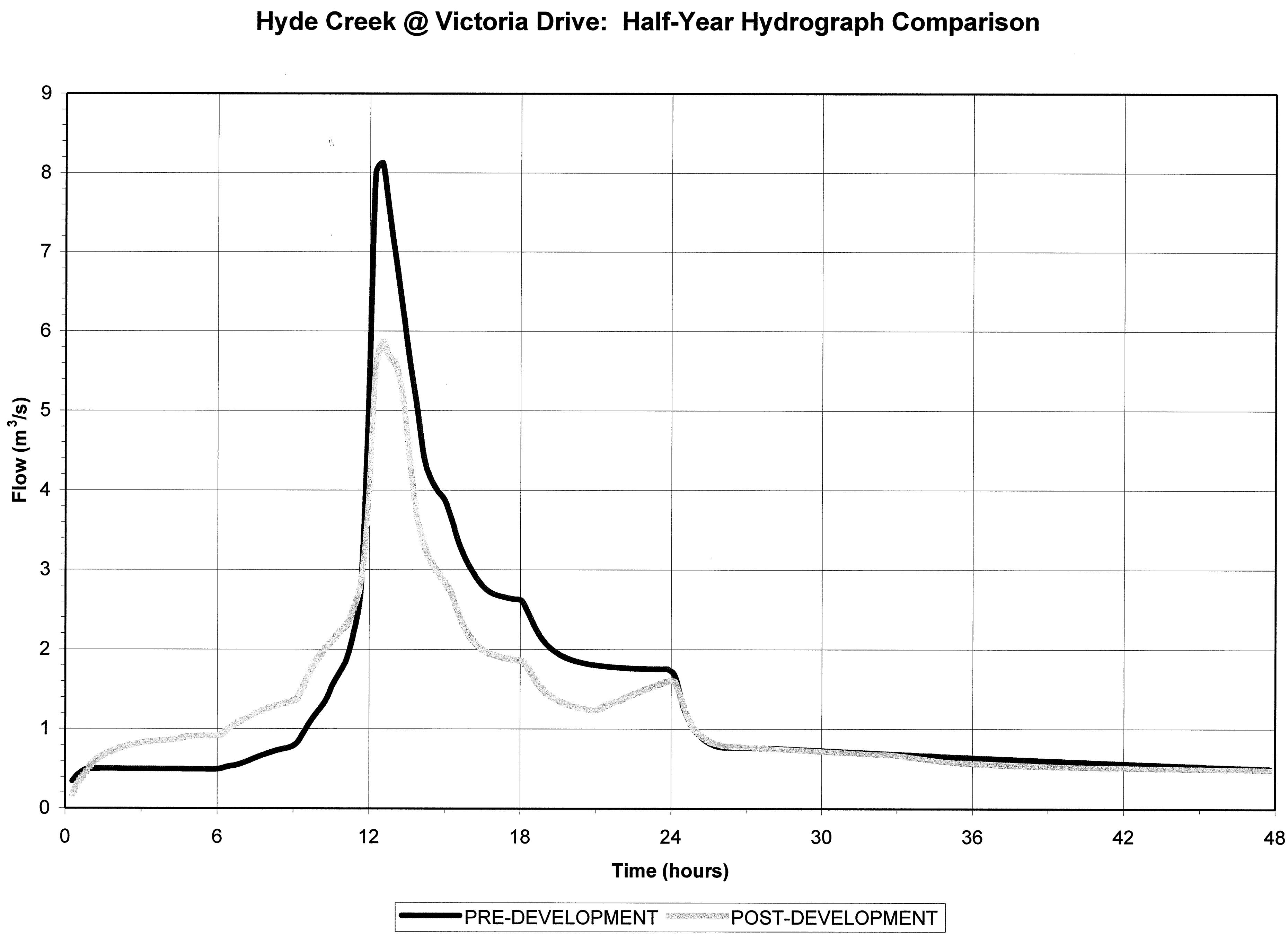
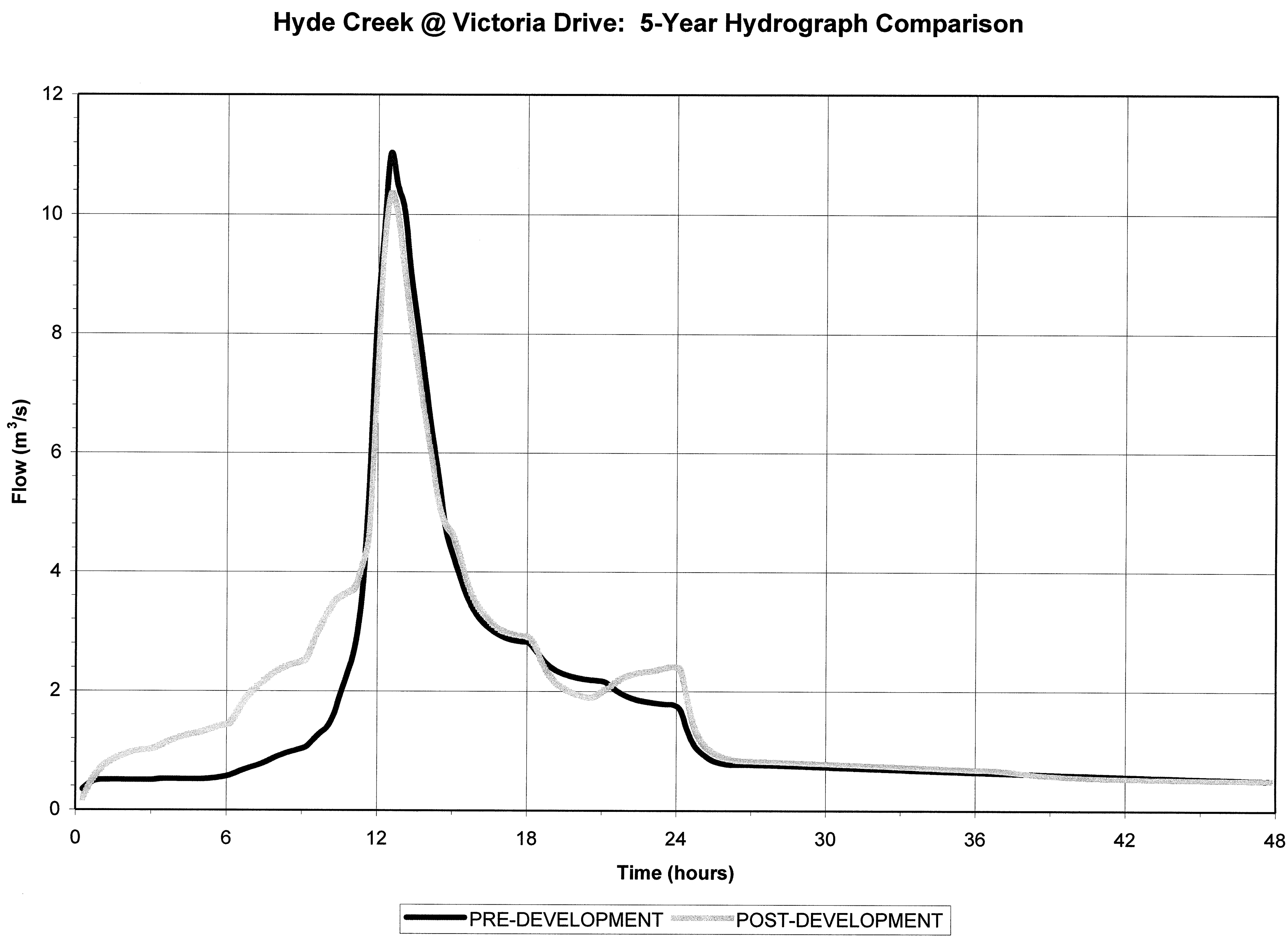

Hyde Creek @ Victoria Drive: Half-Year Hydrograph Comparison
Flow (m3/s)
0
1
2
3
4
5
6
7
8
9
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT

Figure 5.3A



Hyde Creek @ Victoria Drive: 5-Year Hydrograph Comparison
Flow (m^3/s)
0
2
4
6
8
10
12
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT

Figure 5.3B

Hyde Creek @ Victoria Drive: 10-Year Hydrograph Comparison

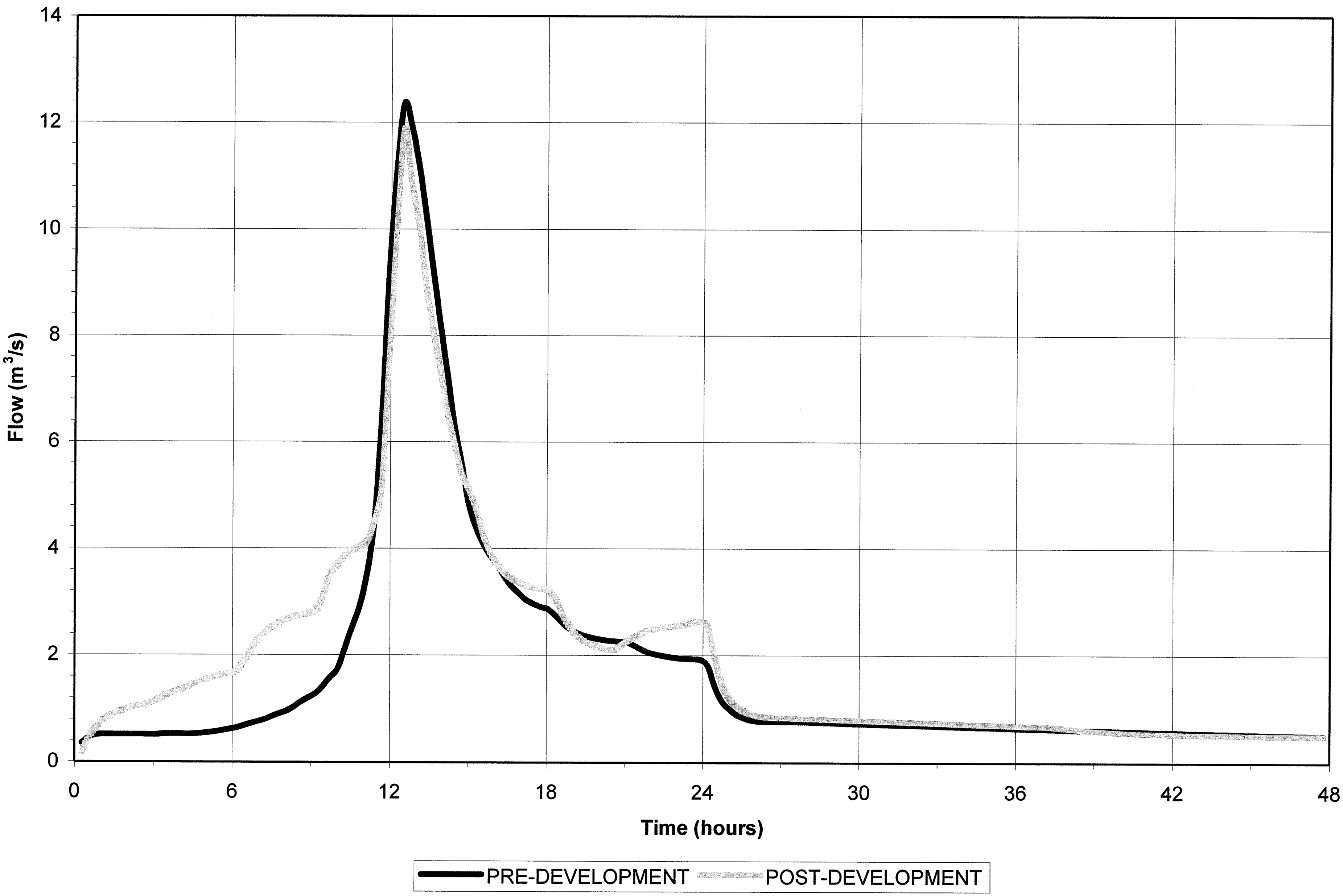


Figure 5.3C

Hyde Creek @ Victoria Drive: 100-Year Hydrograph Comparison

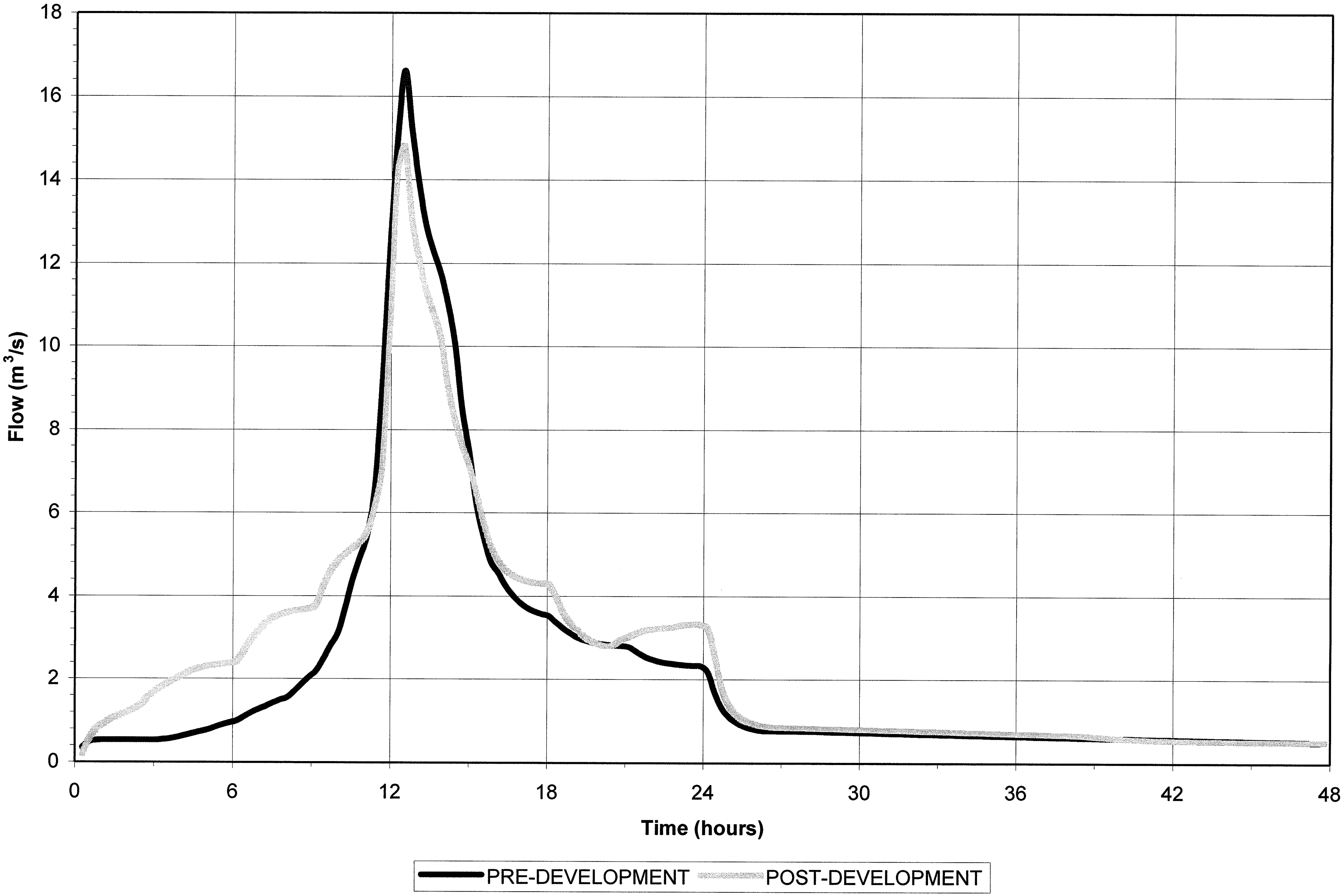
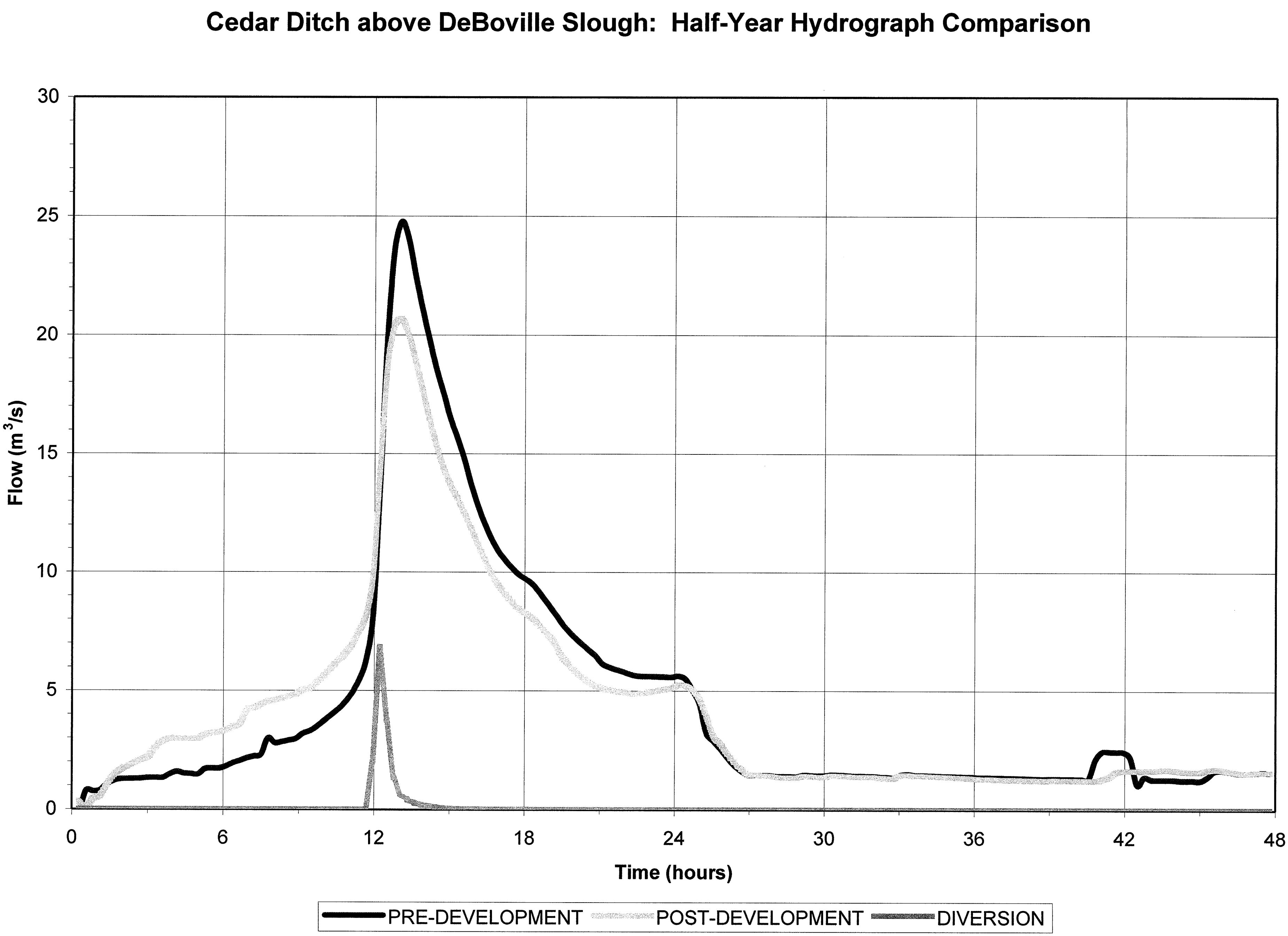


Figure 5.3D



Cedar Ditch above DeBoville Slough: Half-Year Hydrograph Comparison
Flow (m3/s)
30
25
20
15
10
5
0
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT
DIVERSION

Figure 5.4A

Cedar Ditch above DeBoville Slough: 5-Year Hydrograph Comparison

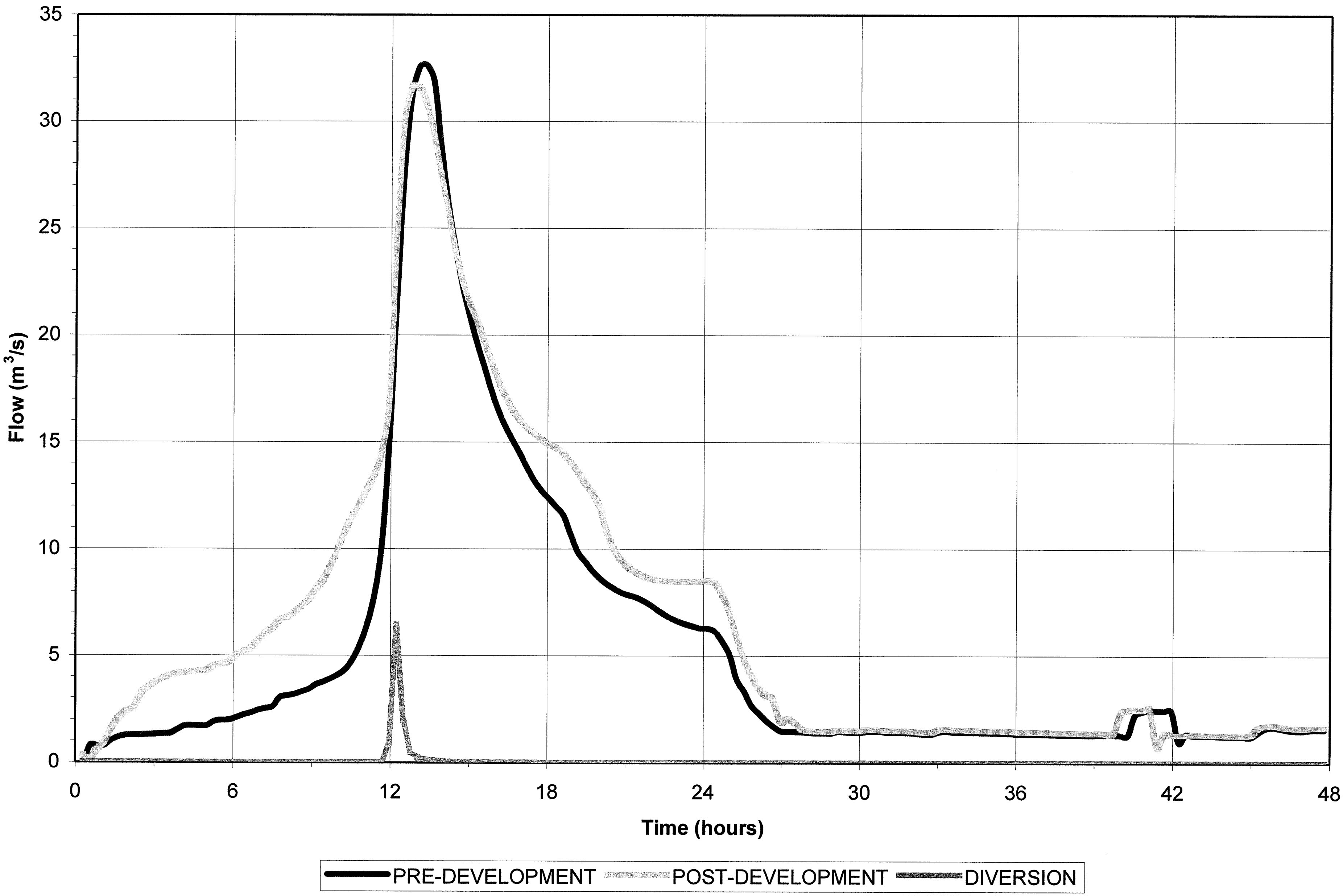
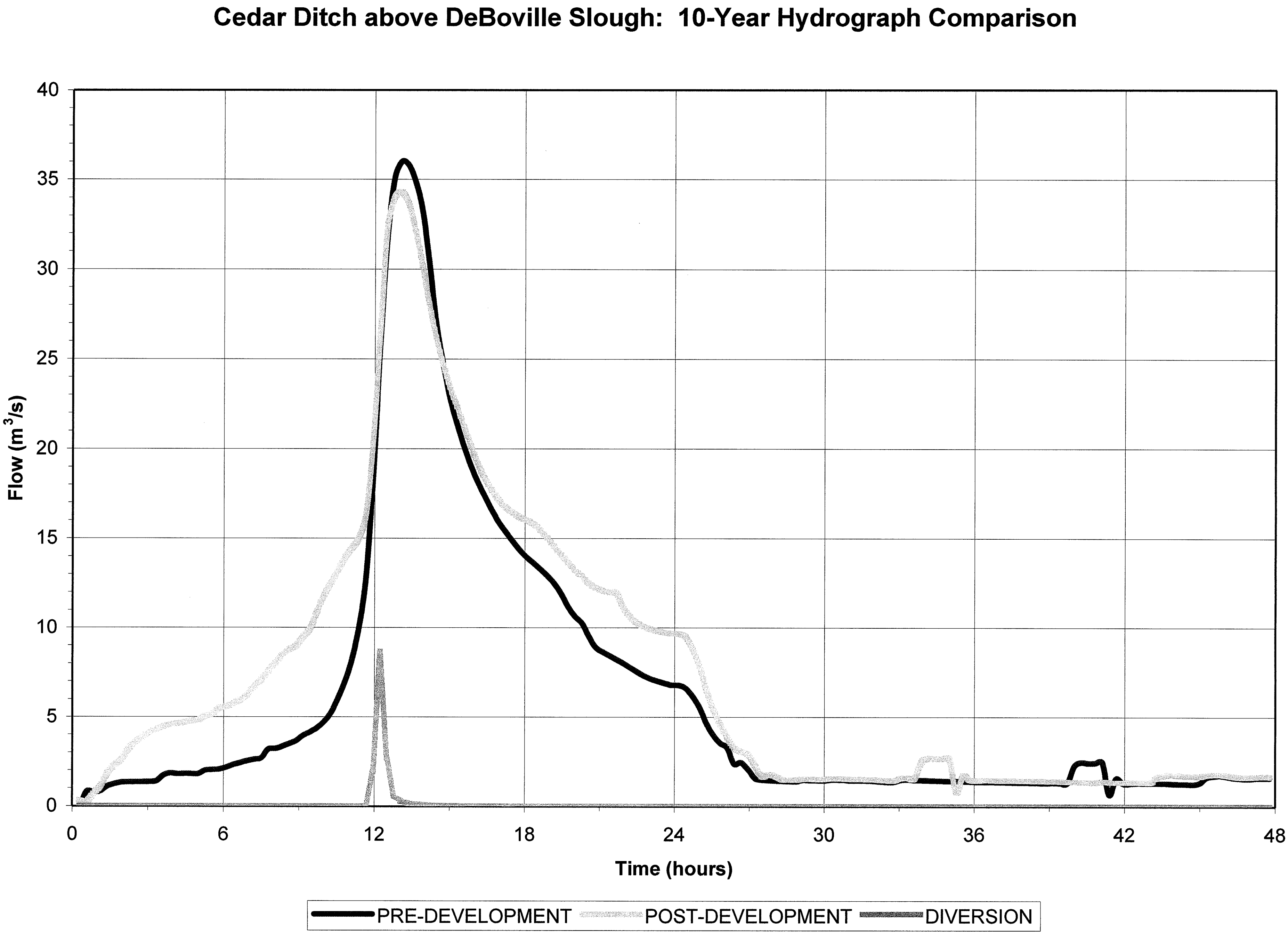


Figure 5.4B



Cedar Ditch above DeBoville Slough: 10-Year Hydrograph Comparison
Flow (m³/s)
40
35
30
25
20
15
10
5
0
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT
DIVERSION

Figure 5.4C

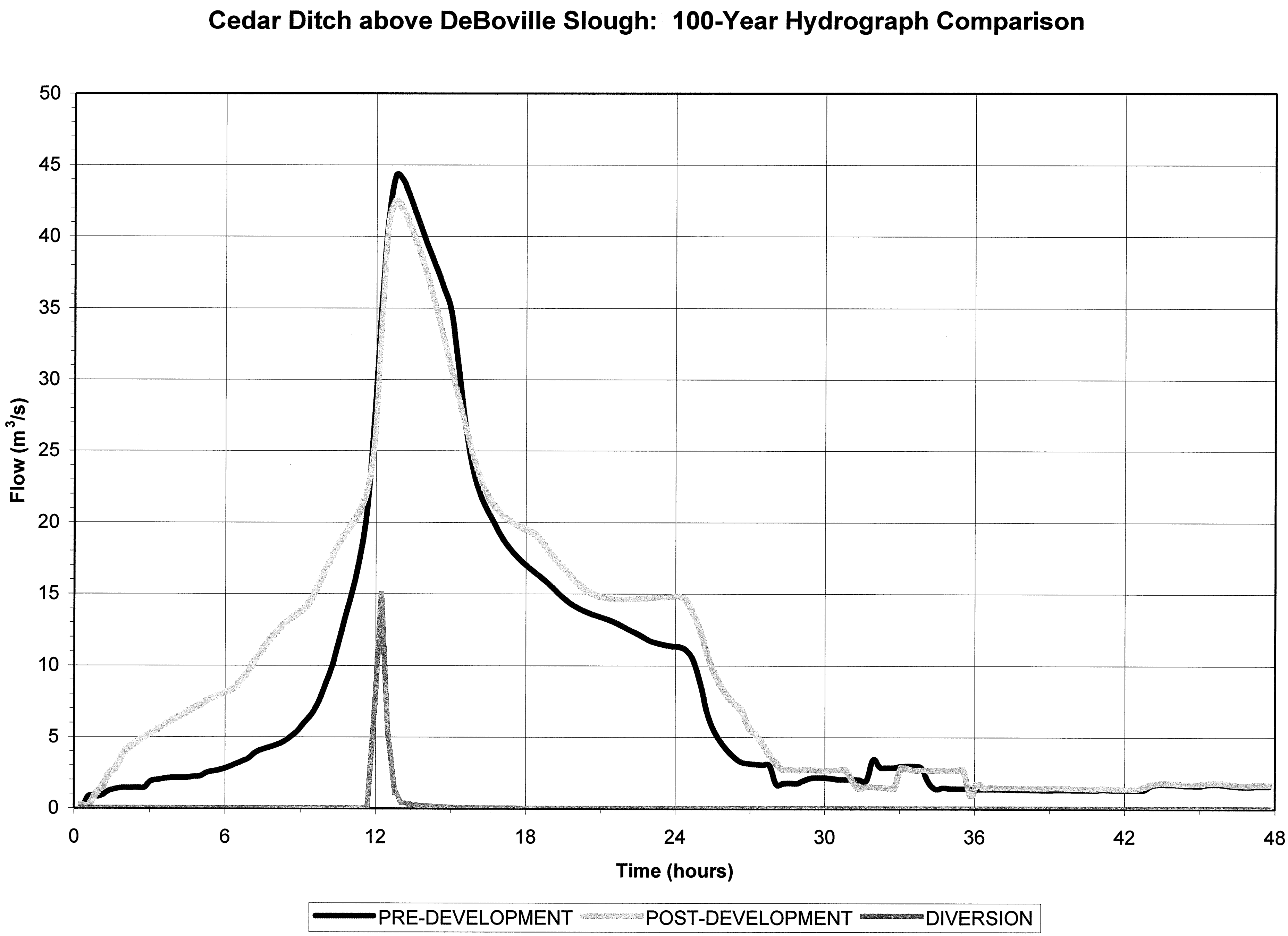

Cedar Ditch above DeBoville Slough: 100-Year Hydrograph Comparison
Flow (m3/s)
Time (hours)
0
5
10
15
20
25
30
35
40
45
50
0
6
12
18
24
30
36
42
48
PRE-DEVELOPMENT
POST-DEVELOPMENT
DIVERSION

Figure 5.4D

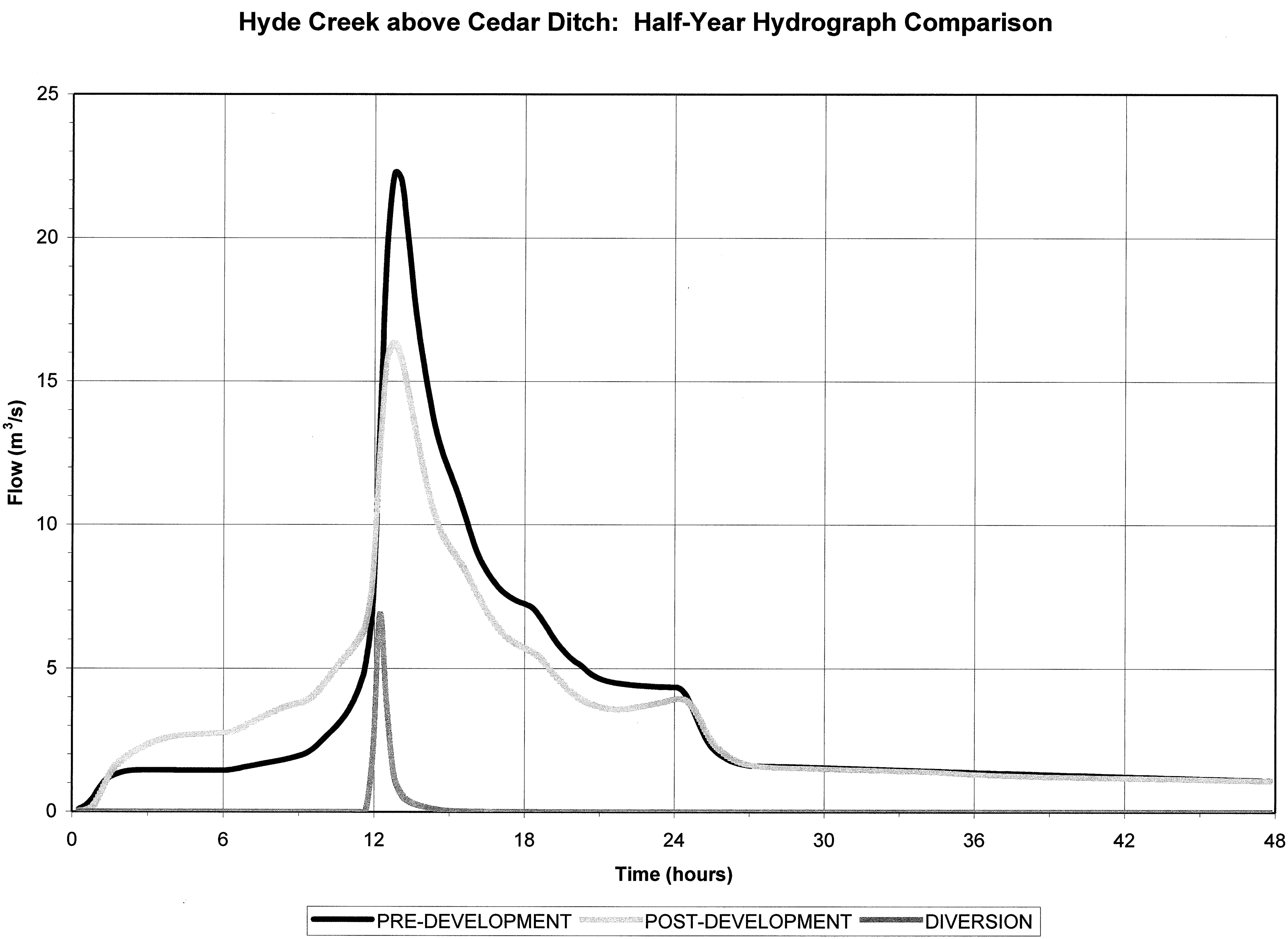

Hyde Creek above Cedar Ditch: Half-Year Hydrograph Comparison
25
20
15
10
5
0
Flow (m³/s)
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT
DIVERSION

Figure 5.5A

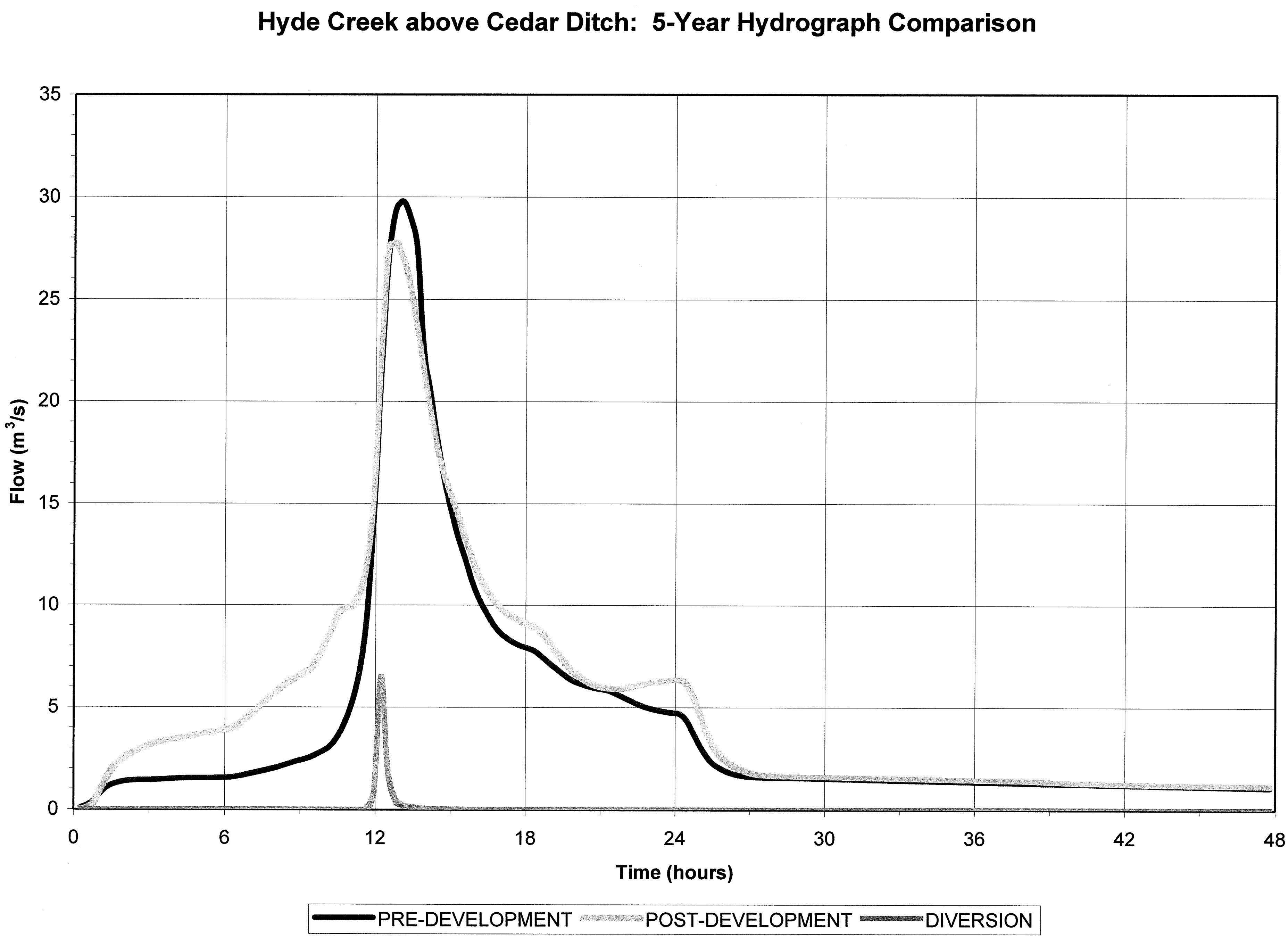

Hyde Creek above Cedar Ditch: 5-Year Hydrograph Comparison
35
30
25
20
15
10
5
0
Flow (m³/s)
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT
DIVERSION

Figure 5.5B

Hyde Creek above Cedar Ditch: 10-Year Hydrograph Comparison

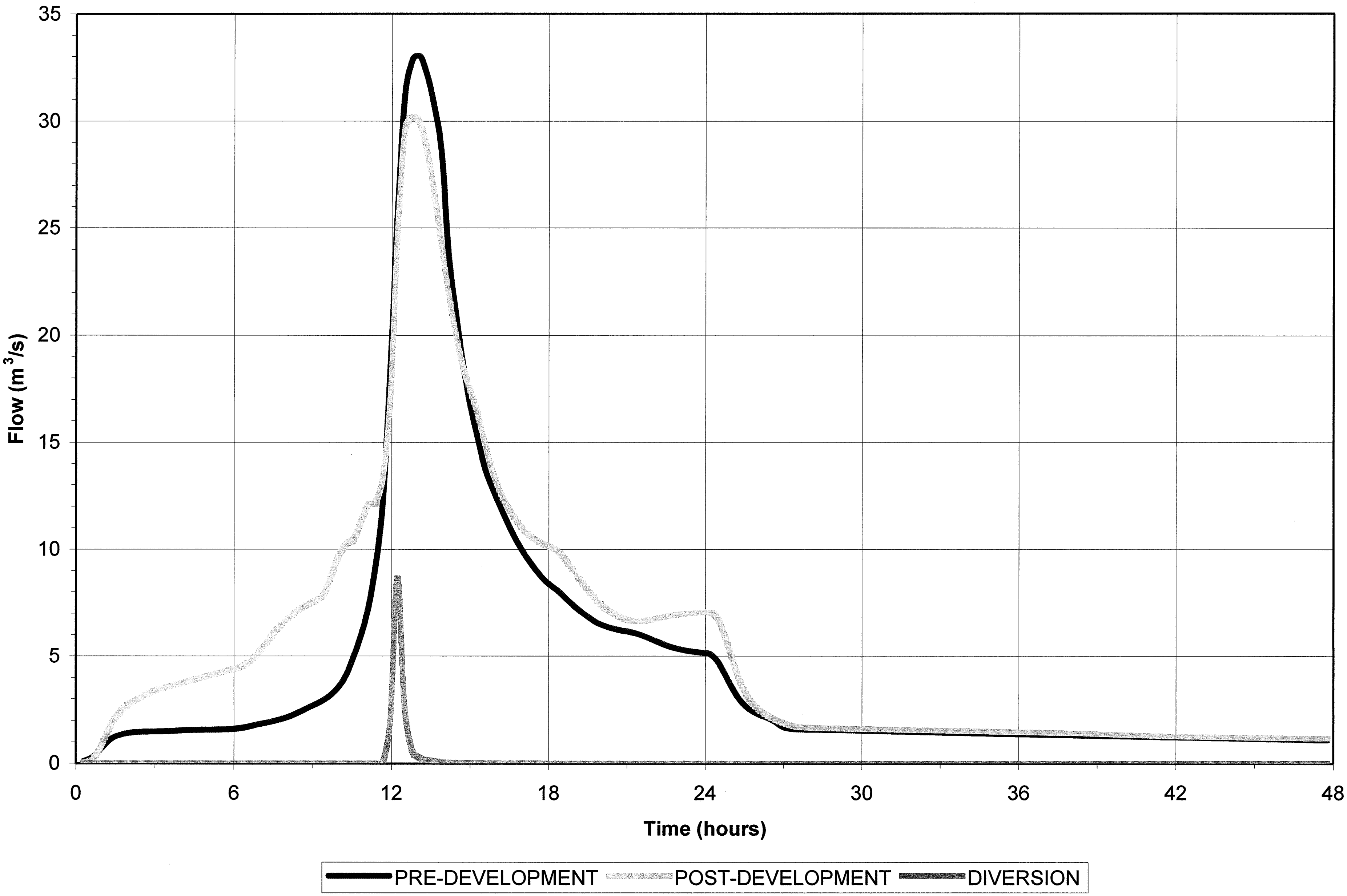


Figure 5.5C

Hyde Creek above Cedar Ditch: 100-Year Hydrograph Comparison

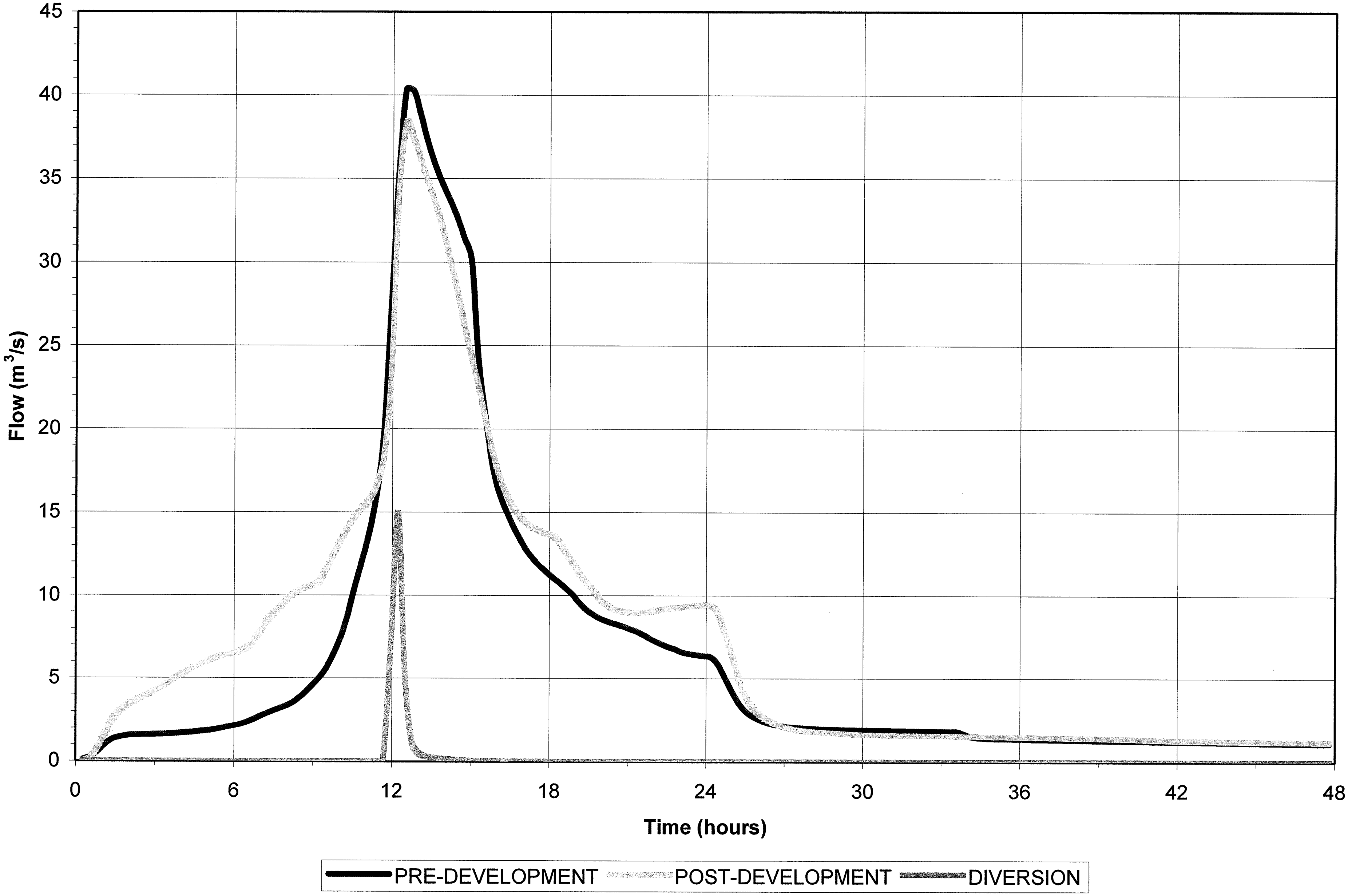


Figure 5.5D

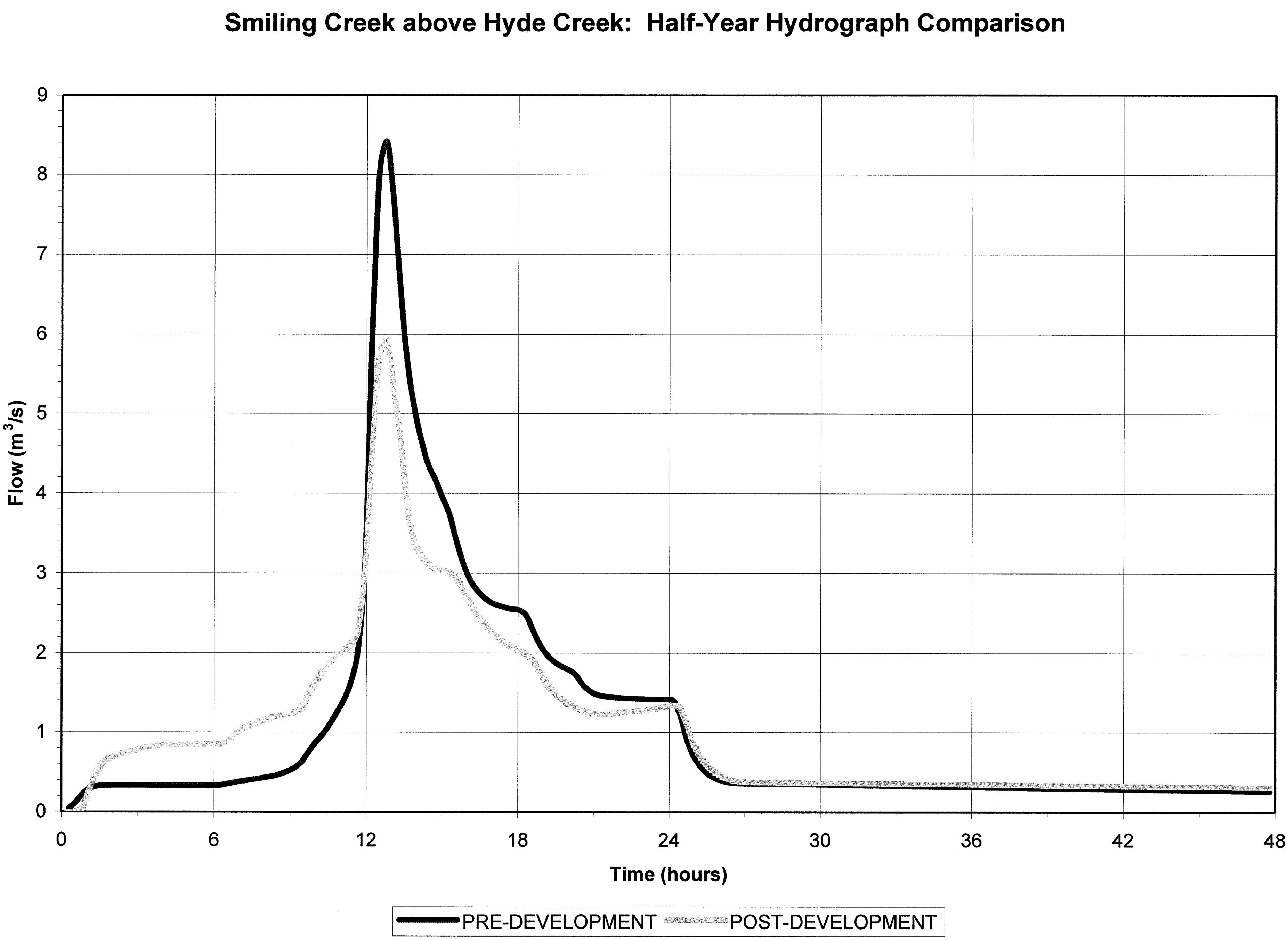

Smiling Creek above Hyde Creek: Half-Year Hydrograph Comparison
9
8
7
6
5
4
3
2
1
0
Flow (m3/s)
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT

Figure 5.6A

Smiling Creek above Hyde Creek: 5-Year Hydrograph Comparison

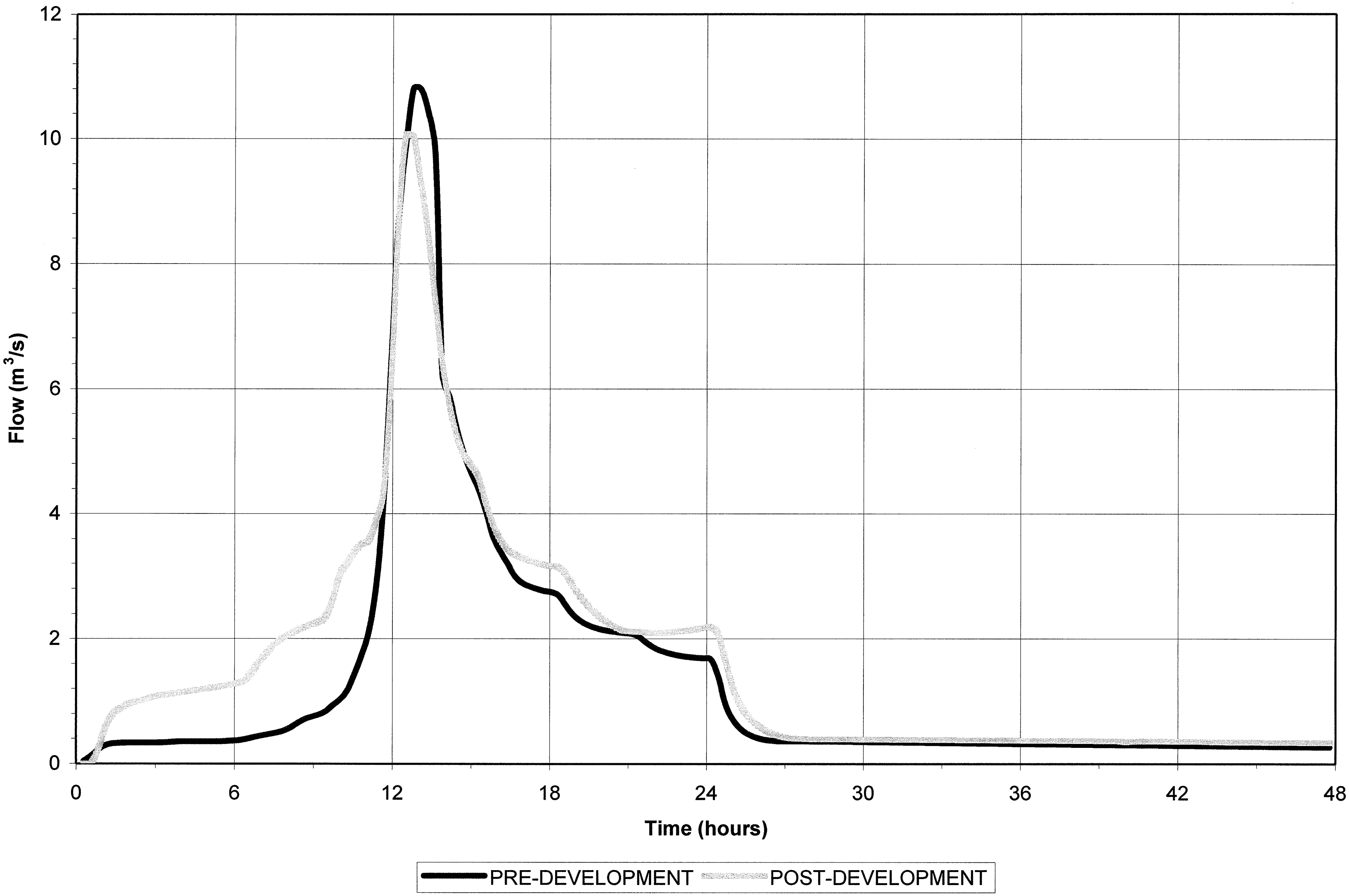
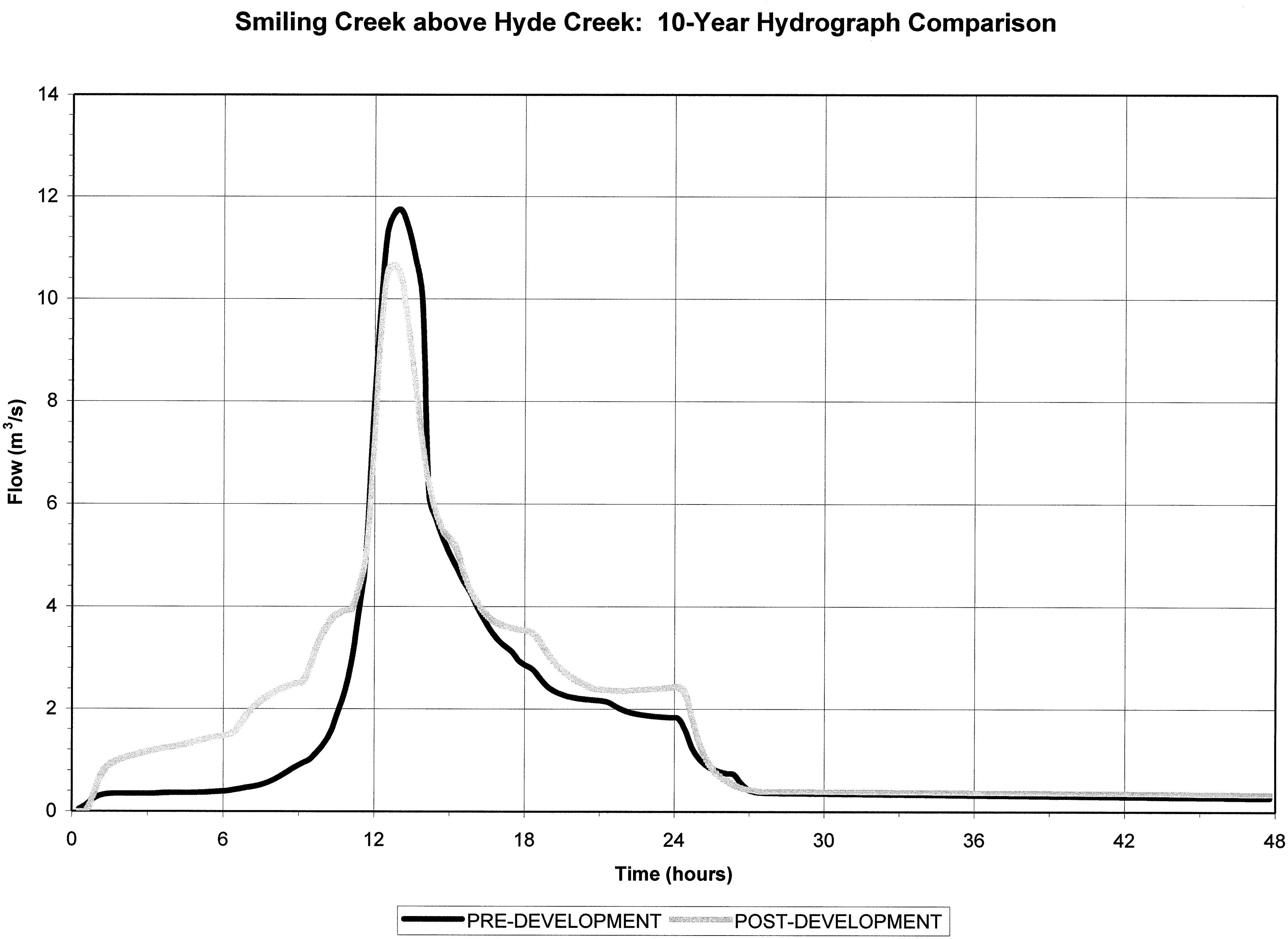
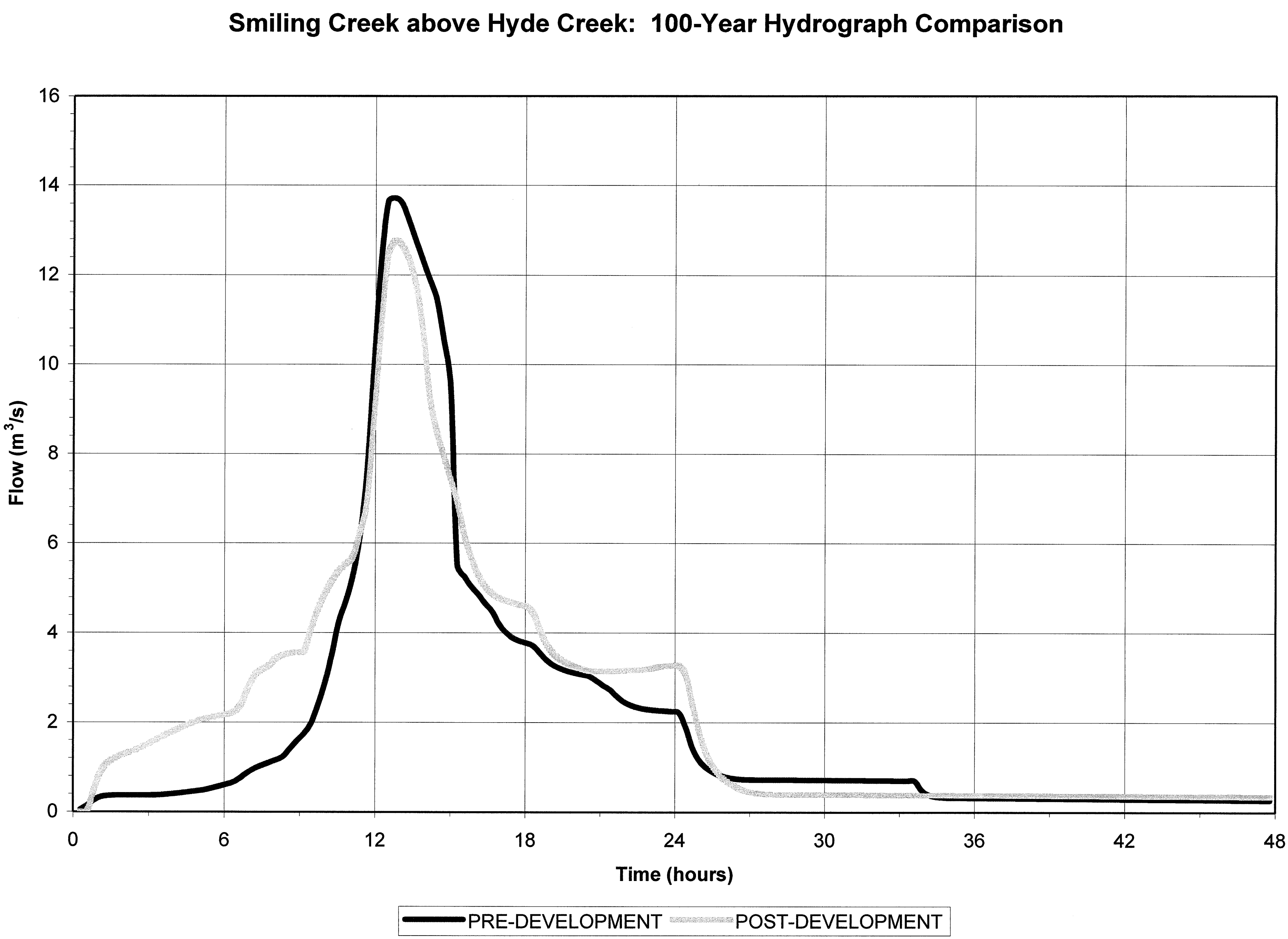


Figure 5.6B



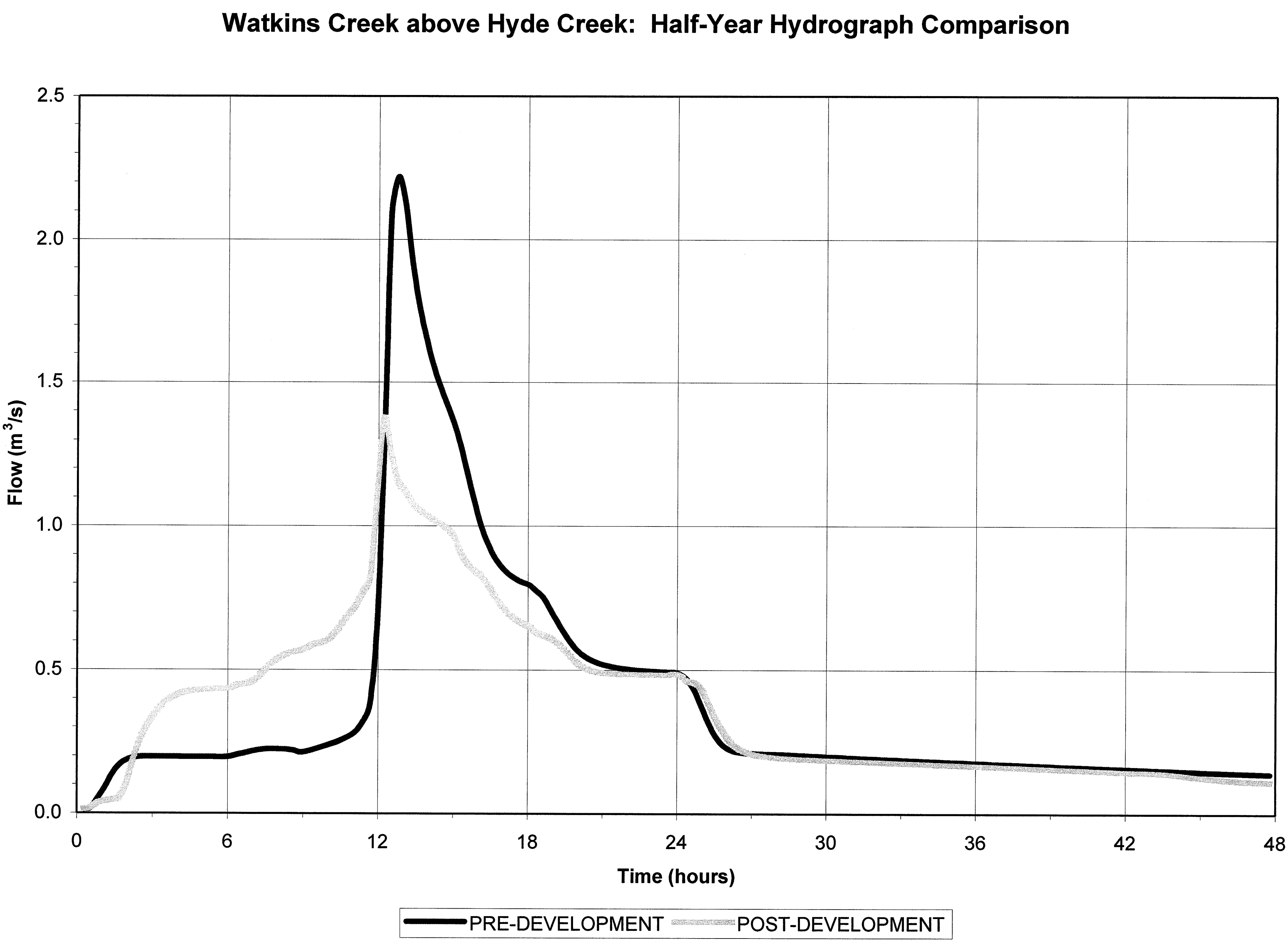
Smiling Creek above Hyde Creek: 10-Year Hydrograph Comparison
Flow (m3/s)
14
12
10
8
6
4
2
0
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT

Figure 5.6C



Smiling Creek above Hyde Creek: 100-Year Hydrograph Comparison
16
14
12
10
8
6
4
2
0
Flow (m3/s)
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT

Figure 5.6D



Watkins Creek above Hyde Creek: Half-Year Hydrograph Comparison
2.5
2.0
1.5
1.0
0.5
0.0
Flow (m^3/s)
0
6
12
18
24
30
36
42
48
Time (hours)
PRE-DEVELOPMENT
POST-DEVELOPMENT

Figure 5.7A

Watkins Creek above Hyde Creek: 5-Year Hydrograph Comparison

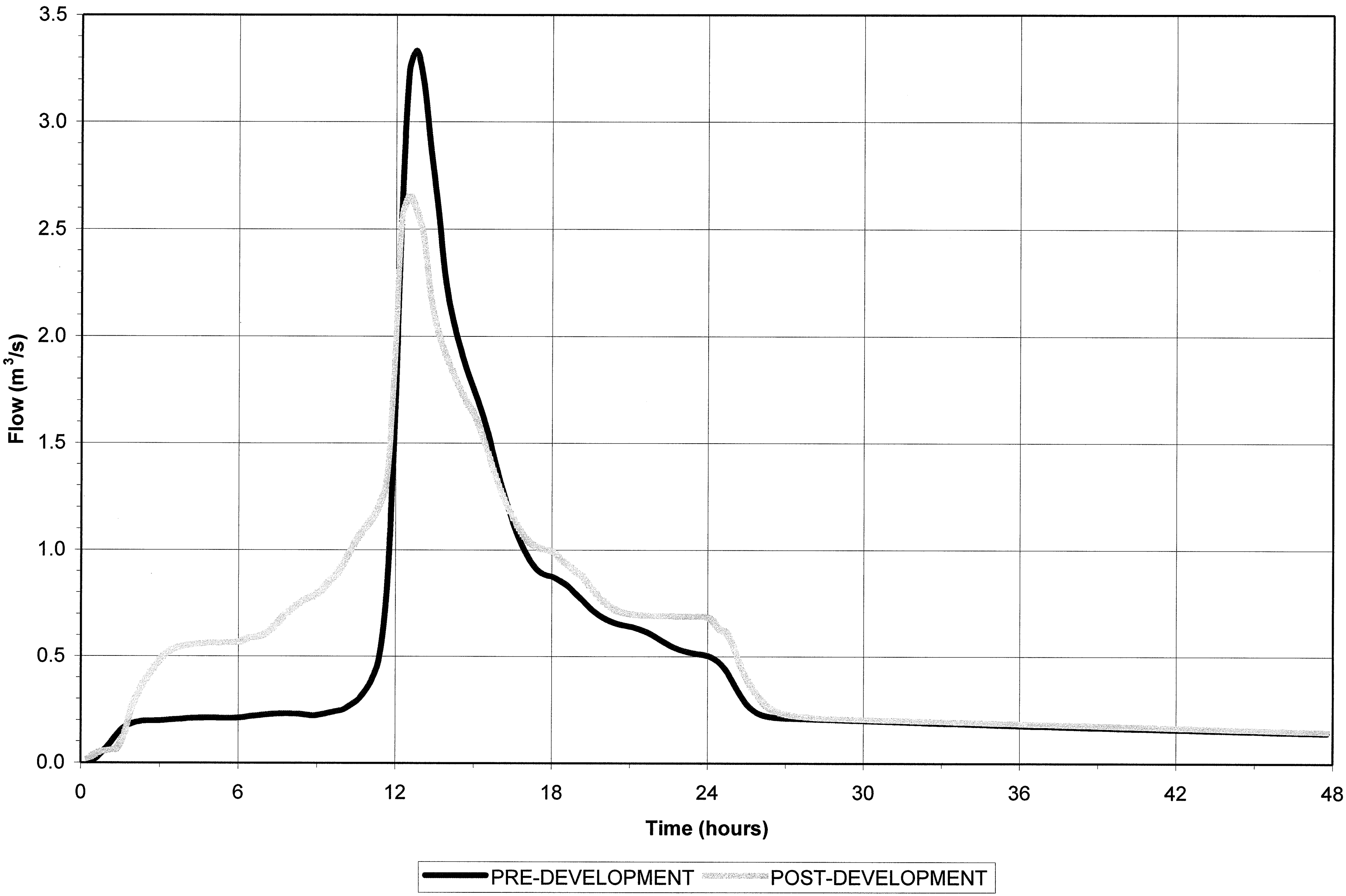


Figure 5.7B

Watkins Creek above Hyde Creek: 10-Year Hydrograph Comparison

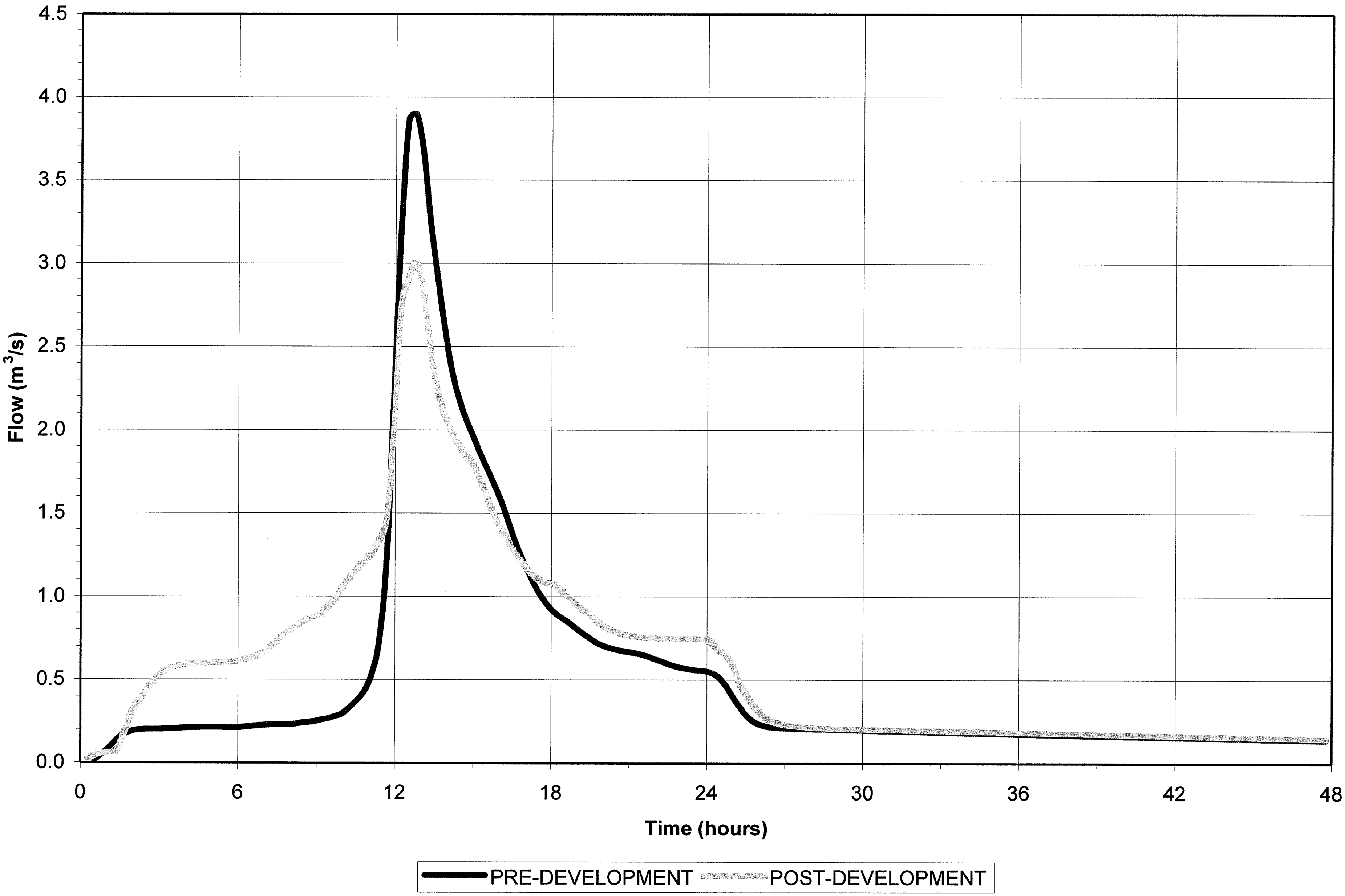


Figure 5.7C

Watkins Creek above Hyde Creek: 100-Year Hydrograph Comparison

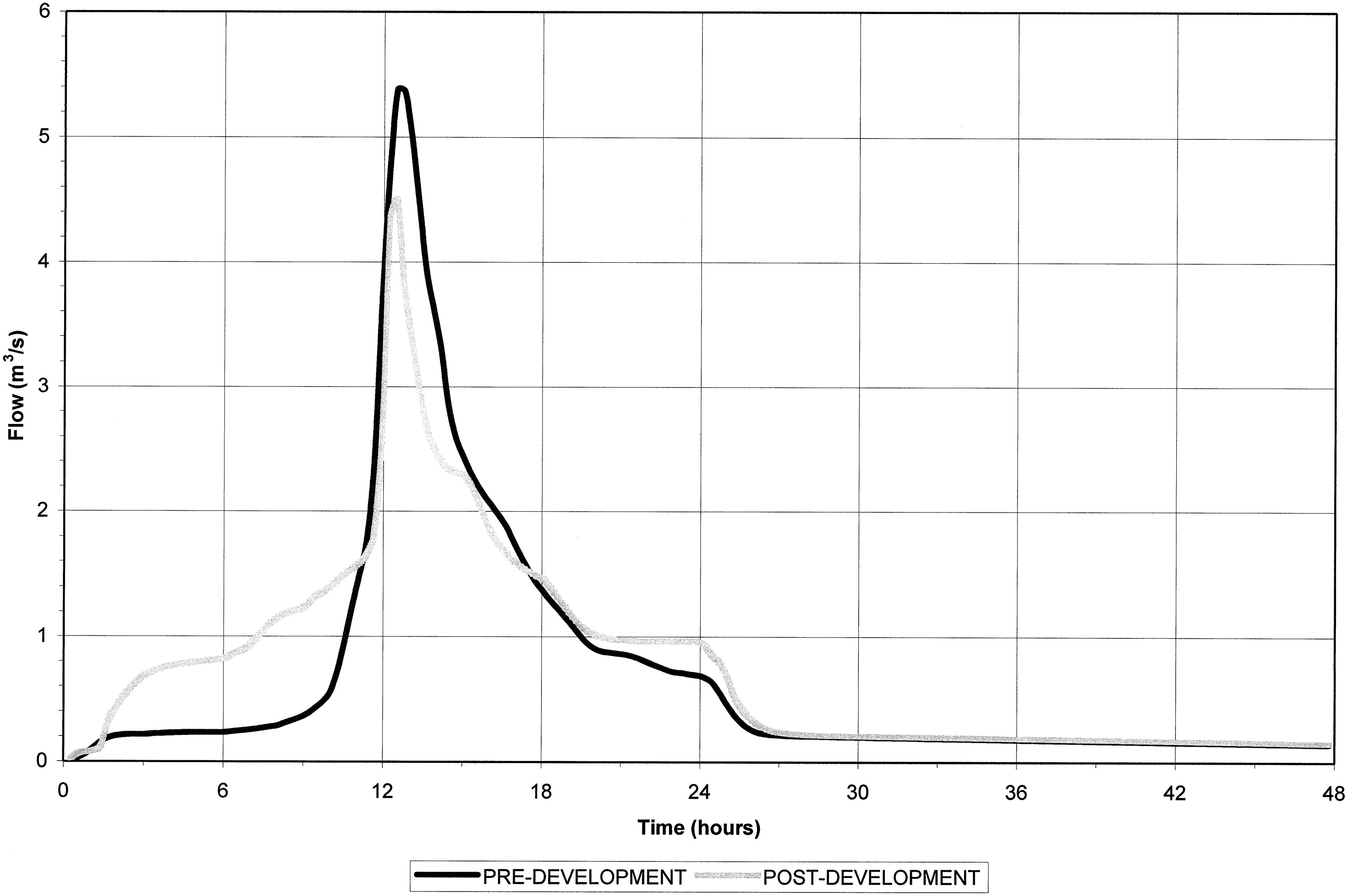


Figure 5.7D

RECOMMENDATIONS

SECTION 6

6.1 WATERSHED MANAGEMENT PLAN RECOMMENDATIONS

6.1.1 Storm Water Management

Storm Water Management Alternative 3 in its final form is presented in Figure 5.2. The final configuration incorporates a high flow diversion and Tier 1 and Tier 2 ponds. In order to reduce sediment and contaminant loads to the natural watercourses the Tier 1 ponds are required, despite the provision of the high flow diversion. The preferred alignment for the lower portion of the diversion, pending the outcome of a detailed alignment assessment, is along the B.C. Hydro right of way, Baycrest Avenue, Rocklin Streets and Victoria Drive as indicated on Figure 5.2.

For Alternative 3, the criteria used for sizing Tier 1 ponds has been further refined. The emphasis of these ponds has changed from attenuating peak flow to addressing sediment settling and other water quality requirements. Therefore, Tier 1 ponds are sized to settle sediments as small as 62 microns (medium silt) at a peak flow rate corresponding to the existing conditions for a twice per year storm. Smaller size sediment will be able to settle during lesser storm events. First flush removals will also occur in the ponds for larger storm events, prior to excess flows being routed to the diversion.

As determined from the model analysis, the required pipe diameters for the high flow diversion, and pond volumes are indicated on Figure 5.2. Note that the collection system necessary to convey the storm water from developed areas to the control structures that route flow to either the ponds or the high flow diversions has not been assessed or included in the overall Hyde Creek Integrated Watershed Management Plan. These details would be required from the neighbourhood planning processes.

We recommend that all of the proposed ponds be configured as wet ponds, planted with appropriate aquatic plant species. As wet ponds, in addition to providing peak flow attenuation, the majority of storm runoff will receive a degree of treatment from the pond prior to discharge to the creek. During larger events, the first flush of storm water, which generally has the highest concentration of contaminants, will be treated as it passes through the ponds. Wet ponds allow turbidity and suspended sediments to settle, thereby significantly improving water quality. The pond volumes indicated on Figure 5.2 are based on the use of wet ponds. Both Tier 1 water quality and Tier 2 detention ponds should be located outside of watercourses and their riparian setback areas. All ponds, whether Tier 1 or Tier 2, could be incorporated as aesthetic water features in public areas or green spaces. There are 9 Tier 1 water quality ponds and 5 Tier 2 detention ponds in the recommended storm water management system.

From a conceptual basis, the implementation of more extensive infiltration based LID measures could allow reductions in Tier 2 detention pond volumes. However it appears likely that infiltration facilities will saturate during the wettest periods of the year, and the effectiveness of LID in significantly reducing design event peak flows and volumes in this particular watershed is uncertain. More detailed hydrogeological investigations and detailed planning of infiltration facilities should be undertaken in order to consider reductions in Tier 2 pond sizes. The infiltration capacity of any such facilities must be established with certainty prior to allowing pond size reduction. As well, ongoing maintenance of the facility and guarantees that the facility will not be removed or bypassed must be confirmed. This issue can be addressed at the neighbourhood planning level. We do not recommend that it be pursued unless a high degree of confidence in the effectiveness and long term performance can be established.

Some of the detention volume of the Tier 2 ponds could be displaced to on-site detention facilities to allow the Tier 2 ponds to be reduced in overall size. However, total storage volumes should be maintained as recommended within a given service area, and total peak flow releases should not exceed the target values. Co-ordination of flow releases from a number of small facilities is more difficult to manage and runs the risk that post-development peak flows will not be attenuated to the degree required. Maintenance costs for a number of smaller dispersed facilities would likely be higher than for community-based ponds, and provision for ongoing maintenance of these on-site facilities should be considered as they will largely be located on private property. Even if all detention storage were shifted to on-site facilities the proposed detention ponds would still have to implemented as smaller Tier 1 water quality ponds, and all flow releases should still be routed through them to provide water quality improvements. The issue of on-site detention storage can be investigated in detail at the neighbourhood planning level.

We recommend the implementation of the high flow diversion scheme proposed as Alternative 3. For a given rainfall, the diversion will handle flows in excess of that generated by pre-development conditions. Conceptually, the difference between the pre-development and post-development runoff is routed to the diversion. In practice the diversion served areas will be over-controlled, with the result that pre-development peak flows on the creek system are actually reduced to a small degree. This measure is necessary to alleviate existing flooding problems and to compensate for Tier 2 ponds that only control to the 10-year return period event. The diversion is intended to handle excess post-development flows up to the 100-year event. The diversion discharges to Deboville slough, where flows from the Hyde Creek Watershed are routed in the existing regime.

On the Cedar Drive Ditch, we recommend that the potential of culvert upgrades to reduce water levels be investigated further. We identified three culverts that experience excessive head losses under at least some conditions. Upgrading of these culverts could potentially reduce water levels along Cedar Drive Ditch significantly (Cedar Drive at DeBoville Slough, Lombardy Street and Prairie Avenue). These conveyance upgrades on Cedar Drive Ditch could reduce the need for the proposed diversion of flow to the Blakeburn Lagoons as a flood control measure.

We note that the proposed storm water management scheme recommended here assumes that the local collection systems and storm water inlets are properly sized and located to ensure that runoff enters the collection, detention and diversion system. This is essential to ensure that the flows from all magnitudes of storms will be properly routed.

Our analysis and conceptual design of the storm water management components were developed using a synthetic design storm, which was scaled for various return periods. This design storm is appropriate for a global planning level study of the watershed. During the Neighbourhood Planning process the sizing and function of local system components should be confirmed with storm durations and distributions appropriate for the local sub-catchments and reflecting their time of concentrations. In addition, control devices, such as weirs and orifices, will have to be investigated at the pre-design and design level, and should be field adjustable to allow for refinement of the peak flow regime to suit actual conditions.

We have not included an allowance for the impact of climate change on rainfall depths in the watershed. The paper "Climate Change and the Greater Vancouver Regional District" (Taylor and Laglois, June 2000) indicates that a 10% to 30% increase in precipitation is possible by the late 21st Century. Over time an increased occurrence of extreme events is expected, with the result that large storms that would have been considered statistically rare will occur more frequently. By implication, the level of service of the proposed storm water management facilities will be gradually reduced as the return period of given events is reduced. The time scale of these change is on the order of a century, but the first effects of climate change will likely be felt during the life of the development.

6.1.2 Low Impact Development

The Piteau Associates' hydro-geological investigation of the watershed, included in Appendix B, indicates that the surficial soils below the approximate lower boundary of the development reserve are the most capable of infiltrating storm water. The major limiting factor is the depth and extent of these soils. During extended periods of wet weather the upper organic soil mantle will become saturated. The underlying soil stratum is impervious, with the result that the upper layer does not drain sufficiently in advance of the next rainfall. Instead, infiltration capacity is limited and groundwater travels down slope parallel to the impervious layer until intercepted by a ditch or creek.

Conventional development will increase the degree of interception of this Telluric seepage, resulting in more rapid drainage of the surface layers, to the detriment of any flow attenuation and contribution to base flows that the surface soil layer provides. Interception of sub-surface flows should be minimized, and continuity of the permeable surficial soil layers should be maintained to the greatest degree possible.

Despite the concern over the infiltration capacity of the surface soils, Piteau identifies several possible LID measures that could be implemented at the site or lot level. Community-based and other concentrated infiltration facilities are not recommended.

Where soil conditions allow, land uses encompassing single-family and possibly multi-family residential, commercial and institutional development including parks and open spaces, should make use of suitable low impact development measures. These include disconnected roof leads which could be routed to on-site infiltration facilities where feasibility is demonstrated. In the latter case, it should also be possible to intercept and direct driveway drainage to those facilities, where grades permit. Where infiltration trenches or chambers are used, they should be equipped with a high level overflow or decant to drain the storm sewer during sustained wet weather when soils are saturated and to avoid drainage problems caused by surface ponding.

A minimum 300 mm layer of absorbent soil cover should be applied to all surfaces that will have lawn or other vegetative cover. Lightly travelled driveways, alleys or emergency access lanes should be constructed with a pervious surface overlying a minimum 300 mm permeable granular base. The feasibility of pervious paving can be confirmed by pilot applications in the initial stages of development.

Where roads border on green spaces or riparian buffer zones, curbs should be eliminated or curb cuts provided at regular intervals. This strategy is acceptable for certain larger watercourses with large established riparian corridors that can filter contaminants; however, it may not be beneficial for smaller, more sensitive watercourses or those with smaller riparian corridors or steep banks that are close to the road. Sidewalks should be situated on the opposite side of the street from the natural drainage direction to avoid interfering with overland flow and infiltration.

Roadside grassed swales or infiltration trenches should continue to be employed wherever possible. Grassed swales could also be employed on the perimeter of parking lots if curbs are omitted or curb cuts provided.

The mean annual rainfall (2 year return period storm) as indicated by the GVRD rain gauge at the Burke Mountain Fire Hall, is approximately 90mm in 24 hours. Appropriate low impact development measures should be implemented in order to strive to infiltrate up to 45 mm of rainfall in 24 hours. However, fail safe measures, such as decants in infiltration chambers, should be employed to prevent flooding, property damage, and nuisance conditions when infiltration is limited by saturated ground conditions during the winter wet season.

All land uses should maximize on-site pervious areas through Best Management Practices including porous surfaces and landscaping.

The scenarios for percentage Effective Impervious Area (EIA) presented in Tables 4.3 and 4.4 are approximate targets that are possible when different suites of Low Impact Development (LID) measures are applied. As Coquitlam has better opportunities to immediately begin applying LID measures, it is possible for Coquitlam to strive towards Scenario 4 and, perhaps, Scenario 5 if opportunities are realized under favourable soil conditions. As discussed in Section 5.4, the EIA tributary to stream corridors is further reduced from that obtained by applying LID measures by the operation of the peak flow diversion and storm water quality ponds.

6.1.3 Correction of Existing Deficiencies

Table 6.1 indicates existing major culverts on Hyde, East and West Watkins, West Smiling, Smiling and Burke Mountain Creeks that do not have sufficient conveyance capacity for the 10-year storm under pre-development conditions. These culverts should be replaced with the suggested upgrades to ensure that road overtopping and washouts do not occur in the creek systems.

The recommended culvert upgrades were determined to pass the 10-year return period event with a minimal surcharge head water depth (HW) to culvert inlet opening (D) ratio (HW/D) of 1.1 at the culvert inlet. These sizes were then confirmed for their ability to pass the 100-year return period event with a surcharge of HW/D of 1.5 at the culvert inlet. A greater degree of surcharge is considered acceptable for infrequently occurring major events, and avoids having to select excessively large culvert openings. However, susceptibility to localized flooding or road overtopping will vary with culvert location, and the acceptability of these surcharge criteria should be re-evaluated during subsequent pre-design engineering work for road upgrades and during the Neighbourhood Community Plan processes.

Field Identified Deficiency (Figure 2.1)	Culvert ID	Municipality	Location	Comments
	Hyde Creek			
	HYD-C10,C20,C30	Port Coquitlam	Coast Meridian Road	Existing culvert is undersized.
	HYD-C40,C50	Port Coquitlam	Lincoln Avenue	Existing culvert is undersized.
	HYD-C60,C70	Port Coquitlam	Kent Avenue	Existing culvert is undersized.
	HYD-C80	Port Coquitlam	Greenmount Avenue	Existing culvert is undersized.
	HYD-C90	Coquitlam	Victoria Drive R/W	Existing culvert is undersized.
C-5	HYD-C104	Coquitlam	Private Driveway	Existing culvert is undersized.
C-4	HYD-C106	Coquitlam	Private Driveway	Existing culvert has sufficient capacity, stabilize fill slopes and extend
C-3	HYD-C110	Coquitlam	Coast Meridian Road	Existing culvert is undersized.
C-1	HYD-C120	Coquitlam	Harper Road	Existing culvert is undersized.
	Smiling Creek			
	SML-C10	Coquitlam	Victoria Drive	Existing culvert is undersized.
	SML-C50	Coquitlam		Existing culverts are undersized. Could use 1 - 2000 mm CSP.
C-17	SML-C60	Coquitlam		Existing culvert is undersized.
C-15	SML-C70	Coquitlam	Galloway Avenue	Existing culvert is undersized.
	SML-C80	Coquitlam	Highland Drive	Existing culvert is undersized.
	SML-C100	Coquitlam		Abandoned culvert - Remove
	SML-C110	Coquitlam	Conifer Drive	Existing culvert is undersized.
	West Smiling Creek			
	UNN-C10	Coquitlam	Victoria Drive	Existing culvert is undersized.
C-18	UNN-C15	Coquitlam	Gislason Avenue	Existing culvert is undersized.
	UNN-C20	Coquitlam	Galloway Avenue	Existing culvert is undersized.
C-11	UNN-C100	Coquitlam	Harper Road	Existing culvert is undersized.
	UNN-C105	Coquitlam	Harper Road	Existing culvert is undersized.
	UNN-C120	Coquitlam	Harper Road	Existing culvert has sufficient capacity.
	Watkins Creek			
C-14	WAT-C90	Coquitlam	David Avenue	Existing culvert has sufficient capacity - fish access - provide fish ladder or regrade channel (Note may be replaced due to road reconstruction)
	Cedar Drive Ditch			
	CED-C10/C11	Port Coquitlam	Cedar Drive to DeBoville Slough	Existing arch culvert has excessive head loss, replace with bridge
	CED-C60	Port Coquitlam	Lombardy Drive D/S	Existing box culvert has excessive head loss, replace with larger
	CED-C70	Port Coquitlam	Lombardy Drive U/S	Existing box culvert has excessive head loss, replace with larger
	CED-C80/C75	Port Coquitlam	Prairie Avenue	Existing box culvert has excessive head loss, replace with larger
	Burke Mountain Creek			
M-5		Coquitlam		Yard waste/debris in channel - remove, install signage and leaflet area
	Hyde Creek			
C-2	HAR-C20	Coquitlam	Harper Road	Perched culvert - regrade channel, or install concrete fish ladder
C-6	Not modelled	Coquitlam		Perched culvert - regrade channel, or install concrete fish ladder
C-7	CME-C320	Coquitlam	Coast Meridian	Perched culvert - regrade channel, or install concrete fish ladder
C-8	CME-C290	Coquitlam	Coast Meridian	Perched culvert - regrade channel, or install concrete fish ladder
E-1		Coquitlam		Erosion control - rip-rap or bio-engineered bank protection
E-2		Coquitlam	Main Stem	Erosion control - rip-rap or bio-engineered bank protection
E-3		Coquitlam	Main Stem	Erosion control - rip-rap or bio-engineered bank protection
E-4		Coquitlam		Erosion control - rip-rap or bio-engineered bank protection
H-1		Coquitlam	Above Coast Meridian	Loss of base flow - supplement with wells or other supply
H-4		Coquitlam		Debris Jams on Hyde Creek - remove only when they present a threat
H-5		Coquitlam		Small dam and pond on private property - remove and reinstate channel
H-6		Coquitlam		Sharp drop in channel - regrade
H-7		Coquitlam		Old log bridge (possibly being used for trail access) - remove or replace
H-8		Port Coquitlam		Loss of base flow - supplement with wells or other supply
H-9		Port Coquitlam		Constrained channel and undermined retaining wall
H-12		Port Coquitlam		Clear Debris Jam
M-3		Port Coquitlam		Remove invasive vegetation
M-4		Port Coquitlam		Fence off trail from creek
	Smiling Creek			
C-10		Coquitlam		Collapsed log crib bridge - Remove
E-6		Coquitlam		Erosion control - rip-rap or bio-engineered bank protection
H-10		Coquitlam		Low footbridge (private) - raise or remove

Table 6.1
Existing Deficiencies and
Enhancement Opportunities

Field Identified Deficiency (Figure 2.1)	Culvert ID	Municipality	Location	Comments
	West Smiling Creek			
M-1		Coquitlam		Failing retaining wall - reconstruct or remove
	Watkins Creek			
C-12	CME-C120	Coquitlam		Existing culvert is perched, replace or otherwise provide fish access
C-13	CMW-C70	Coquitlam		Existing culvert has poor inlet conditions, structurally suspect, reconstruct
C-16	CMW-C30	Coquitlam		Existing culvert is perched with erosion occuring, replace
E-5		Coquitlam		Erosion control - rip-rap or bio-engineered bank protection
M-2		Coquitlam		

N:\022313\HYDGY\Report\April 04 Final\[Major Culverts Summary.xls]TABLE 6.1

Culverts on Cedar Drive Ditch were evaluated on the basis of different criteria, excessive head loss (> 10 cm) through the culvert, rather than entrance conditions. Three culverts were identified as having larger than acceptable head loss. Table 5.3 indicates the headloss through each culvert on Cedar Drive Ditch, and possible culvert upgrades are discussed in section 5.5. Upgrading of the three culverts with the greatest head losses is recommended to reduce hydraulic grade lines on Cedar Drive Ditch, and reduce flooding risk. Note that a concrete slab bridge is recommended for Cedar Drive Ditch at Cedar Drive (immediately above DeBoville Slough). A more detailed hydraulic analysis is required to finalize replacement culvert sizes.

6.1.4 DeBoville Slough Evaluation

The proposed peak flow diversion is intended to discharge to DeBoville slough. The investigation of the impact of this discharge on DeBoville Slough was beyond the scope of the present assignment and has not been assessed. We recommend that a pre-design investigation of the impact of this proposed discharge be carried out.

Such an investigation would consider the impacts to DeBoville Slough from potentially increased flow velocities and water levels during peak flow diversions, and any limitations on hydraulic capacity. These could result in secondary impacts that may include; re-suspension of settled fine sediment, disruption of riparian vegetation, bank erosion and disruption of fish habitat. An environmental assessment would be a component of the pre-design investigation.

A pre-design investigation would determine the best location for the discharge, and any mitigative measures or special circumstances. The cost estimate for the discharge structure and associated works would be refined at this time.

6.2 ENVIRONMENTAL

In addition to the storm water management recommendations discussed above, we recommend the following measures to specifically address other environmental concerns within the watershed, in an attempt to minimize the impact of development.

6.2.1 Riparian Setbacks

Much of a developing watershed's capability to function as productive fish and wildlife habitat can be preserved through the protection of appropriately wide riparian corridors. The general intent is to retain the watercourse and an adequate riparian buffer zone that will maintain its ecological integrity.

Development in Coquitlam within the Hyde Creek Watershed Study Area to date is predominantly rural and/or low density; this type of development has a low percentage of impervious cover. Riparian setbacks will allow for the maintenance/maximization of pervious landscape immediately adjacent to watercourses within the watershed.

In order to identify site conditions and determine the riparian protection and enhancement areas (i.e. leave strips or setbacks) within the Hyde Creek watershed, the City of Port Coquitlam adopted an approach consistent with the Provincial Streamside Protection Regulation of the Fish Protection Act and the Federal Land Development Guidelines for the Protection of Aquatic Habitat in their Watercourse Protection Development Permit Area (DPA) guidelines in the Official Community Plan. All new development within the Watercourse Protection DPAs will be assessed based on these guidelines. The DPAs apply to all property within fifty metres of the specified watercourses and the leave strips range from five to thirty metres depending on the watercourse classification and vegetation within the riparian area.

In July 2000, the City of Coquitlam Northeast Area Plan established DPAs on either side of its watercourses in the plan area. These DPAs, which occur within 50m from the top-of-bank of all watercourses, allow the City to ask for fish and wildlife studies, top-of-bank surveys, riparian setback determinations, analysis of hazard lands and slope stability, and assessments of existing trees and undergrowth. This information will allow for a more complete analysis and understanding of watercourse function and fish and wildlife habitat values. The appropriateness of the setbacks proposed by the consultants will need to meet Fisheries and Oceans Canada (DFO) requirements. Avoidance of environmental impact will be a first consideration, but where impacts are unavoidable and approved by DFO, compensation as authorized by DFO, will be required. Additional requirements may be identified by City staff and authorized by Council at their discretion. This approach recognizes that at the end of the day, the federal Fisheries Act wields the greatest strength in protecting fish and fish habitat.

The City of Coquitlam has taken an approach, at the watershed level, to identify the key limiting factors affecting watercourses in the Hyde Creek watershed. (These limitations may include barriers to fish passage, lack of riparian habitat, poor water quality, low flows.) Appropriate enhancement opportunities will also be identified. (These opportunities may include restoring fish passage, riparian planting, flow augmentation and stormwater treatment.) This information will provide a better understanding of the existing aquatic habitat conditions in the watershed and will form the basis for requiring habitat enhancement and restoration measures, as opportunities arise. This process represents a departure from previous approaches where enhancement opportunities undertaken by development proponents were done in a piece-meal, fragmented and site-specific manner. This new process aims at allocating resources and efforts to achieve prioritized enhancement opportunities that provide the best benefit and function for fish and wildlife resources in the watershed. We will also seek opportunities to involve relevant stewardship groups in the prioritization and implementation of habitat enhancement works.

6.2.2 Sediment Control During Construction

The City of Coquitlam has a bylaw covering the control of sediment on construction sites. This bylaw will be fully applicable to development activities in the Hyde Creek Watershed, and contractors will be responsible for all on-site sediment control measures, as with any other construction site.

The proposed Tier-1 water quality ponds should not be used for sediment control from construction sites. They are intended to settle sediments from urban runoff and they will potentially be overwhelmed if they receive sediment released from construction sites. Further, construction activities should not be relying on City controlled facilities as part of their sediment control plans. All construction related sediment control measures should be separate from, and in addition to, the Tier-1 water quality ponds.

6.2.3 Watershed Environmental Monitoring

In order to properly assess any impacts to the watershed's ecology, ongoing monitoring is required as development proceeds. This investigation should include benthic invertebrate sampling, water quality sampling and flow monitoring to assess the current conditions in the watershed. This can be supplemented by fish sampling, recognizing that fish presence is subject to variation and is not always a reliable indicator of stream health.

A baseline environmental investigation and report should be undertaken to establish current environmental attributes and issues in the watershed prior to the commencement of significant development. This investigation should include benthic invertebrate sampling, water quality sampling and flow monitoring to assess the current conditions in the watershed. A process to communicate the findings and consult with the public should be established.

Periodic reporting on the monitoring results is recommended. The processes and timelines for interpreting the monitoring results and suitable mitigation measures, if warranted, will need to be developed when sufficient information has been derived from the initial monitoring efforts.

It is important to continue monitoring on a consistent and systematic basis. Data gaps make it difficult to analyze trends and assess impacts. Flow monitoring in particular should be carried out on a continuous basis, to allow annual variations, and the impacts on the hydrologic regime, to be assessed as development progresses. Other monitoring programs should be carried out on a systematic basis, at regular intervals.

6.2.4 Adaptive Management

Consistent with the objectives of the Hyde Creek Integrated Watershed Management Plan, an adaptive management approach should be adopted, whereby monitoring results are used to guide adjustments to recommended best management practices (BMPs), ponds and diversions in order to preserve overall watershed health and ensure no net loss of habitat at the watershed level. If the monitoring program indicates that net impacts or impairment or loss of habitat are occurring, appropriate measures should be identified and implemented to restore overall watershed health. An adaptive management approach could respond to flow increases occurring as a result of predicted climate change impacts.

The results of the monitoring program should be reviewed on a regular basis to determine if any net impacts or degradation are occurring. Council may appoint an advisory panel or committee to review the monitoring program results and recommend a response to indicated problems.

6.2.5 Environmental Enhancements

In Section 2, Figure 2.1 indicates deficiencies within the watershed. The deficiencies identified in Figure 2.1 are primarily environmental in nature, including perched culverts, debris blockages and erosion sites. These deficiencies provide opportunities for enhancement, either as compensation for development activity within the watershed or in order to address problems in their own right. Some perched culverts may be replaced with larger culverts in the future to increase capacity. These deficiencies are listed in Table 6.1 in conjunction with existing hydraulic deficiencies identified by the model analysis.

6.2.6 Additional Environmental Recommendations

Envirowest, in their report contained in Appendix A, makes additional recommendations regarding wildlife within the watershed. These are found in Section 6.3 of Envirowest’s report and should be considered during more detailed wildlife studies.

COST ESTIMATES AND IMPLEMENTATION

SECTION 7

7.1 CAPITAL COST ESTIMATES

Capital cost estimates for all major system components were developed from available cost data. Pond sizing and construction cost estimates were developed from data that included costs for clearing, landscaping, and environmental enhancements. Pipe system costs were developed from available data for large diameter concrete pipe installations.

Pricing for land costs are based on a recent major land purchase within North East Coquitlam. The estimated land cost is $520,000/ha. For most of the storm water ponds, the cost estimates are based on the assumption that 50% of the cost of land consumed for the pond is allocated to the capital cost of the diversion. The remaining 50% of the required land area is assumed to be co-occupied with green space, parks and other community facilities and therefore this portion of the cost is not allocated to the diversion. However, four of the storm water detention ponds, all Tier 2, are located in the vicinity of Victoria Drive where the land base has already been sub-divided and developed to a significant degree. For these four ponds, numbers 6, 9, 11 and 14, 100% of the land purchase cost was allocated to the Hyde Creek Integrated Watershed Management Plan capital cost.

For the peak flow diversion system outright purchase of private lands for rights of way was not assumed. Instead, an allowance to negotiate and secure rights of way was included in the cost estimates.

Table 7.1 presents a detailed breakdown of the capital costs for the storm water management scheme proposed for the Hyde Creek watershed in Coquitlam. The capital costs to address existing deficiencies in the watershed, in both Coquitlam and Port Coquitlam, are presented separately in Table 7.3.

A summary of the estimated capital costs is provided below in Table 7.2. All costs are in 2004 dollars. The total estimated capital costs, on the last line of Table 7.2 includes a 25% allowance for engineering and contingency costs.

Storm Water Diversion & Associated Facilities

Section	Diameter (mm)	Length (m)	Unit Cost ($/m)		Capital (Construction)	Annual O&M (1% of Capital)
DIV-C10	2100	30	1900		$57,000	$600
DIV-C20	2100	280	1900		$532,000	$5,400
DIV-C30	2100	200	1900		$380,000	$3,800
DIV-C35	2100	80	1900		$152,000	$1,600
DIV-C40	2100	120	1900		$228,000	$2,300
DIV-C50	2100	250	1900		$475,000	$4,800
DIV-C55	2100	140	1900		$266,000	$2,700
DIV-C60	1500	400	1000		$400,000	$4,000
DIV-C70	1050	540	610		$330,000	$3,300
DIV-C75	1050	50	610		$31,000	$400
DIV-C80	1500	90	1000		$90,000	$900
DIV-C90	1500	410	1000		$410,000	$4,100
DIV-C100	1500	200	1000		$200,000	$2,000
DIV-C110	1200	140	720		$101,000	$1,100
DIV-C120	900	300	500		$150,000	$1,500
DIV-C130	900	80	500		$40,000	$400
DIV-C140	900	40	500		$20,000	$200
DIV-C150	600	130	360		$47,000	$500
DIV-C160	900	100	500		$50,000	$500
DIV-C170	900	120	500		$60,000	$600
DIV-C180	900	200	500		$100,000	$1,000
DIV-C190	600	200	360		$72,000	$800
DIV-C200	900	180	500		$90,000	$900
DIV-C210	900	60	500		$30,000	$300
DIV-C220	900	200	500		$100,000	$1,000
Manholes	30		5,000		$150,000	$1,500
Collector	450	1500	325		$488,000	$4,900
Local Outfalls	250	1000	256		$256,000	$2,600
Item	**Number Req'd**		**Unit Cost ($/ea)**		**Capital (Construction)**	**Annual O&M (1% of Capital)**
Control MH	14		$25,000		$350,000	$3,500
Outlet	1		$100,000		$100,000	$1,000
Stream Crossings	2		$100,000		$200,000	
Pipe Bridge	1		$250,000		$250,000	$2,000
				Subtotal Capital Costs	**$6,205,000**	**$70,000**
				25% E&C On Capital	**$1,551,250**	
				Subtotal Diversion Capital	**$7,756,250**	
				Right of Way Costs	**$200,000**	
				Total Diversion Costs*	**$7,960,000**	

* Rounded to next ten thousand

Detention Ponds

Pond	Tier	Storage V (m^3)	Footprint (ha)	Capital (Construction)	Annual O&M (4% of Capital)
1	2	8,160	1.88	$497,000	$20,000
2	1	513	0.38	$168,000	$7,000
3	1	155	0.20	$143,000	$6,000
4	1	173	0.22	$115,000	$5,000
5	1	412	0.34	$162,000	$7,000
6	2	5,742	1.46	$384,000	$16,000
7	1	761	0.51	$187,000	$8,000
8	1	320	0.29	$151,000	$7,000
9	2	5,310	1.38	$368,000	$15,000
10	1	533	0.47	$175,000	$7,000
11	2	7,101	1.70	$396,000	$16,000
12	1	1,148	0.65	$199,000	$8,000
13	1	297	0.37	$161,000	$7,000
14	2	2,750	0.89	$271,000	$11,000
			Capital Costs - Tier 2 Detention Ponds	**$1,916,000**	**$140,000**
			25% E&C On Capital	**$479,000**	
			Subtotal Tier 2 Ponds Capital Costs	**$2,395,000**	
			Capital Costs - Tier 1 Water Quality Ponds	**$1,461,000**	
			25% E&C On Capital	**$365,250**	
			Subtotal Tier 1 Ponds Capital Costs	**$1,826,250**	
			Land Acquisition Costs	**$4,203,500**	
			Total Storm Water Ponds Costs*	**$8,430,000**	

* Rounded to next ten thousand

Diversion Capital Cost	**$7,960,000**	
Storm Water Pond Capital Cost	**$8,430,000**	
Grand Total	**$16,390,000**	**$210,000**

Table 7.1 Estimated Capital and O and M Costs

Table 7.2
Summary of Estimated Capital Costs

	Diversion System	Tier 1 Water Quality Ponds	Tier 2 Detention Ponds
Construction Capital Cost	$6,205,000	$1,461,000	$1,916,000
25% E&C	$1,551,250	$365,250	$479,000
Item Subtotal	$7,756,250	$1,826,250	$2,395,000
Land or ROW Cost	$200,000	$4,203,500 (all ponds together)	
Subtotal[1]	**$7,960,000**	**$8,430,000 (all ponds together)**	
Total[1]	**$16,390,000**		

[1]Total rounded up to next ten thousand.

The estimated total capital cost to implement the storm water management component of the Hyde Creek Integrated Watershed Management Plan within the City of Coquitlam is $16,390,000.

7.2 EXISTING DEFICIENCIES

Within the Hyde Creek watershed existing deficiencies were identified by both the field investigation and model analysis. The identified deficiencies included undersized culverts, erosion sites, perched culverts, and inadequate base flows during dry periods. These deficiencies were summarized in Table 6.1. In Table 7.3 we have provided conceptual cost estimates for the works required to address these deficiencies. In most cases these cost estimates are only order of magnitude estimates as a more detailed investigation would be required to determine the most appropriate approach and level of effort required.

For erosion sites we have assumed an average cost of $2,000 each to provide rip-rap bank protection over a small area. Some sites with more difficult access or requiring more extensive treatment will be subject to higher costs. Miscellaneous deficiencies are assigned a nominal order of magnitude cost to remedy, in many cases actual costs will depend upon the actual course of action taken and require quotes from contractors or a pre-design assessment to estimate accurately.

Culvert upgrades were identified on the basis of limited capacity, fish passage concerns (i.e. a perched culvert) or a combination of the two. The estimated cost to address inadequate culvert capacity assumes replacement of the existing culvert with one of a similar type of the appropriate size, for example an 1800 diameter corrugated steel pipe culvert replaces a 1200 diameter corrugated steel pipe culvert. Fish passage concerns are addressed by replacing the existing deficient culvert with an identical culvert, but at an appropriate grade and configuration to accommodate fish passage. No salvage value or re-use is assumed for an existing culvert. Where both capacity and fish passage issues exist the culvert would be replaced with one of the required size with an appropriate configuration for fish passage.

Two channel reaches of Hyde Creek have been identified as being particularly deficient in base flow during dry periods. One channel reach is in Coquitlam upstream of Coast Meridian Road, the other is the reach in Port Coquitlam in the vicinity of Coast Meridian Road and the Hyde Creek Nature Reserve. The base flow deficiency on Hyde Creek in Port Coquitlam has been previously identified and partially addressed by the provision of ground water pumping. However, it is our understanding that the low flows in this reach remain a problem and further augmentation may be necessary. The reach in Coquitlam also requires base flow augmentation. However, the presence of an adequate groundwater resource appears unlikely, based on the results of previous soils investigations in the watershed and the tendency of base flow in the subject reach to gradually disappear into the underlying soils. A conceptual cost of $100,000 has been provided to address each of these base flow deficiencies, though given the difficulties in locating ground water resources the actual cost could be higher. These two items have also been given a priority ranking of 2.

A preliminary prioritization is provided for addressing these deficiencies, as indicated in Table 7.3. This prioritization can be modified in accordance with reported problems and monitoring of the watershed. Where large culverts (design flow rates greater than 5 m^3/s) have been identified as having inadequate capacity they have been given a priority ranking of 1. Smaller culverts with inadequate capacity have been given a priority of 2. Where undersize culverts coincide with fish passage concerns these have also been given a priority ranking of 1. Erosion site and miscellaneous problems have been given a priority ranking of 3. Cases that may involve structural failure or blockage of a creek channel have been given a priority ranking of 1, at least until further investigation can

Field Identified Deficiency (Figure 2.1)	Culvert ID	Municipality	Location	Priority	Post-Dev. 100-Year Peak Flow (m3/s)	Culvert Information – Existing – Type	Existing – Size (mm)	Existing – Material	Required – Type	Required – Size (mm) H	Required – Size (mm) V	Required – Material	Comments	Estimated Capital Cost – City of Port Coquitlam	Estimated Capital Cost – City of Coquitlam
	Hyde Creek														
	HYD-C10,C20,C30	Port Coquitlam	Coast Meridian Road	1	15.92	Arch Culvert	2590H x 1880V	SPCSP	Arch Culvert	3730	2290	SPCSP	Existing culvert is undersized.	$128,059	
	HYD-C40,C50	Port Coquitlam	Lincoln Avenue	1	15.71	Box Culvert	3100H x 1450V	Concrete	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.	$152,858	
	HYD-C60,C70	Port Coquitlam	Kent Avenue	1	14.91	Box Culvert	3300H x 1050V	Concrete	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.	$152,858	
	HYD-C80	Port Coquitlam	Greenmount Avenue	1	13.72	Box Culvert	3050H x 1050V	Concrete / Nat. Bottom	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.	$152,858	
	HYD-C90	Coquitlam	Victoria Drive R/W	1	13.52	Box Culvert	2700H x 1600V	Concrete / Nat. Bottom	Box Culvert	3050	2400	Concrete	Existing culvert is undersized.		$152,858
C-5	HYD-C104	Coquitlam	Private Driveway	1	6.03	Circular Culvert	1500	CSP	Circular Culvert	2000		CSP	Existing culvert is undersized.		$57,598
C-4	HYD-C106	Coquitlam	Private Driveway	1	6.06	Circular Culvert	2000	CSP					Existing culvert has sufficient capacity, stabilize fill slopes and extend		$41,924
C-3	HYD-C110	Coquitlam	Coast Meridian Road	1	6.07	Circular Culvert	1500	SPCSP	Circular Culvert	2000		CSP	Existing culvert is undersized.		$57,598
C-1	HYD-C120	Coquitlam	Harper Road	2	4.92	Circular Culvert	1000	CSP	Circular Culvert	1800		CSP	Existing culvert is undersized.		$44,393
	Smiling Creek														
	SML-C10	Coquitlam	Victoria Drive	1	10.13	Box Culvert	2400H x 1200V	Concrete	Box Culvert	2400	2400	Concrete	Existing culvert is undersized.		$123,944
	SML-C50	Coquitlam		1	5.76	Twin Circ. Culverts	2 - 900	CSP	Twin Circ. Culverts	2000		CSP	Existing culverts are undersized. Could use 1 - 2000 mm CSP.		$57,598
C-17	SML-C60	Coquitlam		2	4.88	Circular Culvert	1200	Concrete	Circular Culvert	1800		Concrete	Existing culvert is undersized.		$47,242
C-15	SML-C70	Coquitlam	Galloway Avenue	1	5.07	Circular Culvert	1400	CSP	Circular Culvert	2000		CSP	Existing culvert is undersized.		$57,598
	SML-C80	Coquitlam	Highland Drive	1	5.10	Circular Culvert	1200	Concrete	Circular Culvert	1800		Concrete	Existing culvert is undersized.		$47,242
	SML-C100	Coquitlam		3	5.10	Circular Culvert	900	CSP	Circular Culvert	2000		CSP	Abandoned culvert - Remove		$5,000
	SML-C110	Coquitlam	Conifer Drive	2	2.89	Circular Culvert	1000	CSP	Circular Culvert	1600		CSP	Existing culvert is undersized.		$35,685
	West Smiling Creek														
	UNN-C10	Coquitlam	Victoria Drive	2	1.91	Circular Culvert	900	CSP	Circular Culvert	1400		CSP	Existing culvert is undersized.		$26,825
C-18	UNN-C15	Coquitlam	Gislason Avenue	2	1.98	Circular Culvert	900	CSP	Circular Culvert	1400		CSP	Existing culvert is undersized.		$26,825
	UNN-C20	Coquitlam	Galloway Avenue	2		Circular Culvert	800	CSP	Circular Culvert	1400		CSP	Existing culvert is undersized.		$26,825
C-11	UNN-C100	Coquitlam	Harper Road	2	1.48	Circular Culvert	900	CSP	Circular Culvert	1200		CSP	Existing culvert is undersized.		$20,873
	UNN-C105	Coquitlam	Harper Road	2	1.24	Circular Culvert	600	CSP	Circular Culvert	1200		CSP	Existing culvert is undersized.		$20,873
	UNN-C120	Coquitlam	Harper Road	2	0.11	Circular Culvert	600	CSP					Existing culvert has sufficient capacity.		
	Watkins Creek														
C-14	WAT-C90	Coquitlam	David Avenue	2	0.70	Circular Culvert	1000	CSP	Circular Culvert	1000		CSP	Existing culvert has sufficient capacity - fish access - provide fish ladder or regrade channel (Note may be replaced due to road reconstruction)		$17,398
	Cedar Drive Ditch														
	CED-C10/C11	Port Coquitlam	Cedar Drive to DeBoville Slough	1		Arch Culvert	3890H x 2690V	SPCSP	Bridge				Existing arch culvert has excessive head loss, replace with bridge	$250,000	
	CED-C60	Port Coquitlam	Lombardy Drive D/S	1		Box Culvert	2700H x 1700V	Concrete	Box Culvert	2400	3050	Concrete	Existing box culvert has excessive head loss, replace with larger	$117,051	
	CED-C70	Port Coquitlam	Lombardy Drive U/S	1		Box Culvert	2750H x 1850V	Concrete	Box Culvert	2400	3050	Concrete	Existing box culvert has excessive head loss, replace with larger	$117,051	
	CED-C80/C75	Port Coquitlam	Prairie Avenue	1		Box Culvert	2600H x 1200V	Concrete	Box Culvert	2400	3050	Concrete	Existing box culvert has excessive head loss, replace with larger	$194,634	
	Burke Mountain Creek														
M-5		Coquitlam											Yard waste/debris in channel - remove, install signage and leaflet area		$1,000
	Hyde Creek														
C-2	HAR-C20	Coquitlam	Harper Road	2	2.50	Circular Culvert	750	Concrete	Circular Culvert	1400		CSP	Perched culvert - regrade channel, or install concrete fish ladder		$26,825
C-6	Not modelled	Coquitlam		2									Perched culvert - regrade channel, or install concrete fish ladder		$10,000
C-7	CME-C320	Coquitlam	Coast Meridian	2	1.25	Circular Culvert	1000	CSP	Circular Culvert	1400		CSP	Perched culvert - regrade channel, or install concrete fish ladder		$26,825
C-8	CME-C290	Coquitlam	Coast Meridian	2	1.26	Circular Culvert	1050/1400	Wood Stave/CSP	Circular Culvert	1400		CSP	Perched culvert - regrade channel, or install concrete fish ladder		$26,825
E-1		Coquitlam		3									Erosion control - rip-rap or bio-engineered bank protection		$2,000
E-2		Coquitlam	Main Stem	3									Erosion control - rip-rap or bio-engineered bank protection		$2,000
E-3		Coquitlam	Main Stem	3									Erosion control - rip-rap or bio-engineered bank protection		$2,000
E-4		Coquitlam		3									Erosion control - rip-rap or bio-engineered bank protection		$2,000
H-1		Coquitlam	Above Coast Meridian	1									Loss of base flow - supplement with wells or other supply		$100,000
H-4		Coquitlam		3									Debris Jams on Hyde Creek - remove only when they present a threat		
H-5		Coquitlam		3									Small dam and pond on private property - remove and reinstate channel		$20,000
H-6		Coquitlam		2									Sharp drop in channel - regrade		$2,000
H-7		Coquitlam		1									Old log bridge (possibly being used for trail access) - remove or replace		$5,000
H-8		Port Coquitlam		1									Loss of base flow - supplement with wells or other supply	$100,000	
H-9		Port Coquitlam		1									Constrained channel and undermined retaining wall	$50,000	
H-12		Port Coquitlam		1									Clear Debris Jam	$2,000	
M-3		Port Coquitlam		3									Remove invasive vegetation	$1,000	
M-4		Port Coquitlam		3									Fence off trail from creek	$2,000	
	Smiling Creek														
C-10		Coquitlam		2									Collapsed log crib bridge - Remove		$5,000
E-6		Coquitlam		3									Erosion control - rip-rap or bio-engineered bank protection		$2,000
H-10		Coquitlam		3									Low footbridge (private) - raise or remove		$5,000
	West Smiling Creek														
M-1		Coquitlam		1									Failing retaining wall - reconstruct or remove		$20,000
	Watkins Creek														
C-12	CME-C120	Coquitlam		2		Circular Culvert	600	CSP	Circular Culvert	600		CSP	Existing culvert is perched, replace or otherwise provide fish access		$7,718
C-13	CMW-C70	Coquitlam		1		Circular Culvert	600	Concrete	Circular Culvert	600		Concrete	Existing culvert has poor inlet conditions, structurally suspect, reconstruct		$7,970
C-16	CMW-C30	Coquitlam		2		Circular Culvert	600	CSP	Circular Culvert	600		CSP	Existing culvert is perched with erosion occuring, replace		$7,718
E-5		Coquitlam		3									Erosion control - rip-rap or bio-engineered bank protection		$2,000
M-2		Coquitlam													

N:\022313\HYDGY\Report\April 04 Final\[Major Culverts Summary.xls]TABLE 7.3

	CITY OF PORT COQUITLAM	CITY OF COQUITLAM
Subtotal Estimated Cost by Municipality	**$1,420,000**	**$1,150,000**
25% Engineering and Contingency	**$355,000**	**$288,000**
TOTAL ESTIMATED COST BY MUNICIPALITY	**$1,775,000**	**$1,438,000**

Table 7.3: Estimated Costs to Address Existing Deficiencies

assess their importance. An implementation program to address these deficiencies should be developed.

The estimated total cost to address the identified existing deficiencies within the City of Coquitlam is $1,438,000. For the City of Port Coquitlam the estimated cost to remedy the existing deficiencies within the watershed is $1,775,000. These cost estimates include a 25% allowance for engineering and contingency.

7.3 OPERATING COST ESTIMATES

Generally, annual operating costs were estimated as a percentage of the initial capital cost for each major component. The storm sewer diversion pipe was estimated to have a annual maintenance cost equivalent to 1% of the initial capital cost. Wet ponds, because they require more attention to maintain vegetation and clean out accumulated sediments and debris, were estimated to have an annual maintenance cost equal to approximately 4% of their initial capital cost. In addition, we have added 1 % of overall capital costs to represent the estimated cost of ongoing maintenance and protection of environmental enhancements, creeks and riparian corridors, and spawning habitat etc.

Table 7.4
Estimated Annual Operation and Maintenance Costs

Component	Percentage of Cap.	Est. Annual O&M
Ponds	4%	$140,000
Diversion	1%	$70,000
Environmental	5%	$160,000
Environmental and Flow Monitoring	N/A	$30,000
Total		**$400,000**

The estimated annual operating and maintenance cost for the storm water management system, excluding local collection and conveyance, is $400,000.

7.4 MAJOR COMPONENT IMPLEMENTATION AND PHASING

Construction of the major storm water management components is heavily dependent on the phasing of development within the Hyde Creek watershed. The major difficulty lies with the natural tendency to develop the watershed from west to east. The diversion scheme proposed under Alternative 3, which will divert high flows eastward to Deboville Slough, would then have to be constructed early in the development of the watershed. This will represent a high initial capital cost to be recovered later as development progresses.

The ability of the proposed Tier 1 ponds to act as detention ponds is very limited. A development proponent could temporarily construct detention ponds for storm events up to the 10-year return period and allow the service area to be developed in advance of the construction of the proposed diversion. However, this should require a temporary storm water servicing plan to be submitted to the City of Coquitlam for review and approval. Interim storm water detention ponds should be the responsibility of a development proponent who wishes to pursue this option. The temporary pond should only be used for a short period until the diversion system can be constructed.

The provision of a temporary facility should not interfere with the overall objectives of the Hyde Creek Integrated Watershed Management Plan or preclude the implementation of its recommended components or the requirements of the City's Stormwater Management Policy and Design Manual. Any interim detention facility should be designed to provide attenuation of post-development flows to pre-development levels for storm events up to the 10-year return period.

As detailed in this plan, each service area is provided with one Tier 1 or Tier 2 pond as appropriate. If during the neighbourhood planning process a need to divide these ponds into smaller more dispersed ponds is identified, this can be considered. However, the total storage volume and net peak flows released to the creek system should be maintained as detailed in this report, and divided proportionate to the division of the tributary service area. Generally the number of ponds should be kept to a minimum to simplify flow routing and coordination issues. Also operations and maintenance costs would likely be higher for a number of small ponds rather than a single centralized facility.

7.4.1 Design Criteria and Specifications

Within the City of Coquitlam's portion of the watershed, the recently developed Storm Water Management Policy and Design Manual should be applied to the design of local facilities. However, the overall objectives of the Hyde Creek Integrated Watershed Management Plan, particularly the recommendations to maximize infiltration to the extent possible and control runoff, should be followed.

Construction specifications should be developed to achieve the recommendations of the Hyde Creek Intergrated Watershed Management Plan. These specifications should include locating and sizing of infiltration facilities, provision of decants (overflows) on infiltration facilities, landscaping requirements (primarily pervious organic soil depths and preservation of existing pervious soil stratum), and BMP facility design including Tier 1 and Tier 2 ponds, control manholes and local outfalls to the creek system.

An administration protocol to manage design approval, construction inspection and monitoring of BMPs for single-family and duplex lots is required and must be prepared and duly authorized by Council prior to development approval.

Criteria for determining when swales, ditches or infiltration trenches should be used on road sides will need to be prepared to supplement the Subdivision and Development Servicing Bylaw for consistency and to avoid the need for development variances on a site-by-site basis.

7.4.2 Further Geotechnical and Hydrogeological Investigations

In support of development application reviews a geotechnical investigation should be carried out to establish the viability of infiltration measures within the development locale. The information obtained should include the extent and capacity of the pervious soil layer, depth to groundwater and expected direction of subsurface flow. The investigation should also identify whether subsurface flow may intersect any nearby drainage feature, escarpment, ravine or road cut, and whether other properties will be impacted by groundwater flows originating from infiltration features. A detailed template for the content and methodology of the geotechnical and hydrogeological investigation would need to be prepared.

If more extensive infiltration facilities are to be considered in order to reduce Tier 2 detention pond volumes, then an extensive hydrogeological investigation should be required to establish with confidence the capacity of these facilities. Long term functioning of proposed infiltration facilities must be assured in order to justify reductions in detention pond volume. Assessment of downhill impacts of increased ground water flows during wet weather should be included in the investigation.

7.4.3 Compliance and Enforcement

In order to ensure the ongoing effectiveness of the proposed storm water management facilities, particularly LID infiltration features and facilities, mechanisms must be in place to ensure that they continue to function. Over time infiltration facilities and features such as those proposed in the present plan tend to deteriorate or are removed or decommissioned, particularly when they are subject to the actions of individual property owners.

An extensive education program should be implemented to ensure that property owners are aware of the role of onsite features such as absorbent soils and infiltration chambers in addressing storm water issues and maintaining watershed health. The consequences of increased impervious paving, such as concrete pads for vehicles, or decommissioning or bypassing infiltration chambers should be communicated to property owners. As turnover in property ownership will occur over time, education campaigns should be repeated at periodic intervals. The benefits of maintaining the health of the watershed and a sustainable storm water management strategy should be stressed.

Storm water utility fees could be used to provide an incentive to maintain infiltration facilities and limit impervious cover. Using modern air photography and GIS technologies the impervious coverage of each lot could be tracked over time. A discount to the base storm water utility fee could be applied if the impervious coverage is maintained below a certain level, as specified by bylaw. Penalties could be applied to the storm water utility fee if the impervious lot coverage exceeds a certain percentage. Similarly, if an infiltration facility is removed or bypassed an additional levy could be applied to the storm water utility fee. Assessing impervious surfaces would require some effort and expense on the

City's part and would likely only be carried out on a periodic basis (say five years), perhaps coinciding with the education campaigns. However, linking storm water utility fees to the impervious lot coverage could reduce total runoff and encourage site specific environmentally sensitive management.

Bylaws could be used to directly specify maximum impervious coverage and maintenance of infiltration features. However, bylaw restrictions on impervious lot coverage could prove difficult and costly to enforce, and enforcement should be reserved for the most blatant violations. An incentive approach as discussed above could help to reduce the need for bylaw enforcement or other legal mechanisms.

ENVIROWEST REPORT

APPENDIX

A

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

ENVIRONMENTAL REVIEW (FINAL DRAFT)

THE CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
300-4940 Canada Way
Burnaby, BC, V5G 4M5

April 2004

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, BC V5J 5J4
voice: 604-451-0505
facsimile: 604-451-0557
www.ecl-envirowest.bc.ca

envirowest

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN

ENVIRONMENTAL REVIEW (FINAL DRAFT)

THE CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
300-4940 Canada Way
Burnaby, BC, V5G 4M5

April 2004

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, BC V5J 5J4
voice: 604-451-0505
facsimile: 604-451-0557
www.ecl-envirowest.bc.ca

Report Citation: **Michalak, L., 2004.** Hyde Creek integrated watershed management plan environmental review. ECL-Envirowest Consultants Limited *Prepared for:* The City of Coquitlam and Port Coquitlam.

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

1.0 INTRODUCTION

The City of Coquitlam and the City of Port Coquitlam retained Associated Engineering (B.C.) Ltd. (Associated) to undertake the development of the Hyde Creek Integrated Watershed Management Plan (HCIWMP), for the Hyde, Watkins, Smiling and Burke Mountain Creeks and Deboville Slough watersheds (Hyde Creek Watershed), that would allow the catchments to be developed in recognition of the significant and sensitive nature of Hyde Creek and its associated tributaries.

ECL Envirowest Consultants Limited (Envirowest) was retained by Associated to assist in the design of the Hyde Creek Watershed Management Plan by:

1. Conducting an overview assessment and general classification of the watercourses associated with the Hyde Creek Watershed;
2. Identify areas for enhancing aquatic and riparian environment essential to the survival of resident species;
3. Define mitigation measures to maintain fish production of the watercourses; and
4. Provide recommendations, which will maintain creek integrity and support the viable development and re-development of lands within the watershed.

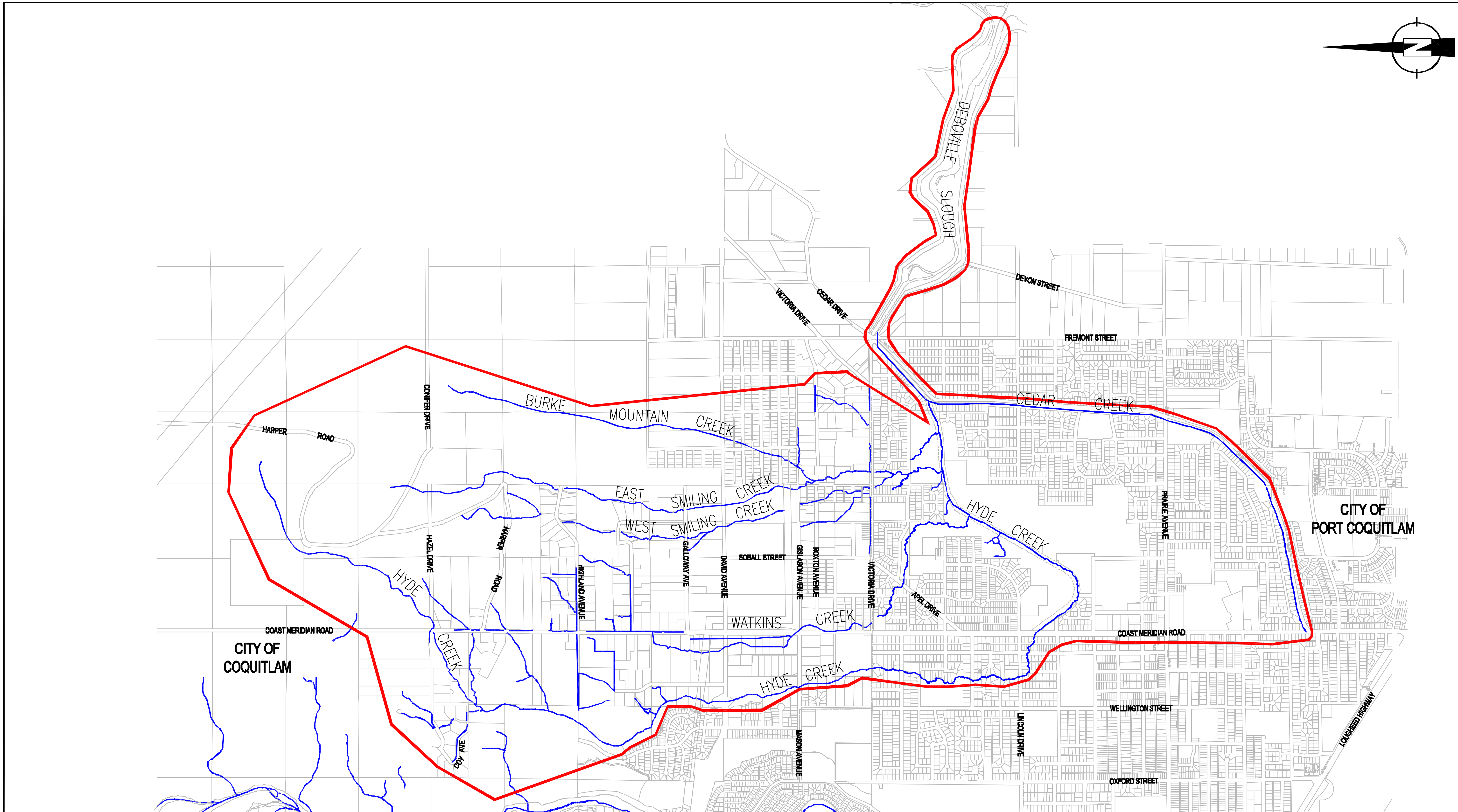
The boundaries of the study area are depicted in Envirowest Figure 1. The study encompasses six tributary streams that are associated with the larger Hyde Creek Watershed. These include the following from west to east:

1. Hyde Creek;
2. Watkins Creek;
3. Smiling Creek (East and West);
4. Burke Mountain Creek
5. Cedar Creek (southern section); and
6. Deboville Slough.

The western boundary of the study area includes all of Hyde Creek. The northern extent includes the headwaters of Hyde, Watkins, Smiling and Burke Mountain Creeks. The downstream limit of the study area is delineated by Hyde Creek at Laurier Avenue and Minnekhada Middle School and to the east it includes Burke Mountain Creek and a section of Cedar Creek in Port Coquitlam along Cedar Drive to Deboville Slough and its outflow to the Pitt River.

The headwaters of all creeks originate in the City of Coquitlam and join Hyde Creek in the City of Port Coquitlam emptying to Deboville Slough to the Pitt River.

Figure 1 Hyde Creek Watershed Study Area



Study Boundary

Watercourse

CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

HYDE CREEK WATERSHED STUDY AREA

DESIGN: LM	DRAWN: SDJ	CHECKED:	REVISION: 01	REVISION DATE: April 16, 2004
SCALE: 1:20000			DRAWING NUMBER:	
DATE: February 16, 2004			FIGURE 1	

2.0 METHODOLOGY

2.1 Literature Review and Contact Information

Envirowest obtained and reviewed the following information to identify environmentally sensitive areas and environmental resources of the project area:

- Conservation Data Centre (CDC) Rare Element Occurrence Report and the CDC Tracking List for rare vertebrates in the Chilliwack Forest District (which includes the study site);
- 1:20,000 scale Terrain Resource Inventory Mapping (TRIM);
- 1:5,000 scale plans of the proposed development;
- Aerial photo interpretation from 1936-1940 to present;
- City of Coquitlam Northeast Coquitlam Terrain and Watershed Study (April 1998) Dayton & Knight Limited;
- The City of Coquitlam Northeast Coquitlam Environmental Assessment (January 1995) Catherine Berris Associates Incorporated;
- City of Coquitlam Citywide Official Community Plan review;
- Sampling and Designation of Previously unclassified Watercourses in the City of Coquitlam (Coast River Environmental Services Ltd.) (January 2001);
- Environmental Assessment of Port Coquitlam (Gartner Lee, 1992);
- Northeast Coquitlam Environmentally Sensitive Areas (Environmental Management Services, City of Coquitlam);
- Development Permit Area Guidelines for Environmentally Sensitive Watercourses, City of Coquitlam (Quadra Planning and Coast River Environmental Services Ltd.);
- Hyde Creek Fish Habitat Enhancement Plan (Coast River Environmental Services Ltd., 2000);
- Reports prepared by ENKON Environmental Limited;:
    i. Preliminary Environmental Assessment Lower Hyde Creek Village Neighborhood Plan, Northeast Coquitlam, B.C.; and
    ii. Environmental Constraints and Development Opportunities Upper Hyde Creek Village Neighborhood Plan, Northeast Coquitlam, B.C.
- Relevant information from the Department of Fisheries and Oceans (DFO), Ministry of Water, Land and Air Protection (MWLAP) databases including:
    i. Department of Fisheries and Oceans: http://habitat.pac.dfo.ca/cfdocs/fiss/dc01.cfm
    ii. FISS Database Search Engine http://www.bcfisheries.gov.bc.ca/fishinv/db/default.asp
    iii. Department of Fisheries and Oceans Watershed Atlas http://habitat.pac.dfo.ca/heb/fhiip/
    iv. Ministry of Water, Land and Air Protection; Fisheries Branch: Stream Query Page http://www.env.gov.bc.ca:80/fsh/ids/dman/rab.html

- Discussions with the Burke Mountain Naturalists (Elaine Golds), and Hyde Creek Stream Keepers (Ted Wingrove), Habitat Conservation & Stewardship Program Coordinator (Janice Jarvis); and
- Discussing with the Ministry of Water Land and Air Protection (MWLAP, Fish Biologist Erin Stoddard).

2.1.1 Stream Surveys

BC Terrain Resource Inventory Mapping (TRIM) (1:20,000) and field surveys conducted between September 06, 12 2002 to November 25, 2002 and for Deboville Slough on November 04, 2003. Watercourses were surveyed to classify streams, identify appropriate setbacks for stream protection and identify areas of environmental concern. Envirowest fisheries biologist walked all segments and tributaries of Hyde, Smiling, Watkins and Burke Mountain Creeks, identifying areas of concern and assessing habitat and stream classification.

2.1.2 Fish Habitat Preliminary Classification

Based on historical information collected and the field sampling performed, watercourses within the study area were classified according to the definitions in the Streamside Protection Regulation (January 19, 2001).

The classification of streams presented in this report are based on an overview assessment and are to be considered preliminary. Stream classifications should be confirmed and reassessed at the neighborhood planning stage.

Definitions of streams are as follows, setback requirements for stream classifications are presented in Table 1 and the stream classifications are presented in Figure 2:

"Fish Bearing Stream" means a stream in which fish are present or potentially present if introduced barriers or obstructions are either removed or made passable for fish;

"Non Fish Bearing Stream" means a stream that

(i) is not inhabited by fish, and

(ii) provides water, food and nutrients to a downstream fish bearing stream or other water body;

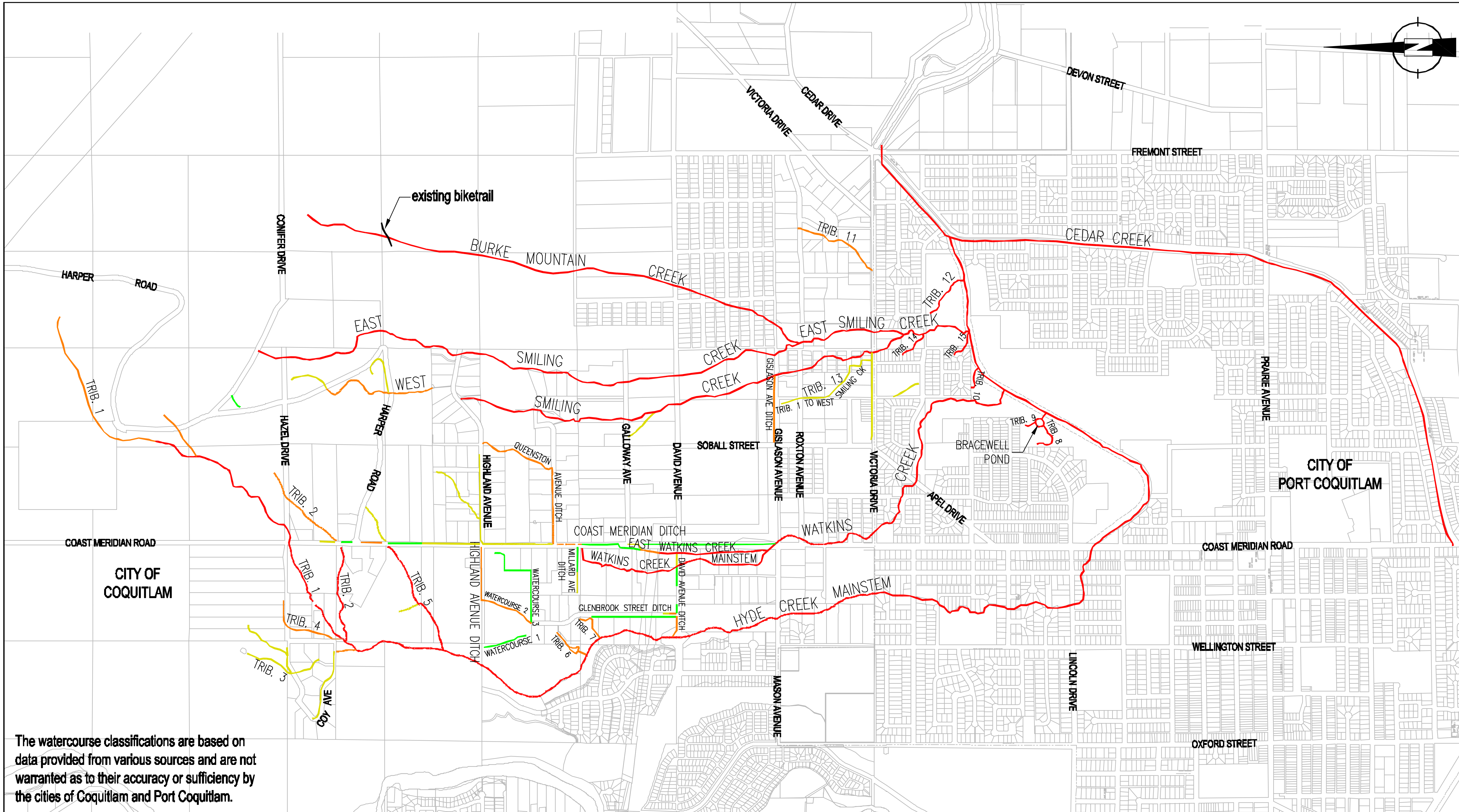
"Non-Permanent Stream" means a stream that typically contains surface waters or flows for periods less than 6 months in duration;

"Permanent Stream" means a stream that typically contains continuous surface waters or flows for a period more than 6 months in duration;

"Non-Habitat Streams/Ponds" means a watercourse, pond or lake not regulated under the Fisheries

Act or the Fish Protection Act-Streamside Protection Regulation.

Figure 2 Hyde Creek Watershed Preliminary Stream Classifications



- Fish Bearing
- Permanent Non Fish Bearing
- Non Permanent Non Fish Bearing
- Non Fish Habitat

CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS
ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

HYDE CREEK WATERSHED PRELIMINARY STREAM CLASSIFICATIONS

DESIGN: LM	DRAWN: SDJ	CHECKED:	REVISION: 02	REVISION DATE: April 16, 2004
SCALE: 1:15000			DRAWING NUMBER:	
DATE: February 16, 2004			FIGURE 2	

Table 1 Streamside Protection Regulation Streamside Setback Widths

Existing or Potential Streamside Vegetation Conditions	Streamside Protection Area Widths		
	Fish Bearing Watercourse	For Non Fish Bearing Watercourses	
		Permanent	Non Permanent
>50 m	At least 30 m	At least 30 m	At least 15 m
>30 m to <50 m	At least 30 m	At least 30 m	At least 15 m
>/=15 m to <30 m	The greater of: • Existing • Potential, or • 15 m	15 m	15 m
<15 m	The greater of: • Existing • Potential, or • 15 m	At least 5 m up to 15 m	At least 5 m up to 15 m

From *Environmental Objectives, Best Management Practices and Requirements for Land Developments*, March, 2001 by the Ministry of Environment, Lands and Parks BC Environment Vancouver Island Region

[1]Existing vegetation means native and non-native vegetation
[2]Potential vegetation
[3]Permanent watercourse typically contains surface water or flows for more than 6 months
[4]Non-permanent watercourse typically contains surface water or flows for less than 6 months

2.1.3 Fish Habitat Assessment

General descriptions of fish habitat in all watercourses were generated for the various branches and tributaries of all creeks associated in the watershed area. Cited references in Section 2.0 and field visits were the key source of habitat information. The fieldwork was undertaken to fill information gaps.

Anecdotal evidence indicated that 2002 was one of the driest periods ever observed for the Hyde Creek watershed. In order to observe the environmental conditions during wet weather, a portion of the field investigation was performed during November 2002 and Deboville Slough was assessed in November 2003.

3.0 RESULTS AND DISCUSSION

3.1 Previous Environmental Studies

Historical environmental studies of the Hyde Creek Watershed study area have focused primarily on the eastern Coquitlam River Watershed, which includes Hyde Creek, Smiling Creek, Burke Mountain Creek, Star and Cedar Creeks. Reviewed studies by Envirowest included:

1. The City of Coquitlam "Northeast Coquitlam Environmental Assessment (January 1995) Catherine Berris Associates Inc.";

2. City of Coquitlam "Northeast Coquitlam Terrain and Watershed Study (April 1998) Dayton & Knight Limited";

3. ENKON Environmental Limited "Environmental Constraints and Development Opportunities Upper Hyde Creek Village Neighborhood Plan, Northeast Coquitlam, B.C. (October 2002)";

4. ENKON Environmental Limited "Preliminary Environmental Assessment Lower Hyde Creek Village Neighborhood Plan, Northeast Coquitlam, B.C. (November 2002)";

5. Coast River Environmental Services Limited, "Sampling and Designation of Previously Unclassified Watercourses in the City of Coquitlam (January 2001)";

6. Coast River Environmental Services Limited, "Hyde Creek: Fish Enhancement Plan (November 2000)"; and

7. Sensitive Habitat Inventory and Mapping Partnership (SHIM) mapping.

The report prepared by Catherine Berris Associates and Dayton & Knight Limited deal primarily with the physical properties of the streams and provide limited information on fish and wildlife habitat and populations. The collection of ENKON reports deal with stream classifications using SPR definitions, fish population surveys identifying presence/absence and wildlife inventories. Reports by both firms identify constraints and opportunities to develop land parcels in the Hyde, East Smiling, West Smiling Creek, Watkins, Burke Mountain Cedar, Star and Partington creek Watersheds. The Berris and Dayton and Knight reports deal with the physical properties of streams and provide limited information on wildlife.

The following section presents the results and conclusions of each environmental report reviewed.

3.1.1 Catherine Berris Associates Report

The Catherine Berris Associates report Northeast Coquitlam Environmental Assessment (Berris 1995) was prepared before the City of Coquitlam reviewed its Northeast Coquitlam Official Community Plan (OCP). It was used to develop the OCP. The report deals primarily with identifying environmentally sensitive areas in Northeast Coquitlam. It designates areas as having high, moderate or some sensitivity with respect to fish, vegetation, wildlife and other resources (e.g. recreation, heritage). The report defines areas of high sensitivity for fish and wildlife as encompassing a 15 m buffer from the top of bank on all streams, including any ditch that is part of a stream. It assigns moderate sensitivity to an unspecified buffer around ditches and channels not identified as part of a stream. In addition, it rates the remaining forested areas of the upper Hyde Creek watershed as having some sensitivity with respect to vegetation. Berris (1995) reviews available information on fish and wildlife in Northeast Coquitlam, observing that Hyde Creek supports chum and coho salmon and contains stretches of excellent fish habitat. Berris (1995) also discusses provincially significant wildlife[1] that may occur in Northeast Coquitlam. Due to their specific habitat requirements not all of the species that Berris (1995) mentions have the potential to occur in the Hyde Creek watershed. Significant mammals mentioned that might occur include the red-listed[2] Pacific water shrew and the blue-listed[3] Trowbridge's shrew. Other significant animals identified and potentially present in the Hyde Creek watershed include the blue-listed red-legged frog and the blue-listed band-tailed pigeon[4]. The report also rates the remaining forested areas of the Smiling Creek watershed as having some sensitivity with respect to vegetation. It also reviews available information on fish and wildlife in Smiling and Burke Mountain Creeks and reports that they do not contain any fish, but they contribute to fish habitat in the Pitt River. The report also notes that the riparian areas of the streams have "High" sensitivity to wildlife species.

3.1.2 Dayton & Knight Report

The Northeast Coquitlam Terrain and Watershed Study Dayton & Knight (1998) primarily addresses the physical attributes of the watersheds in Northeast Coquitlam, but it briefly reviews fish habitat values and enhancement opportunities. An appendix to the report contains a fish habitat map compiled by Envirowest (1997), based on a habitat survey and fish sampling. The Envirowest map shows that Smiling Creek downstream of Victoria Drive contains coho salmon and that cutthroat trout are present in the middle branch upstream of Galloway Avenue, as are rainbow trout, which were introduced by local residents. Dayton & Knight (1998) observe that Smiling Creek has the longest reach of fish habitat in the Northeast Coquitlam area. This map also shows that Partington Creek along Cedar Drive contains chum, pink and coho salmon as well as cutthroat trout. The Dayton & Knight (1998) report and the Envirowest (1997) map also identify barriers to upstream migration and habitat enhancement opportunities on the Northeast Coquitlam creeks. The Envirowest (1997) map shows barriers and stream enhancement opportunities on the west and middle branches of Smiling Creek at Victoria Drive and on the west branch of Smiling Creek at Gislason Avenue. This report briefly discusses the wildlife habitat values of the Northeast Coquitlam watersheds. It rates forested areas of Burke Mountain, riparian forests along the upper reaches of the Northeast Coquitlam watercourses and the forest adjacent to Hyde Creek as very important habitat for wildlife.

3.1.3 ENKON Reports

The October 2002 report entitled "Environmental Constraints and Development Opportunities Upper Hyde Creek Village Neighborhood Plan, Northeast Coquitlam, B.C." concluded the following about the watersheds of Hyde Creek, Watkins and headwaters of East Smiling Creek:

---

[1] Species listed in the CDC Tracking List of Rare Vertebrates (Appendix A)
[2] Red-listed species are considered to be rare or threatened in British Columbia.
[3] Blue-listed species are considered to be sensitive and or vulnerable. They are not threatened, but they are particularly at risk.
[4] Berris states that this species is yellow-listed (not at risk but of management interest). The band-tailed pigeon currently (April 2001) is blue-listed. In addition, Berris (1995) mentions the "blue-listed" Hutton's vireo and western screech owl. These species are not on the current CDC tracking list of rare vertebrates.

1. ENKON classified all streams according to the "*Stream Protection Guidelines*" within the plan area and concluded that they were either fish-bearing or non-fish bearing permanent or non-permanent streams. A few ditches were classified as non-fish habitat;

2. Fish barriers were identified along Watkins and Hyde Creeks from David Avenue to Hazel Avenue;

3. The *Fish Protection Act – Streamside Protection Regulation (January 19, 2001*) and field assessment of habitat values by ENKON required either 15 or 30 m no disturbance setbacks for single family or multi-family development. Reductions in these setbacks were recommended for Watkins Creek due to the existing impacts from residential development and the potential to enhance these impacted areas from re-development;

4. A vegetation survey was performed to identify the occurrence of any rare, threatened or endangered plants in the neighborhood area. The July 2002 field inspection of the Upper Hyde Creek Village Neighborhood Plan area did not identify any rare plant communities or rare significant vascular plants listed in the BC Conservation Data Centre's rare plant community or rare vascular tracking list of the Chilliwack Forest District;

5. Fish sampling using electroshocking and gee-minnow trapping was performed in Hyde Creek above David Avenue to Hazel Avenue, both the Mainstem and Hyde Creek tributaries as well as Watkins Creek. The electroshocking resulted in the capture of coho salmon (*Oncorhynchus kisutch*) fry in the Hyde Creek Mainstem; coho fry in Tributary 5 of Hyde Creek and no fish were captured in Watkins Creek. Gee-minnow trapping resulted in the capture of coho salmon captured throughout the Hyde Creek Mainstem and all tributaries below Hazel Avenue. No fish were captured in Watkins Creek;

In the ENKON report entitled "Preliminary Environmental Assessment Lower Hyde Creek Village Neighborhood Plan, Northeast Coquitlam, B.C." the following was concluded:

1. No red or blue-listed wildlife (mammal, bird or amphibian) species with the exception of band-tailed pigeons (potential nesting site within the Hyde Creek corridor only) were observed or captured. However, habitat on the sites were deemed to be suitable to support the red-listed Pacific water shrew (*Sorex palustris*), the blue-listed Trowbridge's shrew (*Sorex trowbridgii*), the blue-legged frog (*Rana aurora*) and the blue-listed tailed frog (*Ascaphus truei*).

2. All streams (Hyde Creek Mainstem and Watkins Creek), within the plan area were classified as fish-bearing or potentially fish bearing with barrier removal, and a few ditches were classified as non-fish bearing habitat; and

3. Sensitive fish and wildlife habitat include the Hyde Creek and Watkins Creek corridors and the northeast corner of the site for potential use by the red-legged frog.

3.1.4 Coast River Environmental Services Limited Reports

The Coast River Environmental Services Limited report (Coast River), (January 2001) presents fish sampling results and watercourse classifications as well as identifies seasonal areas of use by fish for a number of watercourse ditches in the City of Coquitlam in the Hyde Creek Watershed study site. Surveys were performed on August 09, 2000. Watercourse classification used for this survey followed the color coding and classification system developed by the Ministry of Environment, Lands and Parks and the Department of Fisheries and Oceans Canada. Conclusions of the study are as follows:

1. The roadside ditch along Victoria Drive south of David Avenue ranged from dry at its top to a trickle of water, which was insufficient to sample, where Victoria meets Baycrest Avenue. This takes into account the creeks of Hyde, Watkins, and Smiling Creeks;

2. The roadside ditch along Victoria Drive between Lower Victoria Drive and Burke Mountain Creek, with the exception of a small pool of stagnant water just east of Mitchell Street where a pipe enters the ditch from the north, was dry;

3. The roadside ditch along the north side of Victoria Drive was dry from the intersection of Victoria and Soball Street to approximately 180 m east, where a small piped stream enters the drainage ditch from the north. Upstream of Victoria Drive, the stream had good flow (2.5 cm deep), however no pools were visible in the stream. East of Wedgwood after the stream resurfaces from going sub-surface and before draining into Smiling Creek, it has been classified as having the potential to support fish year-round. Upstream of Victoria Drive it is has been labeled non-fish habitat and insignificant to fish populations;

4. The roadside ditches along Hyde Creek and Watkins Creek tributaries along Coast Meridian Road have been identified as insignificant food and nutrient value as well as insignificant to fish populations. Small pools of standing water were identified during the field visits throughout them. Many areas contained mats of iron-oxidizing bacteria and were covered with an oily film. At its end the Coy Avenue roadside ditch was dry. The roadside ditch along Martin Street was also dry during the survey. The reach of Hyde Creek that crosses Coast Meridian Road at its intersection with Hazel Drive was dry upstream and immediately upstream of the intersection. The roadside ditch at the intersection of Hazel and Coast Meridian was also dry. All were identified as insignificant to fish populations;

5. The roadside ditch along Coast Meridian Road between Hazel Drive and Harper Road was completely dry during the August 09, 2000 survey. A small watercourse joining the roadside ditch from the east between Harper Road and Highland Drive was dry, as was the Watercourse entering the Highland roadside ditch between Coast Meridian and Dayton Streets. The Highland Drive roadside ditch was virtually dry. All have been identified as insignificant food and nutrient value to fisheries populations;

6. The Coast Meridian Ditch on the east side of the road, the Queenston Roadside Ditch and the

tributary entering the Queenston roadside ditch from Highland Drive to Watkins Creek was identified as not able to support fish populations and it provides potentially significant food and nutrients for downstream fish populations;

7. The roadside ditches along Coast Meridian Road south to Watkins Creek were all dry during the survey so they were all classified as not supporting food and nutrient value to downstream fish populations. These watercourses have no documented fish presence and no reasonable potential for fish.

The Coast River Environmental Services Limited, Hyde Creek: Fish Enhancement Plan (November 2001) report presents the results of a study to identify, describe and rank potential fish habitat enhancement projects in the Hyde Creek watershed. The study to provides an action plan for project planning. Several techniques to enhance the stream at various locations are reviewed. It addresses information of habitat conditions, habitat-related issues, enhancement strategies and potential criteria for evaluating and selecting enhancement projects.

3.1.5 SHIM Data

The Sensitive Habitat Inventory and Mapping Partnership (SHIM) is a community-based approach to mapping aquatic habitats and their riparian areas, primarily for settlement areas of British Columbia. The data collected by SHIM in the Hyde, Watkins, Smiling and Burke Mountain creeks provides reliable, current, and spatially accurate information about local fish and wildlife habitats. The data collected for the watersheds is at 1:5,000 scale inventory mapping[5].

The intent of the SHIM data is varied and is designed to:

- help meet municipal government requirements under the Fish Protection Act of BC such as the Stream Side Protection Regulations;
- provide information not previously available to urban planners involved in preparing Neighborhood Plans, Official Community Plans and Regional District Growth Strategies;
- indicate the extent of riparian vegetation available for wildlife habitat conservation, locally and regionally;
- assist in determining watercourse setbacks for development referrals and facilitate Greenway/ESA planning;
- design operational procedures for ditch maintenance in agricultural areas;
- identify fish presence and potential barriers to fish migration;

---

[5] http://www.shim.bc.ca/what.html

- guide management decisions and priorities for habitat restoration and enhancement;
- identify areas with channel instability or water quality problems that may require more detailed studies;
- identify point and non-point sources of pollution; and
- provide a spatially accurate framework and baseline data for future monitoring activities by senior agencies and NGOs (Streamkeepers and Wetlandkeepers).

Mapping performed in the Hyde Creek Watershed Study Area are presented in Appendix B Figures 1-6 and Tables B1-B6. They identify SHIM areas of concern and opportunities for enhancement.

The SHIM mapping obtained by Envirowest for the Hyde Creek Watershed Study Area only assessed Hyde, Watkins and Smiling Creeks from the Hyde Creek junction with Cedar Creek to all three creeks upstream to Victoria Drive and for Burke Mountain Creek from its confluence with Smiling Creek to the headwaters (Appendix B Figures 1-6). Features identified by the mapping present the following data:

1. Fish habitat (spawning and rearing), areas (Appendix B Figure 1);
2. Obstructions to upstream fish migration (Appendix B Figure 2);
3. Erosion sites (Appendix B Figure 3);
4. Discharge locations (Appendix B Figure 4);
5. Culvert locations (Appendix B Figure 5); and
6. Modification and Enhancement Features (Appendix B Figure 6).

Fish Habitat (Spawning and Rearing)

Only four locations with good fish spawning habitat have been identified for lower East Smiling Creek, and Hyde Creek. All other areas identified in Appendix B Figure 1, Table B1 present good rearing habitats in the streams.

Obstructions and Erosion Sites

Obstructions identified in the mapping consist of one in lower Hyde Creek, and a total of ten in Watkins Creek. These consist of six “potential” barriers, three positively identified barriers and one unknown (Appendix B Figure 2 and Table B2);

Erosion Sites

All creeks have been identified with erosion sites (Appendix B Figure 3 and Table B3). These consist of five locations in Watkins Creek, one in lower East Smiling Creek and lower Burke Mountain Creek, while ten are associated with Hyde Creek and its tributaries. Six of the erosion sites have been classified as severe and should be first priority for rehabilitative works. Five are found in the watershed of Hyde Creek and one is found in Watkins Creek. The remaining locations are all rated as moderate severity.

Discharge Locations

Discharge locations have been assessed for all creeks associated with the study area. A total of fifty-five (55) locations have been identified (Appendix B Figure 4, Table B4). Many are point source flow contributions from storm sewer outflows, tile drains and residential properties. Smiling Creek has been identified with a total of five locations consisting of east and west as well as the Mainstem of Smiling Creek. One has been identified on Burke Mountain Creek as agricultural runoff and a total of nine locations have been identified on Watkins Creek. The highest number of discharge locations in the system have been identified on Hyde Creek. These consist of nine locations on lower Hyde Creek and are comprised of tile drainage, house and storm sewer outlet. The remainder of the discharges include twenty-five locations that have been identified throughout the upper Hyde Creek area and consist primarily of tile drainage, house and storm sewer outlet.

Culvert Locations

The SHIM data identifies a total of 30 culvert locations in the study site below Victoria Drive (Appendix B Figure 5 and Table B5). These consist of box culverts and corrugated metal pipes in sizes ranging from 300 mm diameter pipes to 600mm box culvert on Burke Mountain Creek. Five have been identified as barriers to upstream fish migration, two as potential barriers and fourteen as unknown. All others are accessible to fish upstream migration.

Modification and Enhancement Features

Many areas of all of the watercourses have been identified to contain modified or enhanced features instream (Appendix B Figure 6, Table B6). These consist of bridges, fences, roads, and trails, pump stations, water withdrawl sites, retaining walls, large woody debris placements and garbage/pollution locations. Many of these sites may be used for future enhancement and planning opportunities.

4.0 ENVIROWEST FISH AND STREAM SURVEY RESULTS

The following are the results of surveys conducted by Envirowest during field visits to the Hyde Creek Watershed Study Area. Sightings and habitat descriptions were collected during field visits on the dates presented in Section 2.1.1.

4.1 Hyde Creek Mainstem

4.1.1 Upstream of Harper Road

This section of creek was surveyed on October 15/02. Along this section upstream of Harper Road the watercourse was electroshocked for approximately 300 metres to determine whether fish were present. No fish were captured, however four tailed frog tadpoles (red-listed species) were recovered.

The channel morphology in this section of Hyde Creek consists of a series of drop pools with chutes. Substrates are comprised of large boulders (50 %), cobbles (20 %), gravels (20 %) and sands (10 %) and the reach has average wetted width at the time of survey was 0.5-1 metre; water depth was 0.5 metes (in pools) and 0.15 metres (in chutes). The bankfull width is 2-3.5 metres and the bank height is approximately 1 metre.

The riparian habitat consists of a mixed coniferous consisting of western redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*) deciduous broadleaf maple (*Acer macrophyllum*), and red alder (*Alnus rubra*). The canopy cover is approximately 80 % and the shrub layer is dominated by sword fern (*Polystichum munitum*) and salmonberry (*Rubus spectabilis*). Other species include deer fern (*Blechnum spicant*), lady fern (*Athyrium filix-femina*), salal (*Gaultheria shallon*), red huckleberry (*Vaccinium parvifolium*) and vine maple (*Acer circinatum*). The overstream cover provided by the shrub layer is approximately 10% with large woody debris present within the channel.

4.1.2 Downstream of Harper Road

This section of creek was surveyed on October 12/02. Downstream of Harper Road flows are conveyed under Harper Road via a 1,000 mm diameter culvert approximately 12 metres in length. The vertical distance from the invert of the outlet pool to the invert of the culvert is 1.25 metres and this is a barrier to upstream fish migration. The pool outlet depth was 0.5 metres at the time of survey.

During the survey flows were observed upstream and downstream of Harper Rd. The canopy layer is primarily coniferous and comprised of Douglas-fir and western redcedar with a smaller component of red alder and the understorey species include vine maple, salmonberry, lady fern, sword fern, red huckleberry, red elderberry, thimbleberry (*Rubus parviflorus*), stink currant (*Ribes bracteosum*), false azalea (*Menziesia ferruginea*), salal, deer fern, licorice fern (*Polypodium glycyrrhiza*), goat’s beard

(*Aruncus dioicus*), Devil's club (*Oplopanax horridus*), oval-leaved blueberry (*Vaccinium ovalifolium*) and immature western hemlock (*Tsuga heterophylla*) through this section. The canopy species provide between 75 and 90 % cover to the creek; overhanging cover from the understorey layer is between 75 and 100 %.

The wetted width varied between 1-2.5 metres, bankfull width is 2.5-6 metres. Bank height is 0.5 metres, and the water depth at the time of survey was 0.3 metres. This section of stream contained numerous debris jams within this reach of the creek that would be barriers to fish migration.

The physical morphology of the stream consists of substrates containing large boulders (50 %), cobbles (25%), and sands and gravels (25%). The channel gradient averaged 21 % and the channel exhibited a drop pool structure throughout this reach. Sections had some minor bank erosion, and there was abundant downed woody debris observed in the riparian zone and within the wetted perimeter of the channel. In this section the channel is contained within a small ravine; ravine banks 5-20 metres high (bank height increased in downstream direction), floodplain of creek 12-15 metres wide and there is evidence of some potential spawning habitat (short sections of the channel that have a flatter grade i.e. approx. 3 %) where material has built up behind major debris jams).

Downstream of the confluence with the unnamed tributary, the gradient in the Mainstem ranged between 9 and 14 % and within 100 metres of the crossing of the Mainstem at Coast Meridian Road, flows decreased and periodically go subsurface. The channel completely dried from approx. 50 metres upstream of the Coast Meridian Road culvert crossing to downstream of the crossing.

The Coast Meridian Road culvert is 1,500 mm diameter multi-plate corrugated metal pipe comprised of riveted panels with a 1 metre drop from the invert of the culvert to the invert of the outlet pool. It is a barrier to upstream fish migration.

4.1.3 Upstream of Tributary 4

This section of creek was surveyed on November 21/02. This section of Hyde Creek contained many coho salmon spawners. They were observed within the Mainstem. The wetted width is equal to the bankfull width) at the time of survey and was approximately 7.5 metres downstream of Tributary 4. Upstream the wetted width in this section is approximately 3-4 metres. The water depth at the time of the survey was 0.2-0.4 metres.

There is a fairly open mixed canopy; same composition as for Tributary 4, and the understorey is dominated by salmonberry and sword fern; vine maple is also present. The Mainstem is confined within a steep ravine here where the channel substrates are comprised of boulders (30 %), cobbles (30%), gravels (30%), and sands (10%).

Although spawners were noted upstream of the confluence, this section of the Mainstem would not be characterized as typical spawning habitat because substrates were comprised primarily of boulders and large cobbles. The channel gradient is 4 %. Spawners (coho salmon), were observed upstream of confluence with Tributary 2. Here a large woody debris jam (several mature trees, recently fallen)was observed on the Mainstem approximately 30 metres upstream of the confluence with Tributary 2. It is not considered a barrier under high flow conditions (i.e. at the time of the survey) but probably is a barrier during low flows.

A 1,500 mm diameter culvert conveys flows under an access road/driveway approximately 100 metres upstream of confluence with Tributary 2 but it is not considered a barrier to fish passage. However, upstream of the culvert a concrete weir is located in the channel. The weir has been partially removed/broken and there is a 0.5 metre deep pool downstream of the weir, and a 0.9 metre drop from the invert of the weir to the invert of the pool. This weir may be a barrier to juvenile salmonid passage during all flow regimes and is a potential barrier to larger fish during low flows. Another culvert is located approximately 50 metres upstream of the weir to convey flows under a driveway; the culvert is a 2,000 mm diameter corrugated steel pipe with an 8 % grade on the pipe. This culvert is accessible at the downstream end, but the grade and velocity of water within the culvert may make it impassable. A single coho spawner was observed in the pool at the culvert outlet. Spawners were not observed upstream of the culvert.

Another large woody debris jam is located approximately 100 metres upstream of the 2,000 mm diameter culvert with an approximate drop of 1 metre between the channel invert upstream and downstream; the debris jam was resulting in significant bed load retention.

4.1.4 At Highland Drive Alignment

This section of creek was surveyed on September 12/02. At the bottom of a path from Highland Drive there is an existing wooden bridge crossing the creek. Here potential spawning habitat is present within this section of the creek. Many juvenile salmonids were noted downstream of the wooden bridge.

The physical morphology consists of a wetted width of 1-2 metres (September 12) and the water depth was 0.1-0.2 metres. The bankfull width is 6-7metres and the bank height is approximately 0.3 metres. The creek meanders within the floodplain at the base of the ravine banks which are approximately 20 metres high. Channel substrates in this section are comprised of boulders, cobbles, gravels, and sands and the channel gradient is 6 %. The canopy layer provides 80 % cover to the channel; overstream vegetation (i.e. shrub layer) provides 10 % cover to the channel (i.e. along the edges only). The vegetation is composed of a mixed deciduous (broadleaf maple and red alder)/coniferous canopy species; shrub species include salmonberry, red elderberry, sword fern, lady fern, Devil's club, Indian-plum (*Oemlaria cerasiformis*), stink currant and red huckleberry; groundcover species include youth-on-age and various mosses. A red-legged frog (blue-listed species) was identified adjacent to the creek along this reach.

4.1.5 Between David Avenue and Mason Avenue

This section of creek was surveyed on September 12/02. Many juvenile salmonids were noted throughout this section in pools and in areas with undercut banks. There is potential spawning habitat within this section of the creek.

The channel gradient is 5 % and the channel morphology exhibits riffle sections separated by drop pools otherwise it has very similar channel morphology to the Highland Drive alignment. Flows appear to be consistent throughout the year in this section.

Problems associated with this section include erosion noted on west bank of creek at the Mason Avenue alignment, but fairly minor (undercut banks, tree roots exposed). There is an erosion area approximately 1.5 metres high by 5 metres wide by the David Avenue Road east bank under the hydro line. Eroding substrates consist of hardpan clay.

4.1.6 Victoria Drive Right-of-Way

This section of creek was surveyed on September 12/02. There is a box culvert conveying flows under the path along the Hydro Right-of-Way in this section. At this location the creek morphology is still the same as that exhibited further up the ravine at David Avenue and Highland Drive. The box culvert has gravel substrates and the culvert is approximately 6 metres long, 2,700 mm wide by 1,600 mm high.

The riparian habitat is composed of predominantly a deciduous canopy. Species include broadleaf maple and beaked hazelnut; some western redcedar and western hemlock. The shrub species include red elderberry, vine maple, salmonberry, Indian-plum and lady fern; ivy (*Helix sp.*) is prevalent.

Juvenile salmonids were noted upstream and downstream of the culvert in pools and glide areas. This section of Hyde Creek contains potential spawning habitat. The creek at this location is no longer confined within a ravine at this location and the wetted width was 2-5 metres, water depth was 0.25 metres at the time of survey. The bankfull width is 6 metres and the bank height is approximately 0.5-1 metre. Channel substrates throughout this reach area consist of boulders, cobbles, gravels and sands and the channel gradient is 2.5 %

Problems with this section include encroachment within 15 metres of top of bank by both non-native vegetation (landscaping) and houses/structures.

4.1.7 Between Lincoln Ave. and Coast Meridian Road

This section of creek was surveyed on November 25/02. Over 20 dead spawners (chum salmon) were noted within this section of the creek during the survey. This shows that it is an important section for spawning. Additionally, several redds were observed throughout this section.

There is a box culvert conveying flows under Lincoln Avenue to Hyde Creek but it is not a barrier to fish passage. The invert of the culvert has gravels cemented to the concrete.

In this section of the Hyde Creek Mainstem the channel morphology consists of a run/riffle. Wetted width at the time of survey was 3.5 metres, water depth was 0.05-0.45 metres, and the channel gradient is 2 %. Bed substrates are comprised of cobbles (40 %), gravels (30 %), and sands (30 %). There is limited cover provided by overhanging vegetation and there is a mixed canopy over the stream comprised of western redcedar, red alder, broadleaf maple and black cottonwood (*Populus trichocarpa*). Dominant understorey species include salmonberry, sword fern, English ivy (*Herda helix*), Douglas maple (*Acer glabrum*), vine maple, beaked hazelnut (*Corylus californica*), and exotics such as bamboo (*Phyllostachys sp.*), weeping willow (*Salix babilonica*) and other ornamentals. There are houses encroaching on both sides of the channel in this area and sections of the creek are channelized with vertical concrete/stone retaining walls that form the creek banks. In areas there is very limited vegetation and where present consist primarily of Himalayan blackberry (*Rubus discolor*). An associated problem with the area is that one of the retaining walls is undermined in this section.

4.1.8 Hyde Creek between Coast Meridian Road and confluence with Cedar Creek

This section of creek was surveyed on November 25/02. In this section of the Mainstem a pipe arch culvert conveys flows under Coast Meridian Road. It is approximately 1.8 metres high by 2.5 metres wide. The channel has been restored in the section between Coast Meridian Road and large boulders have been placed at the toe of the bank. The channel lacks large woody debris, with the exception of the material that has been placed there.

There is very good spawning habitat in Hyde Creek from Coast Meridian Road to the confluence with Cedar Creek in this section. The substrates are comprised of boulders (5 %), cobbles (5 %), gravels (65 %) and sands (25 %) and the channel morphology is run/riffle. Wetted width at the time of survey was 4-7 metres, the water depth was 0.2-0.3 metres, bankfull width is 4-8.5 metres, and the bank height is 1 metre (north side) and 1-3 metres on the south side.

The canopy is mixed and comprised of black cottonwood, broadleaf maple, red alder, western redcedar, western hemlock and Douglas-fir. Understorey species include beaked hazelnut, Douglas maple, vine maple, sword fern, salmonberry, Nootka rose (*Rosa nootkatensis*), bracken fern (*Pteridium aquilinum*), dull Oregon-grape (*Mahonia nervosa*), red elderberry, and hardhack (*Spirea douglasii*). Himalayan blackberry is the dominant understorey species downstream of confluence with Smiling Creek in this section. The cover from overhanging vegetation (understorey species) varies from 0-30 % and is provided predominantly by salmonberry and sword fern. A two metre wide compacted gravel trail meanders along south side of creek within a park that averages 10 metres from wetted edge of creek. There may be access problems by lack of fencing in this section of the Mainstem of Hyde Creek.

<u>4.2 Hyde Creek Tributaries</u>

4.2.1 Tributary 1 to Hyde Creek Mainstem downstream of Harper Road

This section of creek was surveyed on September 12/02. Tributary 1 to Hyde Creek flows southwest. It is conveyed under Harper Road through a 10 metre long 750 mm diameter concrete culvert that has a 1 metre drop on the downstream end. It poses a fish migration barrier.

Upstream of Harper Road the channel was dry during the survey (September 12), but it was a defined channel with similar dimensions and substrates to the section downstream of Harper Road (flows downstream of Harper Road were due to roadside drainage that was being discharged to the culvert).

Flows were observed in the tributary at the time of the survey downstream. The wetted width was 0.3 metres, water depth was 0.05 metres, bankfull width is 1-1.5 metres, and the bank height is 0.3-0.4 metres. Substrates are comprised of sands, gravels and cobbles and there is a large amount of large and small woody debris within the channel. Throughout the channel gradient averages 10 % (upstream of the steep section at the confluence with the Mainstem).

There is no fish access upstream of the confluence with the Mainstem due to the steep grade up a very steep bank. The vegetation assemblage is the same as that described for the Hyde Creek Mainstem downstream of Harper Road

4.2.2 Tributary 2 to Hyde Creek

Tributary 2 to Hyde Creek Upstream of Coast Meridian Road

This section of creek was surveyed on September 12/02. During the time of the survey no surface flow was present in the channel but pools of water were present throughout. This tributary has the potential to contain fish during higher flows because historically coho have been found in the middle reaches of the tributary.

The overhanging vegetation consists of salmonberry, sword fern, and deer fern and provides 100 % cover to the channel. The canopy cover is limited at Coast Meridian Road and throughout the channel substrates are comprised of boulders, cobbles, gravels and sands. Moss was evident growing on the channel substrates, indicating a typical lack of flow. The bankfull width of the channel is 1.5 metres, bank height is 0.5 metres and the channel displays a step pool structure throughout.

Tributary 2 to Hyde Creek Downstream of Coast Meridian Road

This section of creek was surveyed on September 12/02. The culvert conveying flows across Coast Meridian Road is a 1,000 mm diameter corrugated steel pipe approximately 25 metres long, with a 1.0 metre drop between the culvert invert and the channel invert at the outlet. It may be considered a barrier to upstream fish migration. There was no flow at the time of the survey (within approximately 100 metres of the road) but flows are present during other times of the year.

The canopy assemblage is coniferous with occasional red alder and the shrub layer provides approximately 75 % overhanging cover; canopy cover is approximately 80 %. Here, the channel gradient is 18 % and bankfull width is 1- 2 metres, channel substrates are comprised of cobbles, gravels and large boulders. There are a number of small debris jams present within the channel.

4.2.3 Tributary 3 to Hyde Creek

This section of creek was surveyed on November 21/02. This tributary commences as roadside drainage on north side of Hazel Drive flowing west. Flows are conveyed under Hazel Drive at a culvert by a residential area. The culvert is a 600 mm diameter pipe approximately 20 metres long, concrete pipe. At the outlet the channel flows southwest to Martin Street. At 1506/1508 Martin Street, the channel again becomes a roadside drainage on the east side and conveys flows south to the end of the street. Here the channel becomes naturalized.

There are no barriers to fish movement upstream into this tributary from the Mainstem. The channel substrates are composed of cobbles, gravels and sands. The wetted width at the time of survey was 0.5-1 metre and the water depth was 0.1-0.2 metres.

The vegetation is the same as for Tributary 4 (except for the roadside drainage portions), with the addition of oval-leaved blueberry, salal, and deer fern in the understorey layer.

4.2.4 Tributary 4 to Hyde Creek

This section of creek was surveyed on November 21/02. The east branch upstream of Hazel Drive consists of three poorly defined channels within 10 metres of each other. The most significant one had a wetted width of approximately 0.3 metres at the time of the survey (November 21), and the water depth was 0.05-0.1 metres. The channels are poorly defined and contain a substrate of fines and leaf litter.

Flows enter the roadside drainage on the north side of Hazel Drive and are conveyed west into a 400 mm diameter concrete pipe they are then piped. A culvert conveying flows in the west branch of Tributary 4 south under Hazel Drive. This west branch of Tributary 4 flows further south under Hazel Drive through a 600 mm diameter concrete culvert. Upstream of Hazel Drive, the channel had a 0.5 metre wetted width and 0.1-0.2 metre water depth at the time of survey. The bankfull width is 1.2 metres and the bank height is 0.5 metres. Dense overstream cover is provided by salmonberry and sword fern. Other shrub species include vine maple, European holly (*Ilex aquifolium*), lady fern, and trailing blackberry (*Rubus ursinus*). The canopy is mainly comprised of red alder and is fairly open. The channel morphology consists of a drop pool and riffle structure and the channel is poorly defined. Substrates are comprised mainly of fines with some boulders.

Downstream of Hazel Drive the substrates are comprised of fines, small gravels and occasional boulders . The wetted width averages 1 metre. The water depth was 0.05-0.1 metre and the channel morphology is run/riffle interspersed with drop pools. In this location the canopy layer is not well-developed and consists predominantly of immature black cottonwood and red alder, with lesser components of western redcedar and Douglas-fir. The understorey layer is very well-developed, with dense growth of salmonberry providing 100 % cover to the channel. Other understorey species include red elderberry and beaked hazelnut. From here the channel turns east and becomes poorly defined, almost becoming overland and flowing through the salmonberry and leaf litter. The wetted width is 5 metres wide and contains no boulders, just leaf litter and fines as channel substrates. The areas of ponded water eventually flow west and enter an excavated channel that runs south along the west property line of 3327 Coy Avenue. At this point the channel has a 2 metre wetted width and a water depth of 0.2 metres. The bankfull width is 2 metres (banks are vertical) and bank height is 0.6

metres. The channel substrates are primarily composed of fines.

From downstream flows enter a 600 mm diameter concrete culvert approximately 45 metres in length and it outlets into the roadside drainage channel on the north side of Coy Avenue. From here flow is conveyed underneath Coy Avenue through a 600 mm diameter culvert (concrete at inlet, steel at outlet). Fish access into roadside drainage is not possible because there is an approximate 2 metre drop from invert of roadside drainage to the culvert inlet; the culvert outlet is passable. The channel is confined within a small ravine downstream of Coy Avenue and it has a mixed coniferous (western redcedar, western hemlock)/deciduous (broadleaf maple, red alder) canopy. The shrub species are dominated by sword fern and salmonberry; red huckleberry and bracken fern are also present. Groundcover here is dominated by youth-on-age and there is abundant debris in the channel (i.e. tires, metal and processed wood, pieces of concrete pipe). The channel morphology throughout this section is riffle with drop pools.

During the survey, four spawners (coho salmon) were found in the tributary (both male and female) below Coy Avenue. The furthest upstream was approximately 50 metres from the culvert outlet where the channel gradient is 9 %. Here the channel substrates consist of boulders (10 %), cobbles (25 %), gravels (25 %), and sands (40 %). The wetted width at the time of survey was 2 metres, the water depth was 0.15-0.2 metres, the bankfull width is 3 metres, and bank height is 0.4 metres. There is no barrier to fish movement at the confluence of the tributary with the Mainstem. Incidental observations identified a dead red-legged frog within the creek at this point.

4.2.5 Tributary 5 to Hyde Creek Upstream of Coast Meridian Road

This section of creek was surveyed on September 12/02. This tributary converges through overland forest drainage with the Coast Meridian Road drainage on the east side of the road prior to entering the culvert under Coast Meridian Road. It is rip rapped and has a lined channel. No flow was observed during the field inspection. The upper tributary substrates are comprised of fines, and vegetation was observed growing within the channel. The canopy cover is 75 % and overhanging shrubs provide 100 % cover to the channel. The dominant shrub species include sword fern, salmonberry and vine maple. No flow was observed within the tributary. The physical structure of the creek includes a bankfull width of 0.5 metres and a bank height of 0.3 metres.

4.2.6 Tributary 5 to Hyde Creek Downstream of Coast Meridian Road

This section of creek was surveyed on September 12/02. The Coast Meridian Road culvert inlet is a 1,100 mm diameter wood stave and its outlet is a 1,400 mm diameter corrugated steel pipe culvert that has been partially squashed (i.e. 1,500 mm wide, 1,200 mm high). The culvert is approximately 24 metres long and there is no drop at the outlet.

The canopy here is primarily coniferous and provides 80 % cover to the channel. Overhanging vegetation (i.e. shrub layer) provides 20 % cover and is comprised of red huckleberry, vine maple, immature western hemlock, sword fern and lady fern. There are many areas along the channel that contain small woody debris jams. At the time of the survey no flows were observed in the tributary.

The physical morphology of the stream consists of a bankfull width that is 1 – 3 metres and the bank height is 0.3 metres. The ravine bank in this section is steep on the south side of the channel with a more gradual slope on the north side. The floodplain at the base of the ravine is approximately 8 metres wide, and the channel meanders over the entire width of the floodplain.

A fairly large erosion area was noted approximately 50 metres downstream of Coast Meridian Road. The area is approximately 8 metres wide at the base and 8 metres high. Here the channel substrates are comprised of boulders, cobbles, gravels and sands while the channel gradient is 13 %.

4.2.7 Tributary 6 to Hyde Creek

This section of creek was surveyed on November 25/02. The downstream end of the channel is accessible from the Mainstem and a weir has been constructed at a n online pond. The weir does not allow for fish passage and appears to be in poor condition. It could potentially fail at higher flows. The drop from weir invert to channel invert is approximately 2.5 metres.

Tributary 6 consists of a mature forest canopy composed primarily of red alder trees, Douglas fir, and a subdominant composition of western redcedar. The shrub understorey consists primarily of red alder, salmonberry and Himalayan blackberry. The upper section, before the pool, is open, and flows within an incised channel draining overland flow for approximately 50 m. It empties into a large pond before flowing over a berm and emptying into Hyde Creek Mainstem. Below the pond it flows over a steep channel (>25%) and enters Hyde Creek Mainstem approximately 50 m downstream.

The characteristic stream substrate is dominated by gravel (40%) and fines (30%). Cobbles make up 20% and boulders 10%. The morphology of the stream is a cascade/pool and sections become silted. Small organic debris can be found throughout the channel and the small pools form as a result of woody debris accumulation.

4.2.8 Tributary 7 to Hyde Creek

This section of creek was surveyed on October 15/02. There is a drop at the confluence of this tributary with the Mainstem and it is greater than 1 metre During the survey there was flow in the channel. There was evidence of iron-oxidizing bacteria at the upstream end of the channel (from a piped system).

The riparian habitat consists of a mature forest canopy composed primarily of red alder trees, Douglas fir, and a subdominant composition of western redcedar. The shrub understorey consists primarily of red alder, salmonberry and Himalayan blackberry. Himalayan blackberry dominates the cover in the upper stream areas.

The characteristic stream substrate includes gravel (50%) and fines (30%). Cobbles make up 15% and boulders 5% in the lower reaches of the tributary. Due to the steepness of this tributary to Hyde Creek the morphology is a primarily cascade with a limited amount of silted in pool habitat. Small organic debris can be found throughout the channel and the small pools form as a result of woody debris accumulation.

4.2.9 Bracewell Pond (Tributaries 8 and 9)

This section of creek was surveyed on November 25/02. There are two small channels entering the pond, one from the northwest and one from the southwest and both channels had less than 0.5 metre wetted width at the time of survey.

The pond here is quite shallow and filled with large woody debris. There is a lack of cover for the pond due to the low riparian vegetation and water depth (less than 0.5 metres deep). Small-flowered bulrush is present on the banks of pond. The pond outlet channel is 0.5-1 metre wide the water depth was 0.15 metres at the time of survey.

4.2.10 Tributary 10 to Hyde Creek

This section of creek was surveyed on November 25/02. There is no barrier to fish movement upstream from Hyde Creek at the confluence with this tributary. The wetted width at the time of survey was 0.5 metres, the water depth was 0.05 metres, bankfull width is 1.5 metres, and bank height is 0.5 metres. The channel substrates are comprised of gravels (50 %) and sands (50 %). The tributaries channel morphology is a run/riffle and the cover from overhanging vegetation and from downed trees is 100 %.

4.2.11 Tributary 11 to Hyde Creek at the Confluence

This section of creek was surveyed on November 25/02. There is no barrier to fish passage at the confluence with Hyde Creek but a small drop 0.7 metres is present from the tributary invert to the invert of small pool at outlet the pool is 0.5 metres deep.

The overhanging vegetation primarily composed of salmonberry, provides 100% of the stream cover and large woody debris is present overstream and instream. Other understorey vegetation includes youth-on-age, bracken fern, licorice fern, sword fern, red elderberry, and vine maple. Here the channel substrates are comprised of pea gravels and sands and the channel is incised with morphology of run/drop pool habitat. The wetted width at the time of survey was 1 metre, the water depth was 0.1-0.2 metres, bankfull width is 2.5 metres, and bank height is 1.3 metres. A characteristic of this tributary is the extensive undercutting of banks.

4.2.12 Tributary 12 to Hyde Creek at Lynwood Avenue

This section of creek was surveyed on November 25/02. The discharges from a culvert conveying flows under Lynwood Avenue at Mansfield Place are through a 600 mm diameter concrete culvert with a trash rack. The stream substrate is composed of gravels, silts and sands at the outlet and 100 % of the stream cover is provided by an understorey layer which is comprised primarily of Himalayan blackberry and salmonberry. The wetted width at the time of survey was 1.5 metres. The banks are on average poorly defined in this tributary.

4.2.13 Tributary 13 – Tributary 1 to West Smiling Creek

This section of creek was surveyed on November 22/02. The channel is culverted under both Gislason Ave. and Roxton Avenue. Upstream of Roxton Avenue the flows are conveyed via a rip rap lined channel and a culvert crossing at Roxton Avenue contains a 1,000 mm diameter concrete culvert with a concrete headwall at the inlet and a vertical trash rack. The culvert outlet is not a barrier to upstream fish migration.

Channel flows are conveyed along east property line of Roxton Avenue and the wetted width at the time of the survey was 0.5 metres, and the bankfull width is 1 metre. It is an excavated channel.

4.2.14 Tributary 14 Unnamed Tributary to Smiling Creek from Wedgewood Street

This section of creek was surveyed on November 22, 2002. This area is crossed by a small bridge/boardwalk joining to a pedestrian bridge crossing at Smiling Creek. At the confluence with Mainstem there is access for fish. Here juvenile salmonids were noted in the creek, upstream to the outlet from piped system behind a residence. One dead spawned out female coho salmon (and 1 dead male coho) was found approximately 100 metres downstream of outlet. The channel exhibits good rearing/off-channel habitat for juvenile salmonids, and good spawning habitat.

At the upstream end, the creek flows adjacent to back yards of houses on Wedgewood Street. There is encroachment of exotic vegetation and there is minimal native riparian vegetation. The channel contains a wetted width of 1.2 metres at the time of the survey. The water depth was 0.05-0.15 metres, bankfull width is 3 metres and bank height is 0.4 metres.

The channel substrates are comprised of boulders (10 %), gravels (60 %), and sands (30 %) and the morphology is run/riffle. Vegetation is mixed with a canopy comprised of red alder, western redcedar, and western hemlock. It has a well-developed understorey which consists of salmonberry, lady fern, vine maple, beaked hazelnut, English ivy, deer fern, and sword fern.

4.2.15 Tributary 15 Unnamed tributary to Smiling Creek from Ambleside Close

This section of creek was surveyed on November 25/02. This section flows in from west (south of Ambleside Close). During the survey, coho spawners were observed within the tributary. The channel substrates are comprised of sands/fines and woody debris and the channel morphology is run/drop pool. Over hanging vegetation makes up 100% cover for the stream and the wetted width at the time of survey was 0.5 to 0.8 metres. At the time of the survey the water depth was 0.1 metres, bankfull width was 2 metres, and bank height was 1 metre.

4.3 Watkins Creek

4.3.1 Watkins Creek Mainstem Downstream of Millard Avenue

This section of creek was surveyed on October 15/02. Flows in Watkins Creek were observed at the time of survey. A 400 mm diameter corrugated steel pipe culvert with a 0.6 metre drop from the invert of the culvert to the invert of the outlet pool (pool was 0.3 metres deep) conveys flows under Coast Meridian Road.

The riparian habitat of Watkins Creek Mainstem consists of a mature forest canopy composed primarily of red alder trees and a subdominant composition of western red cedar and Douglas fir. The shrub understorey consists primarily of Himalayan blackberry, red alder and salmonberry. Sections of the ditch are overgrown with Himalayan blackberry that provide 100% of the cover for variable lengths.

The stream substrate is dominated by gravels (40%) and fines (30%). Boulders and cobbles make up the remaining 10% and 10% respectively. The morphology of the stream throughout its length may be defined as a repeating cascade/pool/run with small riffle sections at lower gradients (<3%). Throughout its headwaters it passes through residential areas where the canopy becomes more open and vegetated to the channel by grass. Sections around David Avenue contain undercut banks and small pools which provide potential overwintering habitat for fish.

4.3.2 Millard Avenue Ditch

This section of creek was surveyed on September 06/02. The Millard Avenue Ditch is characterized by trees and shrubs along the north side of the ditch with mowed grass between the bottom of the ditch and the edge of the road (Millard Avenue). Substrate is generally organics, silt and small areas of gravel. At the end of Millard Avenue this ditch enters a grated culvert and flows west contributing flows to Tributary 7 of Hyde Creek. It provides food and nutrient value to downstream fish populations of Hyde Creek.

4.3.3 Highland and Queenston Avenue Ditches

This section of creek was surveyed on September 06/02. The riparian habitat associated with each of these ditches is comprised of trees and shrubs along the north sides of the ditches, while the south sides of both ditches are partially mowed to the road edge. The bottom substrate is primarily comprised of slit, sand, a few sections of angular rip-rap and grasses. Both ditches flow into Watkins Creek, via the Coast Meridian Ditch. The primary function of these ditches is that the contribution of food and nutrients to downstream fish populations.

4.3.4 Coast Meridian Ditch between Highland and Queenston Avenue

This section of creek was surveyed on September 06/02. The Coast Meridian Ditch is comprised of trees and shrubs along the east side of the ditch with the exception of a few areas that have been disturbed by the local landowners. Substrate is primarily composed of silt, organics and angular rip-rap placed to dissipate stream velocities and prevent erosion of the ditch banks. The function of this ditch is to contribute food and nutrients to downstream fish populations.

4.3.5 Watercourse 1

This section of creek was surveyed on November 21/02. The most westerly stream originates just west off the parcel at Highland Drive and it enters the property approximately 85 metres from its origin. Approximately 90 metres later it dissipates over the forest floor. It is composed of silt and small gravels with a thick riparian cover of salmon berry throughout its length. Sections open up in the forest canopy. The average wetted width is approximately 0.5 metres and its banks are ill defined throughout its length.

4.3.6 Watercourse 2

This section of creek was surveyed on November 21/02. This watercourse originates from a 600 mm culvert along Highland Drive and flows south through the property into a 600 mm storm sewer opening at the end of Glenbrook Street into a 900 mm culvert. It is composed of silt and small gravels with a thick riparian cover of salmon berry and subdominant forest canopy throughout its length. The average wetted width is approximately 0.5-0.6 m and its banks are poorly defined in the middle. Watercourse 2 flows into the 900 mm storm sewer along Glenbrook Street and upon day lighting it contributes flows to Tributary 7 of Hyde Creek. It provides food and nutrient value to Hyde Creek fish populations.

4.3.7 Watercourse 3

This section of creek was surveyed on November 21/02. This watercourse originates as overland flow from a parcel located on the southwest corner of Coast Meridian Road and Highland Avenue. Its carries overland flows from the parcel via man made ditches. The watercourse then empties into the Glenbrook Street 900 mm culvert into the storm sewer. For its length it is densely vegetated and approximately 100 to 150 metres from its junction with the 900 mm Glenbrook Street storm sewer it has a dense riparian cover which contributes food and nutrient value to down stream fish populations. Watercourse 3 flows into the 900 mm storm sewer along Glenbrook Street and upon day lighting it contributes flows to Tributary 7 of Hyde Creek.

4.3.8 David Avenue Ditch

This section of creek was surveyed on November 21/02. The David Avenue Ditch is comprised of trees and shrubs along the north side. Substrate is primarily composed of silt, organics and some gravels are present. The eastern portion of the ditch contributes flows to Watkins Creek and the western half flows into Hyde Creek. The function of this ditch is to contribute food and nutrients to downstream fish populations. It flows west and drains down a steep bank that is densely covered with riparian vegetation into Hyde Creek.

4.3.9 Watkins Creek Mainstem at David Avenue

This section of creek was surveyed on October 15/02. The section of Watkins Creek under David Avenue has a 1,000 mm diameter corrugated steel pipe. It has a 1 metre drop from the culvert invert to the channel invert and poses an upstream migration barrier for fish. Flows were observed at the time of survey. It provides food and nutrient function to downstream fisheries.

4.3.10 Watkins Creek at Mason Avenue

This section of creek was surveyed on November 22/02. The flows for this section of Watkins Creek are conveyed under Coast Meridian Road through a 1,400 mm diameter concrete culvert. Upstream of the culvert, the channel is aligned along Coast Meridian Road for approximately 20 metres. There are no barriers to fish passage at the confluence. Upstream of the confluence, the Mainstem had a wetted width of 2 metres at the time of the survey, and a water depth of 0.1 metres. The bankfull width is 3.5 metres and bank height is 0.5 metres. Here the channel morphology is run/riffle/drop pool and channel substrates are comprised of boulders (20%), cobbles (30%), gravels (40%) and sands (10 %). There is a good amount of small woody debris in the channel forming numerous jams. The overstream cover from the understorey layer is approximately 60% and the canopy is fairly open and comprised of western redcedar, western hemlock, Douglas-fir, red alder and broadleaf maple. The understorey is comprised of Douglas maple, salmonberry, Himalayan blackberry, beaked hazelnut, and vine maple.

Many exotic species are encroaching into riparian area on the west side of the channel like Japanese knotweed (*Polygonum cuspidatum*), and bamboo. Garbage was noted adjacent to the creek (i.e. metal drums, fence posts, etc.). This section of Watkins Creek Mainstem could potentially provide some spawning habitat, as well as being a good gravel recruitment area.

4.3.11 Watkins Creek Downstream of Coast Meridian Road

This section of creek was surveyed on November 22/02. The culvert conveying flows under Coast Meridian Road discharges into a 0.5 metre deep pool. The drop from the culvert invert to the pool invert is 0.8 metres (i.e. 0.3 metres from culvert invert to water surface). Several small tributaries discharge into Watkins from the northeast; one conveyed flows from the roadside drainage on Coast Meridian Road.

This section of the channel has undercut banks and good amounts of large woody debris along with good overhanging cover from the understorey vegetation. The canopy is mainly coniferous (western redcedar, western hemlock) with occasional broadleaf maple. The understorey is well developed and comprised of salmonberry, vine maple, sword fern, red huckleberry, deer fern, lady fern, and red elderberry.

The wetted width at the time of survey was 2.5 metres. The water depth was 0.1-0.2 metres, bankfull width is 4 metres, and bank height is 0.5 meters. Stream substrates consist of boulders (5 %), cobbles (40 %), gravels (35 %) and sands (20 %) and the channel gradient is 5 %.

There appeared to be good spawning habitat in the section of creek between Coast Meridian Road and Roxton Avenue and the channel morphology here is run/riffle/drop pool. An old footbridge was noted approximately 120 metres downstream of Coast Meridian Road that is about to collapse into the creek. It may have to be removed. A culvert crossing at Roxton Avenue is not a barrier and the culvert present is a smooth steel pipe 2,200 mm in diameter with concrete wing walls and a concrete apron at the inlet. Spawners (coho salmon) were observed immediately downstream of the Roxton Avenue culvert.

Downstream of Roxton Avenue, the canopy is less developed and the channel is aligned adjacent to Coast Meridian Road with a chain link fence between the road and the creek. Vegetation in this section is limited on the west side of the channel due to the proximity of the road. There is spawning habitat potential downstream of Roxton Avenue until a 40 metre section of channel upstream of next culvert. It is lined with rip rap. This culvert is a 1,500 mm diameter wood stave culvert conveying flows under the driveway of a residential property along Coast Meridian Road. It is not a barrier. Downstream of the culvert, the creek is essentially a roadside drainage with heavy Himalayan blackberry growth providing 100 % cover to the channel and there is some limited canopy cover provided on the east side of the creek. Substrates are composed of gravels and cobbles again. Potential spawning habitat extends from this location to Victoria Drive.

A 1,600 mm diameter steel culvert, complete with gravel substrates extends under a driveway anong Coast Meridian Road. Another steel pipe 1,600 mm diameter with gravel substrates, is not a barrier. Sections of the channel exhibit disturbed riparian vegetation; exotics noted include English ivy, laurel, and knotweed.

At Victoria Drive, the culvert of Watkins Creek is a 2,000 mm diameter steel pipe with a 0.5 metre drop from the invert of the concrete apron at the culvert outlet, to the pool invert (pool depth is 0.4 metres). Rock has been placed at the outlet in fall 2002 and rip rap weirs and pool structures were constructed to make it more passable to fish.

4.3.12 Watkins Creek at confluence with Hyde Creek

This section of creek was surveyed on November 25/02. There is a pedestrian bridge at the confluence of Watkins Creek and Hyde Creek. It does not provide a barrier. During the survey chum salmon spawners were noted within Watkins upstream of confluence.

Here the channel morphology is run/riffle/drop pool structure and the channel substrates are comprised of gravels (70 %) and fines (30 %). During the survey the wetted width was 2 metres, and the water depth is 0.05 to 0.15 metres. The bankfull width is 3.5 metres, bank height is 1.2 metres. The channel is fairly incised in this section with good large woody debris present in the channel. Additionally, there is good cover for the stream which is provided by overhanging vegetation (mostly salmonberry) and undercut banks.

4.4 East Watkins Creek

4.4.1 East Watkins Creek at David Avenue

There were no flows at time of survey (October 15), at a 600 mm diameter concrete extending under David Avenue

4.4.2 East Watkins Creek Upstream of the Confluence with Watkins Creek Mainstem

This section of creek was surveyed on November 22/02. The riparian vegetation on the east side of the creek (i.e. road shoulder) is comprised of salmonberry, Himalayan blackberry, and lady fern. The vegetation on the west side of the creek is comprised of Himalayan blackberry, salmonberry, and sword fern. Overall the canopy species growing on the west side of the channel are the same as the assemblage for the Mainstem. There is good overhanging cover provided by the vegetation on the west side. Physical morphology of the stream consists of a wetted width at the time of survey at 0.6 metres. The water depth was 0.05 to 0.1 metre, bankfull width is 2.5 metres, bank height is 0.4 metres. Throughout, the channel morphology is run/riffle/drop pool and the channel substrates are comprised of boulders (20 %), cobbles (20 %), gravels (40 %) and sands (20 %).

A recent bank failure (3 metres of bank sloughed into the channel) was noted on the west bank of the channel approximately 16 metres south of the driveway culvert at residence on Coast Meridian Road. Adjacent to the failure is a 7 metre long section of undercut bank (the undercut measures 0.5 metres) that could potentially fail as well.

The driveway culvert at 1288 Coast Meridian Road is a 600 mm diameter concrete culvert and is not a barrier to upstream fish migration. Approximately 15 metres upstream of the culvert, the channel moves west away from the road. Within this property, the canopy is mainly coniferous (western redcedar and western hemlock); the understorey is poorly developed and primarily consists of sword fern. There is a good amount of large woody debris in the channel which provides cover for the stream, not much cover is provided by overhanging vegetation. The substrates instream are dominated by gravels. Salmonid spawning opportunities are well represented in this channel section.

A 600 mm diameter corrugated steel pipe culvert conveys flows under driveways for 1,294 and 1,300 Coast Meridian Road with a 1.1 metre drop from the culvert invert to the outlet pool invert. The outlet pool is 0.2 metres deep,; the drop and pool would preclude fish access to upstream reaches.

At the property along Coast Meridian Road, the channel has little cover from overhanging vegetation. It is composed of mainly exotics/ornamentals. At the north end of the property, the creek flows through a 600 mm diameter corrugated steel pipe culvert under an access road/driveway. Here the channel is then day lighted for approximately 10 metres, and then another culvert (460 mm diameter concrete approximately 30 metres long) with a 0.8 metre drop from the culvert invert to the invert of the outlet pool, which is 0.3 metres deep is a potential barrier to fish passage under low flow conditions. The channel then flows through an open field with limited canopy cover (1 broadleaf maple, 1 vine maple, 1 beaked hazelnut). There is good instream vegetation (i.e. grasses) within this section and at the north edge there is a double culvert (both 450 mm diameter corrugated steel pipe culverts) conveying flows under an access road/driveway. It is fish accessible. The next property to the north is the property south of David Avenue is forested/undeveloped and has a mixed canopy with a dense understorey layer.

4.5 WEST SMILING CREEK

4.5.1 Headwaters of West Smiling Creek at Harper Road

This section of creek was surveyed on September 12/02. At the headwaters there is a 900 mm diameter concrete storm sewer crossing Harper Road at the approximate alignment of the stream. It has a defined channel both upstream and downstream of Harper Road. During the visit, flows were not observed in this location at the time of the survey.

4.5.2 Highland Drive

This section of creek was surveyed on November 21/02. The outlet of culvert conveying flows under Highland Drive discharges on the east side of a residence. Here the culvert is a 700 mm diameter concrete pipe with no visible inlet. The wetted width at the time of survey was 2 metres and the water depth was 0.1 to 0.2 metres. The channel morphology is run interspersed with drop pools with lots of woody debris within the channel. Some of the debris creates debris jams, resulting in sections of braided channel. The overstream cover is high, mostly from downed trees (vine maple) and the understorey vigor is limited by dense coniferous canopy cover (mostly western hemlock). Species include sword fern, salmonberry, lady fern, deer fern, and red elderberry. The channel substrates consist of boulders, gravels, and fines.

4.5.3 Queenston Avenue

This section of creek was surveyed on November 21/02. Downstream of Queenston Avenue, the channel flows between two properties within a small ravine with banks approximately 3 metres high. Upstream of Queenston Avenue the creek flows within a small ravine with a well-developed understorey layer comprised of sword fern, salmonberry, and vine maple.

Commencing approximately 100 metres downstream of Queenston Avenue, for approximately 75 metres, there is a failing retaining wall present on the west side. There are concrete blocks in the channel a lack of riparian vegetation providing cover, especially on the west side of the creek, and a bank failure on the east side of the creek. Here the canopy layer is mixed coniferous/deciduous; dominant species are broadleaf maple and western hemlock. The wetted width at the time of survey was 2 metres (same as bankfull width), water depth was 0.1-0.2 metres, bank height is 0.4 metres and the channel morphology throughout was run/riffle/drop pool. The channel substrates comprised of boulders (30%), cobbles (20%), gravels (30%), and sands (20%).

The culvert under Queenston Avenue is a 900 mm diameter concrete culvert with a concrete bag headwall. There is a natural drop within the channel approximately 3 metres in height which occurs on the approximate alignment at the end of Kingston Street. This may be a potential barrier for fish passage during lower flows. Downstream of this drop the east bank of the channel has eroded significantly down to hardpan clay for a section approximately 30 metres long.

4.5.4 Galloway Avenue

This section of creek was surveyed on November 21/02. At Galloway Avenue stream flows are conveyed under Galloway Avenue through an 800 mm diameter corrugated metal pipe. Downstream the channel the morphology is run/riffle/drop. During the survey the wetted width was approximately 1.5 metre. Here the canopy and understorey layers are both well-developed with a coniferous dominated canopy composed of dominant western hemlock.

4.5.5 Gislason Avenue

This section of creek was surveyed on November 22/02. At this point West Smiling Creek is open in the BC Hydro Right-of-Way (ROW). The channel morphology is drop pool with natural drops 0.3 to 0.5 metres in height interspersed with short sections of run habitat. The channel gradient is 15 % upstream of Gislason Avenue to the Hydro ROW. During the survey in this section of West Smiling Creek the wetted width is 1.4 metres and the water depth was 0.05 to 0.2 metres. The bankfull width was 3 metres, and bank height was 0.5 metres. Here the channel substrates are comprised of boulders (30%), cobbles (20%), gravels (30%) and fines (20%) with lots of small woody debris instream

Within the Hydro ROW, no canopy cover is present and overhanging vegetation (i.e. shrub layer) is very dense, comprised of willow, hardhack, Himalayan blackberry, and salmonberry. Immediately downstream of the ROW, the canopy is mainly deciduous (red alder); the understorey layer is fairly open and compromised of salmonberry, sword fern, red huckleberry and bracken fern.

A 900 mm culvert flows under Gislason and it has a 1.5 metre drop from the invert to the outlet pool. The downstream pool is approximately 0.3 metres deep and this culvert is a potential fish barrier.

The east side of the channel has a lack of riparian vegetation in this section and some minor bank erosion is present on the west bank of the creek approximately 7 metres long, less than 1 metre high.

4.5.6 Tributary 1 to West Smiling Creek

This section of creek was surveyed on November 22/02. Tributary 1 to West Smiling Creek flows across the BC Hydro Right-of-Way (ROW). The channel morphology is drop pool with natural drops 0.2-0.5 metres in height interspersed with short sections of run habitat. The channel gradient is 10 % upstream of Gislason Avenue to the Hydro ROW.

Within the Hydro ROW, no canopy cover is present and overhanging vegetation (i.e. shrub layer) is very dense, comprised of willow, hardhack, Himalayan blackberry, and salmonberry. Immediately downstream of the ROW, the canopy is mainly deciduous (red alder); the understorey layer is fairly open and compromised of salmonberry, sword fern, red huckleberry and bracken fern. The tributary enters West Smiling Creek just above Gislason Avenue.

4.5.7 Gislason Ditch

This section of creek was surveyed on November 22/02. This ditch has a good riparian habitat composed of alder and it is grassed throughout its length.

4.5.8 Roxton Avenue Alignment

This section of creek was surveyed on November 22/02. North of the Roxton Avenue alignment within the first property is a natural drop over rock that is approximately 1 metre high and may be considered a barrier to fish passage under lower flow conditions. The channel not confined within a ravine in this section and the general channel morphology consists of a run/riffle/drop pool. The drops for pools are approximately 0.3 to 0.5 metres in height.

The wetted width at the time of the November 22 site visit was approximately 2 metres at a water depth was 0.2 metres, with a bankfull width of approximately 4 metres. The bank height in this area is approximately 0.6 metres. Channel substrates are comprised of boulders (30 %), cobbles (30%), gravels (20%) and sands (20 %). The reach at this point has a channel gradient of approximately 8%.

There is a mixed tree canopy layer comprised of red alder, western redcedar, black cottonwood and western hemlock and the understorey is well-developed and comprised of Himalayan blackberry, salmonberry, sword fern, deer fern, bracken fern, beaked hazelnut, red huckleberry, English ivy and rhododendron (*Rhododendron albiflorum*). The stream in this section has a good overstream cover provided by the understorey layer; the canopy is fairly open.

4.5.9 Upstream of Victoria Drive

This section of creek was surveyed on November 22/02. West Smiling Creek has a channel which is confined within a small ravine here. It has considerable encroachment into riparian zone on both sides of creek specifically houses adjacent to top of bank, native vegetation removed and exotic vegetation planted.

There is a deciduous canopy composed primarily of beaked hazelnut and broadleaf maple. The under storey is well-developed and comprised predominantly of Himalayan blackberry and salmonberry. A 900 mm culvert conveys flows under Victoria Drive, and a 950 mm diameter wood stave pipe is located at the outlet. There is a 1.8 metre high drop from the culvert invert to an outlet pool which is 0.7 metres deep. It is a barrier to upstream fish migration.

Spawning coho salmon were observed in the outlet pool and the downstream of the pool in during the November field visit. It was observed that there is good spawning habitat downstream of site to the confluence with the Mainstem Smiling Creek. The channel substrates are comprised of boulders

(10%), cobbles (30 %), gravels (40 %) and sands (20 %).

4.6 EAST SMILING CREEK

4.6.1 Headwaters of East Smiling Creek

This section of creek was surveyed on September 06/02. In the headwaters of East Smiling Creek a 1,000 mm diameter corrugated steel pipe culvert crosses Conifer Drive. Instream pockets of standing water were observed, primarily upstream of Conifer Drive. The substrates are comprised of boulders, cobbles, gravels and sands. The stream cover is provided by both overhanging and instream woody debris (downed trees, etc.). The shrub layer is poorly developed along the reach and consists of sword fern, deer fern, red huckleberry and salal. The channel exhibits a drop pool structure and it has a wetted width is 0.8 metres. The bankfull width is 1.2 metres, and bank height is 0.5 metres. Overall the gradient for this section is 14 %. The forest canopy is primarily coniferous comprised of Douglas-fir, western hemlock. Western redcedar provides 100 % canopy cover to the channel.

The Conifer Drive culvert is impassable due to drop at outlet into a well-defined ravine. The channel was dry downstream of culvert at time of survey.

4.6.2 East Smiling Creek at bike trail Crossing

This section of creek was surveyed on September 06/02. A 900 mm diameter corrugated steel pipe approximately 6 metres long, located 15 metres upstream of bike trail alignment (possibly put in for old logging road access) is present. The drop from the culvert to a pool inlet is approximately 0.45 metres. The outlet pool is approximately 0.25 metres deep. There is some standing water in this section and a very small amount of flow evident in the culvert. The inlet of the culvert is partially blocked due to settlement, causing flows to go subsurface into the culvert, and it also creates pooling of water upstream of the culvert.

Flow goes subsurface at the bike trail. This trail is located on an old log road/trestle bridge, which creates a barrier for fish migration. Here flows emerge from the rock at the bottom of the bridge structure. There is evidence of surface flows over the trail during higher flow events. The vegetation in this section is comprised of a primarily coniferous canopy; understorey species and includes vine maple, salmonberry, red huckleberry, sword fern, deer fern, lady fern, red elderberry and beaked hazelnut. The understorey provides 100 % overhanging cover to the channel and it contains good amounts of woody debris. The channel substrates are comprised of boulders, cobbles, gravels, and a large amount of sand.

The physical morphology has a wetted width at the time of survey was at 0.5 metres. The bankfull width is generally 1.5 to 2 metres (although in sections there was evidence of overland flow over a 8-10 metre wide area), and water depth was 0.1 to 0.15 metres. The banks are not well defined in this section of the channel and the channel gradient downstream of the bike trail is 14 %.

4.6.3 East Smiling Creek at Highland Drive

This section of creek was surveyed on November 21/02. North of Highland Drive the creek runs along property line. The west side is landscaped (lawn, ornamentals) and east side is woodland. Here the canopy is predominantly a coniferous forest (western redcedar, Douglas-fir, and western hemlock) with a smaller component of red alder and the shrub layer is comprised of salmonberry, salal, bracken fern, deer fern, sword fern, thimbleberry, and red huckleberry. The stream has a wetted width at the time of survey was 1.5 metres (same as bankfull width), water depth during the time of the survey (November 21), was 0.2-0.25 metres, bank height is 0.6 metres. The channel morphology is run interspersed with drop pools and substrates are comprised of boulders (20 %), cobbles (40 %), gravels (20 %) and fines (20 %). Overall the channel gradient upstream of Highland Drive is 16 %.

There is a 1,200 mm diameter concrete culvert complete with a concrete headwall conveying flows under Highland Drive. Downstream of Highland Drive the understorey provides 100 % cover on both sides of the channel (predominantly salmonberry); otherwise the creek is the same as upstream of Highland Drive. The canopy layer is well-developed on both sides of the creek downstream of Highland Drive, and is dominated by western hemlock with a channel morphology consisting of run between drops over large boulders

4.6.4 East Smiling Creek at Galloway Avenue

This section of creek was surveyed on November 21/02. Flows for East Smiling Creek at Galloway Avenue are conveyed under Galloway Avenue through a 1,400 mm diameter corrugated steel pipe culvert. There is a small drop (0.2 metres from culvert invert to water surface) at the outlet of the culvert, but it is not considered a barrier to fish passage. Here the wetted width at the time of the survey was 2.5 metres, water depth was 0.3 metres. The channel morphology is run/drop pool and the canopy layer downstream of Galloway Avenue is mixed with mature western redcedar, western hemlock, red alder, and black cottonwood. Upstream of Galloway Avenue it is characteristic of a disturbed site and is comprised of immature red alder with a dense understorey layer (salmonberry, Himalayan blackberry, and hardhack). Within the property north of Galloway Avenue, a weir is located on the channel with a pool upstream; definite barrier to fish passage. The upstream pool is filled with sands and small gravels and the height of the weir is 1 metre, with an additional drop of 2 metres over rip rap below the weir. Upstream of the property, the canopy layer becomes coniferous again (predominantly western hemlock).

4.6.5 East Smiling Creek at Gislason Avenue Alignment

This section of creek was surveyed on November 22/02. This section of channel is located within a ravine at this location and has a wetted width at the time of survey at 3.5 metres. The water depth was 0.15 to 0.2 metres, bankfull width is 5 metres and bank height is 0.6 metres. The general channel morphology is run/riffle/drop pool (drops are approximately 0.5 metres in height). Channel substrates are comprised of boulders (20 %), cobbles (40 %), gravels (20 %), and sands (20 %) and the canopy is mixed deciduous (red alder and broadleaf maple) and coniferous (western redcedar and western hemlock). The understorey is well-developed and provides good overhanging cover to the channel; species include salmonberry, sword fern, red huckleberry, bracken fern, licorice fern, vine maple and Himalayan blackberry. The floodplain within the ravine is approximately 15 metres wide and has a channel gradient is 13 %.

4.6.6 Confluence of Burke Mountain Creek and East Smiling Creek

This section of creek was surveyed on September 06/02. Immediately upstream of the confluence, Burke Mountain Creek, the flows enter a 1,200 mm diameter concrete pipe culvert approximately to 7 metres long that conveys flows underneath a private driveway. The culvert does not impede fish passage, but 12 metres upstream of the culvert there is a debris jam made up of large boulders that has a 1.2 metre high drop from the top of the boulders to the invert of the pool at the downstream end of the debris jam. Flows were evident in both Burke Mountain Creek and East Smiling Creek upstream of the confluence at the time of survey.

East Smiling Creek flows are also conveyed underneath the driveway in a 1,200 mm diameter concrete pipe culvert 7 metres long. Here both culverts have small pools at the outlet ends (0.3 to 0.4 metres deep) and the creeks are confluent 8 metres downstream of culverts. Erosion was noted at the outlet of the East Smiling Creek culvert and an existing concrete/boulder wall is being undermined, as is a large western redcedar growing adjacent to the wall.

4.6.7 Mainstem Smiling Creek Downstream of Confluence with Burke Mountain Creek

This section of creek was surveyed on September 06/02. The gradient of the channel is 10 % in this section and substrates comprised of cobbles and boulders. The channel structure is comprised of run habit with some drop pools. During the time of the survey the wetted width was 1.2 metres. The bankfull width is 5 metres, bank height is 0.3 to 0.5 metres.

The next creek crossing along another driveway (1255 Burke Mountain St.) has a pair of 900 mm diameter corrugated steel pipe culverts. They are 5 metres in length and the west culvert was partially blocked with gravels and all flows were being conveyed within the east culvert at the time of survey. Here salmonids were noted (furthest upstream visual confirmation of fish presence within Burke Mountain Creek and/or East Smiling Creek) in a pool at the culvert outlets.

There is considerable encroachment of buildings adjacent to creek noted downstream of twin culvert crossing and a section of the creek (approx. 20 metres long) has been channelized where vertical banks have been built with 400 mm diameter rock. In this section, the bankfull width is 2.2 metres, bank height is 1.1 metres, and wetted width at the time of survey was 0.5 metres, and water depth was 0.2 metres. Any flow went subsurface in the creek immediately upstream of Victoria Drive where the channel has an area of cobble substrate.

A small area that could potentially be used as spawning habitat (gravels) was noted within this section of the creek upstream of Victoria Drive. The area was 20 metres long and had a 5 % gradient. The crossing at Victoria Drive consists of a 1,200 mm x 2,400 mm box culvert which is 16 metres long with a 2 % grade. It contains baffles that have been added to the culvert. Three fish ladder boxes have been installed at the outlet. The entrance into the bottom of the fish ladder box may be impeded under low flow conditions. The vertical distance between the invert of the outlet pool and the invert of the notch is 0.65 metres; the pool was 0.15 metres deep at the time of survey.

4.6.8 Smiling Creek Mainstem at Lynwood Avenue Alignment

This section of creek was surveyed on November 22/02. Smiling Creek Mainstem at Lynwood Avenue Alignment has been identified as excellent spawning habitat. Spawners (coho salmon) were observed building a redd from the bridge.

The wetted width at the time of survey was 7 metres and the channel substrates were comprised of cobbles (30 %), gravels (40 %) and sands (30 %). A pedestrian bridge crossing is present at the Lynwood Avenue alignment. The Wedgewood Street tributary is confluent with the Mainstem approximately 20 metres downstream of pedestrian bridge.

4.6.9 Smiling Creek at the Confluence with Hyde Creek

This section of creek was surveyed on November 25/02. There are several mature red alders which have fallen into the two creeks at the confluence. In the future, they may form a large debris jam if not removed.

In this location the channel substrates are composed of peat with a limited amount of gravels and sands overlying the peat. The channel is very incised into the peat/organic material on the banks and as a result the wetted width at the time of survey was 1 to 2 metres. The water depth was 0.3 to 0.5 metres, bankfull width is 5 metres and bank height is 1.5 metres.

There are several channel morphology drops within this section of the creek (0.3-0.6 metres in height). They may be barriers to fish passage during low flow and/or limit juvenile passage upstream. Upstream of the upstream most debris jam (approximately 150 metres downstream of Lynwood Ave. alignment) contains substrates that change to pea gravels and sands. Further, there many small feeder channels in this area. All have been noted adjacent to areas that are marshy. From the upstream most debris jam north there is good spawning habitat and the channel gradient here is 1.5 %.

Immediately downstream of Lynwood Ave. alignment the wetted width at time of survey was 4.5 metres. The water depth was 0.05-0.1 metre, bank height is 0.5 metres, and bankfull width is 7-8 metres. In this area the channel substrates are comprised of large and small gravels (80 %) and sands (20 %).

4.7 Burke Mountain Creek

4.7.1 Headwaters of Burke Mountain Creek

This section of creek was surveyed on September 06/02. There is a 600 mm diameter corrugated steel pipe culvert at a trail crossing which is 4metres long and slightly perched at its outlet. Here the creek substrates are composed of boulders, cobbles, gravels and sands. No flows or standing water was observed at time of survey but a numerous amount of woody debris was observed instream indicating that flows are present throughout the year. The overstream cover was approximately 90 to 100 %.

The canopy for the stream is a mainly deciduous assemblage comprised mainly of red alder and broadleaf maple with some western hemlock and western redcedar. The shrub layer is dominated by salmonberry. Other species present include red elderberry, sword fern, beaked hazelnut, vine maple, thimbleberry, red huckleberry, oval-leaved blueberry, and salal, trailing blackberry, deer fern, lady fern and goat's beard. The groundcover includes dominant Pacific bleeding heart. In this section of the stream the gradient is steep at 31% downstream of the trail. Channel width at the invert is 0.5 to 1 metre and the bankfull width is 1.5 metres. Bank height is 0.5 to 1 metre; banks are fairly vertical. The creek is not located within a ravine in this section and the channel exhibits many debris drops, and is incised to a depth of 1 metre (to top of bank) in some places.

4.7.2 Burke Mountain Creek at Bike Trail Crossing

This section of creek was surveyed on November 22/02. Upstream of bike trail no water was evident during the field work. The vegetation is comprised of a primarily deciduous canopy (red alder and broadleaf maple) and the understorey species include Devil's club, salmonberry, vine maple, red elderberry, red huckleberry, salal, regenerating western hemlock, sword fern, deer fern, lady fern, youth-on-age, and foamflower. Here the channel substrates are comprised of boulders, cobbles, gravels and some sands and the bankfull width is approximately 2 metres and bank height is 1 metre. The channel gradient is 13 %.

4.7.3 Burke Mountain Creek Downstream of the Hydro Right-of-Way

This section of creek was surveyed on September 06/02. Only standing water observed within the channel through the Hydro Right-of-Way (ROW). Downstream of the ROW, the channel is confined within a ravine, which commences as a depression within the south portion of the ROW. Here the wetted width at the time of survey was approximately 0.3 metres, bankfull width of channel is approximately 2 metres; channel substrates are comprised of boulders and cobbles. The channel exhibits a drop pool structure within this section and a large amount of woody debris provides instream cover. The overhanging cover is provided by the shrub layer which is composed of 100 % cover of salmonberry. Shrub species include red huckleberry, beaked hazelnut, salmonberry, Indian-plum, lady fern, deer fern, and trailing blackberry and the canopy layer is mixed and immature, comprised of red alder primarily with a smaller component of western redcedar and western hemlock. The east ravine bank has a steep slope (approximately 1.5H: 1V) and the west ravine bank has a more gradual slope.

Yard waste dumping at the top of ravine bank from adjacent property owners was noted within this section of the creek.

4.8 Cedar Creek

4.8.1 Cedar Creek at Coast Meridian Pipe

This section of Cedar Creek was surveyed on November 22/02. Channel substrates are primarily composed of cobbles (10%), gravels (10%), and sands/fines 80%. During the time of survey the wetted and bankfull widths were both measured at 3.5 metres. The water depth was 0.5-0.4 metres with a bankfull height of 0.5 metres (top-of-bank was 1.2-2.0 metres high). Throughout the section, the stream morphology can be characterized as a run/riffle. The riparian vegetation is limited to a single row of trees/shrubs on either side of the stream which provides variable overhanging cover from 20-100 % in sections. Dominant tree species of riparian vegetation include western redcedar, western hemlock, and black cottonwood. The shrub understorey species include salmonberry, red elderberry, beaked hazelnut, Himalayan blackberry, hardhack, Japanese knotweed, laurel, and Douglas maple.

There is limited spawning habitat for potential spawners, but chum salmon were observed in this location in the fall but due to the dry weather and the lack of flows in Hyde Creek mainstem; the lack of gravels would prohibit a large number of redds being built; also the gravels present appear fairly cemented with fines/sediments. On the north side of the channel, there is a thin strip of riparian vegetation (1-2 metres wide) along residential yards.

Further downstream the channel grade decreases, and the channel morphology becomes a run, the water depth increases limiting the opportunity for salmonid spawning (approximately 300 meters downstream of culverts). The channel substrates also change downstream of this point, to 100% fines and decaying vegetation. There is very little channel complexity and limited to non existent CWD.

4.8.2 Cedar Creek Upstream of Confluence with Hyde Creek

This section of Cedar Creek was surveyed on November 25/02. Along Cedar Drive the riparian vegetation is very limited on the road edge (top half is mowed grass, bottom half of the bank has limited reed canary grass, hardhack and Himalayan blackberry, salmonberry and various ornamental trees and shrub). There are several bridge crossings of the creek along this section for driveway and road access. During the survey the wetted width was 4.0 metres, the water depth was 0.3-0.5 meters, bankfull width was 6.0 metres and the bank height was 3-4.0 metres. Overall through this section the channel morphology is run and the substrates are primarily composed of fines and decaying vegetation.

4.9 Deboville Slough

4.9.1 Downstream of the Confluence of Hyde Creek and Cedar Creek

An initial survey of Deboville Slough was conducted on November 25, 2002 and once again for its entire length to the Pitt River outflow on November 04, 2003. This section is located at the outflow of Cedar Creek and accepts flows from all of the drainages of the study area as well as Partington Creek to the east of the study boundary. It is channelized in this section and has a road on both sides which lack vegetation. Some planting has been conducted, but most of the trees are still very small and being out competed by reed canary grass, which is dominant. Other prevalent riparian species include dense mats of Himalayan blackberry and hardhack.

During the November 25th, 2002 survey the wetted width was 5-7 metres and the water depth on average throughout the section was 5.0-7.0 metre. The water depth was variable from 0.3 to 0.5 metres with a bankfull width of 10.0 metres. There is limited bank complexity throughout this section except for a few boulder clusters. The substrates are composed of small gravels and fines plus boulders (5%). The overall channel morphology is run. Some bank protection has been installed at the toe-of-slope (i.e. boulders) to protect bank slumping. There is limited water cover as well as complexity of the channel (10% from overhanging vegetation).

4.9.2 Downstream of Cedar Drive along the Dyke Trail to the Pitt River

This section of the Slough was surveyed on November 04, 2003. During the visit two adult chum spawners were observed in small pools for the first 100 metres downstream of Cedar Drive. The overall stream morphology in this section is riffle/run. Several small pools are associated with the habitat and are no more than 1 metre deep. The average substrate throughout is composed of fines (80%) and gravels (15%) with 5% boulders. The wetted width during the survey was observed to be approximately 6.0 metres on average and the bank height was approximately 3.4 metres. The riparian habitat is dominated by reed canary grass and in sections dense Japanese knotweed with Himalayan blackberry thickets persist, there is also limited riparian water cover.

After the first 200 metres of habitat downstream of Cedar Drive, the instream habitat becomes dominated by fines, primarily from tidal influence. Some sections have exposed sand bars with absent vegetation. There is limited tree cover for the slough with riparian edges being dominated by reed canary grass, Himalayan blackberry and hardhack, sometimes in impenetrable groups. The entire section of the Slough has a limited CWD complexity and instream cover. A number of locations along the first kilometer of the Slough's outflow from Cedar Drive experiences erosion, mostly due to trail access to the shoreline by people.

5.0 AREAS OF ENVIRONMENTAL SENSITIVITY

Historic and current development within the Hyde Creek watershed (primarily associated with the lower and middle reaches), have impacted salmonid habitat through changes in water quality, water quantity, riparian and instream cover, stream habitat diversity, increased erosion and creation of barriers to fish migration. Areas of special concern within the watershed include critical fish habitat (i.e. spawning and rearing and riparian habitat).

5.1 Fish Habitat

Sixteen important areas of the Hyde Creek watershed have been identified as spawning and rearing habitat for salmonids. These are been listed below and identified in Figure 3.

1. **Hyde Creek Mainstem Downstream of Coy Avenue -** Short sections of the channel are suitably graded for spawning and include sites where gravels have built up behind major debris jams;

2. **Hyde Creek Mainstem Upstream of Tributary 4 -** Spawners were noted upstream of the confluence although this section of the Mainstem is not be characterized as typical spawning habitat because substrates were comprised primarily of boulders and large cobbles. The channel gradient is 4 %. Spawners (coho salmon) were observed upstream of confluence with Hyde Creek Mainstem Tributary 2;

3. **Hyde Creek Mainstem to Highland Drive Alignment -** Potential spawning habitat is present within this section of the creek;

4. **Hyde Creek Mainstem Between David and Mason Avenue -** Many juvenile salmonids were noted throughout this section in pools and in areas with undercut banks. There is potential spawning habitat within this section of the creek;

5. **Hyde Creek Mainstem Victoria Drive Right-of-Way -** This section of Hyde Creek contains potential spawning habitat. The creek no longer is confined within a ravine but open. Channel substrates throughout this reach area consist of boulders, cobbles, gravels and sands and the channel gradient is 2.5%.

6. **Hyde Creek Mainstem Between Lincoln Avenue and Coast Meridian Road -** Over 20 dead spawners (chum salmon) were noted within this section of the creek during the survey (November 25). This shows that it is an important section for spawning. Additionally,

several redds were observed throughout this section;

7. **Hyde Creek between Coast Meridian Road and confluence with Cedar Creek -** There is very good spawning habitat in Hyde Creek from Coast Meridian Road to the confluence with Cedar Creek in this section. The substrates are comprised of boulders (5 %), cobbles (5 %), gravels (65 %) and sands (25 %) and the channel morphology is run/riffle;

8. **Unnamed Tributary to Smiling Creek from Wedgewood St. -** One dead spawned out female coho salmon (and 1 dead male coho) was found and the channel exhibits good rearing/off-channel habitat for juvenile salmonids, and good spawning habitat;

9. **Watkins Creek Downstream of Coast Meridian Road -** There appeared to be good spawning habitat in the section of creek between Coast Meridian Road and Roxton Avenue and the channel morphology here is run/riffle/drop pool. Many spawners (coho salmon) were observed immediately downstream of the Roxton Avenue culvert. Downstream of Roxton Avenue, there is spawning habitat potential until a 40 metre section of channel upstream of next culvert. It is lined with rip rap. Downstream of this culvert substrates are composed of gravels and cobbles and from here to Victoria Drive is all potential spawning habitat;

10. **Watkins Creek at Confluence with Hyde Creek -** During the survey (November 25), spawners (chum salmon) were noted within Watkins upstream of confluence. Here the channel morphology is run/riffle/drop pool structure and the channel substrates are comprised of gravels (70 %) and fines (30%);

11. **East Watkins Creek Upstream of the Confluence with Watkins Creek Mainstem -** Located at the driveway culvert at 1288 Coast Meridian Road. The substrates instream are dominated by gravels. It is a good channel section for salmonid spawning;

12. **Smiling Creek Upstream of Victoria Drive -** Spawning coho salmon were observed in the outlet pool and the downstream of the pool in during the November field visit. It was observed that there is good spawning habitat downstream of site to the confluence with the Mainstem Smiling Creek. The channel substrates are comprised of boulders (10%), cobbles (30 %), gravels (40 %) and sands (20 %);

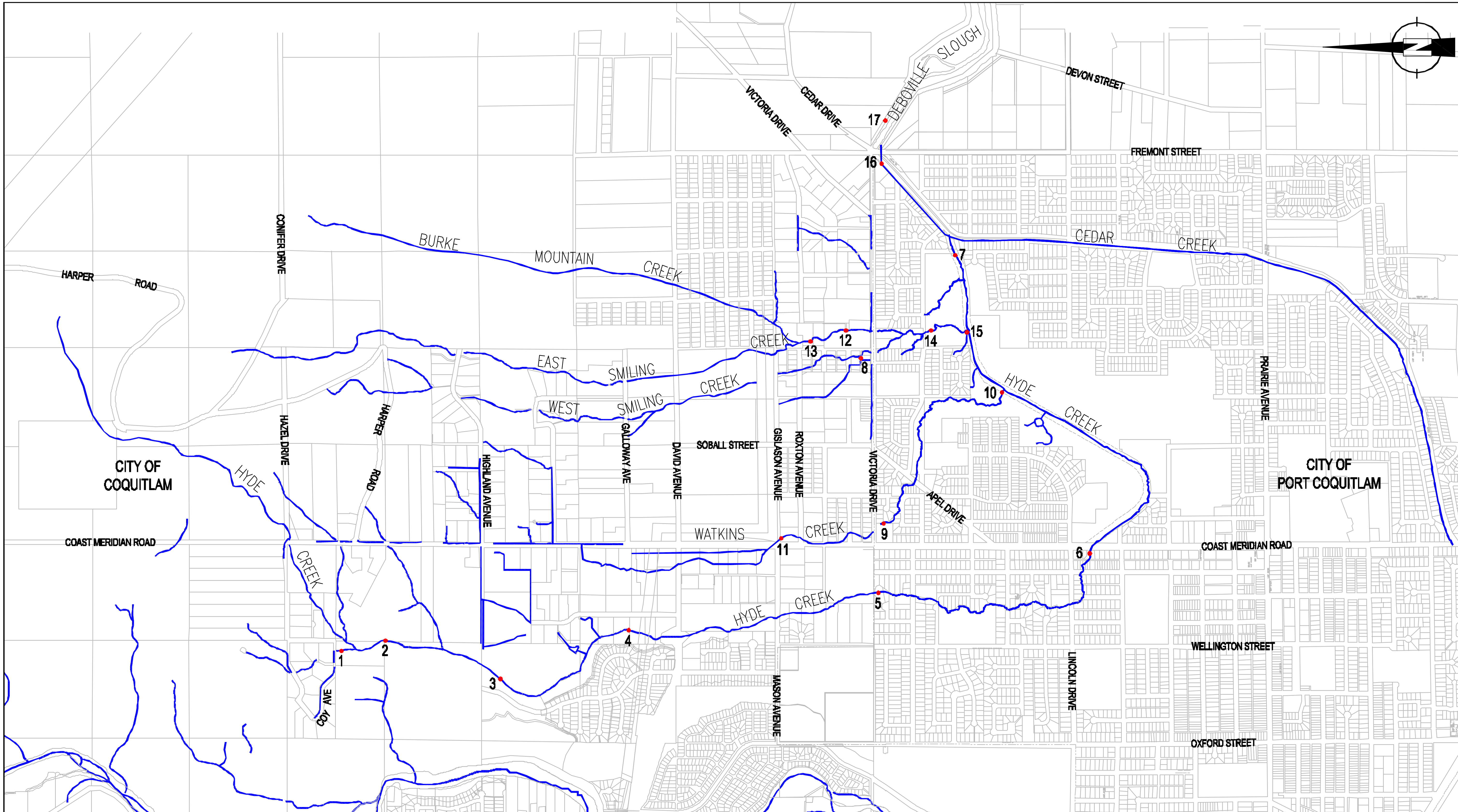
13. **Mainstem Smiling Creek Downstream of Confluence with Burke Mountain Creek -** A small area that could potentially be used as spawning habitat (gravels) was noted within this section of the creek upstream of Victoria Drive. The area was 20 metres long and had a 5 % gradient;

14. **East Smiling Creek Mainstem at Lynwood Avenue Alignment -** Smiling Creek Mainstem at Lynwood Avenue Alignment has been identified as excellent spawning habitat. Spawners (coho salmon) were observed building a redd from the bridge; and

15. **Smiling Creek at the Confluence with Hyde Creek -** From the upstream most debris jam north there is good spawning habitat and the channel gradient here is 1.5 %; and

16. **Cedar Creek at Coast Meridian Pipe -** Limited spawning habitat, but chum salmon were observed in this location. Gravels present appear fairly cemented with fines/sediments. Juvenile salmonids were observed within the channel during the November 22/02 survey.

Figure 3 Identified Spawning Locations



• 1 Identified Spawning Locations

Watercourse

CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

HYDE CREEK WATERSHED
IDENTIFIED SPAWNING LOCATIONS

DESIGN: LM	DRAWN: SDJ	CHECKED:	REVISION: 01	REVISION DATE: April 16, 2004
SCALE: 1:15000			DRAWING NUMBER:	
DATE: February 16, 2004			FIGURE 3	

6.0 WILDLIFE

Information collected from the surveys performed throughout the Hyde Creek watershed study area by Envirowest did not focus on wildlife, but information on wildlife was collected from existing reports. All sightings collected by Envirowest for this report were recorded as incidental. Significant wildlife sightings recorded from historical reports is presented in Section 3.0.

As part of any land use concept plan, in order to plan for environmental sustainability, to retain and enhance environmental wildlife attributes and ecological features for wildlife in landscapes it is necessary to have an understanding of the current habitats and their capability to sustain the species. A broad biophysical analysis approach to land use planning is the first logical step to identifying areas of high, moderate and low biological significance. Owing to the lack of detailed data on the wildlife presence in the Hyde Creek watershed assessment of wildlife habitat for species at the neighborhood stage of planning should include studies that follow provincial standard methodologies. Any wildlife studies in the Hyde Creek Watershed should be conducted as much as possible according to the following documents:

- Species Inventory Fundamentals Standards for Components of British Columbia's Biodiversity No.1 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (November, 1998), (Version 2.0);
- Inventory Methods for Marsh Birds: Bitterns and Rails Standards for Components of British Columbia's Biodiversity No. 7 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (October 7, 1998), (Version 2.0);
- Resource Inventory Standards Committee, Wildlife Branch. 2001. Standard Inventory Methodologies for Components of British Columbia's Biodiversity: Raptors (Version 1.1);
- Inventory Methods for Forest and Grassland Songbirds Standards for Components of British Columbia's Biodiversity No. 15 Prepared for: Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (March 16, 1999), (Version 2.0);
- Inventory Methods for Waterfowl and Allied Species: Loons, Grebes, Swans, Geese, Ducks, American Coot and Sandhill Crane Standards for Components of British Columbia's Biodiversity No.18 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystem Task Force Resources Inventory Standards Committee (May 11, 1999), (Version 2.0);
- Inventory Methods for Woodpeckers Standards for Components of British Columbia's Biodiversity No. 19 Prepared by: Ministry of Environment Lands, and Parks for the Terrestrial Ecosystem Task Force Resources Inventory Standards Committee (September 14, 1999), (Version 2.0);
- Inventory Methods for Bats Standards for Components of British Columbia's Biodiversity No. 20 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch

for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (February 1998) (Version 2.0);

- Inventory Methods for Beaver and Muskrat Standards for Components of British Columbia's Biodiversity No.22 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (December 4, 1998), (Version 2.0);
- Inventory Methods for Small Mammals: Shrews, Voles, Mice & Rats Standards for Components of British Columbia's Biodiversity No. 31 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (May 6, 1998), (Version 2.0);
- Ground-based Inventory Methods for Selected Ungulates: Moose, Elk and Deer Standards for Components of British Columbia's Biodiversity No. 33 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (October 6, 1998), (Version 2.0);
- Inventory Methods for Plethodontid Salamanders Standards for Components of British Columbia's Biodiversity No. 36 Prepared for: Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee (March 1, 1999), (Version 2.0);
- Inventory Methods for Pond-breeding Amphibians and Painted Turtle Standards for Components of British Columbia's Biodiversity No. 37 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (March 13 1998), (Version: 2.0);
- Inventory Methods for Snakes Standards for Components of British Columbia's Biodiversity No. 38 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (March 12, 1998), (Version 2.0); and
- Inventory Methods for Tailed Frog and Pacific Giant Salamander Standards for Components of British Columbia's Biodiversity No. 39 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Standards Committee (March 13, 2000), (Version 2).

An evaluation of habitats, species presence non-detection and the sites significance (i.e. capability) to sustain specific wildlife species should be performed using the British Columbia Wildlife Habitat Rating Standards (RISC 1999). Further, an assessment of a neighborhood's capability to sustain specific species should be performed using the rating standards in a "plot-in-context[6]" analysis.

The following section identifies important habitat areas for each family group of wildlife in the Hyde Creek Watershed Study Area and recommends strategies for developmental planning in all of the associated creek areas of the Hyde Creek Watershed Study Area.

---

[6] A study sites biophysical features importance to fish and wildlife based on surrounding habitats, its use and accessibility as well as influences and overall physical location.

Development associated impacts may be divided into construction and post construction related. Both have associated impacts to wildlife and the success of species survival. Based on the information collected to date, concerns that should be addressed during any proposed development scenario are presented below. Any planning should assess how the proposed development will impact wildlife populations in the Hyde, Smiling, Watkins, and Burke Mountain Creek watersheds.

6.1 Construction Impacts

Any planning and construction for the Hyde Creek watershed study site will result in two major impacts on wildlife; noise and fugitive dust. Heavy machinery and earth moving equipment during any construction processes of both roads and free-standing developments may generate high noise levels. Grading the earth releases tremendous amounts of dust into the atmosphere which can alter the nesting and breeding of some birds (Adams 1994).

Earthmovers and other heavy construction equipment can generate high noise levels. Noise levels may be particularly acute during the grading stages of construction and these noises may interfere with animal communication and detection of predators (*ibid.*). If the construction is performed during the breeding season mating calls may be lost or obscured by the intervening noises.

Fugitive dust, a threat unique to construction, may have noticeable repercussions for plants and nesting birds (i*bid.*). Hydroseeding which is commonly used during winter and spring construction projects to prevent soil erosion is a common practice during development activities. If not performed correctly, hydroseeding can be a threat if invasive, exotic species are used and exotic species could result in severe infestations of exotics such as *Brassica* (Black mustard) and reed canary grass (*Phalaris arundinacae*) which is an invasive grass species that does well in these harsh conditions (Alex undated). This grass grows so fast and so thick that it crowds out the native wetland grasses, rushes and sedges. The result is a less diverse plant system which alters the natural functioning of the ecosystem; it disrupts the use of the wetland areas by birds and amphibians and also changes the food source for birds and benthic species. For hydroseeding during land clearing activities, care should be taken to use grasses, annuals, and perennials indigenous to the area and to use local seed stock. Consultation with MWLAP would be helpful in determining an appropriate seed mix for each location.

Site clearing during the bird breeding season, which is typically March through August in Vancouver Lower Mainland (Campbell *et al.* 1990), could result in potential nest abandonment or loss of habitat for birds actively engaged in incubation/rearing; a violation to Section 34 of the provincial *"Wildlife Act"*. In addition, noise generated during site-preparation activities such as falling, chipping, blasting and grading can disrupt breeding birds at some distance from the actual clearing area and cause other wildlife to avoid the area. Resulting short-term abandonment of nests can cause increased nest predation and also lower the temperature of nest contents to dangerously low levels causing natal mortality (Miller and Hobbs 2000).

Few animals meet all their life requirements within a single location (Riley and Mohr 1994). Most move across the landscape in search of food, mates and favorable microclimates (*ibid.*). Construction clearing activities can interrupt travel/hiding cover and require wildlife to adjust their movement and dispersal patterns (USDA 1979). This, in turn, can result in increased risk of predation and/or failure to access critically important habitats (Riley and Mohr 1994). Construction activities can also cause species (e.g., deer and mink) with diurnal/crepuscular activity patterns to become more nocturnal (Adams 1994).

Habitat fragmentation impacts are closely linked to impacts on wildlife movement patterns as described above (Riley and Mohr 1994). Habitat fragmentation relates primarily to smaller wildlife with limited dispersal ability (Riley and Mohr 1994, Kolozsvary and Swihart 1999). Some amphibians typically perceive roads as significant barriers to movement due to their absence of cover and, in some cases, their hostile microclimate (Rodreguez *et al.* 1996, Kolozsvary and Swihart 1999). Fragmentation of the forest without corridors may result in creation of isolated sub-populations, which are more susceptible to extirpation in the face of changing conditions (Riley and Mohr 1994). Apart from potential road impacts, species groups such as pond-breeding amphibians (i.e. red-legged frog and the rough-skinned newt) can be impacted if their breeding areas become isolated from the moist upland forests, which are required during periods outside of their breeding season (Kolozsvary and Swihart 1999). In addition, lowered soil moisture along the exposed edges of leave strips can render leave areas inhospitable to amphibians, particularly terrestrial salamanders, which require moist skins to respire (Welsh, and Droege. 2001). Additionally, houses and buildings may serve as extensive "rocks" and may affect micro-climate conditions for amphibians and small mammals (Adams 1994).

Urban development characteristically, fragments natural areas and destroys native vegetation (Riley and Mohr 1994). This generally benefits habitat generalists (e.g. brown-headed cowbird, house sparrow and European starling) at the expense of species specialists (Townsend's, black-throated grey and yellow warblers) (*ibid.*). Non-native animals, such as pigeons, starlings, house sparrows, raccoons may increase as native species decrease if care is not taken. Within the native populations of wildlife, diversity could decline but total numbers will not. These types of a population trends indicate that certain species will be favored, but others will be harmed by the urbanization of the area (Adams, 1994).

Sediment-laden stormwater can reduce water quality in wetlands and vernal ponds occurring in the watersheds (Hammer 1989). Excessive sedimentation has the potential to suffocate amphibian egg masses and make foraging difficult for aquatic and semi-aquatic wildlife (Licht 1970), which rely on visual cues to capture prey (e.g. mink) (Maser 1998).

Changes in site hydrology are inherent to development (Hammer 1989). Rooftops, streets, concrete pavement and other impervious surfaces decrease water infiltration and increase storm-water runoff (Goldman *et al.* 1986). Storm-water runoff in urbanized areas is typically polluted due to organic and non-organic particulate matter being washed from houses, cars, and streets (Stevens *et al.* 2002). Other sources of pollution include fertilizer and pesticide treated landscaping (*ibid.*). The affects of changing runoff patterns include decreasing water availability to some animals (Adams, 1994).

During any construction period, road dust may be considered a concern (Adams 1994). Paved and dirt road dust is comprised of organic and inorganic matter. The most common constituents include brake lining wear particles, oil residues, tire wear particles, automobile exhaust, weathered street particles, dust from the side of the road, and organic material which may have settled on the road. Wind produced by natural forces and fast-moving cars constantly disperses the particles through the air but the effects of road dust depend on the composition of the particles (Adams 1994). The result of excessive dust is that it can change the pH of leaf surfaces, chemically react with the plant, and alter soil composition, effects which can be toxic to plant life (USDA 1979).

Regrading of land during construction also poses a large problem to wildlife populations due to runoff. Any development in the watersheds has the potential to affect water quality in a variety of ways. Potential effects of water quality as a result of any development under a low-density development scenario, if left unmitigated could cause problems which result in impacts to aquatic areas such as

- Increased sediment loadings to stream and forest areas;
- Potential spills of construction materials;
- Discharge of oils or other contaminants in stormwater runoff from the construction site; and
- Discharge of fertilizers or pesticides in runoff from the residential areas.

Land clearing in the study area will likely involve Workers' Compensation Board regulations regarding hazardous trees within work zones and end result residential communities. This may result in the removal of "veteran trees" and large diameter snags, which would otherwise perform valuable ecological functions as perches, feeding sites, roosts and nests. These, when at all possible, should be assessed and reviewed for their ecological significance to the site prior to any land clearing in any of the watersheds. Further, accidental fill placement in leave strips around these tree trunks can smother the root systems and cause extensive damage to trees that are to be retained during any land clearing activity. This can occur when as little as 10 cm of fill is piled around a tree trunk (Prichett 1979). Also, excavator work near leave areas can sever the roots of trees to be retained. These impacts can result in the removal of a tree due to its potential safety hazard (*ibid.*).

With respect to upland habitat impacts, few mitigative options are ultimately as effective as retention and protection. This method is to be adhered to as much as possible when associated with important identified wildlife areas. Habitat types meriting additional protection during any planning phases should include the riparian areas and edge shrub habitat of all watersheds. Impacts to these habitats can be reduced somewhat through reclamation of areas to be cleared.

6.2 Post-Construction Impacts

Post construction, it is inevitable that people will use the immediate areas surrounding any development. The most important impacts associated with development in the watersheds are by the creation of trails for walking and biking (Lynn and Brown 2002). The following are impacts associated with any development should be taken into consideration in all the watersheds associated with the study area but should primarily focus on the headwaters of any watercourse.

When people and their pets use the adjacent forest habitat (protected areas), they produce noise disturbance that is harmful to some animal species (*ibid.*). Human and pet presence, and especially voices, adversely affects certain birds (Adams 1994, Lynn and Brown 2002). Voices and noise may alter behavior and may even cause species to desert their nests with close approaches by people; loud voices or sustained conversation will elicit similar responses (Miller and Hobbs 2000). Dogs that bark and disturb areas close to, or at, nesting sites are also harmful to birds (*ibid.*). In subdivisions, dogs often bark relentlessly, regularly contributing to noise disturbance. Further, the impact of human voices on bird species in the area can be expected to be similarly deleterious to some species (*ibid.*). Planning in areas where higher diversity of bird species are located as well as areas around raptor nests should be taken into consideration during planning.

Human use of the surrounding forest and plantings around dwellings can result in the introduction of non-indigenous (invasive-exotic) species (Adams 1994). Some of these "exotics" have significant biological impacts on natural areas. Successful introductions of Scotch broom (*Cytisus scoparius*) and Himalayan blackberry, have in many areas displaced native plants and animals, and disrupted the ecosystem (Cole 1978, Dale and Weaver 1974). Indirect effects of exotics may include the introduction of pathogens not familiar to indigenous species (*ibid.*).

Although the design speed of roads is likely to be fairly low in residential areas throughout the Hyde Creek study area, there is a significant potential for traffic-related wildlife mortality where road networks intersect wildlife movement corridors (Adams 1994). In addition to deer and Eastern cottontail rabbits, several species of small wildlife are also susceptible to traffic-related mortality (Meunier *et al.* 1999). For example, amphibians such as rough-skinned newts may undergo mass migrations to and from breeding ponds, which can result in significant mortality from road traffic (Adams 1994). Reptiles (e.g. common garter snake) can also be vulnerable to traffic-caused mortality as they are frequently attracted to rocks and areas like roads as basking sites (Gregory and Campbell. 1996). Areas of significant wildlife habitat in relation to any proposed development should assess where these “important areas” are.

Road runoff containing hydrocarbons and other deleterious substances can impact water quality for wetland-dependent wildlife (Adams 1994). Runoff containing fertilizers can result in notification of wetland habitats, which can result in algal blooms (Hammer 1989). This, in turn, can affect aquatic species by lowering oxygen levels in the water (*ibid.*). Introduction of pesticides (insecticides, fungicides, herbicides) into watercourses can result in mortalities to aquatic invertebrate, amphibian and aquatic plant communities.

Indigenous insectivorous bats that currently use the area such as the common little brown bat (*Myotis lucifugus*) and the big brown bat (*Eptesicus fuscus*) are of concern because they use urban lighting to catch insects, which may affect the food supply of insectivorous birds (*Empidonax* spp. flycatchers). Bats using houses to nest and roost in are generally not tolerated by homeowners and may be exterminated (Adams 1994).

Household pets, primarily cats and dogs, pose a danger to birds and small animals. The impact of domestic cats on small mammal populations has been discussed in some detail in Galindo-Leal and Runciman (1994). Cats are a significant predatory influence on birds and small mammals (Ehrlich *et al.* 1988). Dogs harass birds and small mammals by chasing them and barking and ones roaming at large are capable of injuring or killing wildlife as large deer (Adams 1994). They may harass indigenous fauna that continue to frequent the less developed parts of the site (*ibid.*).

Pet feces if not controlled may degrade the area and also act as a source of exotic seeds (Adams 1994). Another possible consequence of feces introduction into the natural areas, if the quantity is large enough, is the introduction of additional nutrients to the soil (USDA 1979). In nutrient-poor soils, the alteration of nutrient levels causes a disturbance that may facilitate the introduction of exotics and contribute to the reduction of species richness (Hobbs and Huenneke 1992). Often, grasses, which displace indigenous vegetation, dominate under these circumstances (Hammer 1989, 1992).

Urban developments can increase competition for remaining nest cavities between native birds and more aggressive introduced species (e.g., starlings and house sparrows) (Ehrlich *et al.*1988). In rural areas, some cavity nesters such as flickers, nuthatches and hairy woodpeckers appear to persist in the face of heavy competition for nest cavities with starlings. However, since cavities are often a limiting habitat feature in urban settings, there is still potential for impacts to native birds (Ehrlich *et al.*1988, Adams 1994).

House sparrows, and European starlings are foreign that thrive on the urban/natural space interface (Adams 1994, USDA 1979). In particular, starling species have been observed to nest on light posts (Ehrlich *et al.* 1988). Starlings are insectivores (*ibid.*)and may be decreasing both the food supply for native insectivores, as well as, affecting populations of pollinating insects.

Depending on their orientation and composition, retention of narrow, linear forest strips increases the likelihood of their disturbance by winter storm events (Pritchett 1979). While wind thrown trees may affect some habitat values within a leave-strip, they may also be considered beneficial in introducing a more complex habitat (DeGraaf and Shigo 1985).

Although several of the watersheds currently have passive existing trail systems in place and hikers and cyclists frequent them, this has resulted in a certain degree of habituation to human activity (Miller and Hobbs 2000). Increased human presence via greater development may cause some species to become more nocturnal or abandon the site altogether (Maser 1998). Trail networks encircling wetlands would result in considerably more wildlife disturbance than those that lead to a few well-chosen viewpoints (USDA 1979). These impacts should be addressed during any site level planning to protect wildlife.

Roadside litter can also pose another risk to the animals (Marin County 2003). With any development of housing and associated road network, animal habitat will be exposed to a wide array of human garbage. Items which pose a particular threat include cigarette butts, which can be mistaken for food and eaten, gum, plastics, and food wrappers that opportunist animals may find attractive. These items are not part of a healthy animal diet and plastics interfere with digestive processes. Raccoon, red squirrel, and scavenging birds will suffer the most from human garbage if it is not kept in control (City of Boulder, Colorado Parks Dept. 2003, Australian Marine Safety Authority, City of Boulder 2003, Montana Fish and Wildlife 2003). Plans to address these concerns should be addressed as well.

6.3 Watershed Wildlife Planning Recommendations

6.3.1 Amphibians

During field surveys the red-legged frog was observed at two localities on Hyde Creek, once along the Mainstem of Hyde Creek at Highland Drive on September 12 and again at Tributary 4 to Hyde Creek on November 21. A total of four coastal tailed frogs (*Ascaphus truei*), were collected along the Mainstem of Hyde Creek upstream of Harper Road on October 15.

For all the watercourses in the Hyde Creek watershed study area, the most important habitats for amphibians include the mature forest blocks associated with riparian zones, especially when they occur in areas with pools and stream margins for a recommended distance of 60 metres surrounding the streams. Any development proposed in the study site should be sensitive to frog breeding habitat (i.e. tailed frog, red-legged frog) and reduce or eliminate sediment and sediment accumulation to streams identified essential for amphibian breeding.

Riparian areas of East and West Smiling creeks and the headwaters of Burke Mountain and Hyde creeks are likely the best habitats for amphibians. These areas are associated with coarse woody debris and wet vernal pools important for rearing, protection and shelter during dispersal of adults. Maintaining corridors linking these areas for amphibian travel is important to maintaining populations for red-legged and coastal tailed frogs. Habitat fragmentation impacts are closely linked to impacts on wildlife movement patterns. Fragmentation of the forest areas without maintaining corridors may result in creation of isolated sub-populations, which are more susceptible to extirpation in the face of changing conditions. Species groups such as the red-legged frog and the adult coastal tailed frog can be impacted if their breeding areas become isolated from the moist upland forests, which are required during periods outside of their breeding season. Riparian areas along all the creeks provide necessary soil moisture, shelter and the foraging potential for the adults. If fragmented the exposed edges can render the riparian areas inhospitable to amphibians, particularly terrestrial salamanders, which require moist skins to respire. The loss of the important extensive riparian corridors may affect micro-climate conditions for amphibians.

The blue-listed coastal tailed frog spends its life cycle in clear water with boulder cluster cascades adjacent riparian areas. Boulder and pool habitat suitable for this frog is most present in the upper portions of Burke Mountain and Hyde creeks. Based on the life cycle of both of these species (coastal tailed-frog and the red-legged frog), it is recommended that best management practices of stream setbacks from the defined top-of-bank be implemented for any watercourse where these frogs have been identified according to the following criteria as identified in the Best Management Practices (BMPs), to Protect Water Quality[7]. The following BMPs are provided only as guidelines for establishing appropriate setback widths. Local conditions and requirements may dictate otherwise:

- New homes should have a 35 m setback from a stream.
- Lawns should have a 15 m setback from a stream.
- Septic systems should have a 15 m setback from a stream.
- New roads should have 35 m setback from a stream.
- Paved parking areas should have 15 m setback from a stream.

Additionally, the following general recommendations should be taken into consideration and implemented where possible during watershed planning to reduce potential impacts to all amphibians. They are as follows, where possible:

a) Maintain minimal setback buffers identified in the BMPs around the Mainstem of all central watercourses (Hyde, Smiling and Burke Mountain Creeks), and restrict any access to these habitats via fencing. Where vernal ponds are associated with the mainstems they should be protected because these areas likely contain key natal habitats for red-legged frogs and other amphibians such as salamanders. They have the following important life characteristics:
    1) Year round water flow and course woody debris;
    2) Stable channel beds;
    3) Coarse rocky substrates; and
    4) Winter forest cover hibernating areas.

b) Where possible, land development should be conducted to promote the current secondary or old growth forest characteristics such as the retention of large diameter trees, multi layered canopies, snags and coarse woody debris in all vegetative communities in and adjacent to the proposed development;

c) For tailed frogs, changes in timing, frequency, and duration of high and low flows may affect their survival (Stillwater Sciences 2001). Flushing flows are important because

[7] http://wlapwww.gov.bc.ca/wat/wq/nps/BMP_Compendium/General/Aquatic_Habitat/Management1.htm

they remove sediment and maintain interstitial spaces between rocks and gravels, thereby providing both diurnal cover for larvae and adults, and egg-laying substrate. However, exceptionally high spring runoff levels may cause high larval mortality (Daugherty and Sheldon 1982). Hydrologic regimes are particularly critical to tailed frogs in late summer and early fall, when egg-laying occurs and when stream temperatures are most likely to reach levels harmful to this species. Increases in water temperature (e.g., due to timber harvesting) may increase mortality and reduce distribution of *A. truei* (Hayes 1996).

d) Development should not allow increased fine sediment inputs to streams because this can limit frog distribution and reduce population densities (Corn and Bury 1991, Marshall *et al.* 1996). Fine sediments fill substrate interstices and bury cobble-boulder microhabitats used by tailed frogs for cover and egg deposition (Corn and Bury 1991, Hayes 1996). Given the dependence of tailed frogs on stream corridors and/or continuous moist habitat for terrestrial movement, habitat fragmentation and physical barriers such as dams, waterways, culverts, and residences may prevent or limit tailed frog movements; these should be limited and or reduced in areas where this frog has been identified. Maintaining bank width along permanent headwater creeks, particularly along those creeks that have other characteristics (geomorphic and hydrologic) favorable to tailed frogs, may help mitigate for increased sedimentation as a result of road construction and stream crossings (Dupuis and Steventon 1999);

e) Increased isolation following development or land clearing appears to cause shifts in periphyton away from diatoms in streams, which are the preferred food of larval *A. truei*, towards filamentous green algae, which is less palatable (Kupferberg 1996) and may inhibit the ability of tadpoles to attach to rocks (Bury and Corn 1988). Reductions in stream woody debris in stream channels through flush events and hydrologic regime (i.e. increased flows), are likely to harm tailed frog populations by reducing cover availability and increasing water temperatures. In Diller and Wallace (1999) they identify that the larval stage of *A. truei*, which is restricted to streams, is the most sensitive to the impacts of adjacent land alteration;

f) Particular attention should be placed on preventing sedimentation discharge both during and post development to any natal ponds and/or streams which have been identified as amphibian habitat;

g) Presence of predators of amphibians (domestic animals), are one of the most critical elements in the survival of amphibian species. These should be controlled and eliminated from habitat identified as critical to the two blue-listed amphibians where possible;

h) The forested riparian areas within and adjacent to the study site should be managed according to the recommended "best management practices" from the Riparian Management Area Guidebook; and

i) Maintain natural wildlife corridors for dispersal.

6.4 Birds

6.4.1 Raptors

Envirowest performed no bird surveys during the field visits in the study area. All information collected about birds (raptors and songbirds) has been compiled from existing reports.

For the process of specific site developmental planning areas in the Hyde Creek Watershed Study Area habitat significant to any raptor species should be determined (nests and foraging habitat). Management plans for raptor habitat in all watersheds, should incorporate the following during the planning and design phase:

1. Retention of potential roost trees identified in proposed development areas, where possible. If identified to be significant they should be maintained primarily in relatively large reserve patches or areas of intact forest adjacent to proposed development sites. For this purpose, areas around foraging zones (i.e. the adjacent riparian corridors of the study site), should have corridor widths no less than 30 m and be composed of indigenous vegetation;

2. While core forest habitats such as the headwaters of Hyde, Burke and Smiling Creeks are important for raptor nesting and the adjacent riparian areas may be important as a prey source for nesting and disbursing juvenile raptors, as well as for potential roosting habitat, there should be a balance between the creation of beneficial feeding areas along the riparian edges and cleared areas of forest for other animals necessary for raptors;

3. Adjacent to proposed developments, habitat retention should strive to maintain a diversity of stand structural elements, such as large green trees, snags, logs on the forest floor, and canopy gaps. Older green trees should have structural characteristics such as cracks and holes in the bole where limbs have been shed. Snags that are retained should have cracks, bird holes and hollow interiors or should have the potential to develop these characteristics;

4. An important characteristic for dispersal and foraging for raptors includes maintaining treed linkage corridors. Planning design characteristics should incorporate features in the design phase of land development to maintain edges of treed habitat linked to larger and core forested areas for development. This will ensure connectivity between roosting habitat and any riparian foraging habitat is maintained for all birds. These linkage requirements should be considered and accommodated within forest ecosystem networks that are established through a landscape unit plan; and

5. During development, retain where possible the large snags and coarse woody debris along the development perimeter. This would benefit future habitat conditions for prey species of small mammals.

6.4.2 Songbirds

Planning in the Hyde Creek Watershed study area should incorporate a corridor "greenways" strategy for songbirds rather than a patchy fragmented "edge" or "island" habitat. Forest fragmentation creates an "edge effect", characteristic of human urbanization in forested areas (Riley 1994, Sandilands and Houndsel undated, Tweit and Tweit 1986, Adams 1994). Forest edge communities also support greater diversities and densities of birds (Bessinger and Osborne 1982). Interior-edge effects have been researched extensively with special reference to raptors and neotropical migrant bird species and found that vegetation diversity provides better breeding success (Adams 1994, Robbins *et al.* 1989, Terbrough 1992a, b, Sandilands and Houndsell undated, Scott *et al.*, 1989).

General recommendations for the retention and development of songbird habitat, not specific to any species, should include the following where possible for land planning issues:

1. Land planning, as much as possible, should incorporate the retention as well as enhancement of forest edge habitats, especially along road areas in order to provide escape or thermal cover for passerines. Also, areas disturbed by land clearing should be rehabilitated by accentuating habitat adjacent to mature vegetation with indigenous berry bushes to provide more food, shelter and nesting habitat for songbirds;

2. Development proposed in any of the watersheds should include the placement of nest boxes to benefit cavity nesting songbirds like the red-breasted nuthatch (Sitta canadensis), Bewick's wren (*Thryomanes bewickii*), woodpeckers (*Picadae*), and the chestnut-backed chickadee (*Parus rufescens*). Placement should focus on areas along open primary successive vegetated growth regions where a majority of cavity nesting birds prefer to nest (i.e. swallows, and wrens);

3. Planning for the study area should emphasize the retention of natural corridors for wildlife movement. Disturbed areas should be replanted with native shrubs and trees. This will allow contiguous corridor travel and create safety habitat for birds during the breeding season and during the migration seasons;

4. Land planning should be designed to maintain habitat diversity including vegetation age/successional structure and there should be an avoidance from monoculture stocking when revegetating strategies;

5. Designate areas containing an active band-tailed pigeon nest as a protected area because it may have the potential to act as an area for colony expansion. This area is to be reviewed by the City and MWLAP for placement under protection as a publicly owned wildlife/natural

area in perpetuity. Given the use of this area by the band-tailed pigeon, protection of the site should be considered important wildlife habitat;

6. Habitat revegetation when songbird habitat is considered should be performed using planting/revegetation that refrains from even-aged management and single aged tree removal. There should be an encouragement of three dimensional successional planting of aged tree stands and the process should utilize native plants to promote native bird species. Always, there should be a discouragement from exotic/invasive species planting; and

7. The design of land development proposals should retain and enhance coarse woody debris and brush pilings on forest floors for core forest nesters (i.e. winter wrens) when in close proximity to large forest tracts.

6.5 Small Mammals

Many species of mammals have been identified in the study area. These include species such as shrews (*Sorex sp.*), voles (*Microtus sp.*) and mice (*Peromyscus sp.*). Typically, the most significant habitat for small mammal populations in the Hyde Creek watershed study area occurs along riparian areas and lowland zones of all creeks and the forest communities associated with these areas including any ponds.

Several habitats associated with Hyde Creek, Upper Smiling and Burke Mountain Creeks contain good small mammal habitat characteristics. These have been discussed in Gomez and Anthony (1998) as being attributed to:

- Lack or low density of urban landscapes and pressures from cats and people in the northern extents of the project area;
- Microclimate alteration due to human presence resulting in low coarse woody debris size necessary for insect and shelter production. The abundance and decay class in these areas does not favor small mammals resulting in low insect production; and
- Alterations in hydrologic regimes of watercourses making them seasonal and if containing water, they are limited to very low baseline flows limiting aquatic insect diversity and abundance.

Typical impacts from development encroachment on small mammals populations may include, soil compaction, chemical treatments and degradation of wooded areas along with coarse woody debris removal. Any planning in the Hyde Creek watershed study area should be conducted such that there will be a minimum possibility to reduce any potential impacts on small mammals, thereby, ultimately sustaining this food source for raptors and large mammals. Any proposed development should incorporate the following design criteria:

1. Minimise the range of the disturbance adjacent to forested areas and associated riparian zones;

2. Post-development planning should be performed to allow the remaining protected habitat to provide insects, not only from the forest but also from the remaining/retained watercourses. This means protecting aquatic environments as much as possible and retaining woodlot/riparian areas so that small microclimates can be sustained to favour foraging areas for small mammals;

3. Habitat encroachment by any development should be designed to retain the coniferous and mixed forest habitats that have well developed canopy cover and an abundance of coarse woody debris necessary for microclimate protection and cover for small mammals;

4. Retain loose bark trees and coarse woody debris;

5. Maintain corridor connectivity amongst vegetation units to core forested areas surrounding any areas proposed for land development; and

6. Retain the mature riparian habitat in proposed development areas that contains any wetland/pool habitat. These areas provide critical logs, leaf litter, coarse woody debris, dense herbaceous and shrub cover, as well as forest litter which are critical for security cover.

6.5.1 Red, Blue-listed Small Mammals

There are two rare species of small mammal associated with the potential to occur in the Hyde Creek watershed. They are as follows:

Pacific Water Shrew

Owing to the limited amount of information known about the Pacific water shrew (*Sorex bendirii*) (Craig 2003b), based its life requirements (Craig 2003a and b, Nagorsen 1996, van Zyll de Jong 1983, Zuleta and Galindo-Leal 1994), and on the vegetation/habitat units within the Hyde Creek watershed this species has a theoretically good chance of occurring.

Trowbridge's Shrew

The blue-listed Trowbridge's shrew is most common in dry, mixed forests with a rich soil and decaying leaf litter with coarse woody debris (Nagorsen 1996). It is somewhat of an opportunist and can be found in wet forests, riparian habitats and ravines, but it generally avoids damp marshy areas with saturated soils (Doyle 1990). It prefers dry loose soil and deep litter and avoids areas with a high water table (George 1989). In the southern coastal area of BC and into the US, the Trowbridge's shrew has been captured mostly in mixed forests of red alder, Western hemlock, Western redcedar and big-leaf maple. All these forests have had been in various aged categories with extensive canopy cover (Nagorsen 1996). The food of the shrew consists primarily of centipedes, spiders, slugs, snails, beetles, and other larval insects. They also consume plant material such as fungi and plant seeds from Douglas-fir trees (Whitaker and Maser 1976). Breeding behavior of the Trowbridge's shrew begins in February to late May and reproduction is finished by June (Gashwiler 1976). Owls are the major predator of this shrew (Whitaker and Maser 1976).

For management of these rare small mammals, prior to any neighborhood or site planning it is recommended that the proposed study area be assessed for both species presence using methods identified in Craig 2003a.

6.6 Red, Blue Listed Species

The Conservation Data Centre (CDC) maintains Tracking Lists of rare vertebrates for each Forest District in British Columbia. Species or populations at high risk of extinction or extirpation[8] are placed on the Red List, and are candidates for formal Endangered Species status. Taxa[9] considered vulnerable to human activity or natural events are placed on the Blue List. Red and Blue-Listed species are sometimes referred to as species "at risk." The Yellow List includes all remaining wildlife species. Yellow-listed species are not considered "at risk." However, the CDC tracks some Yellow-listed taxa that are vulnerable during times of seasonal concentration (e.g. breeding colonies).

The May 2003 CDC vertebrate tracking list for the Chilliwack Forest District lists a total of thirty species. From these seven are red-listed, eighteen are blue-listed and five are yellow-listed.

Based on habitat requirements of the Hyde Creek Watershed Study Area, approximately three listed species could occur.

The only red or blue-listed wildlife (mammal, bird or amphibian) species recorded to date were encountered during the surveys of ENKON and Envirowest. It has been identified that based on the habitat structure within Hyde Creek, upper East and West Smiling Creek and Burke Mountain Creek that the following species have been identified and/or are likely to occur:

Fish

- cutthroat trout, (*Oncorhynchus clarki clarki*) blue-listed

Amphibians

- red-legged frog (*Rana aurora*) blue-listed; and
- coastal tailed frog (*Ascaphus truei*) blue-listed.

Birds

[8] A species formerly indigenous to British Columbia, which no longer exists in the wild in British Columbia but exists elsewhere, is "extirpated."
[9] The term "taxa" is used because the tracking lists contain both species and sub-species.

- band-tailed pigeon (*Columba fasciata*) blue-listed.

Mammals

- Pacific water shrew (*Sorex bendirii*) red-listed; and
- Trowbridge's shrew (*Sorex trowbridgii*) blue listed.

6.7 Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC[10]) is a committee of experts that assesses and designates which wild species are in some danger of disappearing from Canada. COSEWIC ratings for species have been confirmed or defined as potentially occurring in the study area based on habitat structure are rated the following ways:

Extinct - A species that no longer exists.

Extirpated - A species that no longer exists in the wild in Canada, but occurs elsewhere (for example, in captivity or in the wild in the United States).

Endangered - A species facing imminent extirpation or extinction.

Threatened - A species likely to become endangered if limiting factors are not reversed.

Vulnerable - A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

Special Concern - A species that has been evaluated and found to be not at risk.

Data Deficient - A species for which there is insufficient scientific information to support status designation.

As of May 2003, COSEWIC lists a total of 201 species (plant and animal) as occurring in British Columbia (Appendix A). Of the 201 COSEWIC-listed species and based on the habitats present in the study area, a total of ten vertebrate species may potentially occur in the Hyde Creek Watershed Study Area. Potential species include:

Threatened

- shrew, Pacific water (*Sorex bendirii*).

Special Concern

[10] **COSEWIC. 2003.** Canadian species at risk, May 2003. Committee on the Status of Endangered Wildlife in Canada 37.pp.

- western screech-owl (*Otus kennicottii kennicottii*);
- coast tailed frog (*Ascaphus truei*); and
- Northern red-legged frog (*Rana aurora*).

Not at Risk

- American black bear (*Ursus americanus*);
- Cooper's hawk (*Accipiter cooperii*);
- red-tailed hawk (*Buteo jamaicensis*);
- ensatina (*Ensatina eschscholtzii*);
- Northwestern salamander (*Ambystoma gracile*); and
- red-backed salamander (*Plethodon vehiculum*).

7.0 ENHANCEMENT OPPORTUNITIES

Many enhancement opportunities exist within the Hyde Creek watershed. Table 2 provides a list of problem areas associated with the creeks that could be used for stream improvement/enhancement. Additionally, the SHIM data (Appendix B), Figures 2, (obstructions), Figure 3 (erosion sites) and Figure 6 (enhancement areas), identify areas that could be enhanced or rehabilitated.

Any enhancement option chosen in the Hyde Creek watershed should be performed locally to a project study area. Priority for enhancement options should focus on the following hierarchy:

1. Removal of debris and garbage/barriers to upstream fish movement instream;

2. Elimination of sediment erosion concerns;

3. Fencing and exclusion of human access to stream habitats;

4. Culvert and manmade barrier replacements/upgrades; and

5. Any other enhancements (stream rehabilitation etc.).

Table 2 Enhancement Opportunities for the Hyde, Watkins, West and East Smiling and Burke Mountain Creeks

SHIM DATA (Appendix B Figure 2)

Obstructions

Location	Creek	Obstruction Type	Barrier	Comments
1	Lower Hyde	Rock	Yes	Boulders along Hyde Crk. Causing channel obstruction at confluence
2	Watkins	Cascade	Potential	Veg. barrier
3	Watkins	-	unknown	Veg. barrier
4	Watkins	Fences	Potential	-
5	Watkins	Fences	Yes	Fence with wire down to bottom
6	Watkins	Fences	Yes	Wire fence down to stream
7	Watkins	Fences	Potential	Wire fence
8	Watkins	Fences	Yes	Wire fence to stream surface
9	Watkins	Fences	Potential	Offset due to fence barrier, wire fence 0.3m to stream, unknown depth of water debris in fence
10	Watkins	Fences	Potential	-
11	Watkins	Persistent Debris	Potential	-

Erosion SHIM DATA (Appendix B Figure 3)

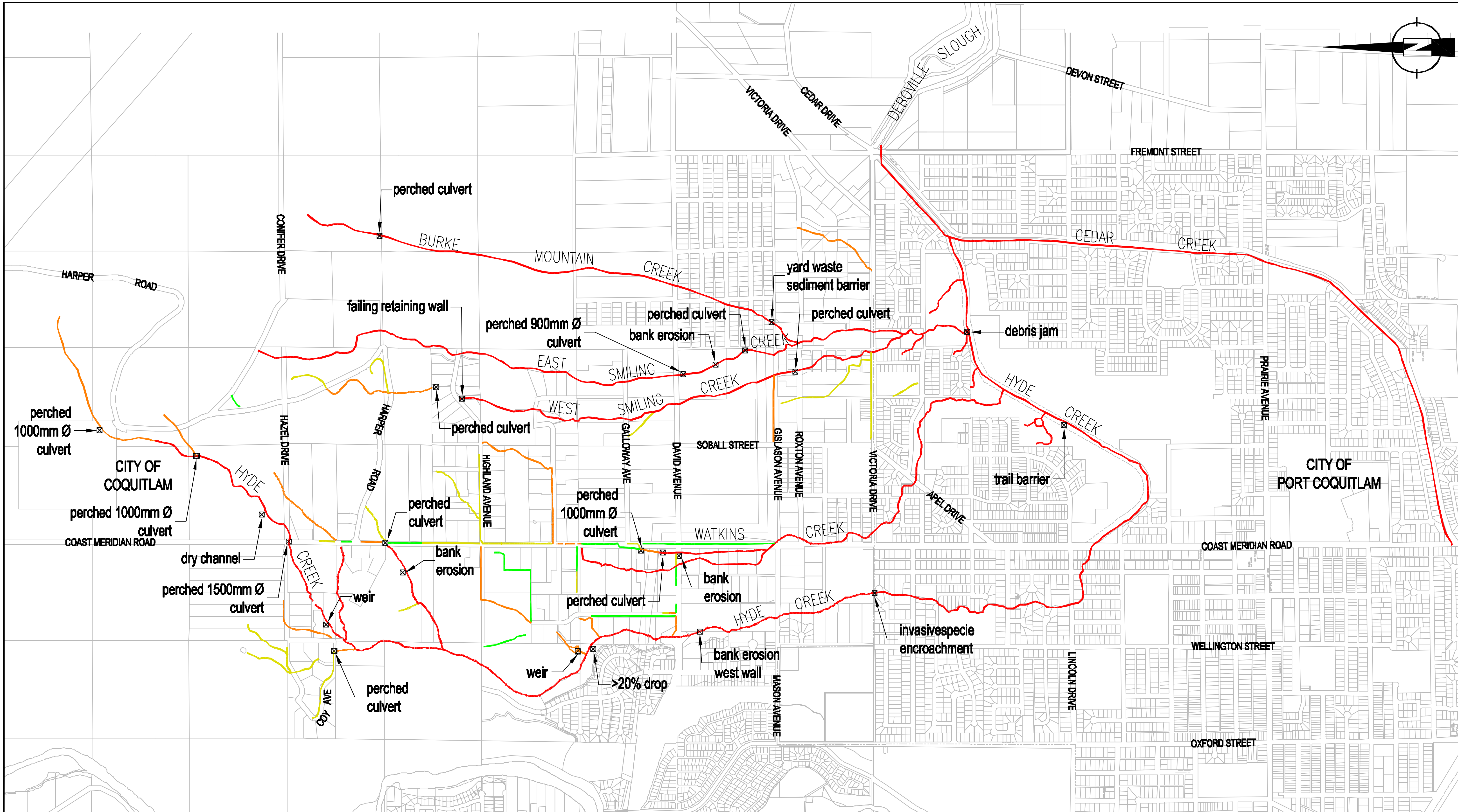
Location	Creek	Source of Erosion	Bank Side	Severity	Exposure
1	Hyde Trib. 12	Bank Erosion	Right	Moderate >5-10m sq	Soil
2	Lower Hyde	Bank Erosion	Left	Severe >10m sq	Soil
3	Watkins	Culvert	Both	Low <5m sq	Soil
4	Watkins	Bank Erosion	Both	Severe >10m sq	Soil
5	Watkins	Bank Erosion	Left	Moderate >5-10m sq	Soil
6	Watkins	Bank Erosion	Left	Moderate >5-10m sq	Soil
7	Watkins	Bank Erosion	Left	Moderate >5-10m sq	Soil
8	Lower E. Smiling	Bank Erosion	Left	Moderate >5-10m sq	Soil
9	Lower Burke Mtn.	Bank Erosion	Left	Moderate >5-10m sq	Soil
10	Lower Hyde	Bank Erosion	Right	Moderate >5-10m sq	Soil
11	Lower Hyde	Bank Erosion	Right	Severe >10m sq	Soil
12	Lower Hyde	Bank Erosion	Right	Severe >10m sq	Soil
13	Lower Hyde	Bank Erosion	Left	Moderate >5-10m sq	Roots

Location	Creek	Culvert Type	Barrier	Substrate	Culvert Diameter
14	Hyde	Bank Erosion	Left	Severe >10m sq	Soil
15	Hyde	Bank Erosion	Left	Severe >10m sq	Soil
16	Hyde	Bank Erosion	Right	Moderate >5-10m sq	Soil
17	Hyde	Bank Erosion	Left	Moderate >5-10m sq	Roots
Culvert Barriers SHIM DATA (Appendix B Figure 5)					
Location	**Creek**	**Culvert Type**	**Barrier**	**Substrate**	**Culvert Diameter**
1	West Smiling	Outlet	Unknown	Culvert	0.60
2	Smiling Trib. 2	Outlet	Unknown	Gravels	0.30
3	Smiling Trib. 1	Outlet	Unknown	Fines	0.40
4	Burke Mtn.	Outlet	Unknown	-	1.20
5	Burke Mtn.	Inlet	Unknown	-	1.20
6	Burke Mtn.	Outlet	Unknown	Gravels	0.60
7	Burke Mtn.	Box Culvert	Unknown	-	0.20
8	Burke Mtn.	Inlet	Unknown	-	60.00
9	Burke Mtn.	Box Culvert	Unknown	-	0.60
10	Lower Hyde Trib. 12	Outlet	Unknown	Culvert	0.70
11	Lower Hyde	Gated Multiple Inlet	Potential	Fines	0.00
12	Absent Trib	Outlet	Yes	Fines	0.45
13	Watkins Trib 10	Outlet	Yes	Culvert	0.45
14	Bracewell Pond	Outlet	Yes	Gravels	0.60
15	Watkins	Outlet	Potential	Culvert	1.50
16	Watkins	Inlet	Unknown	Culvert	1.50
17	Watkins	Box Culvert	Unknown	-	0.00
18	Watkins	Box Culvert	No	Culvert	1.55
19	East Smiling	Outlet	Yes	Culvert	1.00
20	East Smiling	Outlet	Potential	Culvert	1.00
21	Lower Burke Mtn.	Box Culvert	Yes	Culvert	0.00
22	Cedar	Multiple Inlet	No	Gravels	4.00
23	Lower Hyde	Gated Inlet	Unknown	Gravels	0.30
24	Lower Hyde	Inlet	No	Gravels	2.00
25	Lower Hyde	Outlet	No	Gravels	2.00

Location	Creek	Culvert Type	Barrier	Substrate	Culvert Diameter
26	Lower Hyde	Inlet	No	Gravels	2.00
27	Lower Hyde	Outlet	No	Gravels	2.00
28	Hyde	Box Culvert	No	Culvert	0.00
29	Hyde	Gated Outlet	Unknown	Culvert	0.60
30	Hyde	Box Culvert	No	Culvert	0.00
Enhancement Opportunities Envirowest (Appendix B Figure6)					
Location	**Creek**	**Enhancement Opportunity**			
1	Hyde Mainstem	Perched 1,000 mm Culvert			
2	Hyde Mainstem	Perched 1,000 mm Culvert			
3	Hyde Mainstem	Dry Channel			
4	Hyde Mainstem	Perched 1,500 mm Culvert			
5	Hyde Mainstem	Weir			
6	Hyde Trib. 3	Perched Culvert Trib. 3			
7	Hyde Trib. 5	Bank Erosion			
8	Hyde Trib. 5	Culvert Fish Barrier			
9	Hyde Trib. 6	Weir at outlet to pool			
10	Hyde Mainstem	1 m drop gradient >20%			
11	Hyde Mainstem	Erosion on the west wall			
12	Hyde Mainstem	Invasive vegetation encroachment			
13	Hyde Mainstem	Trail access to stream			
14	Watkins	1,000 mm perched culvert			
15	Watkins	Bank erosion (sloughing)			
16	Watkins	1,050 mm perched culvert			
17	West Smiling	3 metre drop from culvert			
18	West Smiling	Failing retaining wall			
19	West Smiling	Perched 950 mm culvert wood stave			
20	East Smiling	900 mm perched culvert			
21	East Smiling	Bank erosion			
22	East Smiling	1 m drop from culvert			
23	Hyde Mainstem	Debris jam			
24	Burke Mountain	Perched culvert on bike trail			

Location	Creek	Enhancement Opportunity
25	Burke Mountain	Yard waste dumping
26	Cedar Creek	The channel substrates are 100% fines and decaying vegetation. There is very little channel complexity and limited to non existent CWD
27	Deboville Slough	The road on both sides lacks vegetation. Some planting has been conducted, but most of the trees are still very small and are being out competed by reed canary grass, which is the dominant vegetation. Other prevalent riparian species include dense mats of Himalayan blackberry
28	Deboville Slough	There is limited bank complexity downstream of the confluence of Hyde Creek and Cedar Creek except for a few boulder clusters. There is limited water cover as well as complexity of the channel (10% from overhanging vegetation).
29	Deboville Slough	Downstream of the confluence of Hyde Creek and Cedar Creek, the road on both sides lacks vegetation.
30	Deboville Slough	The riparian habitat is dominated by reed canary grass and in sections dense Japanese knotweed with Himalayan blackberry thickets.
31	Deboville Slough	The entire section of the Slough has a limited CWD complexity and instream cover.
32	Deboville Slough	A number of locations along the first kilometer of the Slough's outflow from Cedar Drive experiences erosion sites, mostly due to trail access to the water by people.

Figure 4 Opportunities for Enhancement



⊠ Potential Enhancement Areas

CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT
PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

HYDE CREEK WATERSHED ENHANCEMENT LOCATIONS

DESIGN: LM	DRAWN: SDJ	CHECKED:	REVISION: 01	REVISION DATE: April 16, 2004
SCALE: 1:15000			DRAWING NUMBER:	
DATE: February 16, 2004			FIGURE 4	

8.0 MEASURES TO REDUCE STORM WATER IMPACTS

8.1 Riparian Setbacks

Much of a developing watershed's capability to function as productive fish and wildlife habitat can be preserved through the protection of appropriately wide riparian corridors (DFO 1993). The general intent is to retain the watercourse and an adequate riparian buffer zone that will maintain its ecological integrity. Riparian setbacks should be adopted to reflect the SPR guidelines.

Notwithstanding the already urbanized portion of the watershed largely located within Port Coquitlam, development within the Hyde Creek watershed is presently rural and/or low density (City of Coquitlam); this type of development has a low percentage of impervious cover (*ibid.*). Riparian setbacks will also allow for the maintenance/maximization of pervious landscape immediately adjacent to watercourses within the watershed.

8.2 Groundwater Protection

Hammer (1989) states that, impervious surfaces such as paved parking areas and building rooftops prevent rainwater from infiltrating through the ground to recharge groundwater at aquifers. Instead, storm water runoff is often collected and diverted directly to a watercourse or storm sewer. This eliminates any biofiltration of the storm water and also prevents groundwater recharge which may reduce or eliminate baseflows in dry periods. Impervious cover also leads to higher flows and velocities during storm events, generally resulting in increased erosion problems and flooding (*ibid.*).

Methods to reduce impacts on aquifers/groundwater supplies and base flows to streams include construction of storm water biofiltration or detention systems with pervious bottom surfaces, minimizing impervious surfaces during development, and preventing or minimizing development above aquifers and other sites with high infiltration rates (DFO 1993). Special infiltration features should be incorporated into development plans where supported by subsurface geology.

Where possible at the neighborhood stage of planning in the Hyde Creek watershed opportunities should be pursued to use infiltration measures to augment stream segments that have low base flows (e.g. Hyde Creek northeast of Victoria Road upper limit).

8.3 Peak Flow Attenuation

The most conventional approach to managing storm water in an urbanizing catchment area is the provision of detention features that reduce post development flows to a pre-determined percentage of pre-development flows (Hammer 1989). Designs for detention ponds should incorporate biofiltration, exfiltration and fish/wildlife habitat functions wherever possible (ibid.). Detention ponds should be located outside of watercourses and their setback areas. They should be provided upstream of significant fish habitat such as spawning grounds to minimize erosion and degradation of fish habitat associated with increased runoff rates resulting from development.

An alternative to detention ponds that provides similar, and often superior, environmental benefits is a diversion sewer. A portion of peak flow can be bypassed around sensitive aquatic habitats. These diversion sewers should be constructed outside of the stream/riparian corridor.

9.0 MONITORING

Two levels of monitoring are recommended to assess potential responses of the watershed area to land development activities. Watershed-level monitoring will assess long-term effects of urbanization while site-level monitoring will assess the efficiency (and guide the operational refinement) of individual stormwater control features.

On a watershed (large scale) level, monitoring is required to assess potential changes to overall watershed conditions. In the absence of mitigation works such as stormwater detention ponds and other Best Management Practices (BMPs), land development results in notable adverse effects on runoff patterns and water quality. Even without direct impacts to riparian habitat, these changes can have both direct and indirect impacts on stream ecosystems and ultimately result in decreased production of salmonids (DFO 1993). A series of watershed-level monitoring stations should be established and used to track potential long-term effects. Variables that are most appropriate for such monitoring are water quantity, water temperature, and benthic invertebrate community structure. Water quantity and temperature are recommended as they are among the factors most directly affected by development, and can both be reliably measured on a continuous basis with affordable monitoring equipment. In addition, a single precipitation monitoring station would improve the value of stream flow data, and also allow tracking of climatic variability/changes. A monitoring protocol for these variables is described in Section 9.0 1 below. Benthic invertebrates are considered to be a good indicator of ecological health, as they tend to reflect general, longer-term water quality and habitat conditions (*ibid.*). Protocols for invertebrate monitoring are described in Section 9.2 below.

Water quality and fish utilization are other parameters worthy of assessment. However, both are subject to relatively high degrees of variability and require intensive sampling frequencies in order to properly establish trends. Nonetheless, at the watershed scale, these parameters should also be included in the monitoring program.

Recommended sites are described below. The highest priority has been attributed to sites where urbanization of the upstream catchment area has commenced (or is imminent) while the lowest priority has been assigned to sites where urbanization is not expected in the foreseeable future. The lower reaches of all creeks associated with the Hyde Creek watershed plan area have been subjected to the greatest degree of urbanization, and thus, have been included in the watershed level monitoring program.

Site 1 – This site is located on Cedar Creek at Cedar Drive. It was chosen to sample water quality flows in Cedar Creek downstream to its confluence with Hyde Creek.

Site 2 –This site is along the lower section of Hyde Creek and chosen to sample water quality reflecting the combined flow of all tributaries to Hyde Creek.

Site 3 – This site is located along the base of Smiling Creek mainstem after East Smiling and Burke Mountain Creeks join. It is located at the end of Wilkie Avenue. The catchment upstream of this site is primarily forested habitat with very low-density rural/suburban development established on East Smiling Creek and proposed, but not immediate, low density housing for Burke Mountain Creek.

Site 4 – This site is located at the end of Baycrest Avenue just upstream of the confluence of Burke Mountain Creek and East Smiling Creek. Currently this location has no upstream development but moderate density is proposed for the immediate upstream section of Burke Mountain Creek in the foreseeable future. There are no potential spawning habitats; however, a portion of this catchment is comprised of high permeability soils. This site is included as it represents a catchment area of lower topographic relief within Burke Mountain Creek watershed.

Site 5 – This site is located on the west arm of West Smiling Creek on Victoria Drive at an existing water quality sampling site. It is chosen because the upper sections of West Smiling Creek have established development.

Site 6 – This site is located on Watkins Creek at the culvert where Victoria Drive crosses Watkins Creek. It has been chosen because of the increased pressure to upstream development proposed by the Neighbourhood 1 Plan and the impacts that proposed development and associated impervious surfaces will have on fisheries values in downstream Watkins and Hyde creeks.

Site 7 – This site has been chosen to assess the flows in Mainstem of Hyde Creek where it passes Birkshire Place. The site is intended to assess the long-term effects of the proposed development in the headwaters of Hyde Creek as well as assess the efficiency of stormwater control features that are proposed for the area. This section of Hyde Creek has a viable fish population and monitoring will assess the impacts to the critical habitat within Hyde Creek.

Site 8 – This location is set in the headwaters of Hyde Creek at the junction of Hyde Creek with Conifer Avenue in Pinecone-Burke Provincial Park. Because Hyde Creek at this location is likely to be reduced in flows the intent of this station will assess the initial flow volumes for the watershed, act as a control and monitor base line flows for downstream sections. It is situated in an area where development pressure is the least and will be able to monitor existing conditions the creek. It is also a site located upstream of all potential development. Thus, it provides a long-term control site against which data from developed watersheds can be compared. Finally, it also provides a baseline to assess trends unrelated to development (e.g. climate change).

Site 9 - This location is set approximately 200-300 metres downstream of the culverts at Victoria Drive on Deboville Slough. It is chosen to assess any if any contaminant outflows are accumulating.

Site 10 - Finally, this site is located at the outflow of Deboville Slough to the Pitt River. It has been chosen to assess the impacts that the slough and upper watersheds are having on contaminant levels entering the Pitt River and to monitor the levels from the Pitt River to the Slough via high tide fluctuations.

Prior to any future development at the watershed-level monitoring is important to be established to assess the baseline (pre-impact) condition as early as possible so that the effects of development, and the efficiency of completed mitigation works, can be quantified. Monitoring programs should extend through the period of complete build-out for each site's catchment area.

Site-level monitoring is proposed for each of the proposed community-level detention ponds. Although the ponds are to be constructed as "multi-purpose ponds", improving stormwater quality, creating fish and wildlife habitat, and providing aesthetic value, their principle role will be to attenuate peak flows. Recommended monitoring includes continuous water quantity monitoring flows for each pond. A minimum of one year of pre-development data should be collected. Although peak inflows would be expected to increase beyond that time-frame, reflecting increasing levels of land development, the pattern of flow attenuation could be reasonably well established, with operational adjustments made to reflect the findings. The continued monitoring of each pond's outlet flow beyond the initial monitoring period would provide useful data that could be correlated with data from other monitoring sites and/or precipitation data. Protocols for water quantity monitoring are described in Section 9.1 below.

9.1 Water Quantity Monitoring

Water quantity monitoring is recommended at both the watershed-level and site-level monitoring stations. A continuous record of stream flow should be generated by installing and operating a water level sensor with to a data recorder. A pressure transducer type measuring device should be installed in a pool at a location where the channel is stable (not eroding or aggrading). The recording device should collect readings at maximum intervals of five minutes.

The conversion of water level data to stream flow data requires a rating curve for each monitoring site. Stream flow is determined by measuring channel geometry and flow across a uniform channel section. Stream flow is measured under various flow conditions to establish a relationship (the rating curve) between water depth and flow. A minimum of five points are required to establish a reliable rating curve. The mathematical relationship is applied to the water level data to develop a continuous record of stream flow.

Data should be downloaded from recorders at maximum two month intervals (to minimize accidental data loss). Stream flow should be measured a minimum of five times within the first year of site monitoring. In subsequent years only two measurements are recommended (unless inconsistencies in the data are apparent, or if there has been a change in channel configuration or damage to the equipment).

Data analyses should include determination of the following:

- Mean annual flow and total runoff (yield);
- Mean monthly flow and total runoff (yield);
- Maximum instantaneous flows; and
- Minimum instantaneous (and 7-day average) flows.

With the addition of a continuous recording rain gauge, additional analyses could include development of unit hydrographs (assessing the response of stream flow to a rainfall event of given quantity and duration) and (by correlation with established rainfall monitoring stations) the affixing of statistical recurrence periods to storm/stream flow events.

9.2 Benthic Invertebrate Sampling

Benthic invertebrates should be sampled at the ten watershed-level monitoring sites. Sampling techniques should follow standard procedures outlined by Environment Canada[11] and the United States Environmental Protection Agency[12]. Using Benthic Index of Biological Integrity (B-IBI)[13], (a stream-health grading system based on aquatic insects found at monitoring sites), it uses a synthesis of diverse biological information that numerically depicts associations between human influence and biological attributes. This method is composed of several biological attributes or 'metrics' that are sensitive to changes in biological integrity caused by human activities. The multi-metric approach compares what is found at a monitoring site to what is expected using a regional baseline condition that reflects little or no human impact (Karr 1996). These multimetric indexes utilize a variety of measurements to assess the biological condition, or health, of streams.

A standard Surber or Hess sampler should be used to conduct sampling within riffle habitats. Genus Level Taxonomic Identification should be used (10 metric BIBI). Surber samplers are restricted to depths less than 0.3 m and gravel/cobble substrates, and could therefore not be used on slow flowing deepwater channels with heavy instream vegetation and an absence of cobble or gravels. Sampling at lower gradient locations should be conducted using a dip net apparatus of similar dimensions and

---

[11] **Reynoldson, T.B., C. Logan, D. Milani, T. Pascoe and S.P. Thompson. 1998.** Protocols for reference condition databases: field sampling, sample, and data management of benthic community structure and environmental attributes in aquatic ecosystems. National Water Research Institute Report No. 98-129. NWRI, Environment Canada, Burlington, Ontario. 67p.

[12] **Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999.** Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water, Washington, D.C. 326p.

[13] http://www.clallam.net/streamkeepers/html/BIBI_whys___hows.htm

mesh size to the Surber sampler, pulled through the water and aquatic vegetation, over the same approximate area as that sampled by a Surber sampler. Samples should be rinsed from the net, transferred to sample jars, preserved with 10% formalin, and subsequently sorted and identified at a laboratory.

The 10 metric IBI method rates benthic taxa; they are grouped into categories: pollution intolerant, somewhat tolerant of pollution or pollution tolerant. A rapid bio-assessment of each sample would be completed following methods outlined in the Streamkeepers Handbook[14] and including the following calculations: total abundance and density of organisms; predominant taxon; pollution tolerance index; EPT index (*i.e.* total number of sensitive organisms from the orders *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies); EPT to total organism ratio; predominant taxon ratio; and site assessment rating.

9.3 Water Quality Sampling

Water quality should be sampled at the ten watershed-level monitoring sites. Water samples should be collected from the thawleg of the watercourse at each station in hand held bottles. The bottles would be transported to a certified laboratory in a cooler for analysis. Unstable parameters, such as water temperature, pH, conductivity and dissolved oxygen would be analysed in situ. Parameters that should be analysed by the laboratory include the following:

- pH
- conductivity
- total and dissolved metals
- total mineral oil and grease
- EPH (light and heavy extractable petroleum hydrocarbons)
- nitrate, nitrite and ammonia
- total phosphorous
- total kjeldahl nitrogen
- suspended solids

[14] **Taccogna, G. and K. Munro (eds.). 1995.** The Streamkeepers Handbook: a Practical Guide to Stream and Wetland Care. Salmonid Enhancement Program, Department of Fisheries and Oceans, Vancouver, B.C. 171p.

Analysis of the water quality data would be conducted using criteria for the protection of aquatic life as outlined in the *British Columbia Approved Water Quality Guidelines*[15]. Where approved criteria do not exist, the natural range of the constituent in surface waters and working criteria for aquatic life would be reviewed in the Water Quality Sourcebook[16].

9.4 Fish Sampling

Although subject to notable variations even in undeveloped watersheds, some measure of salmonid productivity is suggested as there is a public perception that fish presence is the ultimate indicator of stream health. To a lesser extent, and as requested by DFO, recommended fish sampling procedures involve assessment of juvenile salmonid densities within a standardized sampling reach in proximity to each of the eight watershed-level sampling sites. At each site, a 50 metre stream section including a variety of habitat types would be isolated with seine nets and all fish would be captured by seining and electro-shocking methods. All fish would be identified and enumerated; the fork-length of all salmonids would be measured. All fish would be returned unharmed to the stream. Findings would be reported as aerial densities (fish per square metre) and linear densities (fish per linear metre). This sampling would be performed once per year in the late summer.

10.0 ENVIRONMENTAL REGULATIONS

The following environmental regulations are intended to direct any development within the Hyde Creek Watershed and to act as a guide to future land development in the area. Presented below are environmental concerns for which guidelines have been established by Federal, Provincial as well as Municipal agencies to assist in watershed planning for the Hyde Creek Watershed Study Area.

10.1 Federal Environmental Regulations

10.1.1 Fisheries Act

The federal Fisheries Act protects fish and fish habitat and under Section 35 states the following:

(1): No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat; and

(2): No person contravenes section (1) by causing the alteration, disruption or destruction of

[15] **British Columbia Ministry of Environment, Lands and Parks (MELP). 1998**. British Columbia Approved Water Quality Guidelines (Criteria): 1998 Edition. Water Management Branch, Environment and Resource Management Department, MELP. 70p.
[16] **McNeely, R.N., V.P. Neimanis and L. Dwyer. 1979.** Water Quality Sourcebook: A Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa, Ontario. 88p.

> fish habitat by any means or under any condition authorized by the Minister or under regulations made by the Governor in Council under this Act.

Any alterations to streams, including changes to the channel, installation of culverts or other crossings and removal of riparian vegetation (i.e., any vegetation within the 15-m buffer zone), are considered “harmful alteration.” As such, under Subsection 35(2) these changes require approval from the Department of Fisheries and Oceans (DFO).

Under its “no net loss” policy, DFO would require habitat compensation for any loss of riparian vegetation or changes to the stream channel (e.g. culvert installation).

10.1.2 Federal Migratory Bird Act

The following federal laws apply to all actively nesting birds on the proposed works areas. Federal migratory bird protection under the *Migratory Bird Act* Section 6 states that:

Subject to subsection 5(9), no person shall:

a) disturb, destroy or take a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird, or

b) have in his possession a live migratory bird, or a carcass, skin, nest or egg of a migratory bird except under authority of a permit therefore. SOR/80-577, s. 4.

10.2 Provincial Environmental Regulations

10.2.1 Fish Habitat

Streamside Protection Regulation

The purpose of this regulation is to protect streamside protection and enhancement areas from residential, commercial and industrial development so that the areas can provide natural features, functions and conditions that support fish life processes

The recommended no disturbance setbacks under the *Streamside Protection Regulation* (January 19, 2001) are as follows:

1. Any **Fish Bearing** or **Permanent Non-Fish Bearing Stream** that is not in a ravine or in a ravine <60-m wide must have at least a 30-m no-disturbance buffer. The buffer width is measured perpendicularly from the top-of-bank or top-of-ravine bank on either side of the stream.

2. Any **Fish Bearing** or **Permanent Non-Fish Bearing Stream** that is in a ravine >60-m wide, not including the stream channel within its active floodplain boundaries, must have at least a 10-metre no-disturbance buffer.

3. All **Non-Fish Bearing Non-Permanent Streams** must have at least a 15-m no disturbance buffer measured perpendicularly from the top-of-bank or top-of-ravine bank on either side of the stream.

4. Streams or other watercourses classified as **Non Fish Habitat** are not required to have buffers. These apply to roadside ditches, which have no connection to any watercourse that either contains fish, nor have any surficial contribution of food and nutrient value to a permanent or non-permanent non-fish bearing stream.

10.2.2 Stormwater Management

The Ministry of Water, Land and Air Protection recommends that any development in the Hyde Creek watershed be performed in accordance to the following *Best Management Practices*. The following are a number of these BMPs which would apply to the area:

- *Best Management Practices Guide for Stormwater* (Dayton & Knight 1999, prepared for the Greater Vancouver Regional District);
- *Best Management Practices for Streambeds and Streambanks* (Ministry of Environment, Lands and Parks 2001);
- *Best Management Practices to Protect Water Quality* (Ministry of Environment, Lands and Parks 2001); and
- *Best Management Practices to Prevent Urban Runoff* (Ministry of Environment, Lands and Parks 2001).

Planning for any development of the watershed should incorporate the practices recommended in these documents.

10.2.3 Water Act

The provincial *Water Act* regulates and requires any development to obtain approval for any changes "in and about" a stream or make the changes "in accordance with terms and conditions specified by a habitat officer." The provisions of the *Water Act* would apply to any culverts or other crossings of Shadow Brook. Other provisions of the *Water Act* include requirements to:

- assess the effects of the changes on the stream channel;
- protect water quality during construction and from any ongoing effects of construction; and
- protect fish and habitat, including (but not limited to) adherence to timing windows for instream work, maintenance of flows, salvage or protection of fish or wildlife and restoration of the site after construction.

These provisions affect the information requirements for approvals crossing construction, the precautions that must be taken during construction and the timing of construction.

10.2.4 Wildlife Act

Existing wildlife habitat protection legislation is very limited. Section 34 of the provincial *Wildlife Act* is the only legislation that protects wildlife. The *Wildlife Act* deals primarily with eagles, herons, peregrine falcons, osprey, gyrfalcon and burrowing owls. It protects the nests of these species at all times. In addition, Section 34 of the act states that a person commits an offence if the person, except as provided by regulation, possesses, takes, injures, molests or destroys:

1) A bird or its egg;

2) The nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl; or

3) The nest of a bird not referred to in paragraph (b) when the nest is occupied by a bird or its egg.

To comply with this act, any land clearing should occur outside the nesting season. Alternatively, any active nests must be protected until fledglings have left the nest. The *Wildlife Act* does not specify measures to protect birds, eggs or nests.

10.3 Municipal Environmental Regulations

10.3.1 City of Coquitlam

The *Northeast Coquitlam Official Community Plan* (Bylaw 3418, amended February 5, 2001) designates the area within 50 m of the top of bank of any watercourse shown on Schedule D as a Watercourse Protection Development Permit Area pursuant to Section 919.1(a) and (b) of the *Local Government Act*. Hyde Creek is shown on Schedule D. Thus, any development within 50 m of the tops of bank of this watercourse will be subject to Policy A-9.7 and A-9.8 of the OCP, which deal with Development Permit Areas.

The stated objectives of designating a Watercourse Protection Development Permit Area (Policy A-9.7) are:

- To identify, evaluate, protect and enhance watercourses, adjacent riparian areas and where appropriate, any associated ecosystems and natural features;
- To maintain drainage capacity and water quality of watercourses and to avoid creation of flood hazards; and
- To encourage development which is environmentally sensitive.

Policy A-9.8 (Development Permit Requirement and Application Process) outlines the application procedure for obtaining a Development Permit and lists the information that the City of Coquitlam may require in order to evaluate the application. The possible information requirements are not limited to fisheries values but address all environmental components. The potential requirements include assessment by a registered professional biologist, to identify environmentally sensitive features, analyze impacts of the development and recommend measures to eliminate or mitigate the identified impacts. Thus, an environmental impact assessment likely will be required for any development of the properties. Other potential information requirements include:

- a top-of-bank survey completed by a British Columbia Land Surveyor;
- information on slope and elevations sufficient to determine compliance with Section 519 of Coquitlam's Zoning Bylaw No. 3000;
- a geotechnical assessment to identify and provide mitigation for any potential hazard of land slippage, bank erosion, flooding or drainage blockage;
- a plan by a Professional Engineer for all proposed drainage collection, retention, detention and discharge works (i.e. a stormwater management plan); and
- assessment by a certified arborist.

In addition, Policy A-9.5 (Watercourse Protection) notes that development in areas along watercourses will be regulated to protect known fisheries values. The protection of fisheries values under this policy is unlikely to impose any constraints beyond those imposed by the federal *Fisheries Act* and the provincial *Streamside Protection Regulation.*

Vegetation

The only federal and provincial regulations that address tree cutting/vegetation removal are included in the legislation that protects fish habitat (Section 10.2.1) and are limited to riparian vegetation. The City of Coquitlam protects vegetation through provisions of the Northeast Coquitlam OCP and the *Tree Cutting Permit Bylaw*, applies to areas both within and outside the riparian zone. Constraints imposed by municipal bylaws and policies that deal with vegetation are discussed in the following paragraphs.

The possible information requirements outlined in OCP Policy A-9.8 - Development Permit Requirement and Application Process include an assessment by a certified arborist. Where tree removal is proposed, the arborist's tasks include preparing a tree replacement plan consistent with the tree replacement criteria of the Ministry of Environment, Lands and Parks (now the Ministry of Water, Land and Air Protection).

In addition, OCP Policy A-9.15 - Tree Protection and Management includes provisions for the retention and/or replanting of vegetation. It notes that the City will "encourage the identification of important greenways to provide opportunities for the preservation of natural vegetation, particularly significant trees." It also states that tree protection measures in Development Permit Areas "shall generally be consistent with the City's *'Habitat Protection Tree Replacement'* criteria." The setbacks required under the *Streamside Protection Regulation* provide opportunities for the preservation of natural vegetation. Provided that a more detailed survey of the property does not identify any "significant vegetation[17]," the allocation of additional land as greenway should be unnecessary.

The City of Coquitlam *Tree Cutting Permit Bylaw* (Bylaw No. 2169 and Amendment No. 3403) could apply to some sections along all creeks in the watershed study area in the City of Coquitlam. Specifically, the Bylaw designates any slope of 20° or greater, where the slope has a vertical height of 3 m or greater, as a Tree Cutting Permit area. Before cutting any trees >5 m high in a Tree Cutting Permit Area the developer must apply for and receive a permit from the City. However, most of the slopes >20% are within the setback areas required under the *Streamside Protection Regulation*. Tree removal will not be permitted in these areas. In addition, a Tree Cutting Permit is not required where the cutting of trees in a Tree Cutting Permit Area has been authorized under a Development Permit or an approved Subdivision Plan (*Subdivision Control Bylaw* No. 2038).

Stormwater Management

The Northeast Coquitlam OCP contains several policies (A9.1 through A9.3) that pertain to stormwater management. These policies primarily are intended to guide integrated stormwater management plans for Hyde Creek and other drainages in Northeast Coquitlam, which are to be "undertaken as a component of more detailed neighborhood plans." These policies also contain guidelines that should be considered in designing any development within the watershed.

To address requirements for stormwater management, planning for any development of the watershed should include, where possible, the following principles and specific measures:

1) ***Impervious Area Reduction*** – Increases in Total Impervious Area (TIA) should be minimized as much as possible. Impervious Areas should be hydraulically disconnected wherever possible to reduce the frequency of threshold runoff events that cause habitat degradation. Source control, interception, infiltration and detention storage/diversion should be used to reduce impervious areas.

    a) Grass/landscaped strips should be provided between the sidewalks and the property line;

    b) Boulevards and streets should be planted with native tree and shrub species to intercept rainfall;

    c) Absorbent landscape materials and irrigation strategies should be used to recharge groundwater;

    d) Where acceptable to the City of Coquitlam, permeable surfaces should be used for any trail development and emergency access;

[17] Significant vegetation would include old growth and older mature trees

e) Where acceptable to the City of Coquitlam, pavement widths should be minimized to reduce the total impervious area; and

f) Dry swales with underdrains (where practical) should be installed where grades and adjacent land use permit.

2) ***Maintenance of Water Quality*** - Water quality control facilities should be designed to mitigate water quality impacts to the creeks by collecting, diverting and treating (i.e. low flow splitters into wetlands, direct surface runoff into grassed swales, etc.)"first flush" events of smaller storms (more frequent runoff events) from impervious areas.

3) ***Peak Flow Events*** – Post development peak flow regimes should mimic pre-development peak flows as much as possible, and should be designed to reduce downstream flooding and erosion problems through detention and/or diversion systems as appropriate.

4) ***Base Flow Augmentation*** - Base flows should be maintained in Hyde Creek between rain storms through a combination of techniques including:

a) Where appropriate, interceptor channels should be constructed along the upper limits of the developments to collect and discharge surface water/subsurface seepage into the creek;

b) Residential lots backing on to all creeks should include roof leader downspouts and overflow splash pads to direct water toward side yard swales that lead toward creeks;

c) Where possible, disconnect piped systems (i.e. low flow splitters) into wetlands and low flow retention systems;

d) Building foundation drainage from the developments should be directed into the ground, where practical; and

e) Any utility trench seepage that would migrate along a watermain, storm or sanitary trench bedding should be directed towards creeks, where practical.

10.3.2 City of Port Coquitlam

The City of Port Coquitlam has environmental protection primarily associated with watercourse protection in the creek drainages as stated in the *Development Permit Area XVI – Watercourse Protection (DPA).* This DPA deals with development areas in the City through the Development Permit Area under the Local Government Act, Section 919.1 Subsection (a) for the protection of the natural environment, its ecosystems and biological diversity, and Subsection (b) for protection of development from hazardous conditions.

The *Watercourse Protection Development Permit Area* includes all lots any portion of which are within 50 metres of the top-of-bank of a watercourse identified as a Class A Watercourse or Class B Watercourse on Development Permit Area Map XVII for the City of Port Coquitlam.

The objectives of the *Development Permit Area XVII – Watercourse Protection* (DPAWP), adopted by the City of Port Coquitlam are to provide:

1. Protection and conserve of the natural environments, ecosystems and biological diversity of watercourses, and to restore or enhance these habitats to an ecologically healthy condition;

2. Maintain drainage and flood protection functions of watercourses such as Hyde, Smiling and Burke Mountain Creeks;

3. Facilitate development that is compatible with conservation of watercourses; and

4. To regulate development activities within and near watercourses to achieve the above goals.

The guidelines of the DPAWP allow development in the City under the following environmental conditions:

1. Any development within watercourse protection development permit areas (i.e. lower Hyde, Smiling, and Burke Mountain) will require a development permit. This must be obtained prior to any land alteration. Further, a Subdivision shall not be approved unless uses permitted under the existing zoning can be accommodated in the lot area of each lot exclusive of the Watercourse Protection Areas as defined in the Development Permit Area XVII – Watercourse Protection;

2. All watercourses associated with any proposed development shall have all streams classified and protection areas will be established according to the DPAWP;

3. Any permit applications for development will require the following:

    i. Preliminary proposal for application;

    ii. Development permit application;

    iii. Inventory of all watercourses and physical elements of the property as well as wildlife attributes;

    iv. Define the project proposed;

    v. A development of sediment and erosion control plans;

    vi. Define watercourse protection areas and create an area management plan;

and

vii. Conduct an environmental assessment of the proposed watercourse protection areas.

4. Vegetation replanting requirements for any development of any land will require an analysis of existing vegetation and all works will be supervised by a professional acceptable to the City.

5. All vegetation replanted shall be native and chosen to accentuate fish and fish habitat. Where possible all proposed plantings should be salvaged from the development site and replanted.

11.0 REFERENCES

Acharya, Lalita, and Brock Fenton. 1999. Bat attacks and moth defensive behavior around street lights. Can. J. Zool. 77:27-33.

Adams, Lowell, W. 1994. Urban wildlife habitats: A Landscape perspective. University of Minnesota Press, Minneapolis, London. 186 pp.

American Ornithologist's Union. 1957. Checklist of North American birds. Fifth ed. Amer. Ornith. Union, Baltimore, 691 pp.

Andersen, D.E., O.J. Rongstad, and W.R. Mytton 1985. Line transect analysis of raptor abundance along roads. Wildl. Soc. Bull. 13:533-539

Australian Marine Safety Authority. 2002. http://www.amsa.gov.au/index.htm.

Bent, A.C. 1937. Life histories of North American birds of prey. Part I. U.S Nat. Mus. Bull.

Berris, Catherine, and Associates Incorporated. 1995. Northeast Coquitlam Environmental Assessment. Prepared for the City of Coquitlam.

Bessinger, Steven, R. and David Osborne. 1982. Effects of urbanization on avian community organization. Condor 84:75-83.

Brooke, M. and Tim Birkhead, ed. 1991. The Cambridge encyclopedia of ornithology. Cambridge University Press. 362pp.

Burt, William, H., and Richard P. Grossenheider. 1980. A field guide to the mammals of North America: Peterson Field Guide. Houghton Mifflen Press.

Campbell, R. Wayne, Neil K. Dawe, Ian McTaggart-Cowan, John M. Cooper, Gary W. Kaiser, Micheal C.E. McNall. 1990. The birds of British Columbia – Vol. 1-4. Univ. B.C. Press.

Cannings, Richard, J. and A.P. Harcombe (eds.). 1990. The Vertebrates of British Columbia: Scientific and English names. Royal British Columbia Museum Heritage Record No. 20; Wildlife Report No R24. Ministry of Municipal Affairs, Recreation and Culture and Min. of Environ., Victoria, B.C.

City of Coquitlam. 2001. Northeast Coquitlam Official Community Plan (July 2001).

City of Port Coquitlam. 2001). City of Port Coquitlam Tree Cutting Permit Bylaw (May 2001).

City of Port Coquitlam. 2002. Watercourse and river protection development permit areas. City of Port Coquitlam.

Coast River Environmental Services Ltd. 2001. Sampling and Designation of Previously unclassified Watercourses in the City of Coquitlam (Coast River Environmental Services Ltd.) (January 2001).

Cole, David. 1978. Estimating the susceptibility of wildland vegetation to trailside alteration. J. of Appl. Ecol. 15:281-286.

Corkan, Charlotte, C., and Chris Thoms. 1996. Amphibians or Oregon, Washington and British Columbia: A field identification guide. Lone Pine Press, pp175.

Corn, P. S., and R. B. Bury. 1991. Terrestrial amphibian communities in the Oregon Coast Range. Pages 305-317 in L.F. Ruggiero, K. B. Aubry, A. B. Carey and M. H. Huff, editors. Wildlife and vegetation of unmanaged Douglas-fir forests. General Technical Report PNW-GTR-285. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Craig, Vanessa. 2003a. Pacific water shrew, information pamphlet for local planners (Draft). Prepared by EcoLogic Research for the Pacific Water Shrew Recovery Team March 31, 2003.

Craig, Vanessa. 2003b. Species account and preliminary habitat ratings for Pacific water shrew (*Sorex bendirii*). Prepared by: Ecologic Research for the Ministry of Water, Land and Air Protection (March 2003).

Dale, D., and T. Weaver. 1974. Trampling effects on vegetation of the trail corridors of North Rocky Mountain forests. J. of Appl. Ecol. 11(2):767-772.

Daugherty, C. H., and A. L. Sheldon. 1982. Age-determination, growth, and life history of a Montana population of the tailed frog (*Ascaphus truei*). Herpetologica 38: 461-468.

Dayton & Knight Ltd. 1998. Northeast Coquitlam Terrain and Watershed Study. Prepared for the City of Coquitlam.

Dayton & Knight Ltd. 1999. Best Management Practices Guide for Stormwater Appendix H Construction Site Erosion and Sediment Control Guide. Greater Vancouver Regional District.

DeGraaf, Richard M., and Alex L. Shigo. 1985. Managing cavity trees for wildlife in the northeast. United States Dept. of Agri. Forest Service. Northern Forest Experiment Station. General Tech. Report NE-101. p.21.

Department of Fisheries and Oceans. 1993. Land development guidelines for the protection of aquatic habitat. *Complied and edited by* Barry Chillibeck, Dept. of Fisheries and Oceans and Geoff Chislett and Gary Norris, Ministry of Environment, Lands and Parks. 129 pp.

Department of Fisheries and Oceans. FISHERIES ACT [RSBC 1996] CHAPTER 149.

Diller, L. V., and R. L. Wallace. 1999. Distribution and habitat of *Ascaphus truei* in streams on managed, young growth forests in north coastal California. Journal of Herpetology 33: 71

Doyle, A.T. 1990. Use of riparian and upland habitats by small mammals. Journal of Mammalogy, 71(1):14-23.

Dupuis, L., and D. Steventon. 1999. Riparian management and the tailed frog in northern coastal forests. Forest Ecology and Management 124: 35-43.

Ehrlich, Paul, E. Dobkin, David, S. and Darryl Wheye. 1988. The birder's handbook: A field guide to the natural history of North American birds. 785pp.

Envirowest (ECL Envirowest Consultants). 1997. Watercourse classification of the northeast Coquilam Study Area.

Galindo-Leal, Carlos, and J. Bruce Runciman. 1994. Status on the pacific water shrew *Sorex bendirii* in Canada. Prepared for the Committee on the Status of Endangered Wildlife in Canada.

Gashwiler, J.S. 1976. Notes on the reproduction of Trowbridge's shrews in western Oregon. Murrelet 57:58-62.

George, S.B. 1989. Sorex trowbridgii. Mammalian Species 337.

Goldman, Steven, J., Katherine Jackson, and Taras A. Bursztynsky. 1986. Erosion and sediment control handbook. McGraw Hill Book Co.

Graham, D.,S. 1988. Habitat management guidelines for forest birds of the Norfolk sand plain. Bird Studies Canada, Long Point Bird Obs. 68p.

Green M. David, and R. Wayne Campbell 1992. The amphibians of British Columbia. Royal British Columbia Museum Handbook No. 45. pp.100.

Gregory Patrick, T., and R. Wayne Campbell 1996. The Reptiles of British Columbia. Royal British Columbia Museum Handbook No. 45. pp.102.

Hammer ,Donald, A. 1992. Creating freshwater wetlands. Lewis Pub. 298 pp.

Hammer, D.,A. 1989. Constructed wetlands for wastewater treatment, municipal, industrial and agricultural.831 pp.

Harrison, H.H., 1979. A field guide to western birds' nests. Boston, MA: Houghton Mifflin Co. 279 p.

Harrison, H.H. 1979. A field guide to western birds' nests. Boston, MA: Houghton Mifflin Co. 279 p.

Hobbs, R.J. and Huenneke, L.F. 1992. Disturbance, diversity, and invasion: Implications for conservation. Conservation Biology 6:324-337.

Hayes, M. P. 1996. Wildlife issues pertaining to amphibians and the western pond turtle (*Clemmys marmorata*) on the North Umpqua Hydroelectric Project area. Prepared for USDA Forest Service, Umpqua National Forest, Roseburg, Oregon under subcontract to Resources Northwest, Inc.

James, Paul, C. 1988. Urban merlins in Canada. British Birds 81: 274-277.

James, R., D. 1984. Habitat management guidelines for Ontairio's forest nesting Accipiters, Buteos and Eagles. Royal Ontario Mus. Bull. For Ont. Min. Nat. Res. p.33.

Karr, J.R. 1996b. Rivers as Sentinels: Using the biology of rivers to guide landscape management. Pp in RJ. Naiman and R.E. Bilby, eds. *The Ecology and Management of Streams and Rivers in the Pacific Northwest Coastal Ecoregion*. Springer-Verlag, New York.

Kirkley, John, S. and Mark A. Spriger. 1980 Nesting populations of red-tailed hawks and great-horned owls in central Ohio. Raptor Research 14 (1):22-28.

Kolozsvary, Mary, B., and Swihart, Robert, K. 1999. Habitat fragmentation and distribution of amphibians: patch and landscape correlates in farmland. Can. J. Zool. 77:1288-1299.

Kupferberg, S. J. 1996. The ecology of native tadpoles (*Rana boylii* and *Hyla regilla*) and the impact of invading bullfrogs (*Rana catesbeiana*) in a northern California river. Doctoral dissertation. University of California, Berkeley. In http://www.ncasi.org/forestry/secure/headwater/tailfrog.pdf

Leviton, Alan E. 1971. Reptiles and Amphibians of North America. Doubleday & Company, Inc., New York.

Licht, L. E. 1969. Comparative breeding behavior of the red-legged frog (*Rana aurora aurora*) and the western spotted frog (*Rana pretiosa pretiosa*) in southwestern British Columbia. Can. J. Zool. 47:1287-1299.

Licht, L. E. 1970. Breeding habitats and embryonic thermal requirements of the frogs, *Rana aurora* and *Rana pretiosa pretiosa,* in the Pacific Northwest. Ecology 52(1):116-124.

Licht, L. E. 1971. Breeding habits and embryonic thermal requirements of the frogs (*Rana aurora aurora*) and (*Rana pretiosa pretiosa*), in the Pacific Northwest. Ecology 52:116-124.

Lynn, Natasha A., and Robert D. Brown. 2002. Effects of recreational use impacts on hiking experiences in natural areas. Landscape and Urban Planning 976:1-11.

Marin County. 2003. Marin county stormwater pollution prevention program. P.O. Box 4186 San Rafael, CA 94913-4186. Newsletter. Marin County, CA.

Marshall, D. B., M. W. Chilcote, and H. Weeks. 1996. Species at risk: sensitive, threatened and endangered vertebrates of Oregon. Second edition. Oregon Department of Fish and Wildlife, Portland.

Maser, Chris 1998. Mammals of the Pacific Northwest: From the Coast to the High Cascades. Oregon State University Press.

Mattison, Chris. 1995. The Encyclopedia of Snakes. Facts on File, Inc., New York.

McComb, W.C., K. McGarigal and R.G. Anthony. 1993. Small mammal and amphibian abundance in streamside and upslope habitats of mature Douglas-fir stands, western Oregon. Northwest Science 67:7-15.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. B.C. Ministry of Forests, Victoria, B.C.

Meunier, Francis, D. Johanna Corbin, Christophe, Verheyden, and Pierre Jouventin. 1999. Effects of landscape type and extensive management on use of motorway roadsides by small mammals. Can. J. Zool. 77:108-117.

Miller James, R., and N. Thompson Hobbs. 2000. Recreational trails, human activity, and nest predation in lowland riparian areas. Landscape and Urban Planning 50:227-236

Ministry of Environment, Lands and Parks (MELP). 2001. Best Management Practices - Land Development. Vancouver Island Region (Region 1).

Ministry of Environment, Lands and Parks (MELP). 2000. Fish Protection Act Streamside Protection Regulation (January 2001).

Ministry of Environment, Lands and Parks (MELP). 2000. Best Management Practices for Streambeds and Streambanks (September 2000).

Ministry of Environment, Lands and Parks (MELP). 2000. Best Management Practices for Wildlife (September 2000).

Ministry of Environment, Lands and Parks (MELP). 2000. Best Management Practices to Protect Water Quality (September 2000).

Ministry of Environment, Lands and Parks (MELP). September 2000. Best management Practices for Urban Runoff (September 2000).

Ministry of Environment, Lands and Parks (MELP). 1988. *Water Act* Water Regulation (Part 7 Changes in and about a Stream).

Ministry of Environment, Lands and Parks (MELP). 1995. Biodiversity Guidebook. Internet web site: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

Ministry of Environment, Lands and Parks (MELP). 1997. B.C. Conservation Data Centre: Rare Vertebrate Animal Tracking List. Internet web site: http://www.env.gov.bc.ca/wld/cdc/atrkprov.htm

Ministry of Environment, Lands and Parks (MELP). 1997. B.C. Conservation Data Centre: Rare Vertebrate Animal Tracking List. Internet web site: http://www.env.gov.bc.ca/wld/cdc/atrkprov.htm

Ministry of Environment, Lands and Parks (MELP). 1998. Inventory Methods for Small Mammals: Shrews, Voles , Mice & Rats. Standards for Components of British Columbia's Biodiversity, N0. 31.

Ministry of Water, Land and Air Protection - Ministry of Forests Web page hhttp://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/other/species/species%2D15.htm

Montana Fish And Wildlife Parks Department. 2003. http://www.fwp.state.mt.us/parks/smith/default

Nagorsen David, W. 1996. Opossums shrews and moles of British Columbia. Royal British Columbia Museum handbook.

Nussbaum, R.A., E.D. Brodie and R.M. Storm. 1983. Amphibians and Reptiles of the Pacific Northwest. University Press of Idaho.

Palmer, R S. 1988. Handbook of North American Birds, Diurnal Raptors. Vol. 4 and 5. Palmer (ed.). Yale Univ. Press, New Haven, CT. Smithsonian Institution.

Pattie, D. 1973. *Sorex bendirii*. Mammalian Species 27.

Pritchett, William L. 1979. Properties and management of forest soils. John Wiley and Sons, Inc. p. 500.

Resource Inventory Standards Committee. 1999. British Columbia wildlife habitat rating standards. Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee (Version 2.0).

Resource Inventory Standards Committee. 1998. Inventory Methods for Marsh Birds: Bitterns and Rails Standards for Components of British Columbia's Biodiversity No. 7 Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee October 7, 1998 (Version 2.0);

Resource Inventory Committee, Wildlife Branch. 1997. Inventory Methods for Pond-breeding Amphibians and Painted Turtle Standards or Components of British Columbia's Biodiversity No. 37 (Version 2.0).

Resource Inventory Standards Committee, Wildlife Branch. 2001. Standard Inventory Methodologies for Components of British Columbia's Biodiversity: Raptors (Version 1.1).

Resource Inventory Committee, Wildlife Branch. Conducting Wildlife Inventory" in Species Inventory Fundamentals (No.1).

Riley, John, L. and Pat Mohr. 1994. The natural heritage of southern Ontario's settled landscapes: A review of Conservation and restoration ecology for land-use and landscape planning. Ont. Min. Nat. Res. 77pp.

Robbins, C. S., J. R. Sauer, R. S. Greenberg and Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proceedings of the National Acadamy of Sciences 86:7658-7662.

Rodreguez, Alejando, Guila Crema, and Miguel Delibes. 1996. Use of non wildlife passages across high speed railway by terrestrial vertebrates. J. Appl. Ecol. 33(6):1527-1540.

Rosenfield, R. N., and J. Bielefeldt. 1993. Cooper's Hawk. The Birds of North America, No. 75. Edited by Poole, A., and F. Gill. The academy of natural sciences of Philadelphia. pp 23.

Sandilands, A. P., and Steve Houndsel. undated. Affects of 500kv transmission facilities on forest birds on two wetland forest ecosystems in southern Ontario-Testing for edge effect. Ont. Hydro, Tor. Ont. 12 pp.

Scott, G. Mills, Jouhn, B. Dunning, Jr. and John M. Bates. 1998. Effects of urbanization on breeding bird community structure in southwestern desert habitats. Condor 91:416-428.

Sibley David Allen. 2000. The Sibley guide to birds. National Audubon Society 3rd Ed. Alfred A. Knopf, New York pp 544.

Snodhi, N. S., L. W. Oliphant, P. C. James and I. G. Warkentin. 1993. Merlin. The Birds of North America, No. 44. Edited by Poole, A., and F. Gill. The academy of natural sciences of Philadelphia. pp 19.

Snyder, N. F. R. and H. A. Snyder. 1991. Birds of prey: natural history and conservation of North American raptors. Voyageur Press, Inc. Stillwater MN.

Stebbins, R.C. 1954. Amphibians and Reptiles of Western North America. McGraw-Hill, New York.

Stevens, Kim, A., Patrick Graham, and David Ried. 2002. Stormwater planning: a guidebook for British Columbia. British Columbia Ministry of Water, Lands and Air Protection.

Stillwater Sciences. 2001. NCASI Headwater Streams Project (January 2001). http://www.ncasi.org/forestry/secure/headwater/tailfrog.pdf

Terborgh. J. 1992a. Perspectives on conservation of neotropical migrant land birds. Pp. 7-12, in J. M. Hagan and D.W. Johnston (eds.). Ecology and Conservation of Neotropical Landbirds, Smithsonian Institution Press. 609 pp.

Terborgh. J. 1992b. Why American songbirds are vanishing. Scientific American 266(5):98-104

Andersen, D.E., O.J. Rongstad, and W.R. Mytton. 1985. Line transect analysis of raptor abundance along roads. Wildl. Soc. Bull. 13:533-539.

Tweit, Robert, C., and Joan C. Tweit. 1986. Urban development effects on the abundance of some common resident birds of the Tucson area of Arizona. Amer. Birds 40: 431-436.

U.S. Dept. of Agriculture and Forest Service. 1979. Wildlife habitat in managed forests: the blue mountains or Oregon and Washington. ed. Jack Ward Thomas. Agriculture handbook No. 553.

Van Zyll de Jong, C.G. 1983. Handbook of Canadian Mammals: Marsupials and Insectivores. National Museum of Sciences, National Museums of Canada.

Vantyne, Josselyn and Berger Andrew, J. 1971. The fundamentals of ornithology. Dover Pub. Inc. New York. 624 pp.

Welsh, Hartwell, H., Jr., and Sam Droege. 2001. A case for using Plethodontid salamanders for monitoring biodiversity and ecosystem integrity of North American forests. Conservation Biology 15(3):558-569.

Whittaker, J.O. Jr., and C. Maser. 1976. Food habits of five western Oregon shrews. Northwest Science 50:102-7

Appendix A

(Conservation Data Center's Vertebrate Tracking List for the Chilliwack Forest District and COSEWIC Listed Species of Concern)

B.C. COSEWIC SPECIES[1]

COSEWIC Mandate

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, mosses, and lichens.

DEFINITIONS

SPECIES - Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.

EXTINCT - A species that no longer exists.

EXTIRPATED - A species no longer existing in the wild in Canada, but occurring elsewhere.

ENDANGERED - A species facing imminent extirpation or extinction.

THREATENED - A species likely to become endangered if limiting factors are not reversed.

SPECIAL CONCERN - A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

NOT AT RISK - A species that has been evaluated and found to be not at risk.

DATA DEFICIENT - A species for which there is insufficient scientific information to support status designation.

[1] **Source:** May 2003 COSEWIC List http://www.elements.nb.ca/theme/endangeredspecies/legislation/es.htm

EXTINCT

Mammals (1)

Caribou Dawson's subspecies, Woodland *Rangifer tarandus dawsoni* BC 1920s May 2000

Birds (0)

Reptiles (0)

Amphibians (0)

Fishes (2)

Stickleback, Benthic Hadley Lake *Gasterosteus* sp. BC 1999 May 2000

Stickleback, Limnetic Hadley Lake *Gasterosteus* sp. BC 1999 May 2000

Lepidopterans (0)

Molluscs (0)

Plants (0)

Mosses (0)

Lichens (0)

EXTIRPATED CATEGORY

Mammals (0)

Birds (1)

Grouse, Sage *Centrocercus urophasianus phaios.* Not observed since 1960s May 2000

Reptiles (3)

Gophersnake, Pacific *Pituophis catenifer catenifer.* BC not observed since 1957 May 2002

Lizard, Pygmy Shorthorned *Phrynosoma douglassii douglassii.* BC last reported in 1898, near Osoyoos, BC May 2000

Turtle, Pacific Pond *Clemmys marmorata.* BC not observed since 1959 May 2002

Lepidopterins (1)

Marble, Island *Euchloe ausonides* BC before 1910 May 2000

ENDANGERED CATEGORY

Mammals (3)

Badger *jeffersonii* subspecies, *Taxidea taxus jeffersonii* BC May 2000

Marmot, Vancouver Island *Marmota vancouverensis* BC May 2000

Mole, Townsend's *Scapanus townsendii* BC May 2003

Birds (7)

Chat, Western Yellowbreasted *Icteria virens auricollis* British Columbia population BC Nov 2000

Curlew, Eskimo *Numenius borealis* YT NT NU BC AB SK MB ON QC NB NS PE NF May 2000

Owl, Burrowing *Athene cunicularia* BC AB SK MB May 2000

Owl, Northern Spotted *Strix occidentalis caurina* BC May 2000

Screech-owl *macfarlanei Otus kennicottii macfarlanei* BC May 2002 subspecies, Western

Thrasher, Sage *Oreoscoptes montanus* BC AB SK Nov 2000

Woodpecker, White-headed *Picoides albolarvatus* BC Nov 2000

Reptiles (2)

Nightsnake *Hypsiglena torquata* BC May 2001

Snake, Sharp-tailed *Contia tenuis* BC Oct 1999

Amphibians (4)

Frog, Northern Leopard *Rana pipiens* Southern Mountain population BC May 2000

Frog, Oregon Spotted *Rana pretiosa* BC May 2000

Frog, Rocky Mountain Tailed *Ascaphus montanus* BC May 2000

Salamander, Tiger *Ambystoma tigrinum* Southern Mountain population BC Nov 2001

Fishes (11)

Dace, Nooksack *Rhinichthys* sp. BC May 2000

Dace, Speckled *Rhinichthys osculus* BC Nov 2002

Lamprey, Morrison Creek *Lampetra richardsoni* BC May 2000

Salmon, Coho *Oncorhynchus kisutch* Interior Fraser population BC May 2002

Salmon, Sockeye *Oncorhynchus nerka* Cultus population BC Pacific Ocean May 2003

Salmon, Sockeye *Oncorhynchus nerka* Sakinaw population BC Pacific Ocean May 2003

Stickleback, Benthic Paxton Lake *Gasterosteus* sp. BC May 2000

Stickleback, Benthic Vananda Creek *Gasterosteus* sp. BC May 2000

Stickleback, Limnetic Paxton *Gasterosteus* sp. BC May 2000

Stickleback, Limnetic Vananda Creek *Gasterosteus* sp. BC May 2000

Sucker, Salish *Catostomus* sp. BC Apr 1986

Lepidopterans (3)

Blue, Island *Plebejus saepiolus insulanus* BC Nov 2000

Checkerspot, Taylor's *Euphydryas editha taylori* BC Nov 2000

Metalmark, Mormon *Apodemia mormo* Southern Mountain population BC May 2003

Molluscs (2)

Forestsnail, Oregon *Allogona townsendiana* BC Nov 2002

Physa, Hotwater *Physella wrighti* BC May 2000

Plants (16)

Ammannia, Scarlet *Ammannia robusta* BC ON May 2001

Balsamroot, Deltoid *Balsamorhiza deltoidea* BC May 2000

Bugbane, Tall *Cimicifuga elata* BC May 2001

Buttercup, Water-plantain *Ranunculus alismaefolius* var. *alismaefolius* BC May 2000

Catchfly, Coastal Scouler's *Silene scouleri* ssp. *grandis* BC May 2003

Fern, Southern Maidenhair *Adiantum capillus-veneris* BC May 2000

Lotus, Seaside Birds-foot *Lotus formosissimus* BC May 2000

Lupine, Prairie *Lupinus lepidus* var. *lepidus* BC May 2000

Lupine, Streambank *Lupinus rivularis* BC Nov 2002

Owl-clover, Bearded *Triphysaria versicolor* ssp. *versicolor* BC May 2000

Paintbrush, Golden *Castilleja levisecta* BC May 2000

Rush, Kellogg's *Juncus kelloggii* BC May 2003

Sanicle, Bear's-foot *Sanicula arctopoides* BC May 2001

Toothcup *Rotala ramosior* BC ON May 2000

Triteleia, Howell's *Triteleia howellii* BC May 2003

Woolly-heads, Tall *Psilocarphus elatior* Pacific population BC May 2001

Mosses (4)

Moss, Margined Streamside *Scouleria marginata* BC Nov 2002

Moss, Poor Pocket *Fissidens pauperculus* BC Nov 2001

Moss, Rigid Apple *Bartramia stricta* BC May 2000

Moss, Silver Hair *Fabronia pusilla* BC Nov 2002

Lichens (1)

Seaside Centipede *Heterodermia sitchensis* BC May 2000

THREATENED CATEGORY

Mammals (6)

Bat, Pallid *Antrozous pallidus* BC May 2000

Bison, Wood *Bison bison athabascae* YT NT BC AB May 2000

Caribou, Woodland *Rangifer tarandus caribou* Boreal population NT BC AB SK MB ON QC NF May 2002

Caribou, Woodland *Rangifer tarandus caribou* Southern Mountain population BC AB May 2002

Ermine *haidarum* subspecies *Mustela erminea haidarum* BC May 2001

Shrew, Pacific Water *Sorex bendirii* BC May 2000

Birds (3)

Falcon, Anatum Peregrine *Falco peregrinus anatum* YT NT NU BC AB SK MB ON QC NB NS NF May 2000

Goshawk, Queen Charlotte *Accipiter gentilis laingi* BC Nov 2000

Murrelet, Marbled *Brachyramphus marmoratus* BC Nov 2000

Reptiles (11)

Snake, Great Basin Gopher *Pituophis catenifer deserticola* BC May 2002

Reptiles (0)

Amphibians (2)

Salamander, Pacific Giant *Dicamptodon tenebrosus* BC Nov 2000

Spadefoot, Great Basin *Spea intermontana* BC Nov 2001

Fishes (3)

Lamprey, Cowichan Lake *Lampetra macrostoma* BC Nov 2000

Sculpin, Cultus Pygmy *Cottus* sp. BC Nov 2000

Sculpin, Shorthead *Cottus confusus* BC May 2001

Lepidopterans (2)

Hairstreak, Behr's (Columbia) *Satyrium behrii columbia* BC Nov 2000

Skipper, Dun *Euphyes vestris* Western population BC Nov 2000

Molluscs (1)

Jumping-slug, Dromedary *Hemphillia dromedarius* BC May 2003

Plants (8)

Aster, White-top *Sericocarpus rigidus* BC May 2000

Corydalis, Scouler's *Corydalis scouleri* BC May 2001

Fern, Lemmon's Holly *Polystichum lemmonii* BC May 2003

Lily, Lyall's Mariposa *Calochortus lyallii* BC May 2001

Mosquito-fern, Mexican *Azolla mexicana* BC May 2000

Orchid, Phantom *Cephalanthera austiniae* BC May 2000

Sanicle, Purple *Sanicula bipinnatifida* BC May 2001

Violet, Yellow Montane *Viola praemorsa* ssp. *praemorsa* BC May 2000

Mosses (1)

Moss, Haller's Apple *Bartramia halleriana* BC AB Nov 2001

Lichens (0)

Skink, Western *Eumeces skiltonianus* BC May 2002

Amphibians (4)

Frog, Coast Tailed *Ascaphus truei* BC May 2000

Frog, Northern Red-legged *Rana aurora* BC May 2002

Salamander, Coeur d'Alène *Plethodon idahoensis* BC Nov 2001

Toad, Western *Bufo boreas* YT NT BC AB Nov 2002

Fishes (6)

Dace, Umatilla *Rhinichthys umatilla* BC Apr 1988

Sculpin, Columbia Mottled *Cottus bairdi hubbsi* BC May 2000

Stickleback, Giant *Gasterosteus* sp. BC Apr 1980

Sticklebacks, Charlotte Unarmoured *Gasterosteus* sp. BC Apr 1983

Sturgeon, Green *Acipenser medirostris* BC Apr 1987

Sturgeon, White *Acipenser transmontanus* BC Apr 1990

Lepidopterans (1)

Monarch *Danaus plexippus* BC AB SK MB ON QC NB NS PE Nov 2001

Molluscs (2)

Jumping-slug, Warty *Hemphillia glandulosa* BC May 2003

Oyster, Olympia *Ostrea conchaphila* BC Nov 2000

Plants (4)

Beggarticks, Vancouver Island *Bidens amplissima* BC Nov 2001

Fern, Coastal Wood *Dryopteris arguta* BC Nov 2001

Helleborine, Giant *Epipactis gigantea* BC Apr 1998

Meadowfoam, Macoun's *Limnanthes macounii* BC Apr 1988

Mosses (0)

Lichens (4)

Cryptic Paw *Nephroma occultum* BC Apr 1995

Oldgrowth Specklebelly *Pseudocyphellaria rainierensis* BC Apr 1996

Seaside Bone *Hypogymnia heterophylla* BC Apr 1996

NOT AT RISK

Mammals (5)

Bear, American Black *Ursus americanus* YT NT NU BC AB SK Apr 1999 MB ON QC NB NS NF

Lynx, Canada *Lynx canadensis* YT NT NU BC AB SK May 2001 MB ON QC NB NS NF

Squirrel, Cascade Mantled Ground *Spermophilus saturatus* BC Apr 1992

Wolf, Northern Grey *Canis lupus occidentalis* YT NT NU BC AB SK MB ON QC NF Apr 1999

Wolf, Southern Grey *Canis lupus nubilus* BC Apr 1999

Birds (27)

Coot, American *Fulica americana* YT NT NU BC AB SK MB ON QC NB NS Apr 1991

Cormorant, Double-crested *Phalocrocorax auritus* YT NT BC AB SK MB Apr 1978 ON QC NB NS PE NF

Crane, Greater Sandhill *Grus canadensis tabida* BC MB ON Apr 1979

Eagle, Bald *Haliaeetus leucocephalus* YT NT NU BC AB SK Apr 1984 MB ON QC NB NS PE NF

Eagle, Golden *Aquila chrysaetos* YT NT NU BC AB SK MB ON QC NF Apr 1996

Falcon, Prairie *Falco mexicanus* BC AB SK Apr 1996

Flycatcher, Grey *Empidonax wrightii* BC Apr 1992

Goshawk, Northern *Accipiter gentilis atricapillus* YT NT NU BC AB SK Apr 1995 MB ON QC NB NS PE NF

Grebe, Red-necked *Podiceps grisegena* YT NT NU BC AB SK Apr 1982 MB ON QC NS NF

Gyrfalcon *Falco rusticolus* YT NT NU BC AB SK Apr 1987 ON QC NS PE NF

Harrier, Northern *Circus cyaneus* YT NT NU BC AB SK Apr 1993 MB ON QC NB NS PE NF

Hawk, Cooper's *Accipiter cooperii* BC AB SK MB ON QC NB NS Apr 1996

Hawk, Red-tailed *Buteo jamaicensis* YT NT NU BC AB SK Apr 1995 MB ON QC NB NS PE NF

Hawk, Rough-legged *Buteo lagopus* YT NT NU BC MB ON QC NF Apr 1995

Hawk, Sharp-shinned *Accipiter striatus* YT NT NU BC AB SK Apr 1997 MB ON QC NB NS PE NF

Loon, Common *Gavia immer* YT NT NU BC AB SK Apr 1997 MB ON QC NB NS PE NF

Loon, Yellow-billed *Gavia adamsii* YT NT NU BC AB MB QC Apr 1997

Merlin *Falco columbarius* YT NT NU BC AB SK Apr 1985 MB ON QC NB NS PE NF

Owl, Boreal *Aegolius funereus* YT NT NU BC AB SK Apr 1995 MB ON QC NB NS PE NF

Owl, Great Grey *Strix nebulosa* YT NT BC AB SK MB ON QC Apr 1996

Owl, Northern Hawk *Surnia ulula* YT NT BC AB SK MB Apr 1992 ON QC NB NF

Pelican, American White *Pelecanus erythrorhynchos* BC AB SK MB ON Apr 1987

Sparrow, Nelson's Sharp-tailed *Ammodramus nelsoni* BC AB SK MB ON QC NB NS PE Apr 1998

Swan, Trumpeter *Cygnus buccinator* YT NT BC AB SK ON Apr 1996

Tern, Black *Chlidonias niger* NT BC AB SK MB ON QC NB NS Apr 1996

Tern, Caspian *Sterna caspia* NT BC AB SK MB ON QC NF Apr 1999

Wren, Canyon *Catherpes mexicanus* BC Apr 1992

Reptiles (3)

Gartersnake, Northwestern *Thamnophis ordinoides* BC May 2003

Lizard, Northwestern Alligator *Elgaria coerulea principis* BC May 2002

Racer, Western Yellow-bellied *Coluber constrictor mormon* BC Apr 1991

Amphibians (4)

Ensatina *Ensatina eschscholtzii* BC Apr 1999

Frog, Columbia Spotted *Rana luteiventris* YT BC AB May 2000

Salamander, Northwestern *Ambystoma gracile* BC Apr 1999

Red-backed *Plethodon vehiculum* BC Nov 2001

Fishes (5)

Chiselmouth *Acrocheilus alutaceus* BC May 2003

Dace, Leopard *Rhinichthys falcatus* BC Apr 1990

Sculpin, Spoonhead *Cottus ricei* YT NT BC AB SK MB ON QC Apr 1989

Sucker, Mountain *Catostomus platyrhynchus* BC AB SK Apr 1991

Y-Prickleback *Allolumpenus hypochromus* BC Apr 1991

SPECIAL CONCERN CATEGORY

Mammals (9)

Bat, Fringed *Myotis thysanodes* BC Apr 1988

Bat, Keen's Long-eared *Myotis keenii* BC Apr 1988

Bat, Spotted *Euderma maculatum* BC Apr 1988

Bear, Grizzly *Ursus arctos* YT NT NU BC AB May 2002

Beaver, Mountain *Aplodontia rufa* BC Nov 2001

Caribou, Woodland *Rangifer tarandus caribou* Northern Mountain population YT NT BC May 2002

Cottontail, Nuttall's *Sylvilagus nuttallii nuttallii* British Columbia population BC Apr 1994

Mouse, Western Harvest *Reithrodontomys megalotis megalotis* British Columbia population BC Apr 1994

Wolverine *Gulo gulo* Western population YT NT NU BC AB SK Apr 1989 MB ON

Birds (10)

Curlew, Long-billed *Numenius americanus* BC AB SK Apr 1992

Falcon, Peale's Peregrine *Falco peregrinus pealei* BC Nov 2001

Heron, Pacific Great Blue *Ardea herodias fannini* BC Apr 1997

Murrelet, Ancient *Synthliboramphus antiquus* BC Apr 1993

Owl, Barn *Tyto alba* Western population BC Nov 2001

Owl, Flammulated *Otus flammeolus* BC Nov 2001

Owl, Short-eared *Asio flammeus* YT NT NU BC AB SK Apr 1994 MB ON QC NB NS PE NF

Rail, Yellow *Coturnicops noveboracensis* NT BC AB SK MB ON QC NB Nov 2001

Screech-owl *kennicottii Otus kennicottii kennicottii* BC May 2002 subspecies, Western

Woodpecker, Lewis's *Melanerpes lewis* BC Nov 2001

Reptiles (2)

Boa, Rubber *Charina bottae* BC May 2003

Lepidopterans (0)

Molluscs (1)

Capshell, Rocky Mountain *Acroloxus coloradensis* Western population BC AB Nov 2001

Plants (4)

Brickellia, Large-flowered *Brickellia grandiflora* BC AB Apr 1996

Fameflower *Talinum sediforme* BC Apr 1990

Rhododendron, Pacific *Rhododendron macrophyllum* BC Apr 1997

Wooly-heads, Slender *Psilocarphus tenellus* var. *tenellus* BC Apr 1996

Mosses (0)

Lichens (0)

DATA DEFICIENT

Mammals (0)

Birds (1)

Poorwill, Common *Phalaenoptilus nuttallii* BC AB SK Apr 1993

Tern, Forster's *Sterna forsteri* BC AB SK MB ON Apr 1996

Reptiles (0)

Amphibians (0)

Fishes (0)

Lepidopterans (0)

Molluscs (0)

Plants (1)

Goldenweed, Rabbit-brush *Ericameria bloomeri* BC Apr 1997

Mosses (0)

Lichens (0)

Appendix B

(Sensitive Habitat Inventory and Mapping Partnership (SHIM))

Table B1 - Important Fish Habitat Identified by SHIM Mapping

Locations	Associated Creek	Habitat Type	Bank Side
1	Lower Hyde Trib. 10	Deep Pool	Instream
2	Lower Hyde Trib. 10	Deep Pool	Instream
3	Lower Hyde Trib. 10	Deep Pool	Instream
4	Lower Hyde Trib. 10	Large Woody Debris	Instream
5	Lower Hyde Trib. 10	Deep Pool	Instream
6	Burke Mtn.	Deep Pool	Instream
7	West Smiling Crk.	Large Woody Debris	Both
8	Absent Trib.	Large Woody Debris	Both
9	Absent Trib.	Large Woody Debris	Both
10	Lower Hyde Trib. 10	Large Woody Debris	Both
11	Watkins Creek	Large Woody Debris	Instream
12	Watkins Creek	Deep Pool	Left
13	Watkins Creek	Large Woody Debris	Instream
14	Watkins Creek	Deep Pool	Instream
15	Watkins Creek	Deep Pool	Instream
16	Watkins Creek	Large Woody Debris	Instream
17	Watkins Creek	Deep Pool	Instream
18	Watkins Creek	Large Woody Debris	Instream
19	Watkins Creek	Deep Pool	
20	Watkins Creek	Deep Pool	Instream
21	Watkins Creek	Deep Pool	Both
22	East Smiling Crk.	Deep Pool	Instream
23	East Smiling Crk.	Undercut Bank	Both
24	Lower East Smiling Crk.	Undercut Bank	Right
25	Lower East Smiling Crk.	Spawning Habitat	Instream
26	Lower East Smiling Crk.	Deep Pool	Instream
27	Lower East Smiling Crk.	Deep Pool	Instream
28	Lower East Smiling Crk.	Deep Pool	Instream
29	Lower East Smiling Crk.	Deep Pool	Instream
30	Lower East Smiling Crk.	Deep Pool	Instream
31	Lower East Smiling Crk.	Deep Pool	
32	Lower East Smiling Crk.	Deep Pool	Instream
33	Lower East Smiling Crk.	Undercut Bank	Both
34	Lower East Smiling Crk.	Other	Right
35	Lower East Smiling Crk.	Deep Pool	Instream
36	Lower East Smiling Crk.	Deep Pool	Instream
37	Lower Burke Mtn. Crk.	Deep Pool	Instream
38	Lower Burke Mtn. Crk.	Large Woody Debris	Both
39	Lower Hyde Crk.	Deep Pool	Instream
40	Lower Hyde Crk.	Spawning Habitat	Instream
41	Lower Hyde Crk.	Undercut Bank	Both
42	Hyde Creek	Spawning Habitat	Instream
43	Hyde Creek	Spawning Habitat	Instream
44	Lower Hyde Crk.	Deep Pool	Instream
45	Hyde Creek	Deep Pool	Instream
46	Hyde Creek	Undercut Bank	Left
47	Hyde Creek	Undercut Bank	Right
48	Hyde Creek	Undercut Bank	Left

Table B2 - Obstructions in Hyde and Watkins Creek Identified in SHIM Mapping

Location	Creek	Obstruction Type	Barrier	Comments
1	Lower Hyde	Rock	Yes	Boulders along Hyde Crk. Causing channel obstruction at confluence
2	Watkins	Cascade	Potential	Veg. barrier
3	Watkins		unknown	Veg. barrier
4	Watkins	Fences	Potential	
5	Watkins	Fences	Yes	Fence with wire down to bottom
6	Watkins	Fences	Yes	Wire fence down to stream
7	Watkins	Fences	Potential	Wire fence
8	Watkins	Fences	Yes	Wire fence to stream surface
9	Watkins	Fences	Potential	Offset due to fence barrier, wire fence 0.3m to stream, unknown depth of water debris in fence
10	Watkins	Fences	Potential	
11	Watkins	Persistent Debris	Potential	

Table B3 - Erosion Sites Identified in Hyde, Watkins, Smiling and Burke Mountain Creeks in SHIM Mapping

Location	Creek	Source of Erosion	Bank Side	Severity	Exposure
1	Hyde Trib. 12	Bank Erosion	Right	Moderate >5-10m sq	Soil
2	Lower Hyde	Bank Erosion	Left	Severe >10m sq	Soil
3	Watkins	Culvert	Both	Low <5m sq	Soil
4	Watkins	Bank Erosion	Both	Severe >10m sq	Soil
5	Watkins	Bank Erosion	Left	Moderate >5-10m sq	Soil
6	Watkins	Bank Erosion	Left	Moderate >5-10m sq	Soil
7	Watkins	Bank Erosion	Left	Moderate >5-10m sq	Soil
8	Lower E. Smiling	Bank Erosion	Left	Moderate >5-10m sq	Soil
9	Lower Burke Mtn	Bank Erosion	Left	Moderate >5-10m sq	Soil
10	Lower Hyde	Bank Erosion	Right	Moderate >5-10m sq	Soil
11	Lower Hyde	Bank Erosion	Right	Severe >10m sq	Soil
12	Lower Hyde	Bank Erosion	Right	Severe >10m sq	Soil
13	Lower Hyde	Bank Erosion	Left	Moderate >5-10m sq	Roots
14	Hyde	Bank Erosion	Left	Severe >10m sq	Soil
15	Hyde	Bank Erosion	Left	Severe >10m sq	Soil
16	Hyde	Bank Erosion	Right	Moderate >5-10m sq	Soil
17	Hyde	Bank Erosion	Left	Moderate >5-10m sq	Roots

Table B4 - Discharge Locations Identified in the Hyde, Watkins, Smiling and Burke Mountain Creeks from SHIM Data

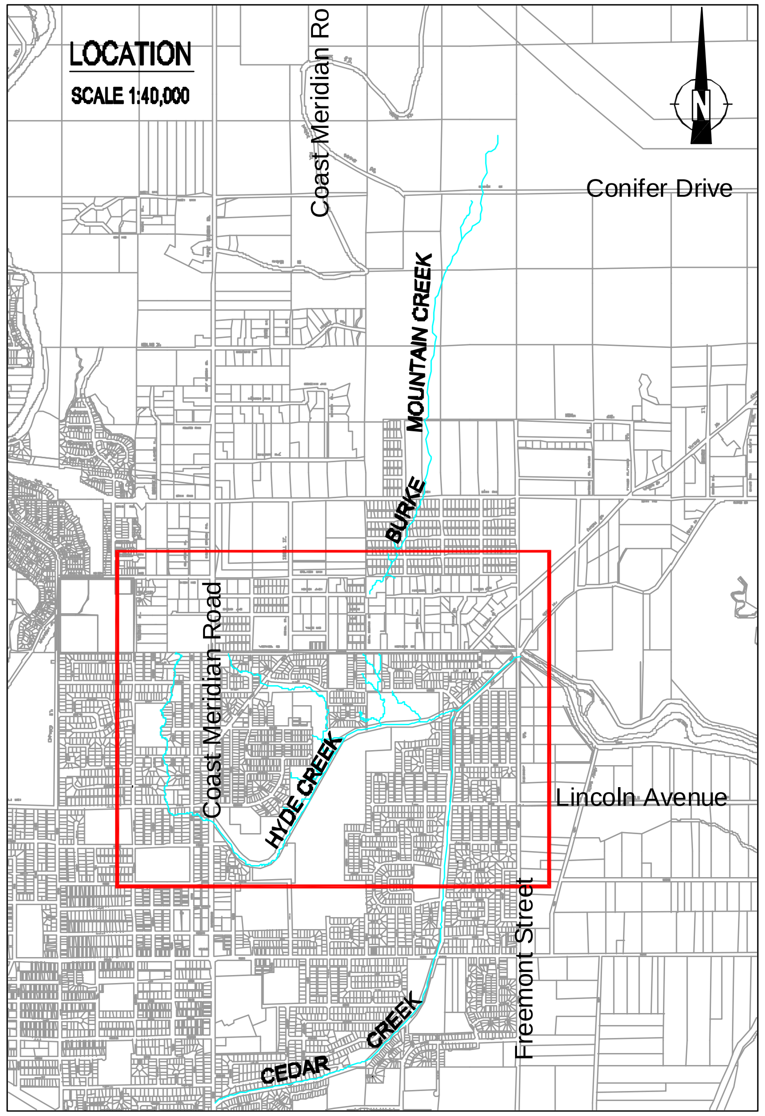
Location	Creek	Discharge Type	Bank Side	Diameter	Comments
1	W. Smiling	Other	Right	0.30	Discharge 5 m from stream; from road - to smiling trib 2
2	W. Smiling	Other	Left	0.10	To smiling trib 2
3	Smiling Trib 1	Other	Left	0.10	pvc material; to smiling trib 1
4	Smiling Trib 2	Other	Right	0.10	From house; to smiling trib 1
5	Burke Mtn	Agricultural Runoff	Left	0.00	
6	Watkins	Storm Drain	Left	0.00	
7	Watkins	HouseEffluent	Left	0.10	drainage from house eaves trough
8	Watkins	HouseEffluent	Right	0.15	seems to be soapy dissappears underground
9	Watkins	HouseEffluent	Right	0.10	2 plastic pipes
10	Watkins	HouseEffluent	Right	0.10	
11	Watkins			0.00	offset from outside fence outfall from pool
12	Watkins			0.20	
13	Watkins	Storm Drain	Right	0.20	
14	Watkins	Storm Drain	Left	0.15	
15	E. Smiling	Other	Left	0.10	PT 6-Smiling trib-Outlet-overflow from pond?
16	Lower Burke		Right	0.10	pt34-Smiling Cr-plastic currogated pipe
17	Lower Hyde	Other	Right	0.30	
18	Cedar	Storm Drain	Right	0.30	
19	Cedar	Storm Drain	Left	0.40	
20	Cedar	Storm Drain	Left	0.50	
21	Cedar	Storm Drain	Left	0.50	
22	Hyde	HouseEffluent	Left	0.25	From Evestrough
23	Lower Hyde	Tile Drain	Instream	0.05	
24	Lower Hyde	HouseEffluent	Right	0.10	Property Drainage
25	Lower Hyde	HouseEffluent	Right	0.05	
26	Lower Hyde	Tile Drain	Left	0.05	
27	Lower Hyde	Storm Drain	Left	0.30	
28	Lower Hyde	Other	Right	0.10	Well water to main stream flow
29	Lower Hyde	Storm Drain	Right	0.25	
30	Lower Hyde	Storm Drain	Right	0.20	
31	Hyde	Other	Left	0.00	Outfall pipe
32	Hyde	Other		0.20	
33	Hyde	Other	Right	0.00	
34	Hyde	Tile Drain	Left	0.10	
35	Hyde	Other	Left	0.25	
36	Hyde	Other	Right	0.20	
37	Hyde	Other	Left	0.20	
38	Hyde	Other	Right	0.20	Driveway
39	Hyde	Other	Left	0.02	Small Rubber Hosepipe from Underground
40	Hyde	Tile Drain	Right	0.10	
41	Hyde	Tile Drain	Right	0.15	Corrugated Plastic Pipe
42	Hyde	Tile Drain	Left	0.10	
43	Hyde	Tile Drain	Left	0.10	
44	Hyde	Tile Drain	Right	0.00	
45	Hyde	Tile Drain	Left	0.10	
46	Hyde	Tile Drain		0.10	
47	Hyde	HouseEffluent	Left	0.20	Soapy Small
48	Hyde	HouseEffluent	Left	0.10	From Eavestrough
49	Hyde	Tile Drain	Left	0.10	Three plastic outfall pipes
50	Hyde	Tile Drain	Right	0.10	In retaining wall
51	Hyde	Tile Drain		0.05	
52	Hyde	Tile Drain	Left	0.00	
53	Hyde	Tile Drain	Left	0.20	
54	Hyde	Tile Drain	Left	0.10	
55	Hyde	Septic Effluent	Left	0.30	

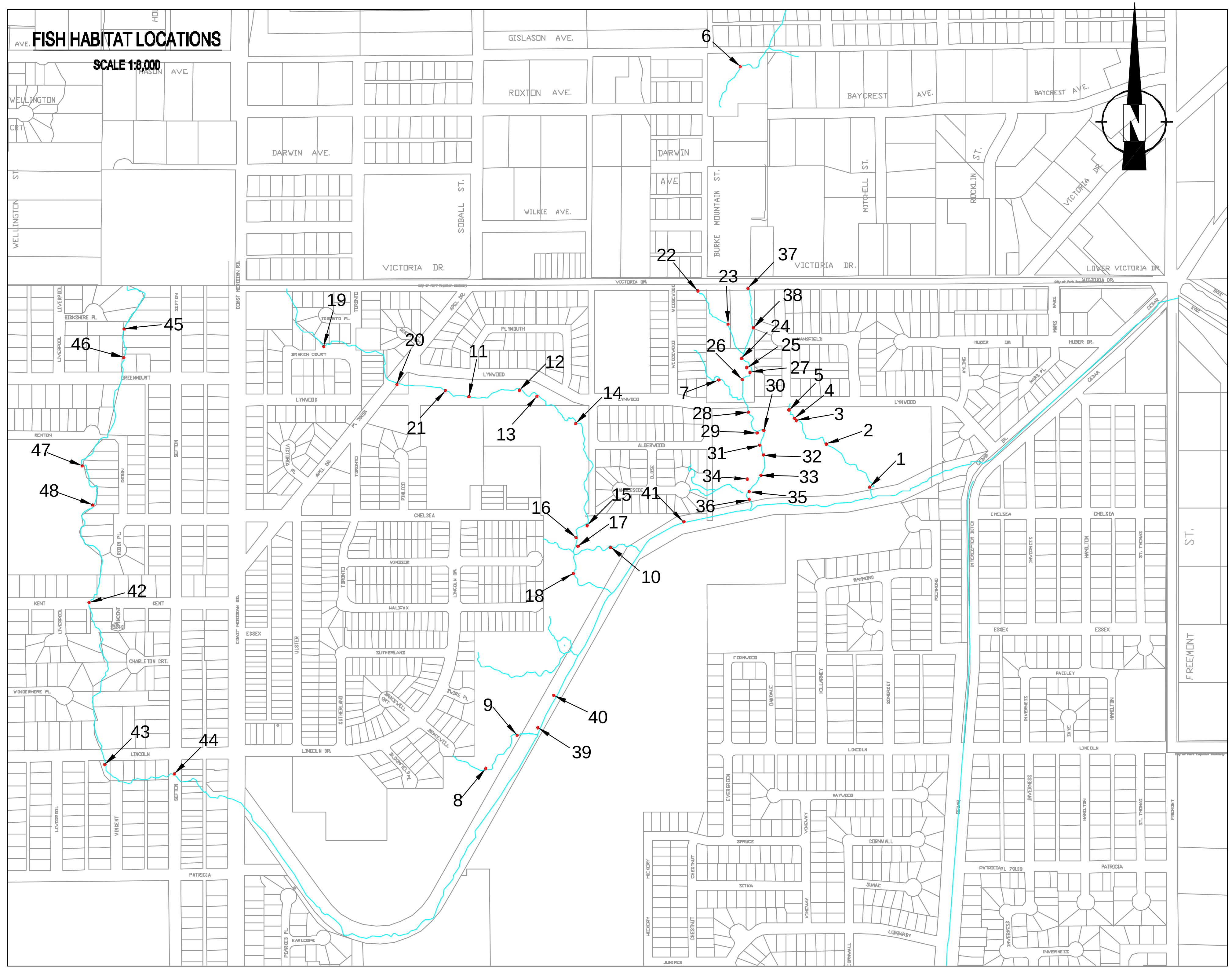
Table B5 - Culvert Locations Identified in the SHIM Data Mapping

Location	Creek	Culvert Type	Barrier	Substrate	Culvert Diameter
1	West Smiling	Outlet	Unknown	Culvert	0.60
2	Smiling Trib. 2	Outlet	Unknown	Gravels	0.30
3	Smiling Trib. 1	Outlet	Unknown	Fines	0.40
4	Burke Mtn.	Outlet	Unknown		1.20
5	Burke Mtn.	Inlet	Unknown		1.20
6	Burke Mtn.	Outlet	Unknown	Gravels	0.60
7	Burke Mtn.	Box Culvert	Unknown		0.20
8	Burke Mtn.	Inlet	Unknown		60.00
9	Burke Mtn.	Box Culvert	Unknown		0.60
10	Lower Hyde Trib. 12	Outlet	Unknown	Culvert	0.70
11	Lower Hyde	Gated Multiple Inlet	Potential	Fines	0.00
12	absent Trib	Outlet	Yes	Fines	0.45
13	Watkins Trib 10	Outlet	Yes	Culvert	0.45
14	Bracewell Pond	Outlet	Yes	Gravels	0.60
15	Watkins	Outlet	Potential	Culvert	1.50
16	Watkins	Inlet	Unknown	Culvert	1.50
17	Watkins	Box Culvert	Unknown		0.00
18	Watkins	Box Culvert	No	Culvert	1.55
19	East Smiling	Outlet	Yes	Culvert	1.00
20	East Smiling	Outlet	Potential	Culvert	1.00
21	Lower Burke Mtn.	Box Culvert	Yes	Culvert	0.00
22	Cedar	Multiple Inlet	No	Gravels	4.00
23	Lower Hyde	Gated Inlet	Unknown	Gravels	0.30
24	Lower Hyde	Inlet	No	Gravels	2.00
25	Lower Hyde	Outlet	No	Gravels	2.00
26	Lower Hyde	Inlet	No	Gravels	2.00
27	Lower Hyde	Outlet	No	Gravels	2.00
28	Hyde	Box Culvert	No	Culvert	0.00
29	Hyde	Gated Outlet	Unknown	Culvert	0.60
30	Hyde	Box Culvert	No	Culvert	0.00

Table B6 - Modification and Enhancement Features on Hyde, Watkins, Smiling and Burke Mountain Creeks Identified by SHIM Mapping

Locations	Modification/Enhancement Features	Bank Side	Type	Comments
1	Bridge	Both	Wood	Total width of bridge is 22 m - Smiling Trib. 2
2	Fences	Both	Other	Chainlink fence -smiling trib 2
3	Fences	Both	Other	Streamside veg. left bank cut to waist ht; chain link - Smiling Trib 2
4	Bridge	Both	Wood	Smiling Trib. 2
5	Road	Both	Wood	Road follows left bank of unnamed Trib. 2 from Watkins to Hyde Crk.-
6	Trail	Instream	Other	Pt. 2 trail through stream - flow discontinuous for 5m
7	Trail	Right	Other	
8	Trail	Both	Other	Trail hits Alderwood Drive
9	Trail	Both	Other	
10	PipeCrossing	Instream	Other	Iron pipe half buried in sediment approx. 0.15m diameter 0.1m under water
11	Retain Wall/Bank Stb	Left	Wood	
12	Retain Wall/Bank Stb	Left	Stonework	
13	Fences	Left	Wood	Fence within 0.1m of stream
14	Bridge	Both	Wood	
15	Fences	Both	Wood	
16	Bridge	Both	Wood	Old foot bridge
17	Retain Wall/Bank Stb	Both	Concrete	Offset due to fence barrier
18	Bridge	Both	Wood	
19	Retain Wall/Bank Stb	Right	Concrete	
20	Bridge	Both	Other	Steel bridge at Chelsea Park and Lynwood St.
21	Bridge	Both	Wood	PT 9 - Smiling Crk.
22	Garbage/Pollution	Right	Other	Pt. 30 - Smiling Crk. -garbage litter along right bank property and streamside
23	Bridge	Both	Wood	
24	Retain Wall/Bank Stb	Right	Stonework	
25	Other	Right	Concrete	Floodgates at Cedar pump station Pt. 124
26	Bridge	Both	Wood	
27	Pump Station	Right	Other	Cedar pumpo station - confluence of Cedar and Hyde Crks.
28	Pump Station	Instream		Cedar Crk. enters pumpstation with debris rack
29	PipeCrossing	Both		Water main crossing
30	Trail	Left	Gravel	Top of Bank
31	Side Channel/Pools	Left	Existing	Rearing pool
32	Other	Left	Existing	Creek widening riparian planting boulder placement
33	Bridge	Both	Wood	
34	Water Withdrawal	Right	Other	
35	Bridge	Both	Wood	
36	Retain Wall/Bank Stb	Both	Stonework	
37	Bridge	Both	Concrete	Box culvert passes under road
38	Retain Wall/Bank Stb	Both	Stonework	
39	Retain Wall/Bank Stb	Left	Concrete	
40	Retain Wall/Bank Stb	Right	Concrete	
41	Riparian Plantings	Right	Potential	
42	Riparian Plantings	Right	Existing	Enhanced until mouth
43	LWD Placement	Both	Existing	Riparian plantings rock placement
44	Spawning Gravel	Instream	Potential	Existing enhanced gravel washed out
45	Bridge	Both	Concrete	
46	Retain Wall/Bank Stb	Left	Stonework	
47	Retain Wall/Bank Stb	Left	Concrete	
48	Bridge	Both	Asphalt	
49	Retain Wall/Bank Stb	Right	Stonework	
50	Bridge	Both	Concrete	Footbridge
51	Retain Wall/Bank Stb	Left	Stonework	
52	Retain Wall/Bank Stb	Both		Both banks cement and stone
53	Retain Wall/Bank Stb	Left		
54	Retain Wall/Bank Stb	Both	Stonework	





CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

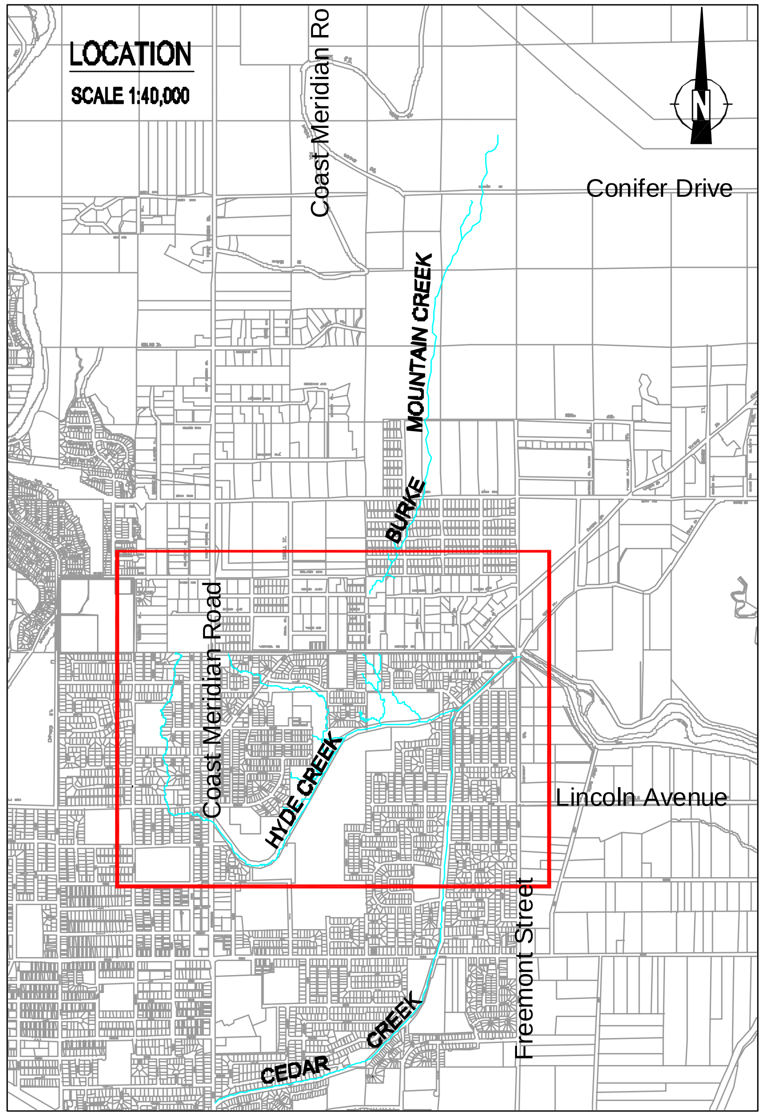
HYDE CREEK INTEGRATED WATERSHED MANAGEMENT
PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

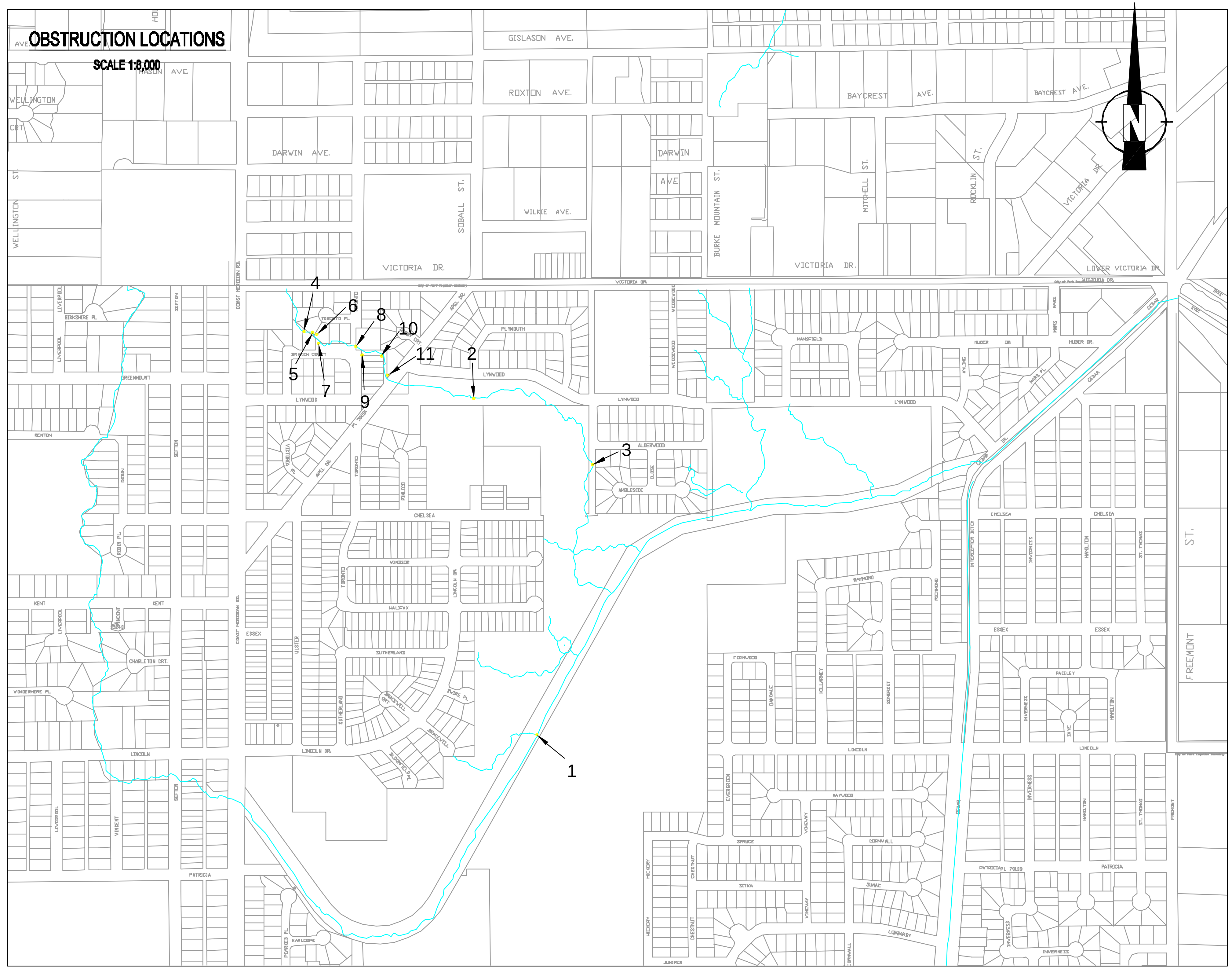
envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

FISH HABITAT
(SHIM DATA)

DESIGN: LM	DRAWN: NMG	CHECKED:	REVISION: 00	REVISION DATE:
SCALE: As Shown			DRAWING NUMBER: APPENDIX B FIGURE 1	
DATE: June 02, 2003				





CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

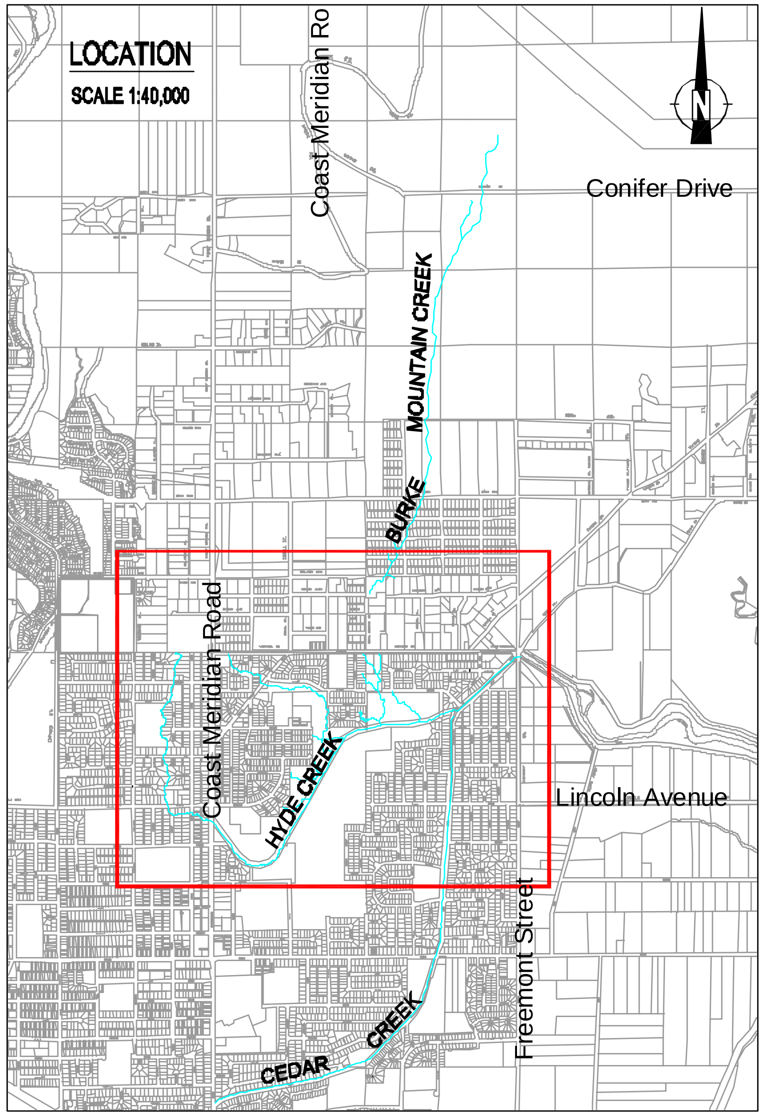
envirowest
ENVIRONMENTAL CONSULTANTS

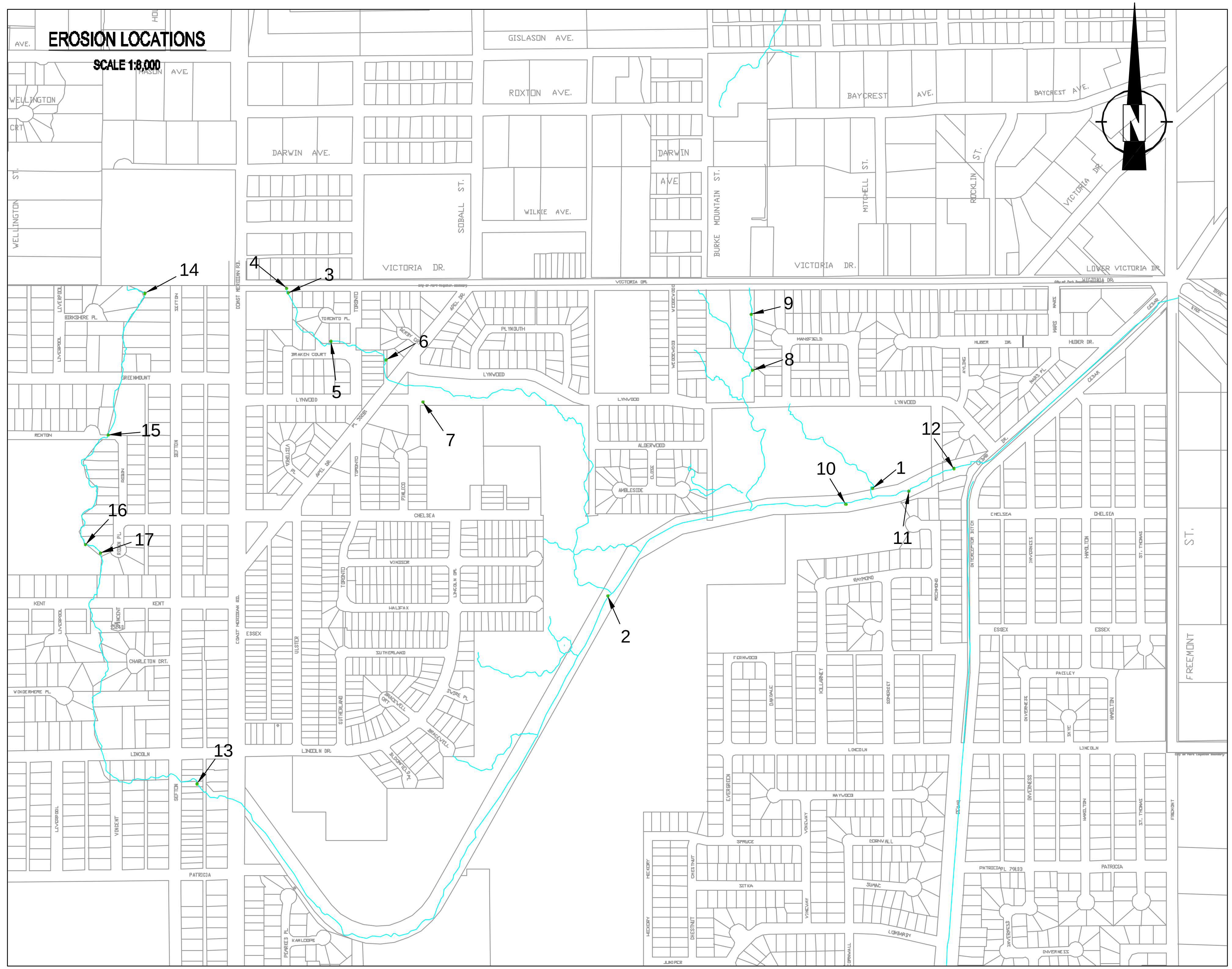
ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

OBSTRUCTIONS (SHIM DATA)

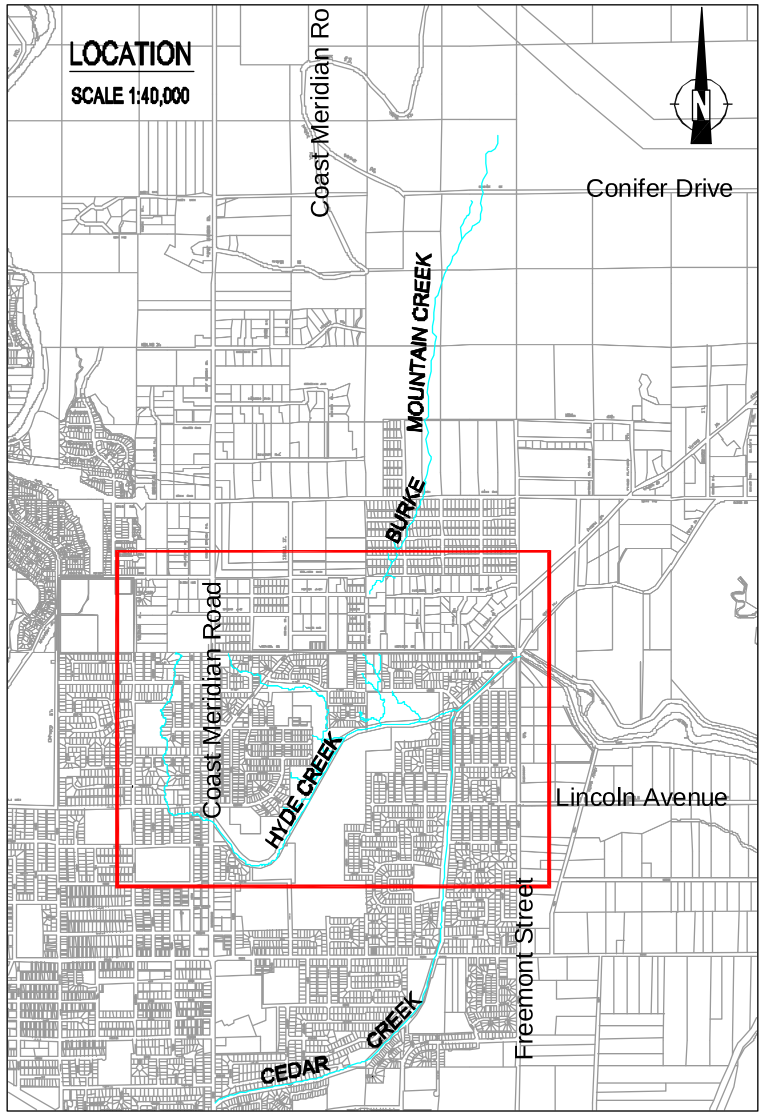
DESIGN:	DRAWN:	CHECKED:	REVISION:	REVISION DATE:
LM	NMG		00	

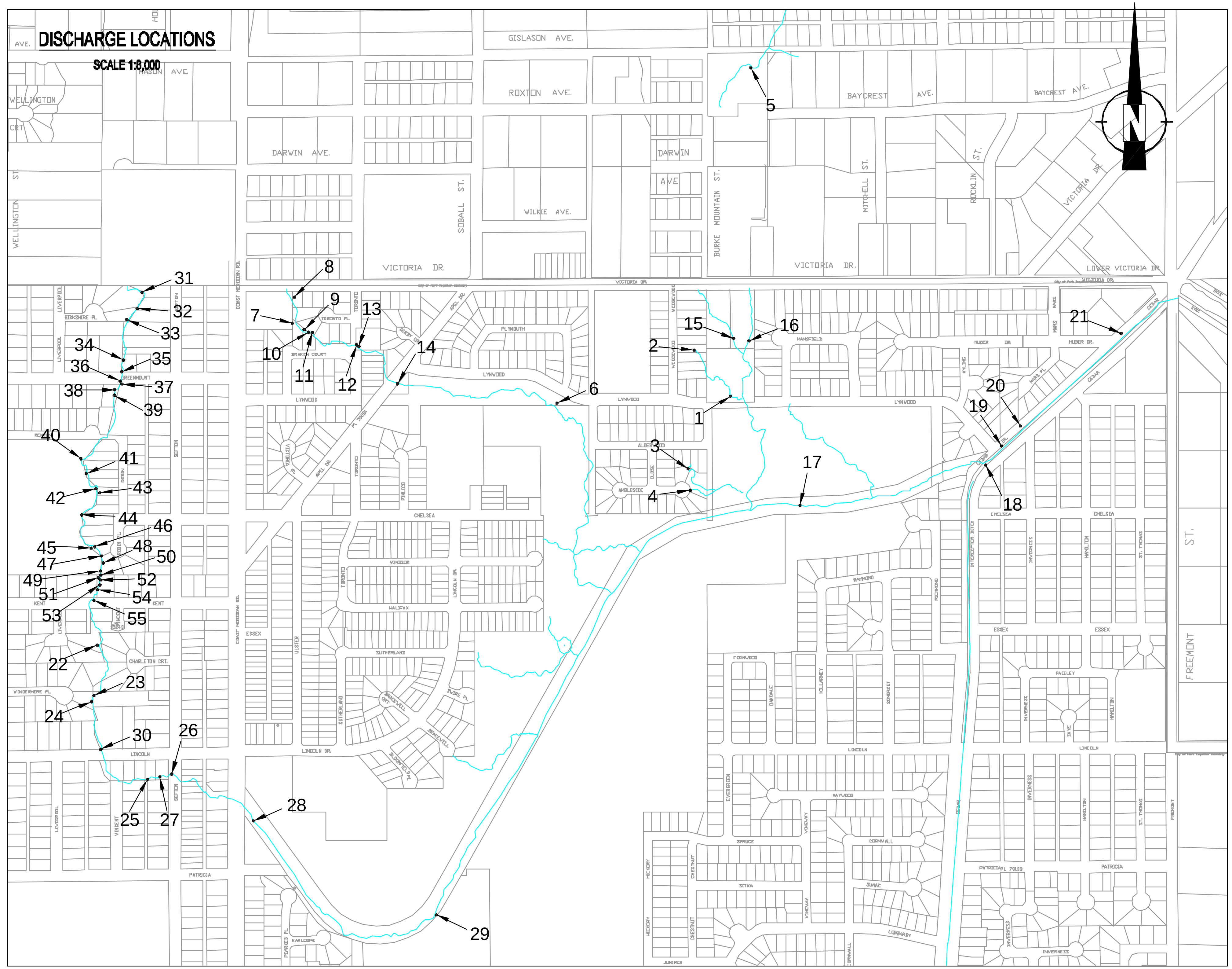
SCALE: As Shown
DATE: June 02, 2003
DRAWING NUMBER: APPENDIX B FIGURE 2





CITY OF COQUITLAM AND CITY OF PORT COQUITLAM c/o ASSOCIATED ENGINEERING (BC) LTD. Burnaby, BC	envirowest ENVIRONMENTAL CONSULTANTS	EROSION (SHIM DATA)
HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW Coquitlam, BC	ECL ENVIROWEST CONSULTANTS LIMITED Suite 130 - 3700 North Fraser Way Burnaby, B.C. V5J 5J4 www.ecl-envirowest.bc.ca voice: 604-451-0505 facsimile: 604-451-0557	DESIGN: LM · DRAWN: NMG · CHECKED: · REVISION: 00 · REVISION DATE: SCALE: As Shown · DRAWING NUMBER: APPENDIX B FIGURE 3 DATE: June 02, 2003





CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS
ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

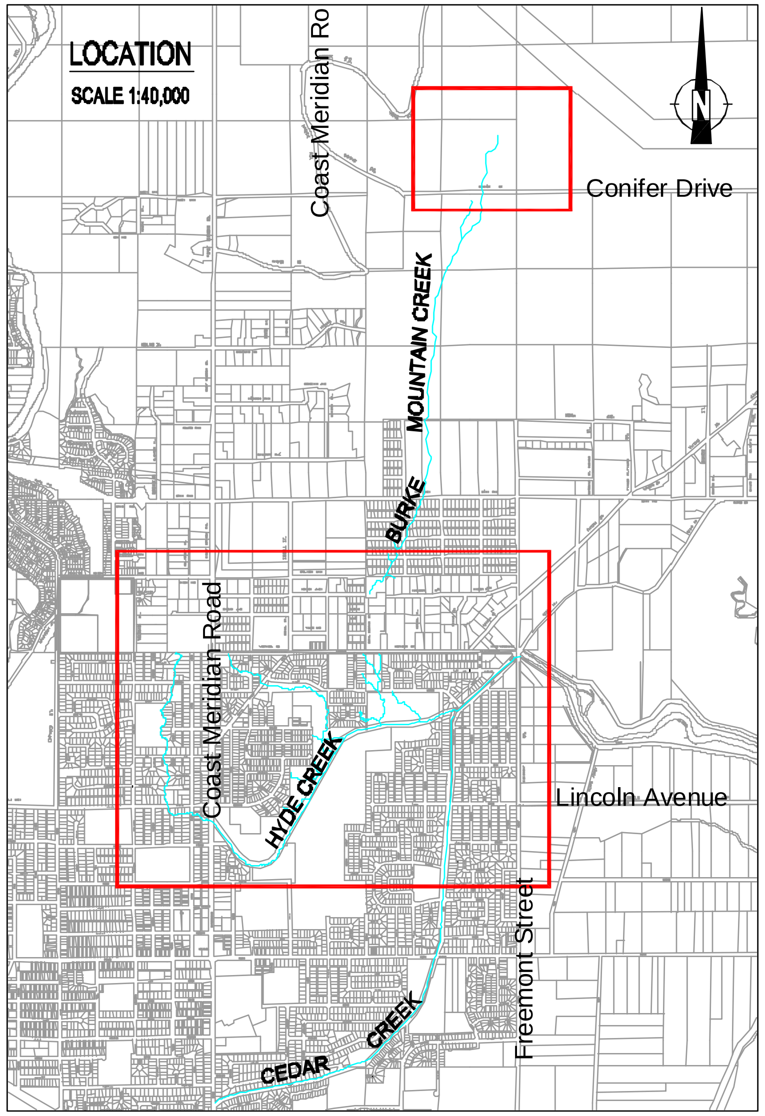
DISCHARGE (SHIM DATA)

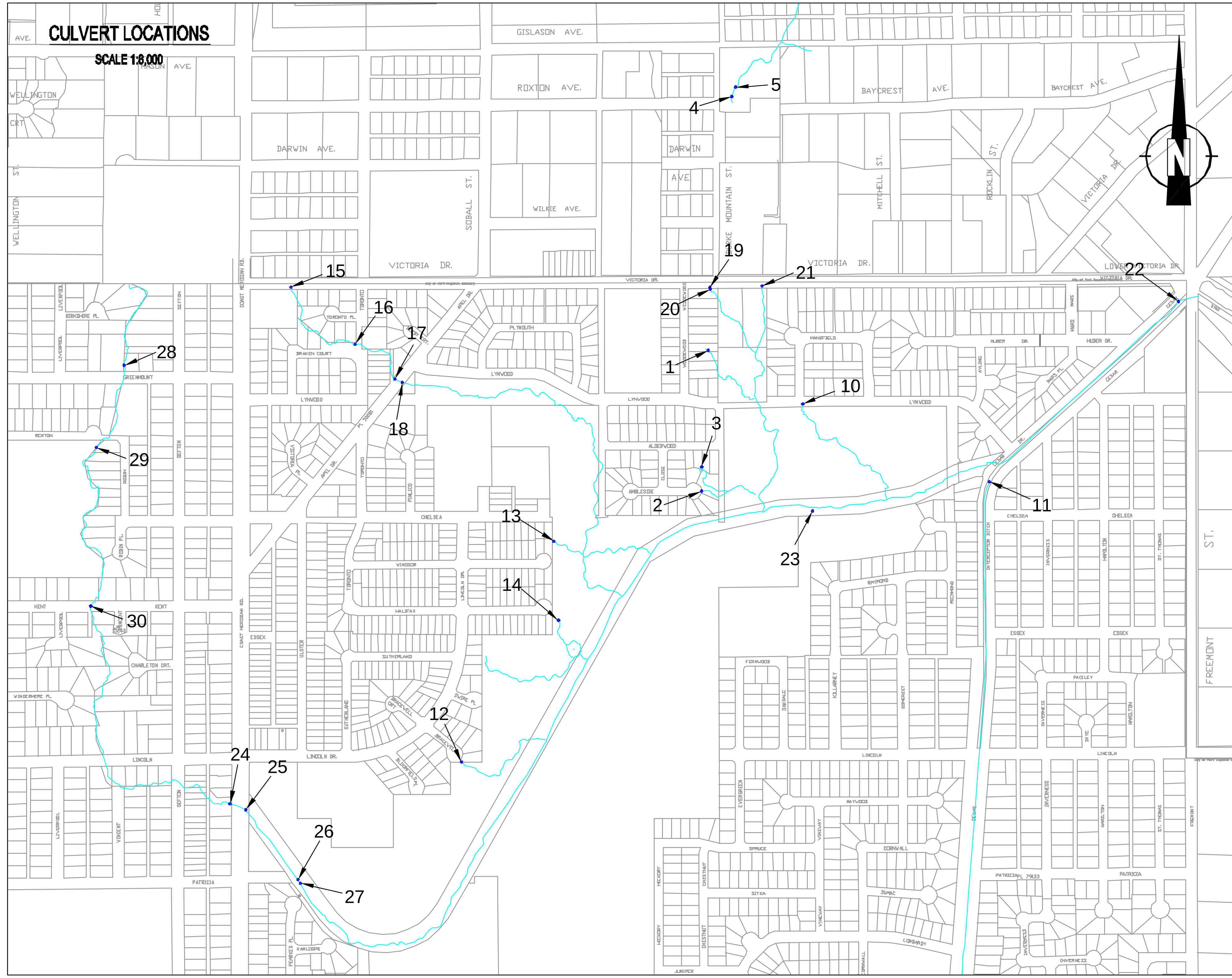
DESIGN:	DRAWN:	CHECKED:	REVISION:	REVISION DATE:
LM	NMG		00	

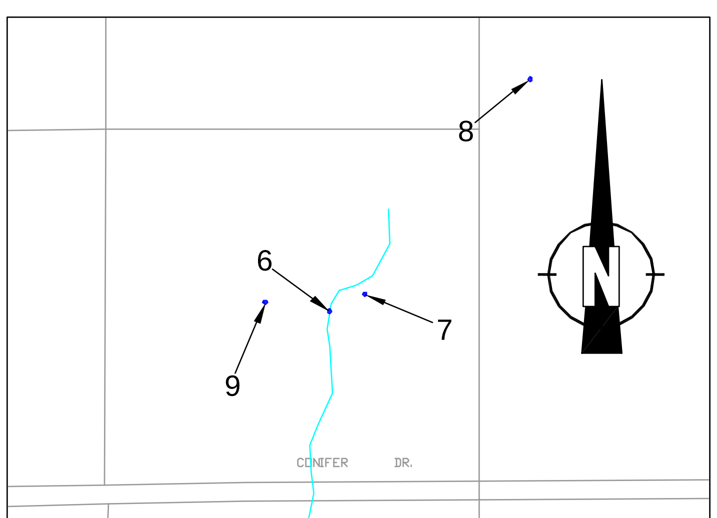
SCALE: As Shown

DATE: June 02, 2003

DRAWING NUMBER: **APPENDIX B FIGURE 4**







CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4

www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

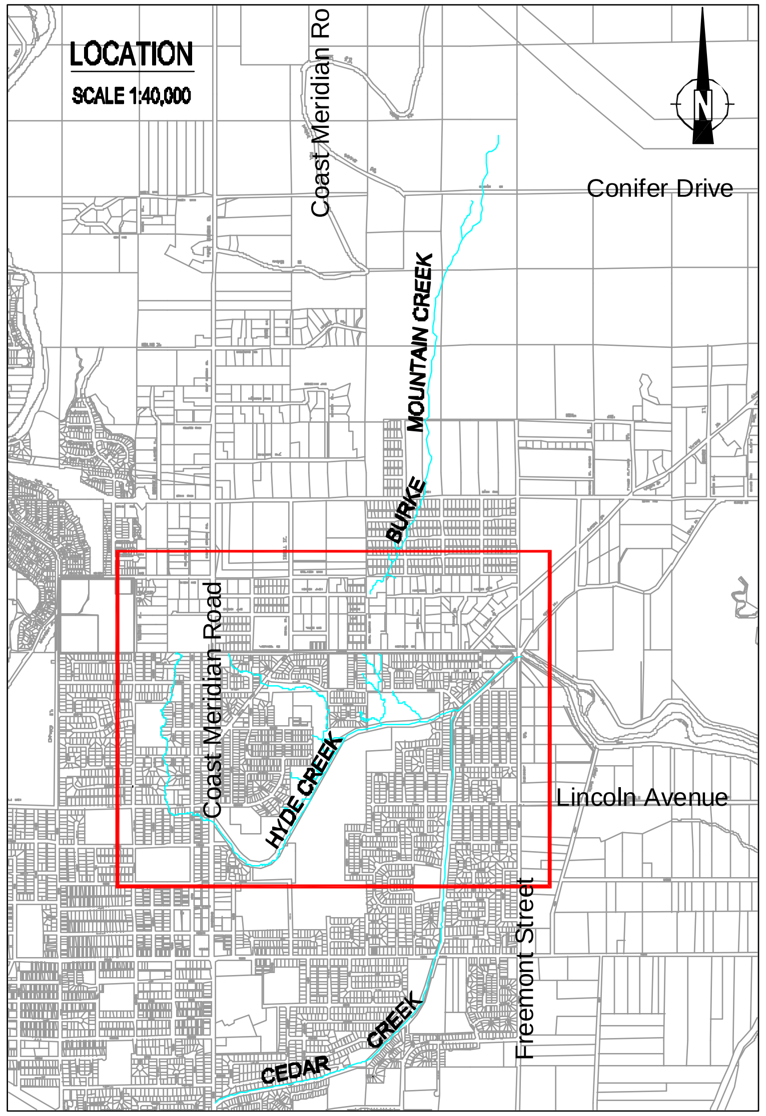
CULVERTS
(SHIM DATA)

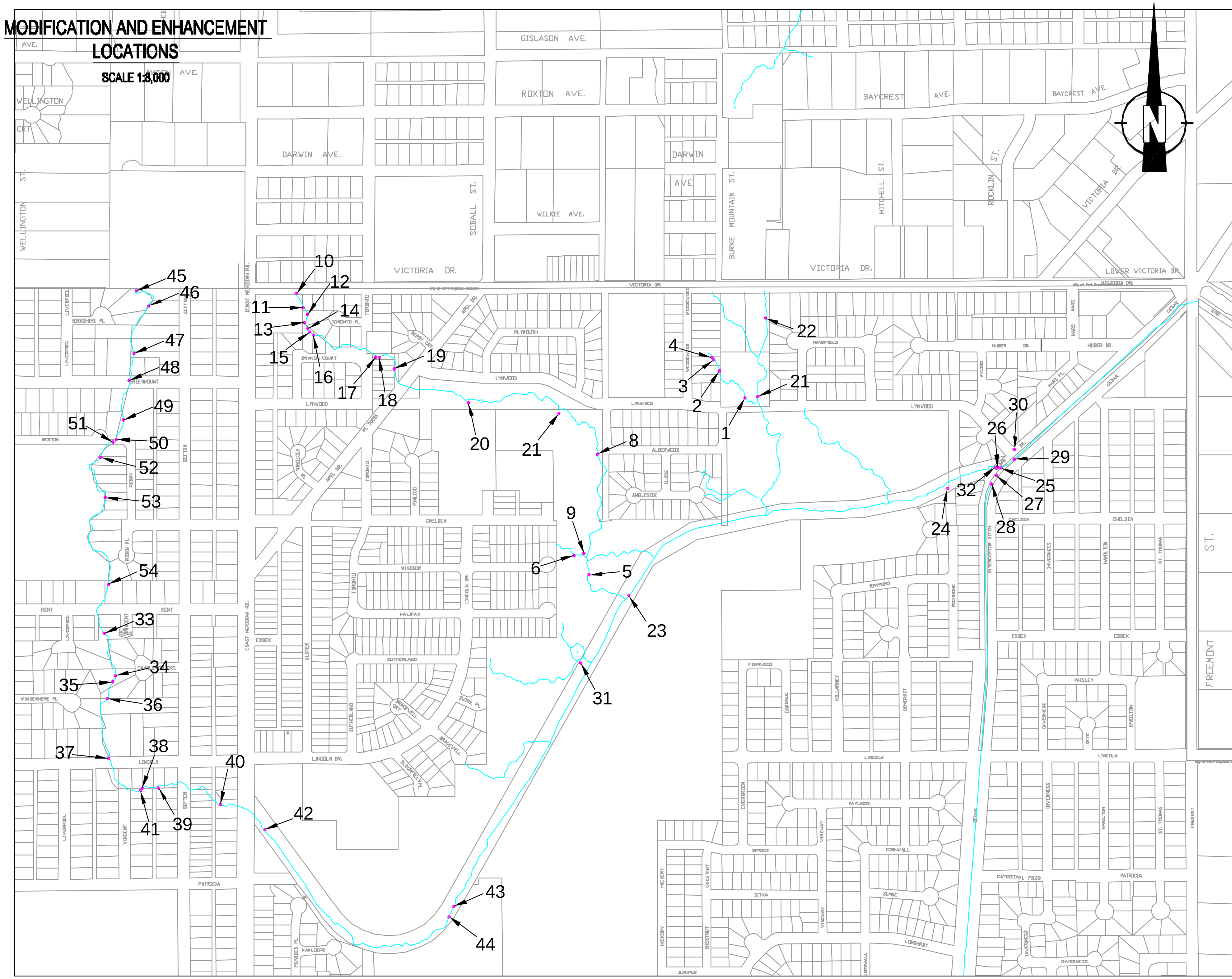
DESIGN:	DRAWN:	CHECKED:	REVISION:	REVISION DATE:
LM	NMG		00	

SCALE: As Shown

DATE: June 02, 2003

DRAWING NUMBER: APPENDIX B FIGURE 5





CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

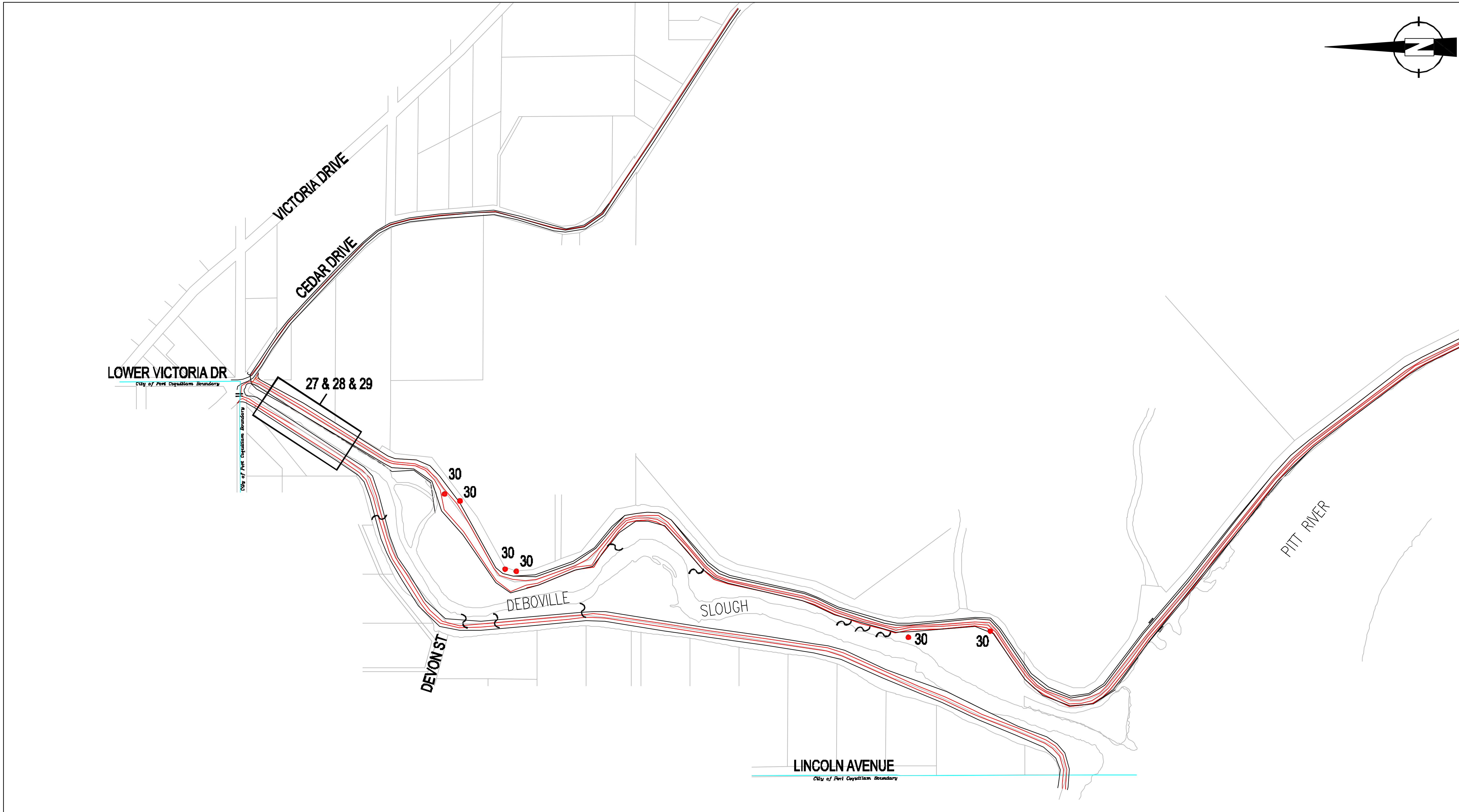
envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4

www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

MODIFICATION AND ENHANCEMENT FEATURES (SHIM DATA)

DESIGN: LM	DRAWN: NMG	CHECKED:	REVISION: 00	REVISION DATE:
SCALE: As Shown			DRAWING NUMBER: APPENDIX B FIGURE 6	
DATE: June 02, 2003				



~ (Table 2) Himalayan Blackberry/Japanese Knotweed

• 30 Trail Access

CITY OF COQUITLAM AND CITY OF PORT COQUITLAM
c/o ASSOCIATED ENGINEERING (BC) LTD.
Burnaby, BC

HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ENVIRONMENTAL REVIEW
Coquitlam, BC

envirowest
ENVIRONMENTAL CONSULTANTS

ECL ENVIROWEST CONSULTANTS LIMITED
Suite 130 - 3700 North Fraser Way
Burnaby, B.C. V5J 5J4
www.ecl-envirowest.bc.ca
voice: 604-451-0505
facsimile: 604-451-0557

DEBOVILLE SLOUGH ENHANCEMENT AREAS

DESIGN:	DRAWN:	CHECKED:	REVISION:	REVISION DATE:
LM	SDJ		00	
SCALE: 1:7500			DRAWING NUMBER: APPENDIX B FIGURE 7	
DATE: February 16, 2004				

PITEAU ASSOCIATES HYDRO-GEOLOGICAL ASSESSMENT

APPENDIX

B

PITEAU ASSOCIATES
GEOTECHNICAL AND
HYDROGEOLOGICAL CONSULTANTS

215-260 WEST ESPLANADE
NORTH VANCOUVER, B.C.
CANADA V7M 3G7
TELEPHONE: (604) 986-8551
FAX: (604) 985-7286
WEBSITE: http://www.piteau.com

Our file: 2411

April 10, 2003

Associated Engineering
300 – 4940 Canada Way
Burnaby, B.C.
V5G 4M5

Attention: Michael MacLatchy, Ph.D., P.Eng.

Dear Sirs:

Re: Hydrogeological Assessment - Hyde Creek Integrated Watershed Management Plan

Piteau Associates Engineering Ltd. (Piteau) was retained by Associated Engineering to investigate hydrogeological conditions within the Hyde Creek Watershed, which lies partially within The City of Coquitlam and The City of Port Coquitlam, B.C. (the Communities). A detailed assessment of subsurface conditions within the watershed was required to address objectives of the Integrated Watershed Management Plan proposed by the Communities. The primary objective of our investigation was to assess the potential for ground infiltration of stormwater within the northern portion of the watershed. The following report provides a summary of the findings of our field investigation and provides recommendations relating to ground infiltration potential.

BACKGROUND

The overall study area has been identified as the portion of the Hyde Creek watershed situated north of Victoria Avenue (Fig. 1). However, the northernmost (upslope) portion of the watershed lies entirely within Pinecone Burke Provincial Park and is therefore not available for residential development. In addition, an approximately 500m wide “Development Reserve” has been designated adjacent to the park’s southern boundary, where further development will be restricted (Fig. 2).

Accordingly, the remaining 350 Ha (560 acre) watershed area north of Victoria Avenue and south from the “Development Reserve” represents the effective study area for the current hydrogeological investigation (Fig. 2).

FIELD INVESTIGATION

A field reconnaissance of the study area was completed February 8, 2003 by Matthew Munn, P.Eng., of Piteau. Sediment exposures in road-side ditches and watercourses were visually examined to assess soil types and general distribution. Several relatively shallow test pits were also hand-dug. Based on the results of the cursory site survey, suitable sites were identified for additional exploration using deeper test holes.

Ten test holes were excavated February 24, 2003 (Fig. 2), using a Case 570 rubber-tired backhoe, to depths ranging from 0.7 to 1.5m below ground. Representative sediment samples were collected during excavation for visual classification. All samples were returned to Piteau's laboratory for storage and further analysis, if required. Following examination of subsurface conditions, all test holes were backfilled with materials originally excavated.

Observations of groundwater conditions were also made during excavation of the test holes. To facilitate long term monitoring of groundwater levels, standpipe piezometers constructed of 25mm diameter PVC pipe were installed in test holes TH03-01, TH03-03 and TH3-06 to TH03-10 (Photo 1). Levelogger™ dataloggers were then installed at test holes TH03-01, TH03-07 and TH03-10 to monitor variations in groundwater levels during the period March 4 to 11, 2003. A hydrograph of the resulting piezometric data (water levels) is included as Fig. 3. Total daily precipitation data collected at Environment Canada's Pitt Meadows automated station have also been plotted in Figure 3 for the same period.

A record of subsurface conditions encountered at the test hole locations, along with standpipe construction details, has been summarized in the detailed logs included in Appendix A.

Infiltration testing was completed at five sites where sediment texture (gradation) was judged to be representative of the range of textures within the overall study area. Shallow holes of approximately 0.30 to 0.65m depth were hand dug and a double ring infiltrometer assembly installed directly within the exposed sediment horizon (Photo 2). Water from nearby residences and watercourses was used to maintain a constant hydraulic head within two concentric aluminum pipes of 0.25m and 0.50m diameter. The rate at which water is added to the inner pipe provides a direct measurement of infiltration rates, which approaches the hydraulic conductivity as the sediment becomes progressively saturated. Infiltration test results, including projected hydraulic conductivity (K) estimates, are tabulated in Appendix A.

The Ministry of Water, Land and Air Protection's on-line water well database indicates that five domestic water wells are/were located near the southeast corner of the study area (Fig. 2). Driller's records for these wells contain some pertinent information regarding near-surface sediments. Therefore, detailed logs for each well are included in Appendix B.

SUBSURFACE INFORMATION

The results of our field investigation indicate that subsurface conditions vary significantly within the study area, which is consistent with previous regional mapping of the area (Luttmerding, 1981). Specifically, the surficial sediment profile (strata thickness), sediment texture, and groundwater depth changes considerably over relatively small horizontal distances.

Sediment Profile

Sediments over the entire study area are primarily fine-textured, ranging from silty sand/gravel strata to dense silt/sand till and dense laminated silts. The denser sediments are commonly overlain by a 0.5 to 1.0m layer of compact, silty surficial sand/gravel (Photos 3 to 7) and less extensively by deposits of slightly silty sand or sand/gravel (Photo 8). Surficial sediments are generally thinner within the "Development Reserve" and on terrain immediately downslope, resulting in frequent exposure of dense till within roadside ditches (Photos 9 & 10).

Luttmerding (1981) identified a soil boundary that is aligned approximately parallel to the "Development Reserve" boundary (Fig. 2). Our field investigation has verified that the inferred soil boundary denotes a transition to relatively thicker surficial deposits and a more common occurrence of coarser textured (granular) sediments. These coarser surficial sand/gravel deposits were encountered to depths of approximately 1.0m at test holes TH03-03 and TH03-10, overlying dense sediments (Photos 11 & 12). Similar sand/gravel layers of 0.25 to 0.45m thickness were also encountered below a very silty surficial horizon at TH03-04, TH03-07 and TH03-08 (Photo 13). Sediment profiles in the remaining test holes were comprised of silt and/or very silty sand/gravel overlying dense till or dense silt (Fig. 2).

Lithologic information from five domestic water well logs also indicate the presence of till at very shallow depths. The log for well #23635 includes very silty sand/gravel to a depth of 0.9m (3ft) overlying till, while the well #33007 log notes "soil" to a depth of 0.9m (3ft) overlying till. Clean sand and/or gravel is recorded in each of the well logs, but at depths greater than 9m (30ft).

Bedrock was not observed during the site reconnaissance, and was not encountered during excavation of the test holes. A relatively thin, variably developed topsoil horizon was observed at all test hole locations.

Surface Drainage and Groundwater

The two major drainage features within the watershed are Hyde Creek and Smiling Creek (Fig. 2). Both watercourses trend north-south (overall) and flow southward within well-defined banks. The upper reaches of Hyde Creek include deeply gullied sections.

Active surface runoff was evident on open slopes throughout the entire investigated area, but uncontrolled surface erosion was not observed. In most areas the ground surface was noted to be generally soft and saturated at surface, particularly on the northern side of the noted soil boundary/transition. The relatively thin surficial soil profile in that area reduces the capacity for infiltration, resulting in significant overland flow (runoff).

Seepage of groundwater was evident at several locations within excavations (ditches) along Harper Road. The moderate seepage originated from the interface between the surficial sediments and the less permeable, underlying till.
Groundwater depths measured in each of the piezometers on March 11, 2003 ranged from 0.69

to 0.90m below ground, except at TH03-03 and TH03-08 where the piezometers were dry, indicating water depths exceeding 1.20m and 1.45m, respectively.

A strong correlation between precipitation and water levels in piezometers at TH03-01, TH03-07 and TH03-10 can been observed in Figure 3. A trace amount of precipitation was recorded for the period March 4 to 8, 2003, during which water levels steadily declined (overall) in the three piezometers. During a 23mm storm event on March 9, water levels rapidly increased by 0.20 to 0.25m in the three piezometers. Continued precipitation on March 10 and 11 further reduced the depth to groundwater to 0.7m at TH03-01 and TH03-10, while the depth at TH03-07 was 0.7m of ground surface.

It is noteworthy that the water table declined at a rate of approximately 2.5 cm/day during the dry period between March 4 and 8, and rose about 25 cm on March 9, in response to 23mm of precipitation (Fig. 3). This indicates that the flow regime is not sufficiently rapid to cycle water out of storage, and that the soil profile could become saturated to near surface during any sustained storm events.

Infiltration Testing

Projected hydraulic conductivity values (K) from double ring infiltration tests, ranged from 2.0×10^{-4} m/s (Site #8) to 7.0×10^{-5} m/s (Site #3). The relatively high K value at Site #8 is due to the coarseness of the sand/gravel strata, which has trace to no silt content. The slightly silty sand at Site #3 and variably silty sand/gravel at Site #4 yielded intermediate K values of 7.0×10^{-5} m/s and 4.0×10^{-5} m/s, respectively. The lowest K values (1.0×10^{-5} m/s) were recorded at Site #7 and Site #10, where slightly silty to silty sand/gravel are present.

DISCUSSION

Conventional stormwater infiltration within the study area should be feasible, but will likely be very limited due to the relatively thin surficial sediment profiles and high water table conditions that are perched on the dense till that underlies the entire area. More favourable conditions are present at some locations adjacent to watercourses, where higher permeability sediments are likely more common and the water table is locally depressed due to the nearby channels. Accordingly, due to the highly variable subsurface conditions, design of an effective stormwater infiltration system would require examination of subsurface conditions on a relatively small scale.

Ground Infiltration Potential

The highly variable texture of surficial sediments is reflected in the broad range of hydraulic conductivity values (i.e. 1×10^{-5} to 2×10^{-4} m/s). Infiltration rates corresponding to these K values are very high, and range from approximately 0.86 $m^3/day/m^2$ to 17.0 $m^3/day/m^2$ (860 to 17,000 mm/day). Therefore, virtually all incident precipitation could infiltrate to the soil, if sufficient storage capacity was available in the soil profile. However, due to the thin layer of permeable soils that underlie the study area, soil pore space and the ability for the soil to convey groundwater down the slope are both very limited, and will restrict the quantity of precipitation that can be infiltrated.

Greater depths to groundwater were measured at TH03-03 and TH03-08 (Fig. 2), where the piezometers have remained dry, even following the relatively wet period of March 9 to 11. It is anticipated that lower water table conditions will also be present at other locations adjacent to both Hyde Creek and Smiling Creek. This will be most evident in areas adjacent to gullied reaches, where topographic relief will result in higher gradients that will promote more rapid subsurface drainage. The greater depth of unsaturated sediments present beneath areas adjacent to creeks will provide a greater infiltration potential relative to areas between the creeks.

Stormwater Management Plan

Soils that underlie the study area offer some limited potential to infiltrate storm water during drier periods in the fall to spring months, and probably significant potential during the summer months. Infiltration capacity during very wet periods will be limited by high water table conditions, and a lack of subsurface storage in the shallow permeable soil profile.

Roads and service trench excavations will penetrate the dense till, and will promote drainage of the upper soil horizons. This will be a benefit to surface trafficability and will also increase the capacity of the shallow groundwater flow regime to cycle water out of storage between storm events. However, the groundwater flow recession curve will steepen, which will result in a more rapid approach to baseflow conditions following periods of wet weather.

Community scale infiltration measures are not recommended, due to the limited receiving capacity of the soil. Only measures that distribute groundwater recharge over large areas, such as individual lots systems, should be considered.

Infiltration measures along roads are generally not considered to be practicable. While some infiltration from perforated storm sewers may be possible, there would be a risk of concentrated infiltration in some areas. This could create chronic seepage problems, and possibly related instability on the fill sections of the roads. Seepage recharged by under road infiltration measures could also adversely affect lots immediately below the road alignments. Measures such as permeable pavements, which would promote a more uniform infiltration rate when conditions are suitable, could be considered.

Individual lot infiltration measures should be considered to reduce flows to storm sewers during storm events with dry antecedent conditions. These measures would reduce peak flows during storm events, and would also enhance stream flows following storm events. They would not reduce peak flows or enhance baseflows during periods of sustained wet weather, when the soil would not have the storage capacity required to receive infiltration.
Infiltration measures that increase groundwater recharge near the crests of ravines should be avoided, unless site specific geotechnical investigations are conducted to address potential adverse impacts on slope stability.

Individual Lot Infiltration Measures

Areas proposed for infiltration should be examined individually to assess suitability for stormwater disposal. Most areas will be unsuitable for infiltration during winter months, but could accept stormwater during drier months when the water table would be lower and a sufficient thickness of unsaturated sediments would be available to receive the infiltrated stormwater. Systems that would be suitable for this application are subsurface infiltration trenches. Roof and driveway drains could be directed to the trenches. Water would be infiltrated to the soil beneath the trenches whenever unsaturated soil porosity was available. Decants to conventional storm sewers would be required to discharge most of the winter precipitation and intense storms in the summer months, when water storage capacity would not be available in the soil profile.

Due to the high infiltration capacity of the soils in the study area relative to the available storage capacity, relatively small infiltration structures could be employed. These would be aligned along contours, as far as possible from foundation drains or drainage measures beneath or alongside adjacent access roads. A typical site layout and infiltration trench design is presented in Fig. 4. Decant elevations from the trenches should be set to maintain the water table below a depth of 0.3m beneath lawns and landscaped areas, and 0.6m beneath driveways. Any decant should be directed to a conventional storm sewer.

LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in British Columbia. No warranty is expressed or implied.

The information presented in this report represents soil and groundwater conditions at the points sampled. Due to natural variations in geological conditions, no inference is made to the sediment or groundwater conditions between sampling points.

This report is prepared for the sole use of Associated Engineering, The City of Coquitlam and The City of Port Coquitlam. Any use, interpretation or reliance on this information by other parties is at the risk of that party, and Piteau Associates Engineering Ltd. accepts no liability for such unauthorized use.

CLOSURE

We trust that this letter report is sufficient for your present purposes. Please contact the undersigned for additional information or clarification.

Yours very truly,

PITEAU ASSOCIATES ENGINEERING LTD.

Matthew D. Munn, M.Sc., P.Eng.

Reviewed by:

Andrew T. Holmes, P.Eng.
Principal

MDM/cls

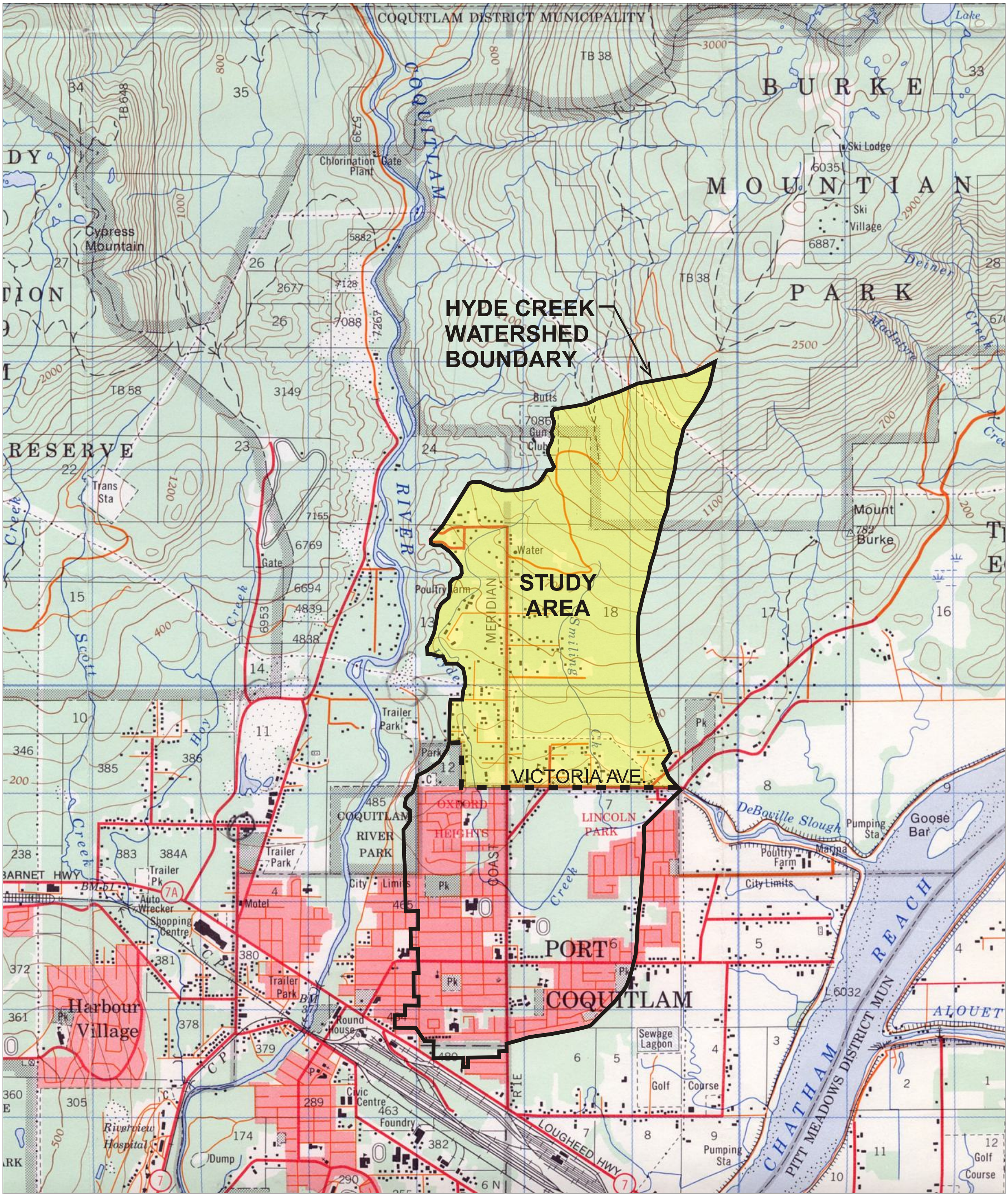
Att.

REFERENCES

Luttmerding,H.A. (1981). "Soils of the Langley - Vancouver Map Area". Volume 3, Description of the Soils, RAB Bulletin 18, Report No. 15, British Columbia Soil Survey.

FIGURES

DWG. NUMBER: 2411-002.CDR



PREPARED SOLELY FOR THE USE OF OUR CLIENTAND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH PITEAU ASSOCIATES ENGINEERING LTD. HAS NOT ENTERED INTO A CONTRACT.

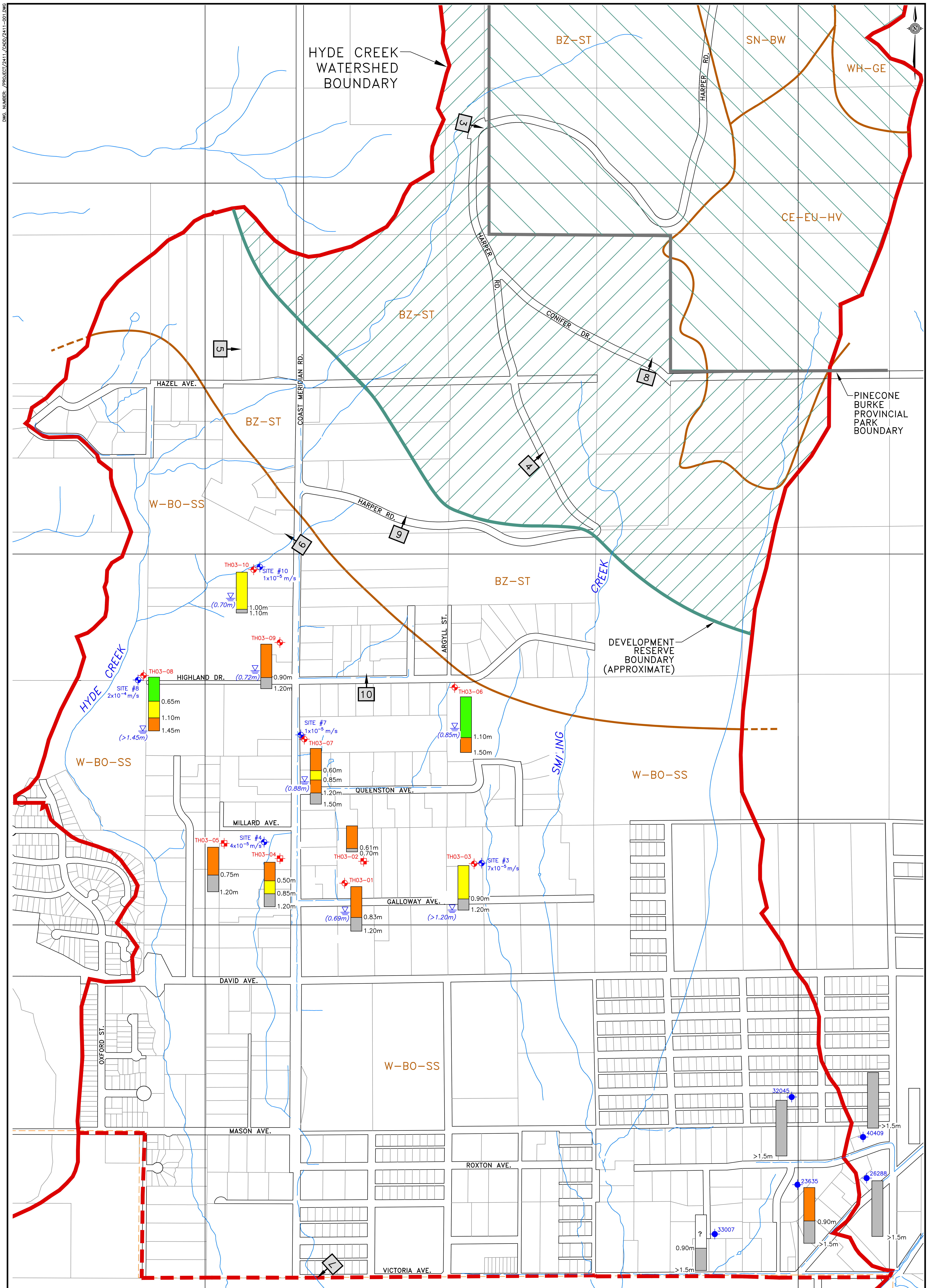
ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS
VANCOUVER LIMA

HYDROGEOLOGIC ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

SITE LOCATION

BY:	DATE:
MDM/ss	APR. 03
APPROVED:	FIG: 1



LEGEND

- TH03-05 — TEST HOLE EXCAVATED BY PITEAU ASSOCIATES ENGINEERING LTD., FEBRUARY 2003
- TH03-10 — TEST HOLE WITH STANDPIPE PIEZOMETER EXCAVATED BY PITEAU ASSOCIATES ENGINEERING LTD., FEBUARY 2003
- SITE #5 — DOUBLE RING INFILTRATION TEST SITE BY PITEAU ASSOCIATES ENGINEERING LTD., MARCH 2003 WITH PROJECTED INFILTRATION RATE (HYDRAULIC CONDUCTIVITY) SHOWN
- 32045 — FORMER/EXISTING WATER SUPPLY WELL WITH MWLAP WELL TAG NUMBER SHOWN
- W-BO-SS — APPROXIMATE SOIL BOUNDARY WITH ABBREVIATED SOIL NAME SHOWN (AFTER LUTTMERDING, 1981)
- WATERSHED BOUNDARY
- SOUTHERN STUDY AREA BOUNDARY
- 3 — PHOTOGRAPH LOCATION (DIRECTION INDICATED BY ARROW; SEE REPORT)

LITHOLOGICAL SECTION BASED ON TEST HOLES AND DRILLER'S LOGS

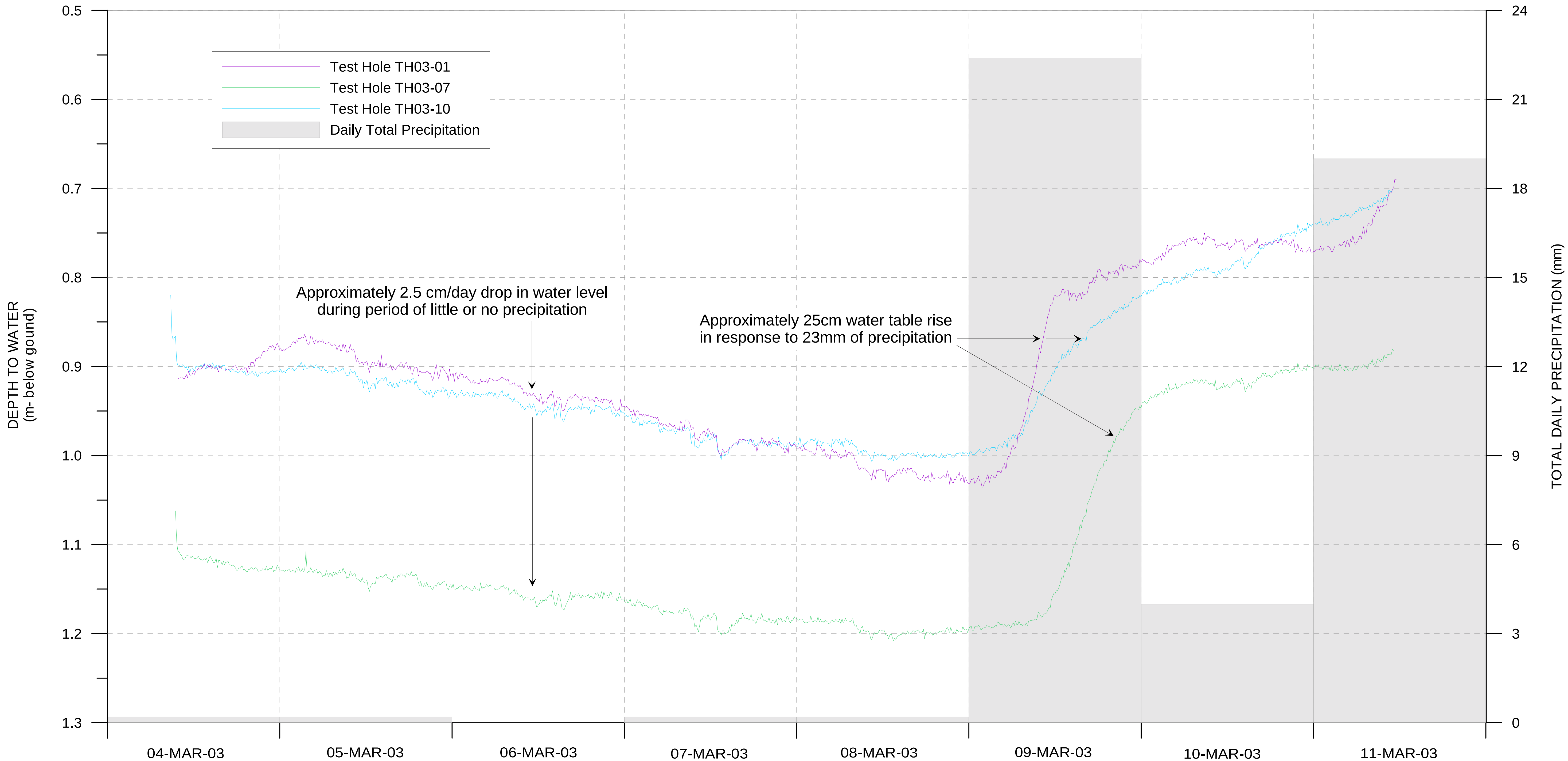
- SAND AND/OR GRAVEL, TRACE SILT TO SLIGHTLY SILTY
- VERY SILTY SAND AND/OR GRAVEL
- SILT; SANDY AND/OR GRAVELLY
- DENSE TILL, DENSE LAMINATED SILT OR SANDY SILT

SURFICIAL SEDIMENT
0.50m — STRATA DEPTHS
0.85m — UNDERLYING SEDIMENTS
1.20m — TEST HOLE DEPTH
(>1.20m) — APPROX. DEPTH TO WATER TABLE MAR.11/03

0 50 100 150 200 250m
SCALE 1:5000

PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH PITEAU ASSOCIATES ENGINEERING LTD. HAS NOT ENTERED INTO A CONTRACT.

ASSOCIATED ENGINEERING	PITEAU ASSOCIATES GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS VANCOUVER LIMA	
HYDROGEOLOGICAL ASSESSMENT HYDE CREEK IWMS COQUITLAM, B.C.	SITE PLAN	BY: MDM/ss DATE: APR. 03 APPROVED: FIG: 2

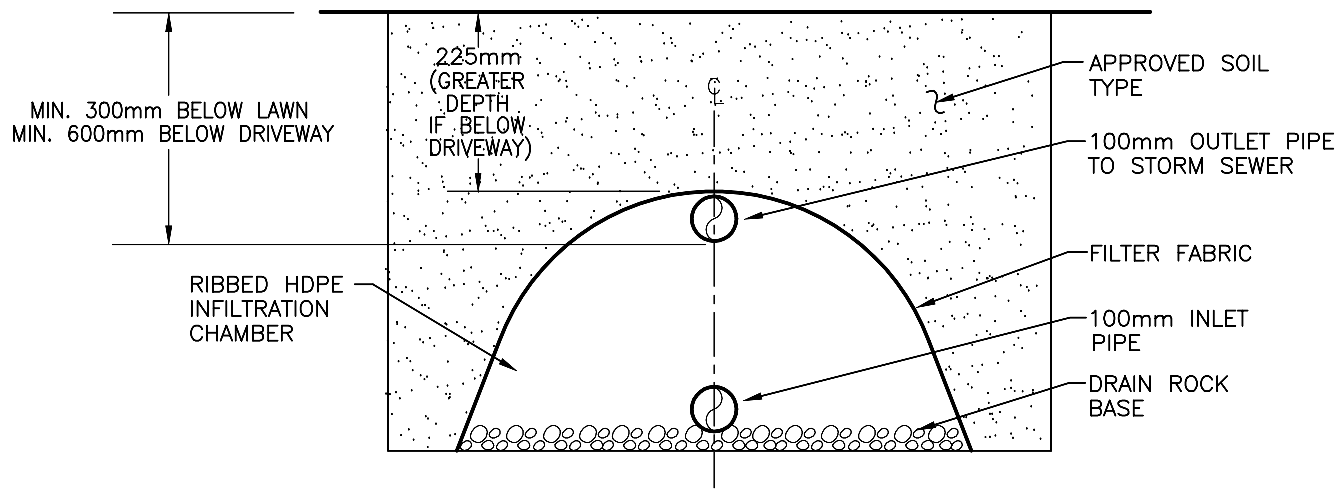


file: H:\project\2411\Grapher\dataloggers.grf

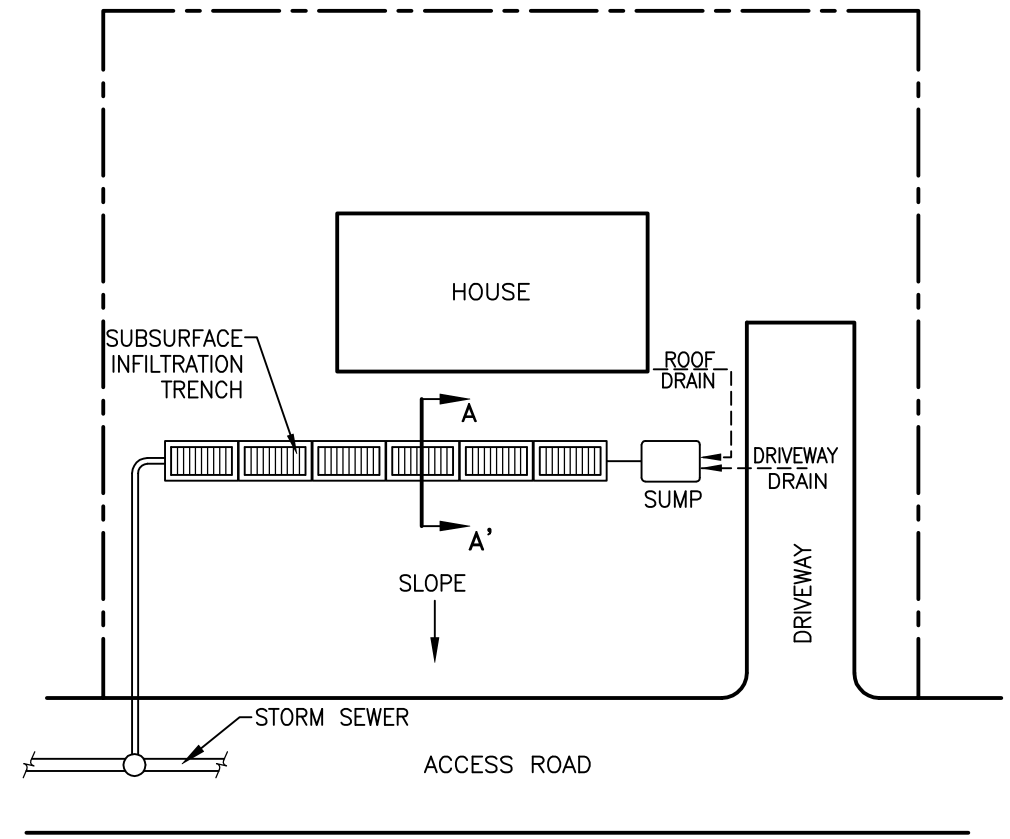
NOTE: 1) Climate data from Environment Canada's Pitt Meadows automated weather station
2) Water level data obtained with automated pressure tranducers installed in standpipe piezometers

ASSOCIATED ENGINEERING	PITEAU ASSOCIATES GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS VANCOUVER CALGARY		
HYDROGEOLOGICAL ASSESSMENT HYDE CREEK IWMS COQUITLAM, B.C.	HYDROGRAPHS FOR PIEZOMETERS AT TEST HOLES TH03-01, TH03-07 & TH03-10	BY: MDM	DATE: MAR 03
		APPROVED:	FIG: 3

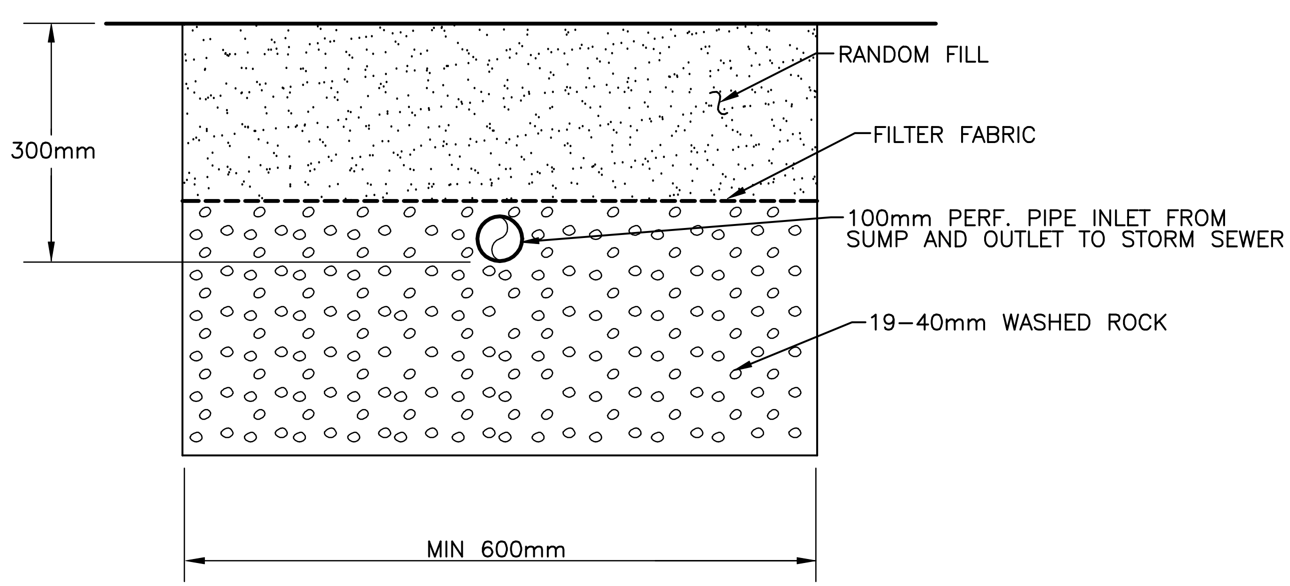
DWG. NUMBER: /PROJECT/2411/CADD/2411-002.DWG



DETAIL SECTION A–A' – GRAVELLESS TRENCH
N.T.S.



PLAN
N.T.S.



ALTERNATE DETAIL SECTION A–A' CONVENTIONAL TRENCH
N.T.S.

PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH PITEAU ASSOCIATES ENGINEERING LTD. HAS NOT ENTERED INTO A CONTRACT.

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS
VANCOUVER LIMA

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TYPICAL INDIVIDUAL LOT SUBSURFACE INFILTRATION TRENCH SYSTEM

BY: ATH/cz
DATE: APR. 03
APPROVED:
FIG: 4

APPENDIX A

TEST HOLE LOGS
DOUBLE RING INFILTRATION TEST RESULTS

Test Pit No: **TH 03-01**
Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: North side of Galloway Avenue (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 119
Standpipe Stick-up (m): 0.35
Standpipe Depth (m): 1.20

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	119.0
	Damp			0.0 - 0.15	Black, firm, slightly sandy silt - Organic TOPSOIL	
	Moist		0.25			
			0.50	0.15 - 0.83	Brown, compact, very silty SAND with some gravel	
					Water table depth 0.69m March 11, 2003	
	Wet		0.75			
			1.00	0.83 - 1.20	Grey, dense, laminated SILT/SAND with gravel clasts	117.8
			1.25		**End of excavation at approx. 1.2m depth** **Rapid seepage observed at approx. 0.8m depth** **25mm diam. PVC standpipe tube installed at approx. 1.2m depth**	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-01

BY: MDM
DATE: Mar-03
APPROVED:
FIG: **A-1**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-02**

Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: North side of Galloway Avenue (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 126
Standpipe Stick-up (m): N/A
Standpipe Depth (m): N/A

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	126
				0.0 - 0.15	Black, firm, slightly sandy silt - Organic TOPSOIL	
	Moist		0.25			
	Damp			0.15 - 0.61	Reddish brown, compact/firm, silty SAND/GRAVEL Some small cobbles Upper 200mm very sandy (coarse) and slightly silty	
			0.50			
	Wet					
				0.61 - 0.70	Grey, dense, very sandy SILT and silty SAND with some gravel	125.3
			0.75		**End of excavation at approx. 0.7m depth** **Rapid seepage observed at approx. 0.6m depth**	
			1.00			
			1.25			

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-02

BY: MDM
DATE: Mar-03
APPROVED:
FIG: **A-2**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-03**
Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: North side of Galloway Avenue (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 150
Standpipe Stick-up (m): 0.23
Standpipe Depth (m): 1.20

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	150
				0.0 - 0.15	Black, firm, slightly sandy silt - Organic TOPSOIL	
0.3	Damp		0.25			
			0.50	0.15 - 0.90	Reddish brown, compact, med-coarse SAND Trace to some silt Becomes grey with depth	
			0.75			
0.9	Damp		1.00	0.90 - 1.20	Grey, dense, laminated SILT/SAND with gravel clasts **Water table depth >1.20m March 11, 2003**	148.8
			1.25		**End of excavation at approx. 1.2m depth** **No seepage observed in Test Hole** **25mm diam. PVC standpipe tube installed at approx. 1.2m depth**	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-03

BY: MDM
DATE: Mar-03
APPROVED
FIG: **A-3**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-04**
Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: West side of Coast Meridian Road (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 116
Standpipe Stick-up (m): N/A
Standpipe Depth (m): N/A

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	116
				0.0 - 0.20	Black, firm, slightly sandy silt - Organic TOPSOIL	
			0.25			
			0.50	0.20 - 0.85	Dark reddish brown, SAND/GRAVEL with trace to some silt Silty from 0.20 - 0.50m depth	
0.8	Damp		0.75			
			1.00	0.85 - 1.20	Grey, firm to stiff SILT with some coarse gravel	114.8
			1.25		**End of excavation at approx. 1.2m depth** **No seepage observed in Test Hole**	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-04

BY: MDM
DATE: Mar-03
APPROVED:
FIG: **A-4**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-05**
Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: South side of Millard Avenue (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 114
Standpipe Stick-up (m): N/A
Standpipe Depth (m): N/A

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	114
	Damp		0.25	0.0 - 0.50	Dark brown, comapct, very silty SAND and GRAVEL	
	Damp		0.50	0.50 - 0.75	Brown, compact, slightly silty to silty SAND and GRAVEL	
	Moist		0.75 1.00	0.75 - 1.20	Grey, dense, laminated SILT/SAND with gravel clasts	112.8
			1.25		**End of excavation at approx. 1.2m depth** **No seepage observed in Test Hole**	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-05

BY: MDM
DATE: Mar-03
APPROVED
FIG: **A-5**

Notes:
1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-06**

Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: South side of Highland Avenue (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 180
Standpipe Stick-up (m): 0.10
Standpipe Depth (m): 1.50

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	180
			0.25	0.0 - 0.60	Dark brown, firm, sandy SILT with some coarse gravel	
			0.50			
			0.75	0.60 - 1.10	Brown, firm, sandy SILT Damp throughout **Water table depth 0.85m March 11, 2003**	
			1.00			
1.2	Moist		1.25	1.10 - 1.50	Grey, compact/dense, very silty SAND and sandy SILT with large cobbles **End of excavation at approx. 1.5m depth** **Minor seepage observed at approx. 1.1m depth** **25mm diam. PVC standpipe tube installed at approx. 1.5m depth**	178.5

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-06

BY: MDM
DATE: Mar-03
APPROVED:
FIG: **A-6**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-07**
Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: East side of Coast Meridian Road (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 140
Standpipe Stick-up (m): 0.00
Standpipe Depth (m): 1.50

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	140
			0.25	0.0 - 0.60	Dark brown, very silty sand and gravel with some cobbles	
			0.50			
				0.60 - 0.65	Relic topsoil horizon - Very silty sand, organic	
0.8	Moist		0.75	0.65 - 0.85	Brown, oxidized, compact, med-coarse SAND with trace s	
			1.00	0.85 - 1.20	**Water table depth 0.90m March 11, 2003** Brown, gravelly silty SAND and sandy silty GRAVEL Compact	
			1.25	1.20 - 1.50	Brown, stiff, laminated sandy SILT **Rapid seepage observed at approx. 1.2m depth** **25mm diam. PVC standpipe tube installed at approx. 1.5m depth**	138.5

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-07

BY: MDM
DATE: Mar-03
APPROVED
FIG: **A-7**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-08**

Date Excavated: February 24, 2003

Method: CASE 580

Approximate Location: South side of Hig0land Avenue (See Figure 2)

Supervised By: MDM

Ground Elevation (m, approx.): 136

Standpipe Stick-up (m): 0.15

Standpipe Depth (m): 1.37

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	136
			0.25	0.0 - 0.65	Black, compact/firm, very sandy SILT and very silty SAND	
			0.50			
			0.75	0.65 - 1.10	Dark reddish brown, compact, SAND and GRAVEl Mostly med-coarse sand portion and fine gravel portion Trace to some silt in matrix	
0.9	Damp		1.00			
			1.25	1.20 - 1.45	Grey, dense, grey/brown, SAND and GRAVEL in sandy silt matrix **End of excavation at approx. 1.45m depth** **Minor seepage observed at approx. 1.1m depth** **25mm diam. PVC standpipe tube installed at approx. 1.45m depth**	134.6
					Water table depth >1.45m March 11, 2003	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-08

BY: MDM | DATE: Mar-03 | APPROVED: | FIG: **A-8**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-09**
Date Excavated: February 24, 2003
Method: CASE 580
Approximate Location: West side of Coast Meridian Road (See Figure 2)

Supervised By: MDM
Ground Elevation (m, approx.): 159
Standpipe Stick-up (m): 0.00
Standpipe Depth (m): 1.20

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	159
	Damp Moist		0.25	0.0 - 0.25	Black, firm, slightly sandy silt - Organic TOPSOIL	
			0.50 0.75 1.00	0.25 - 1.05	Brown, compact, very silty SAND with some fine gravel **Water table depth 0.72m March 11, 2003**	
	Very Moist			1.05 - 1.20	Grey (oxidized), dense, laminated sandy SILT	157.8
			1.25		**End of excavation at approx. 1.2m depth** **Moderate seepage observed at approx. 1.1m depth** **25mm diam. PVC standpipe tube installed at approx. 1.2m depth**	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-09

BY: MDM
DATE: Mar-03
APPROVED
FIG: **A-9**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

Test Pit No: **TH 03-10**

Date Excavated: February 24, 2003

Method: CASE 580

Approximate Location: West side of Coast Meridian Road (See Figure 2)

Supervised By: MDM

Ground Elevation (m, approx.): 172

Standpipe Stick-up (m): 0.00

Standpipe Depth (m): 1.05

Samples / depth (m)	Moisture conditions	Standpipe water (m)	Depth (m)	Depth Range (m)	SOIL DESCRIPTION	Approx. Elev. (m-asl)
			0.0		Ground Surface	172
	Damp			0.0 - 0.20	Black, firm, slightly sandy silt - Organic TOPSOIL	
	Moist		0.25			
			0.50	0.20 - 1.00	Brown, firm/compact, slightly silty SAND Damp to wet below approx. 0.5m dept	
					Water table depth 0.70m March 11, 2003	
			0.75			
	Wet					
			1.00	1.00 - 1.05	Grey (oxidized), dense, sandy SILT with some medium gravel	170.9
					End of excavation at approx. 1.1m depth	
			1.25		**Moderate seepage observed at approx. 0.9m depth** **25mm diam. PVC standpipe tube installed at approx. 1.1m depth**	

ASSOCIATED ENGINEERING

PITEAU ASSOCIATES
GEOTECHNICAL & HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT
HYDE CREEK IWMS
COQUITLAM, B.C.

TEST HOLE LOG
TH 03-10

BY: MDM
DATE: Mar-03
APPROVED:
FIG: **A-10**

Notes: 1. Shading indicates a relatively lower permeability unit
2. Elevations are estimated from topographic maps

File: 2411\Logs.xls

APPENDIX B

BC MINISTRY OF WATER, LAND & AIR PROTECTION DOMESTIC WATER WELL LOGS

BRITISH COLUMBIA

Well Tag Number 000000033007

Owner: R IHAKSI

Address: 3553 VICTORIA DR.

Area: PT COQUITLAM

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot Plan 21357 Lot 5
Township 40 Section 7 Range
Indian Reserve Meridian Block
Quarter NE
Island
BCGS Number (NAD 27) 092G027341 Well 1

Well Use Unknown Well Use
Construction Method Unknown Constru
Diameter 6.0 inches
Well Depth 120.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 0 to 0 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19750721

Driller A & H Construction
License Number

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield 20 GPM
Artesian Flow
Static Level 75 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From 0 To 3 Ft. Soil
From 3 To 112 Ft. Till
From 112 To 120 Ft. Sand and gravel

Information Disclaimer:
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000023635

Owner: RUSSELL REZANSOFF

Address: 1239 ROCKLIN DR.

Area:

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot Plan 22154 Lot 21
Township 40 Section 7 Range
Indian Reserve Meridian Block
Quarter SE
Island
BCGS Number (NAD 27) 092G027343 Well 2

Well Use Unknown Well Use
Construction Method Drilled
Diameter 0.0 inches
Well Depth 128.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 0 to 0 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19700602

Driller RURAL WELL DRILLERS
License Number

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield 5 GPM
Artesian Flow
Static Level 101 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	3	Ft.	Tan silty sand and gravel
From	3	To	72	Ft.	Cobbly till
From	72	To	78	Ft.	Bouldery till
From	78	To	92	Ft.	Gravelly till
From	92	To	127	Ft.	Compact gravelly silt
From	127	To	128	Ft.	Sand and gravel with silt, (W.B.)
From	0	To	0	Ft.	Well finished open end csg

7 rows selected.

Information Disclaimer:
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000026288

Owner: C HAUSER

Address: 3570 BAYCREST DR.

Area: PORT COQUITLAM

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot Plan 22154 Lot 9
Township 40 Section 7 Range
Indian Reserve Meridian Block
Quarter SE
Island
BCGS Number (NAD 27) 092G027343 Well 1

Well Use Unknown Well Use
Construction Method Drilled
Diameter 6.0 inches
Well Depth 209.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 191 to 195 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19720514

Driller PACIFIC WATER WELLS
License Number

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield 4 GPM
Artesian Flow
Static Level 146 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From 0 To 107 Ft. Till
From 107 To 119 Ft. Boulder
From 119 To 148 Ft. Till
From 148 To 180 Ft. Cemented sand and gravel
From 180 To 196 Ft. Sand some silt
From 196 To 209 Ft. Clay

6 rows selected.

Information Disclaimer:
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000040409

Owner: MAC FRASER

Address: 3454 GISLASON AVE.

Area: PORT COQUITLAM

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot Plan 19985 Lot
Township 40 Section 7 Range
Indian Reserve Meridian Block
Quarter NW
Island
BCGS Number (NAD 27) 092G027343 Well 4

Well Use Unknown Well Use
Construction Method Drilled
Diameter 6.0 inches
Well Depth 94.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 0 to 0 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19780819

Driller JAY DEE DRILLING
License Number

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield 300 GPH
Artesian Flow
Static Level 19 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	16	Ft.	Brown till, boulders
From	16	To	29	Ft.	Grey till, boulders
From	29	To	31	Ft.	Sand, brown, fine slightly water bearing
From	31	To	64	Ft.	Boulders
From	64	To	94	Ft.	Till, boulders, small water bearing
From	0	To	0	Ft.	layers

6 rows selected.

Information Disclaimer:
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000032045

Owner: WAYNE COOLEDGE

Address: 3564 BAYCREST DR.

Area: PORT COQUITLAM

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot Plan 22154 Lot 20
Township 40 Section 7 Range
Indian Reserve Meridian Block
Quarter NE
Island
BCGS Number (NAD 27) 092G027343 Well 3

Well Use Unknown Well Use
Construction Method Drilled
Diameter 5.0 inches
Well Depth 168.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 0 to 0 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19750130

Driller JAY DEE DRILLING
License Number

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield 15 GPM
Artesian Flow
Static Level 118 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:
REC. PUMP SET 145'

From 0 To 6 Ft. Brown clay till, boulders to 4'
From 6 To 14 Ft. Grey clay till, boulders
From 14 To 42 Ft. Lean grey clay till water bearing at 42'
From 42 To 120 Ft. Grey lean till
From 120 To 141 Ft. Grey sand dense water bearing at 141'
From 141 To 144 Ft. Gravel
From 144 To 156 Ft. Grey till
From 156 To 168 Ft. Gravel, water bearing

8 rows selected.

Information Disclaimer:
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

Date entered to WELL

PHOTOGRAPHS

<u>Photo 1.</u>
Completed standpipe piezometer installation at TH03-03.

<u>Photo 2.</u>
Double ring infiltrometer installed at Site #10.

Photo 3.
1m exposure of oxidized, silty sand and gravel over brown dense till (east side of Harper Road at park boundary).

Photo 4.
Very silty sand/gravel over dense till in ditch exposure (east side of Harper Road). Note seepage from sand/gravel.

<u>Photo 5.</u>
3m exposure of brown silty sand/gravel over grey dense till (Lot #5 Hazel Avenue, looking east).

<u>Photo 6.</u>
1.8m exposure of silty sand and gravel over brown dense till (west side of Coast Meridian Road, looking northwest).

Photo7.
1.8m exposure of silty sand/gravel over dense till (south side of Victoria Avenue).

Photo 8.
2m exposure of compact slightly silty sand (north side of Conifer Drive).

Photo 9.
2m exposure of silty sand (silty) over dense till (north side of Harper Road, looking north).

Photo 10.
Grey till exposed in base of roadside ditch (north side of Highland Drive).

Photo 11.
Test Hole TH03-03. Compact medium-coarse sand over dense, grey sit/sand.

Photo 12.
Test Hole TH03-10. Brown firm/compact sand over grey, dense sandy silt.

Photo 13.
Test Hole TH03-04. Silty sand and gravel over firm/stiff grey silt.

WATERSHED SUBCATCHMENT DATA

APPENDIX C

CITY OF COQUITLAM / PORT COQUITLAM - HYDE CREEK IWMP
TABLE C1: SUB-CATCHMENT INVENTORY AND MODELLING PARAMETERS

Sub-catchment Number (Model Node)	Location (Coq or Poco)	Physical Characteristics: Area (ha)	Elev. Band (see Note)	Land Use (see Note): Existing	Land Use (see Note): Future	Percent Impervious Area: Existing (%)	Percent Impervious Area: Future (%)	Width (m)	Slope (m/m)	Soil Type (see Note)	Manning's "n" Coefficient for Overland Flow: Impervious Area	Manning's "n": Pervious Area	Impervious Area Zero Detention (%)	Existing: Horton Infiltration Values: Maximum Rate (mm/hr)	Existing: Minimum Rate (mm/hr)	Existing: Decay Rate (1/s)	Existing: Depression Storage: Impervious Area (mm)	Existing: Pervious Area (mm)	Existing: Estimated Ground Water Base Flow (L/s/ha)	Existing: Base Flow (m^3/s)	Future: Horton Infiltration Values: Maximum Rate (mm/hr)	Future: Minimum Rate (mm/hr)	Future: Decay Rate (1/s)	Future: Depression Storage: Impervious Area (mm)	Future: Pervious Area (mm)	Future: Estimated Ground Water Base Flow (L/s/ha)	Future: Base Flow (m^3/s)
ALD-N10	Poco	5.54	A	DSF		30	30	600	0.035	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0011	6.0	3.0	0.00050	1.0	3.0	0.20	0.0011
ALD-N100	Poco	1.87	A	DSF		40	40	300	0.040	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004
ALD-N140	Coq	5.04	A	C		25	40	200	0.080	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0010	9.0	3.0	0.00050	1.0	3.0	0.20	0.0010
BRK-N20	Coq	4.44	A	F		2.5/2.5	85/65	155	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0009	12.5	6.3	0.00005	1.0	3.0	0.20	0.0009
BRK-N30	Coq	14.33	A	F		2.5/2.5	90/65	685	0.125	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0029	12.5	6.3	0.00005	1.0	3.0	0.20	0.0029
BRK-N40	Coq	23.06	A	F		2.5/2.5	75/40	1760	0.150	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0046	9.0	3.0	0.00050	1.0	3.0	0.20	0.0046
BRK-N50	Coq	8.15	B	F		2.5/2.5	10/10	1200	0.240	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0016	9.0	3.0	0.00050	1.0	3.0	0.20	0.0016
BRK-N70	Coq	6.70	C	F		2.5	2.5	2200	0.400	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0013	9.0	3.0	0.00010	1.0	3.0	0.20	0.0013
CED-N20.1	Coq	5.59	A	F		15	80	300	0.115	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0011	12.5	6.3	0.00005	1.0	3.0	0.20	0.0011
CED-N20.2	Poco	1.19	A	DR		20	20	150	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002
CED-N30	Poco	2.64	A	DSF		35	35	270	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005
CED-N40	Poco	1.58	A	DSF		40	40	200	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
CED-N50	Poco	2.15	A	DSF		40	40	360	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004
CED-N60	Poco	0.28	A	C		20	20	150	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0001	6.0	3.0	0.00050	1.0	3.0	0.20	0.0001
CED-N100	Poco	0.28	A	DSF		50	50	50	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0001	6.0	3.0	0.00050	1.0	3.0	0.20	0.0001
CED-N140	Poco	0.83	A	DSF		40	40	200	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002
CED-N150	Poco	5.00	A	DSF		45	45	350	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0010	6.0	3.0	0.00050	1.0	3.0	0.20	0.0010
CED-N180	Poco	13.67	A	DSF		45	45	880	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0027	6.0	3.0	0.00050	1.0	3.0	0.20	0.0027
CED-N200	Poco	3.30	A	DSF		45	45	250	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0007	6.0	3.0	0.00050	1.0	3.0	0.20	0.0007
CED-N210	Poco	1.48	A	DSF		45	45	350	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
CED-N220	Poco	8.38	A	DSF		45	45	640	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0017	6.0	3.0	0.00050	1.0	3.0	0.20	0.0017
CED-N230	Poco	2.78	A	C		15	15	140	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0006	6.0	3.0	0.00050	1.0	3.0	0.20	0.0006
CED-N240	Poco	6.64	A	DSF		40	40	630	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0013	6.0	3.0	0.00050	1.0	3.0	0.20	0.0013
CED-N260	Poco	2.47	A	DSF		40	40	500	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005
CED-N275	Poco	10.54	A	DSF		45	45	600	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0021	6.0	3.0	0.00050	1.0	3.0	0.20	0.0021
CED-N290	Poco	41.82	A	DSF		40	40	1540	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0084	6.0	3.0	0.00050	1.0	3.0	0.20	0.0084
CED-N300	Poco	5.00	A	DSF		40	40	450	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0010	6.0	3.0	0.00050	1.0	3.0	0.20	0.0010
CED-N310.1	Poco	8.15	A	DSF		40	40	630	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0016	6.0	3.0	0.00050	1.0	3.0	0.20	0.0016
CED-N310.2	Poco	3.13	A	DSF		40	40	450	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0006	6.0	3.0	0.00050	1.0	3.0	0.20	0.0006
CED-N320	Poco	9.22	A	DSF/DMF		40	40	500	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0018	6.0	3.0	0.00050	1.0	3.0	0.20	0.0018
CED-N330	Poco	3.94	A	DSF		40	40	630	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008
CED-N340.1	Poco	119.43	A	C/DSF		40	40	2900	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0239	6.0	3.0	0.00050	1.0	3.0	0.20	0.0239
CED-N340.2	Poco	10.86	A	DSF		40	40	900	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0022	6.0	3.0	0.00050	1.0	3.0	0.20	0.0022
CME-N10	Coq	5.29	A	F		5	55	290	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0011	12.5	6.3	0.00005	1.0	3.0	0.20	0.0011
CME-N50	Coq	2.80	A	F/C		5	65	150	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0006	12.5	6.3	0.00005	1.0	3.0	0.20	0.0006
CME-N55	Coq	3.71	A	F/C		2.5	65	600	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
CME-N110	Coq	0.71	A	F		2.5	65	50	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0001	12.5	6.3	0.00005	1.0	3.0	0.20	0.0001
CME-N120	Coq	0.67	A	F		5	65	80	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0001	12.5	6.3	0.00005	1.0	3.0	0.20	0.0001
CME-N140	Coq	0.19	A	DR		40	65	30	0.100	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0000	9.0	3.0	0.00050	1.0	3.0	0.20	0.0000
CME-N190	Coq	0.98	A	DR		15	65	150	0.090	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
CME-N240	Coq	1.31	A	C		10	65	100	0.095	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0003	9.0	3.0	0.00050	1.0	3.0	0.20	0.0003
CME-N300	Coq	3.41	A	F/DR		10	65	200	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
CME-N410	Coq	1.01	A	DR		30	75	120	0.110	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
CME-N430	Coq	5.48	A	F		5	75	100	0.120	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0011	9.0	3.0	0.00050	1.0	3.0	0.20	0.0011
CME-N465	Coq	2.61	A	F		10	75	100	0.130	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0005	9.0	3.0	0.00050	1.0	3.0	0.20	0.0005
CME-N500	Coq	1.12	A	F		10	60	130	0.105	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
CME-N510	Coq	1.92	A	C		20	60	300	0.115	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004
CME-N550	Coq	0.86	B	C		20	75	60	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
CME-N560	Coq	10.46	B	F		5	5	600	0.130	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0021	9.0	3.0	0.00050	1.0	3.0	0.20	0.0021
CMW-N10	Coq	2.98	A	F		7.5	55	150	0.080	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0006	12.5	6.3	0.00005	1.0	3.0	0.20	0.0006
CMW-N90	Coq	1.68	A	F/C		20	50	360	0.080	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0003	12.5	6.3	0.00005	1.0	3.0	0.20	0.0003
CMW-N110	Coq	1.47	A	C		15	50	400	0.075	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0003	9.0	3.0	0.00050	1.0	3.0	0.20	0.0003
DAY-N20	Coq	3.02	B	F		2.5	25	400	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0006	9.0	3.0	0.00050	1.0	3.0	0.20	0.0006
GAL-N10	Coq	8.11	A	F/C		7.5	65	360	0.120	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0016	12.5	6.3	0.00005	1.0	3.0	0.20	0.0016
GBK-N50	Coq	6.38	A	F		5	75	320	0.090	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0013	12.5	6.3	0.00005	1.0	3.0	0.20	0.0013
HAR-N10	Coq	18.51	B	F		5	25	500	0.165	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0037	9.0	3.0	0.00050	1.0	3.0	0.20	0.0037
HAR-N30	Coq	20.57	B	F		2.5	2.5	700	0.245	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0041	9.0	3.0	0.00050	1.0	3.0	0.20	0.0041
HLD-N30	Coq	2.42	A	C		10	75	100	0.055	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0005	9.0	3.0	0.00050	1.0	3.0	0.20	0.0005
HLD-N50	Coq	3.72	A	F		5	75	220	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
HLD-N70	Coq	2.08	A	F		7.5	70	90	0.130	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004
HLD-N80	Coq	2.15	A	F		7.5	70	390	0.125	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004
HLD-N100	Coq	2.01	A	F		10	70	90	0.095	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004

CITY OF COQUITLAM / PORT COQUITLAM - HYDE CREEK IWMP
TABLE C1: SUB-CATCHMENT INVENTORY AND MODELLING PARAMETERS

Sub-catchment Number (Model Node)	Location (Coq or Poco)	Physical Characteristics: Area (ha)	Elev. Band (see Note)	Land Use (see Note): Existing	Land Use (see Note): Future	Percent Impervious Area: Existing (%)	Percent Impervious Area: Future (%)	Width (m)	Slope (m/m)	Soil Type (see Note)	Manning's "n" Coefficient for Overland Flow: Impervious Area	Manning's "n": Pervious Area	Impervious Area Zero Detention (%)	Existing Development Condition Modelling Characteristics: Horton Infiltration Values: Maximum Rate (mm/hr)	Existing: Minimum Rate (mm/hr)	Existing: Decay Rate (1/s)	Existing: Depression Storage: Impervious Area (mm)	Existing: Depression Storage: Pervious Area (mm)	Existing: Estimated Ground Water Base Flow (L/s/ha)	Existing: Estimated Ground Water Base Flow (m^3/s)	Future Development Condition Modelling Characteristics: Horton Infiltration Values: Maximum Rate (mm/hr)	Future: Minimum Rate (mm/hr)	Future: Decay Rate (1/s)	Future: Depression Storage: Impervious Area (mm)	Future: Depression Storage: Pervious Area (mm)	Future: Estimated Ground Water Base Flow (L/s/ha)	Future: Estimated Ground Water Base Flow (m^3/s)
HLD-N140	Coq	0.78	A	C		15	70	150	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
HLD-N150	Coq	1.81	A	F		5	70	150	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004
HLD-N160	Coq	1.46	A	F		5	45	200	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0003	9.0	3.0	0.00050	1.0	3.0	0.20	0.0003
HYD-N10.1	Poco	3.89	A	F		5	5	250	0.065	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0008	9.0	3.0	0.00010	1.0	3.0	0.20	0.0008
HYD-N10.2	Poco	3.20	A	F		10	10	460	0.005	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0006	9.0	3.0	0.00010	1.0	3.0	0.20	0.0006
HYD-N30	Poco	3.07	A	F		15	15	300	0.050	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0006	9.0	3.0	0.00010	1.0	3.0	0.20	0.0006
HYD-N40	Poco	5.18	A	F		10	10	400	0.060	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0010	9.0	3.0	0.00010	1.0	3.0	0.20	0.0010
HYD-N50.1	Poco	10.85	A	DSF		50	50	500	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0022	6.0	3.0	0.00050	1.0	3.0	0.20	0.0022
HYD-N50.2	Poco	3.95	A	F		5	5	370	0.060	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0008	9.0	3.0	0.00010	1.0	3.0	0.20	0.0008
HYD-N50.3	Poco	6.19	A	F		5	5	500	0.005	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0012	9.0	3.0	0.00010	1.0	3.0	0.20	0.0012
HYD-N60.1	Poco	3.78	A	DSF		50	50	300	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008
HYD-N60.2	Poco	1.55	A	F		5	5	150	0.040	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0003	9.0	3.0	0.00010	1.0	3.0	0.20	0.0003
HYD-N70.1	Poco	1.25	A	DSF		50	50	200	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
HYD-N70.2	Poco	7.81	A	F/DSF		25	25	500	0.025	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0016	6.0	3.0	0.00050	1.0	3.0	0.20	0.0016
HYD-N70.3	Poco	2.48	A	DC		60	60	200	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005
HYD-N80	Poco	6.37	A	DSF		40	40	400	0.010	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0013	6.0	3.0	0.00050	1.0	3.0	0.20	0.0013
HYD-N90	Poco	7.39	A	DSF		50	50	500	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0015	6.0	3.0	0.00050	1.0	3.0	0.20	0.0015
HYD-N110	Poco	11.54	A	DSF		50	50	800	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0023	6.0	3.0	0.00050	1.0	3.0	0.20	0.0023
HYD-N115	Coq	4.92	A	C		20	55	1000	0.055	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0010	9.0	3.0	0.00050	1.0	3.0	0.20	0.0010
HYD-N130	Poco	2.11	A	DSF		40	40	250	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004
HYD-N150	Poco	1.03	A	DSF		45	45	200	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002
HYD-N170	Poco	23.47	A	DSF		45	45	800	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0047	6.0	3.0	0.00050	1.0	3.0	0.20	0.0047
HYD-N180	Poco	1.27	A	DSF		40	40	200	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
HYD-N190	Poco	1.37	A	DSF		40	40	200	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
HYD-N200	Poco	1.32	A	DSF		45	45	200	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
HYD-N230	Poco	2.73	A	DSF		35	35	200	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005	6.0	3.0	0.00050	1.0	3.0	0.20	0.0005
HYD-N240	Poco	4.13	A	DSF		35	35	350	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008
HYD-N250.1	Poco	11.76	A	DSF		40	40	590	0.055	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0024	6.0	3.0	0.00050	1.0	3.0	0.20	0.0024
HYD-N250.2	Poco	1.15	A	DSF		35	35	200	0.055	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002
HYD-N270	Poco	4.89	A	DSF		35	35	300	0.050	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0010	6.0	3.0	0.00050	1.0	3.0	0.20	0.0010
HYD-N300	Coq	3.49	A	F		2.5	2.5	720	0.240	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
HYD-N310	Coq	4.72	A	F		5/2.5	55/2.5	720	0.240	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0009	12.5	6.3	0.00005	1.0	3.0	0.20	0.0009
HYD-N320	Coq	9.00	A	C		10/2.5	75/2.5	560	0.100	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0018	9.0	3.0	0.00050	1.0	3.0	0.20	0.0018
HYD-N330	Coq	2.00	A	C		10/2.5	75/2.5	85	0.160	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004
HYD-N340	Coq	9.13	A	C		10/2.5	70/2.5	170	0.120	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0018	9.0	3.0	0.00050	1.0	3.0	0.20	0.0018
HYD-N350	Coq	7.56	A	F/DR		5/2.5/25	50/2.5/25	720	0.180	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0015	9.0	3.0	0.00050	1.0	3.0	0.20	0.0015
HYD-N370	Coq	4.31	A	F		5/2.5/5	50/2.5/5	350	0.160	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0009	12.5	6.3	0.00005	1.0	3.0	0.20	0.0009
HYD-N380.1	Coq	8.80	A	F		5/2.5/5	75/2.5/5	560	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0018	12.5	6.3	0.00005	1.0	3.0	0.20	0.0018
HYD-N380.2	Coq	9.82	A	F		10/10	65/70	950	0.130	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0020	12.5	6.3	0.00005	1.0	3.0	0.20	0.0020
HYD-N390.1	Coq	40.29	A	F		5/5	10/70	600	0.155	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0081	9.0	3.0	0.00050	1.0	3.0	0.20	0.0081
HYD-N390.2	Coq	3.51	A	F		5/5	10/50	600	0.150	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
HYD-N410	Coq	12.97	B	F		5/5	10/5	1700	0.200	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0026	9.0	3.0	0.00050	1.0	3.0	0.20	0.0026
HYD-N450	Coq	48.40	C	F		2.5	2.5	500	0.300	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0097	9.0	3.0	0.00050	1.0	3.0	0.20	0.0097
LIN-N90	Poco	5.41	A	F		5	5	600	0.005	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0011	9.0	3.0	0.00010	1.0	3.0	0.20	0.0011
MAN-N20	Poco	7.53	A	DSF		40	40	630	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0015	6.0	3.0	0.00050	1.0	3.0	0.20	0.0015
MAN-N120	Coq	3.88	A	DR		10	80	700	0.060	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0008	9.0	3.0	0.00050	1.0	3.0	0.20	0.0008
MAN-N140	Coq	5.77	A	F		5	90	500	0.090	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0012	12.5	6.3	0.00005	1.0	3.0	0.20	0.0012
MIL-N50.1	Coq	2.15	A	C		10	75	300	0.080	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004
MIL-N50.2	Coq	4.06	A	C		10	75	190	0.080	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0008	9.0	3.0	0.00050	1.0	3.0	0.20	0.0008
OXF-N20	Coq	7.98	A	DSF		30	30	560	0.060	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0016	9.0	3.0	0.00050	1.0	3.0	0.20	0.0016
PRA-N70	Poco	45.85	A	DSF		40	40	1600	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0092	6.0	3.0	0.00050	1.0	3.0	0.20	0.0092
PRA-N100	Poco	9.93	A	F		5	5	300	0.005	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0020	9.0	3.0	0.00010	1.0	3.0	0.20	0.0020
QSN-N70	Coq	6.69	A	F		7.5	65	300	0.120	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0013	12.5	6.3	0.00005	1.0	3.0	0.20	0.0013
QSN-N150	Coq	3.37	A	F		5	65	500	0.095	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
REN-N70	Poco	11.45	A	F		10	10	630	0.060	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0023	9.0	3.0	0.00010	1.0	3.0	0.20	0.0023
RCH-N30	Poco	6.00	A	F/C		20	20	700	0.005	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0012	6.0	3.0	0.00050	1.0	3.0	0.20	0.0012
SML-N20	Poco	3.04	A	F/DSF		25	25	300	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0006	6.0	3.0	0.00050	1.0	3.0	0.20	0.0006
SML-N40.1	Coq	12.34	A	F		7.5/7.5	85/60	300	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0025	12.5	6.3	0.00005	1.0	3.0	0.20	0.0025
SML-N40.2	Coq	5.92	A	C/DR		15	80	120	0.080	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0012	9.0	3.0	0.00050	1.0	3.0	0.20	0.0012
SML-N40.3	Coq	1.73	A	F		7.5/7.5	80/50	300	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0003	12.5	6.3	0.00005	1.0	3.0	0.20	0.0003
SML-N40.4	Coq	3.35	A	C/DR		15/15	80/50	120	0.080	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0007	9.0	3.0	0.00050	1.0	3.0	0.20	0.0007
SML-N150	Coq	26.80	A	F		2.5/2.5	65/60	1050	0.130	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0054	12.5	6.3	0.00005	1.0	3.0	0.20	0.0054

CITY OF COQUITLAM / PORT COQUITLAM - HYDE CREEK IWMP
TABLE C1: SUB-CATCHMENT INVENTORY AND MODELLING PARAMETERS

Sub-catchment Number (Model Node)	Location (Coq or Poco)	Physical Characteristics: Area (ha)	Elev. Band (see Note)	Land Use (see Note): Existing	Land Use (see Note): Future	Percent Impervious Area: Existing (%)	Percent Impervious Area: Future (%)	Width (m)	Slope (m/m)	Soil Type (see Note)	Manning's "n" Coefficient for Overland Flow: Impervious Area	Manning's "n": Pervious Area	Impervious Area Zero Detention (%)	Existing Development Condition Modelling Characteristics: Horton Infiltration Values: Maximum Rate (mm/hr)	Existing: Minimum Rate (mm/hr)	Existing: Decay Rate (1/s)	Existing: Depression Storage: Impervious Area (mm)	Existing: Pervious Area (mm)	Existing: Estimated Ground Water Base Flow (L/s/ha)	Existing: Estimated Ground Water Base Flow (m^3/s)	Future Development Condition Modelling Characteristics: Horton Infiltration Values: Maximum Rate (mm/hr)	Future: Minimum Rate (mm/hr)	Future: Decay Rate (1/s)	Future: Depression Storage: Impervious Area (mm)	Future: Pervious Area (mm)	Future: Estimated Ground Water Base Flow (L/s/ha)	Future: Estimated Ground Water Base Flow (m^3/s)
SML-N170	Coq	11.96	A	F		5/5	55/55	1260	0.130	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0024	12.5	6.3	0.00005	1.0	3.0	0.20	0.0024
SML-N200	Coq	18.68	B	F		2.5/2.5	15/45	420	0.185	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0037	9.0	3.0	0.00050	1.0	3.0	0.20	0.0037
SML-N220	Coq	32.29	B	F		5/5	5/5	600	0.280	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0065	12.5	6.3	0.00005	1.0	3.0	0.20	0.0065
SML-N240	Coq	25.78	C	F		2.5	2.5	400	0.350	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0052	9.0	3.0	0.00050	1.0	3.0	0.20	0.0052
UNN-N20	Coq	3.63	A	F		7.5/7.5	55/45	810	0.130	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007	12.5	6.3	0.00005	1.0	3.0	0.20	0.0007
UNN-N24	Coq	9.73	A	F		7.5/7.5	60/60	900	0.130	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0019	12.5	6.3	0.00005	1.0	3.0	0.20	0.0019
UNN-N28	Coq	1.92	A	F		5	65	70	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004
UNN-N40	Coq	2.48	A	F/DR		5/5	55/55	300	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0005	12.5	6.3	0.00005	1.0	3.0	0.20	0.0005
UNN-N50	Coq	3.79	A	DR		10/10	55/55	340	0.110	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0008	9.0	3.0	0.00050	1.0	3.0	0.20	0.0008
UNN-N60	Coq	1.91	A	F		7.5	65	150	0.105	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004
UNN-N90	Coq	5.38	B	F		5/5	55/60	700	0.115	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0011	9.0	3.0	0.00050	1.0	3.0	0.20	0.0011
UNN-N150	Coq	1.04	B	F		2.5	5	300	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
UNN-N170	Coq	2.12	B	F		2.5	5	300	0.115	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004
UNN-N176	Coq	19.57	B	F		5	5	600	0.115	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0039	9.0	3.0	0.00050	1.0	3.0	0.20	0.0039
UNN-N180	Coq	1.91	B	F		2.5	5	300	0.125	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004	9.0	3.0	0.00050	1.0	3.0	0.20	0.0004
UNN-N200	Coq	0.87	B	F		5	5	150	0.115	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
WAT-N10.1	Poco	3.37	A	DSF		45	45	250	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0007	6.0	3.0	0.00050	1.0	3.0	0.20	0.0007
WAT-N10.2	Poco	3.07	A	F		10	10	400	0.060	2	0.015	0.200	0	9.0	3.0	0.00010	1.0	3.0	0.20	0.0006	9.0	3.0	0.00010	1.0	3.0	0.20	0.0006
WAT-N30.1	Poco	1.39	A	DSF		40	40	250	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
WAT-N30.2	Poco	4.05	A	DSF		40	40	250	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008	6.0	3.0	0.00050	1.0	3.0	0.20	0.0008
WAT-N40	Poco	0.95	A	DSF		45	45	150	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002	6.0	3.0	0.00050	1.0	3.0	0.20	0.0002
WAT-N50	Poco	2.16	A	F/DSF		25	25	300	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004	6.0	3.0	0.00050	1.0	3.0	0.20	0.0004
WAT-N70	Coq	0.94	A	DSF		30	65	100	0.040	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002	9.0	3.0	0.00050	1.0	3.0	0.20	0.0002
WAT-N150	Coq	5.08	A	F		10	60	400	0.080	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0010	12.5	6.3	0.00005	1.0	3.0	0.20	0.0010
WAT-N170	Coq	10.48	A	F		5	65	120	0.085	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0021	12.5	6.3	0.00005	1.0	3.0	0.20	0.0021
WAT-N200.1	Coq	2.46	A	F		15/15	50/50	700	0.080	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0005	12.5	6.3	0.00005	1.0	3.0	0.20	0.0005
WAT-N200.2	Coq	6.11	A	C		15	55	400	0.070	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0012	9.0	3.0	0.00050	1.0	3.0	0.20	0.0012
WAT-N220	Coq	5.77	A	F/DR		10/10	70/70	720	0.080	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0012	12.5	6.3	0.00005	1.0	3.0	0.20	0.0012
WDG-N10	Poco	1.25	A	DSF		45	45	280	0.060	1	0.015	0.200	0	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003	6.0	3.0	0.00050	1.0	3.0	0.20	0.0003
WDG-N40	Coq	3.40	A	DR		20	60	200	0.090	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0007	9.0	3.0	0.00050	1.0	3.0	0.20	0.0007
WDG-N115	Coq	6.71	A	F		10	65	300	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0013	12.5	6.3	0.00005	1.0	3.0	0.20	0.0013
WDG-N130	Coq	5.87	A	F		15	55	300	0.100	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0012	12.5	6.3	0.00005	1.0	3.0	0.20	0.0012
WDG-N180	Coq	1.97	A	F		10	65	120	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004	12.5	6.3	0.00005	1.0	3.0	0.20	0.0004
WDG-N200	Coq	7.27	A	F		10	65	300	0.110	3	0.015	0.200	0	12.5	6.3	0.00005	1.0	3.0	0.20	0.0015	12.5	6.3	0.00005	1.0	3.0	0.20	0.0015
WEL-N20	Coq	4.76	A	F/DSF		20	20	400	0.060	4	0.015	0.200	0	9.0	3.0	0.00050	1.0	3.0	0.20	0.0010	9.0	3.0	0.00050	1.0	3.0	0.20	0.0010

Total Catchment Area (ha)	1157.18
Coquitlam portion of Catchment Area (ha)	645.83
Port Coquitlam portion of Catchment Area (ha)	511.35

Land Use Designations (based on predominant cover type)

- **F:** Forested
- **C:** Cleared
- **DR:** Developed Rural
- **DC:** Developed Commercial
- **DSF:** Developed Single Family
- **DMF:** Developed Multi Family

Elevation Bands
(to account for orographic effect on rainfall)

- **A:** < 200 m
- **B:** 200 m to 400 m
- **C:** > 400 m

Soil Type (used to estimate infiltration parameters)

- **1:** Developed Land - low or uncertain infiltration
- **2:** Forested Land - low or uncertain infiltration
- **3:** Forested Land - moderately well drained soils or better
- **4:** Developed Land - moderately well drained soils or better
  or Forested Land - mixed characteristics
  or Cleared Land - moderately well drained soils

APPENDIX D

WATERSHED INVENTORY DATA

CITY OF COQUITLAM / PORT COQUITLAM - HYDE CREEK IWMP
TABLE D1A: EXISTING CULVERT INVENTORY - FROM RECORD DRAWINGS AND FIELD INVESTIGATION

NOTES: Links Modelled Together | Links Not Modelled | *Assumed Information*

CULVERT I.D.	GENERAL INFORMATION					INVERT ELEVATION			SURFACE ELEVATION		MODEL NODE CONNECTED TO CULVERT	
	DESCRIPTION	SIZE (mm)	MATERIAL	MANNING'S "n"	LENGTH (m)	U/S (m)	D/S (m)	SLOPE (%)	U/S (m)	D/S (m)	U/S	D/S
Alderwood Avenue												
ALD-C10	Storm Sewer Outlet	375	Concrete	0.013	43.0	8.00	6.62	3.21%	10.02	8.05	ALD-N30	ALD-N20
ALD-C20	Storm Sewer	375	Concrete	0.013	71.2	10.10	8.04	2.90%	12.06	10.02	ALD-N40	ALD-N30
ALD-C30	Storm Sewer	375	Concrete	0.013	96.0	11.66	10.22	1.50%	13.57	12.06	ALD-N50	ALD-N40
ALD-C40	Storm Sewer	375	Concrete	0.013	75.5	12.93	11.79	1.51%	16.40	13.57	ALD-N60	ALD-N50
ALD-C50	Storm Sewer	450	Concrete	0.013	53.0	13.23	12.96	0.51%	14.52	16.40	ALD-N70	ALD-N60
ALD-C60	Storm Sewer Inlet	375	Concrete	0.013	14.5	13.79	13.30	3.38%	15.25	14.52	ALD-N80	ALD-N70
ALD-C70	Storm Sewer Outlet	450	Concrete	0.013	68.6	20.35	19.71	0.93%	22.75	20.80	ALD-N100	ALD-N90
ALD-C80	Storm Sewer	450	Concrete	0.013	91.0	21.17	20.38	0.87%	24.50	22.75	ALD-N110	ALD-N100
ALD-C90	Storm Sewer	375	Concrete	0.013	116.6	23.94	21.30	2.26%	27.10	24.50	ALD-N120	ALD-N110
ALD-C100	Storm Sewer	600	CSP	0.024	7.1	26.50	23.31	44.93%	27.80	27.10	ALD-N130	ALD-N120
ALD-C110	Storm Sewer	300	PVC	0.010	5.9	27.07	26.50	9.66%	28.16	27.80	ALD-N140	ALD-N130
Burke Mountain Creek												
BRK-C10	Circular Culvert	1200	Concrete	0.013	7.0	32.90	32.50	5.71%	35.00	35.00	BRK-N20	BRK-N10
BRK-C20	Circular Culvert	600	CSP	0.024	4.0	429.10	428.80	7.50%	430.00	429.80	BRK-N70	BRK-N60
Cedar Ditch												
CED-C10	Arch Culvert	3890H x 2690V	SPCSP	0.030	24.0	*0.89*	*0.89*	0.00%	5.00	5.00	CED-N20	CED-N10
CED-C11	Arch Culvert	4370H x 2870V	SPCSP	0.030	20.0	*0.89*	*0.89*	0.00%	5.00	5.00	CED-N20	CED-N10
CED-FB	Twin Floodboxes	2 - 1830H x 1830V	Concrete	0.013	20.0	1.40	0.94	2.30%	5.18	5.18	CED-N90	CED-N70
CED-PUMP	Pump Station										CED-N90	CED-N80
CED-C20	Driveway Bridge	2300 clearance	Natural Bottom	0.040	4.0	1.50	1.50	0.00%	4.10	4.10	CED-N110	CED-N100
CED-C30	Driveway Bridge	2300 clearance	Natural Bottom	0.040	4.0	1.54	1.54	0.00%	4.20	4.20	CED-N130	CED-N120
CED-C40	Footbridge	3000 clearance	Natural Bottom	0.040	2.5	1.64	1.64	0.00%	4.10	4.10	CED-N170	CED-N160
CED-C50	Twin Box Culverts	2 - 2100H x 2100V	Concrete	0.013	14.5	2.05	2.05	0.00%	4.35	4.35	CED-N190	CED-N180
CED-C60	Box Culvert	2700H x 1700V	Concrete / Nat. Bottom	0.013 / 0.040	14.0	1.68	1.68	0.00%	4.20	4.20	CED-N230	CED-N220
CED-C70	Box Culvert	2750H x 1850V	Concrete	0.013	14.0	1.92	1.92	0.00%	4.57	4.57	CED-N250	CED-N240
CED-C75	Box Culvert Outlet	2600H x 1200V	Concrete / Nat. Bottom	0.013 / 0.040	8.0	1.96	1.96	0.00%	4.66	4.66	CED-N275	CED-N270
CED-C80	Box Culvert Inlet	2600H x 1200V	Concrete / Nat. Bottom	0.013 / 0.040	19.0	1.96	1.96	0.00%	4.66	4.66	CED-N280	CED-N275
Coast Meridian (East)												
CME-C10	Circular Culvert	600	Concrete	0.013	6.0	56.50	56.00	8.33%	57.50	57.00	CME-N10	WAT-N180
CME-C20	Circular Culvert	450	Concrete	0.013	2.0	74.40	74.20	10.00%	75.20	75.00	CME-N30	CME-N20
CME-C30	Circular Culvert	450	Concrete	0.013	6.0	82.50	82.00	8.33%	83.30	83.00	CME-N50	CME-N40
CME-C35	Circular Culvert	450	Concrete	0.013	4.0	82.60	82.50	2.50%	83.30	83.30	CME-N55	CME-N50
CME-C40	Circular Culvert	450	Concrete	0.013	2.0	90.20	90.10	5.00%	91.00	90.90	CME-N70	CME-N60
CME-C50	Circular Culvert	375	Concrete	0.013	2.0	90.80	90.70	5.00%	91.50	91.40	CME-N90	CME-N80
CME-C60	Circular Culvert	375	Concrete	0.013	6.0	95.30	95.00	5.00%	96.00	95.70	CME-N110	CME-N100
CME-C70	Circular Culvert	900	Woodstave	0.012	12.0	99.10	98.80	2.50%	101.00	100.50	CME-N120	CMW-N130
CME-C80	Circular Culvert	300	Concrete	0.013	12.0	106.70	106.10	5.00%	107.50	107.00	CME-N140	CME-N130
CME-C90	Circular Culvert	600	CSP	0.024	12.0	109.00	108.00	8.33%	110.00	109.00	CME-N150	CMW-N210
CME-C100	Circular Culvert	300	Concrete/PVC	0.013/0.010	5.0	116.40	116.20	4.00%	117.00	116.80	CME-N170	CME-N160
CME-C110	Circular Culvert	300	Concrete	0.013	5.0	117.40	117.20	4.00%	118.00	117.80	CME-N190	CME-N180
CME-C120	Circular Culvert	600	CSP	0.024	12.0	119.20	118.20	8.33%	120.50	120.50	CME-N200	WAT-N230
CME-C130	Circular Culvert	800	CSP	0.024	7.0	122.80	122.00	11.43%	124.00	123.20	CME-N220	CME-N210
CME-C140	Circular Culvert	600	Concrete	0.013	4.0	125.00	124.80	5.00%	126.00	125.80	CME-N240	CME-N230
CME-C150	Circular Culvert	600	Concrete	0.013	12.0	128.10	127.60	4.17%	129.00	128.50	CME-N260	CME-N250
CME-C160	Circular Culvert	600	Concrete	0.013	6.0	132.80	132.50	5.00%	134.00	133.70	CME-N280	CME-N270
CME-C170	Circular Culvert	600	Concrete	0.013	5.0	135.80	135.50	6.00%	137.00	136.70	CME-N300	CME-N290
CME-C180	Circular Culvert	600	Concrete	0.013	9.0	146.00	145.50	5.56%	147.00	146.50	CME-N320	CME-N310
CME-C190	Circular Culvert	300	Concrete	0.013	12.0	150.40	150.20	1.67%	151.00	150.80	CME-N340	CME-N330
CME-C200	Circular Culvert	600	CSP	0.024	16.0	151.60	150.10	9.38%	152.50	151.00	CME-N350	HLD-N60
CME-C210	Circular Culvert	600	Concrete	0.013	6.0	154.90	154.60	5.00%	155.80	155.50	CME-N370	CME-N360
CME-C220	Circular Culvert	580	PVC	0.010	4.0	156.10	155.90	5.00%	157.00	156.80	CME-N390	CME-N380
CME-C230	Circular Culvert	600	Concrete	0.013	6.0	158.10	157.80	5.00%	159.00	158.70	CME-N410	CME-N400
CME-C240	Circular Culvert	600	Concrete	0.013	4.0	159.50	159.30	5.00%	161.60	161.40	CME-N430	CME-N420
CME-C250	Storm Sewer Outlet	375	Concrete	0.013	16.5	160.61	160.51	0.61%	162.35	161.40	CME-N450	CME-N440
CME-C260	Storm Sewer Inlet	250	Concrete	0.013	50.3	164.32	160.80	7.00%	166.00	162.35	CME-N460	CME-N450
CME-C265	Storm Sewer Inlet	250	Concrete	0.013	4.0	164.32	164.32	0.00%	166.00	166.00	CME-N465	CME-N460
CME-C270	Circular Culvert	600	Concrete	0.013	6.0	177.10	176.50	10.00%	178.00	177.50	CME-N480	CME-N470
CME-C280	Circular Culvert	200	PVC	0.010	6.0	180.50	180.30	3.33%	181.00	180.80	CME-N500	CME-N490
CME-C290	Circular Culvert	1050/1400	Woodstave/CSP	0.012/0.024	24.0	181.00	180.00	4.17%	182.00	181.70	CME-N510	CMW-N220
CME-C300	Circular Culvert	600	Concrete	0.013	6.0	186.10	185.80	5.00%	187.00	186.80	CME-N530	CME-N520
CME-C310	Circular Culvert	375	Concrete	0.013	12.0	194.80	194.00	6.67%	195.50	194.80	CME-N550	CME-N540
CME-C320	Circular Culvert	1000	CSP	0.024	25.0	199.00	198.50	2.00%	201.00	200.50	CME-N560	CMW-N230
Coast Meridian (West)												
CMW-C10	Circular Culvert	600	Concrete	0.013	13.0	46.60	45.60	7.69%	47.50	47.50	CMW-N10	WAT-N150
CMW-C20	Circular Culvert	600	Concrete	0.013	4.0	64.40	64.30	2.50%	66.00	65.90	CMW-N30	CMW-N20
CMW-C30	Circular Culvert	600	CSP	0.024	12.0	73.40	73.30	0.83%	75.00	75.00	CMW-N50	CMW-N40
CMW-C40	*Circular Culvert*	*600*	*CSP*	*0.024*	*26.0*	78.10	77.00	*4.23%*	79.00	78.00	CMW-N70	CMW-N60
CMW-C50	Circular Culvert	*600*	*Concrete*	*0.013*	*4.0*	81.10	81.00	*2.50%*	82.00	81.90	CMW-N90	CMW-N80
CMW-C60	Circular Culvert	600	Concrete	0.013	10.0	87.60	87.40	2.00%	89.00	88.80	CMW-N110	CMW-N100
CMW-C70	Circular Culvert	600	Concrete	0.013	8.0	98.70	98.30	5.00%	100.00	99.70	CMW-N121	CMW-N120
CMW-C71	Rect. Culvert Inlet	2 - 200H x 600V	Concrete	0.013	2.0	98.80	98.70	5.00%	100.00	100.00	CMW-N130	CMW-N121
CMW-C80	Circular Culvert	600	Concrete	0.013	7.0	101.80	101.30	7.14%	103.00	102.50	CMW-N150	CMW-N140
CMW-C90	Circular Culvert	600	Concrete	0.013	6.0	103.00	102.70	5.00%	104.20	103.90	CMW-N170	CMW-N160
CMW-C100	Circular Culvert	200	Concrete	0.013	3.0	105.00	104.90	3.33%	105.50	105.40	CMW-N190	CMW-N180
CMW-C110	Circular Culvert	600	Concrete	0.013	6.0	108.00	107.70	5.00%	108.90	108.60	CMW-N210	CMW-N200
Dayton Street												
DAY-C10	Circular Culvert	375	Concrete	0.013	14.4	191.36	190.51	5.91%	193.00	192.50	DAY-N20	DAY-N10
Galloway Avenue												
GAL-C10	Circular Culvert	900	Woodstave	0.012	12.0	106.60	105.60	8.33%	108.00	107.00	GAL-N10	CME-N130
Glenbrook Street												
GBK-C10	Storm Sewer Outlet	600	Concrete	0.013	35.3	111.80	110.54	3.57%	113.95	111.80	GBK-N30	GBK-N20
GBK-C20	Storm Sewer	525	Concrete	0.013	104.4	117.45	111.86	5.35%	119.65	113.95	GBK-N40	GBK-N30
GBK-C30	Storm Sewer Inlet	450	Concrete	0.013	7.8	118.69	117.85	10.77%	120.00	119.65	GBK-N50	GBK-N40
Harper Road												
HAR-C10	Circular Culvert	600	Concrete	0.013	12.0	195.00	194.00	8.33%	196.00	195.00	HAR-N10	CME-N540
HAR-C20	Circular Culvert	750	Concrete	0.013	10.0	299.60	299.10	5.00%	300.70	300.20	HAR-N30	HAR-N20
Highland Drive												
HLD-C10	Circular Culvert	450	Concrete	0.013	10.0	135.30	135.00	3.00%	136.10	135.80	HLD-N30	HLD-N20
HLD-C20	Circular Culvert	600	Concrete	0.013	10.0	137.20	136.90	3.00%	138.10	137.80	HLD-N50	HLD-N40
HLD-C30	Circular Culvert	300	Concrete	0.013	14.0	151.40	150.40	7.14%	152.00	151.00	HLD-N70	CME-N330
HLD-C32	Circular Culvert	450	Concrete	0.013	6.0	158.34	157.83	8.50%	159.44	158.93	HLD-N80	HLD-N75
HLD-C34	Circular Culvert	375/400	Concrete/PVC	0.013/0.010	15.0	161.78	160.49	8.60%	162.58	161.29	HLD-N83	HLD-N82
HLD-C36	Circular Culvert	375	Concrete	0.013	10.0	166.42	165.56	8.60%	167.82	166.96	HLD-N86	HLD-N85
HLD-C38	Circular Culvert	375	Concrete	0.013	10.0	170.71	169.85	8.60%	172.11	171.25	HLD-N88	HLD-N87
HLD-C40	Circular Culvert	450	Concrete	0.013	12.0	175.30	175.00	2.50%	177.00	176.60	HLD-N100	HLD-N90
HLD-C50	Storm Sewer Outlet	525	Concrete	0.013	55.0	180.60	180.32	0.51%	182.50	181.20	HLD-N120	HLD-N110
HLD-C60	Storm Sewer Outlet	250	Concrete	0.013	17.0	180.47	179.87	3.53%	182.50	181.00	HLD-N120	HLD-N130
HLD-C70	Storm Sewer	300	Concrete	0.013	38.0	182.14	180.85	3.39%	183.30	182.50	HLD-N140	HLD-N120
HLD-C80	Storm Sewer Inlet	375	Concrete	0.013	14.0	182.00	180.60	10.00%	183.50	182.50	HLD-N150	HLD-N120
HLD-C90	Storm Sewer	300	Concrete	0.013	147.5	194.08	180.80	9.00%	196.20	182.50	HLD-N160	HLD-N120
Hyde Creek												
HYD-C10	Arch Culvert Outlet	2590H x 1880V	SPCSP	0.030	3.0	11.43	11.40	1.00%	15.90	15.90	HYD-N100	HYD-N90
HYD-C20	Arch Culvert	2590H x 1880V	SPCSP	0.030	15.0	11.60	11.43	1.13%	16.10	15.90	HYD-N110	HYD-N100
HYD-C25	Storm Sewer	*600*	*Concrete*	*0.013*	*900.0*	*37.00*	*12.60*	*2.71%*	*16.10*	*15.90*	HYD-N115	HYD-N110
HYD-C30	Arch Culvert Inlet	2590H x 1880V	SPCSP	0.030	8.0	11.70	11.60	1.25%	16.20	16.10	HYD-N120	HYD-N110
HYD-C40	Box Culvert Outlet	3100H x 1450V	Concrete	0.013	5.0	13.92	13.75	3.40%	17.75	17.65	HYD-N170	HYD-N160
HYD-C50	Box Culvert Inlet	3100H x 1450V	Concrete	0.013	5.0	14.10	13.92	3.60%	17.85	17.75	HYD-N180	HYD-N170
HYD-C60	Box Culvert Outlet	3300H x 1050V	Concrete	0.013	5.0	19.23	18.90	6.60%	23.70	23.70	HYD-N220	HYD-N210
HYD-C70	Box Culvert Inlet	3300H x 1050V	Concrete	0.013	5.0	19.55	19.23	6.40%	23.70	23.70	HYD-N230	HYD-N220
HYD-C80	Box Culvert	3050H x 1050V	Concrete / Nat. Bottom	0.013 / 0.030	10.0	31.10	30.75	3.50%	35.10	35.10	HYD-N270	HYD-N260
HYD-C90	Box Culvert	2700H x 1600V	Concrete / Nat. Bottom	0.013 / 0.030	6.0	34.50	34.45	0.83%	39.55	39.55	HYD-N300	HYD-N290
HYD-C100	Footbridge	4000H x 1200V	Log / Natural Bottom	0.030 / 0.050	2.0	117.00	116.90	5.00%	120.70	120.70	HYD-N370	HYD-N360

NOTES: Links Modelled Together | Links Not Modelled | *Assumed Information*

CULVERT I.D.	GENERAL INFORMATION DESCRIPTION	SIZE (mm)	MATERIAL	MANNING'S "n"	LENGTH (m)	INVERT ELEVATION U/S (m)	INVERT ELEVATION D/S (m)	SLOPE (%)	SURFACE ELEVATION U/S (m)	SURFACE ELEVATION D/S (m)	MODEL NODE CONNECTED TO CULVERT U/S	MODEL NODE CONNECTED TO CULVERT D/S
WAT-C60	Circular Culvert	1500	Woodstave	0.012	6.0	45.50	45.40	1.67%	47.50	47.40	WAT-N150	WAT-N140
WAT-C70	Circular Culvert	2100	Riveted Steel	0.018	10.0	48.90	48.70	2.00%	52.00	52.00	WAT-N170	WAT-N160
WAT-C80	Circular Culvert	1500	Concrete	0.013	18.0	57.00	56.00	5.56%	60.00	59.00	WAT-N190	WAT-N180
WAT-C90	Circular Culvert	1000	CSP	0.024	10.0	86.50	86.20	3.00%	89.00	88.80	WAT-N220	WAT-N210
Wedgewood Street												
WDG-C10	Storm Sewer Outlet	600	Concrete	0.013	32.0	12.41	12.15	0.81%	14.88	14.00	WDG-N10	UNN-N5
WDG-C20	Storm Sewer	525	Concrete	0.013	47.3	13.21	12.49	1.52%	15.63	14.88	WDG-N20	WDG-N10
WDG-C30	Storm Sewer	450	Concrete	0.013	75.3	16.39	13.33	4.06%	18.73	15.63	WDG-N30	WDG-N20
WDG-C40	Storm Sewer Inlet	300	Concrete	0.013	7.0	16.79	16.50	4.14%	17.80	18.73	WDG-N40	WDG-N30
WDG-C50	Storm Sewer Inlet	450	CSP	0.024	2.0	*16.41*	16.41	*0.00%*	*18.73*	18.73	WDG-N50	WDG-N30
WDG-C55	Circular Culvert	600	Concrete	0.013	6.0	16.90	16.84	1.00%	17.69	17.69	WDG-N55	WDG-N50
WDG-C60	Circular Culvert	450	Concrete	0.013	4.0	17.34	17.30	1.00%	18.00	17.80	WDG-N65	WDG-N60
WDG-C65	Circular Culvert	450	Concrete	0.013	4.0	18.59	18.46	3.25%	19.63	19.50	WDG-N75	WDG-N70
WDG-C70	Circular Culvert	450	Concrete	0.013	4.0	19.03	18.90	3.25%	22.97	22.97	WDG-N85	WDG-N80
WDG-C75	Circular Culvert	450	Concrete	0.013	4.0	20.40	20.28	3.00%	22.97	22.97	WDG-N95	WDG-N90
WDG-C80	Circular Culvert	450	Concrete	0.013	6.0	22.22	22.03	3.17%	22.97	22.97	WDG-N105	WDG-N100
WDG-C85	Circular Culvert	600	Concrete	0.013	2.0	23.75	23.69	3.00%	24.77	24.77	WDG-N115	WDG-N110
WDG-C90	Storm Sewer Outlet	675	Concrete	0.013	31.6	26.74	25.78	3.04%	28.75	26.69	WDG-N130	WDG-N120
WDG-C100	Storm Sewer	600	Concrete	0.013	73.7	33.00	26.75	8.48%	34.96	28.75	WDG-N140	WDG-N130
WDG-C110	Storm Sewer	525	Concrete	0.013	98.1	42.96	33.02	10.13%	44.92	34.96	WDG-N150	WDG-N140
WDG-C120	Storm Sewer Inlet	450	Concrete	0.013	5.5	44.64	42.97	30.36%	45.29	44.92	WDG-N160	WDG-N150
WDG-C130	Circular Culvert	1050	Concrete	0.013	20.0	43.50	42.50	5.00%	45.20	44.20	WDG-N180	WDG-N170
WDG-C140	Circular Culvert	600	Concrete	0.013	12.0	55.00	54.50	4.17%	56.00	55.50	WDG-N200	WDG-N190
Wellington Street												
WEL-C10	Storm Sewer	375	Concrete	0.013	38.7	42.52	40.60	4.96%	44.65	42.31	WEL-N10	REN-N40
WEL-C15	Storm Sewer	375	Concrete	0.013	15.8	43.31	42.52	5.00%	45.42	44.65	WEL-N15	WEL-N10
WEL-C20	Storm Sewer Inlet	*375*	*Concrete*	*0.013*	*15.0*	*44.00*	*43.31*	*4.60%*	*46.00*	45.42	WEL-N20	WEL-N10
WEL-C25	Circular Culvert	300	Concrete	0.013	4.0	46.20	46.00	5.00%	46.85	46.65	WEL-N26	WEL-N23
WEL-C30	Storm Sewer Outlet	450	Concrete	0.013	39.4	48.94	48.71	0.58%	51.26	49.40	WEL-N40	WEL-N30
WEL-C40	Storm Sewer	375	PVC	0.010	49.3	52.11	49.15	6.01%	54.40	51.26	WEL-N50	WEL-N40
WEL-C50	Storm Sewer Inlet	375	PVC	0.010	8.0	53.80	52.11	21.13%	56.30	54.40	WEL-N60	WEL-N50
WEL-C60	Circular Culvert	300	Concrete	0.013	7.0	57.02	56.62	5.71%	57.60	57.30	WEL-N80	WEL-N70
WEL-C70	Storm Sewer Outlet	300	PVC	0.010	23.3	58.96	58.71	1.07%	61.35	60.50	WEL-N100	WEL-N90
WEL-C80	Storm Sewer	300	PVC	0.010	47.7	62.26	58.96	6.91%	64.20	61.35	WEL-N110	WEL-N100
WEL-C90	Storm Sewer	300	PVC	0.010	49.0	64.65	62.29	4.82%	67.00	64.20	WEL-N120	WEL-N110
WEL-C100	Storm Sewer	300	PVC	0.010	7.8	49.04	49.00	0.51%	51.25	51.26	WEL-N129	WEL-N40
WEL-C109.1	FC MH - orifice	67	PVC	0.010		49.04			51.25	51.25	WEL-N130	WEL-N129
WEL-C109.2	FC MH - OvFl weir	300	PVC	0.010		50.35			51.25	51.25	WEL-N130	WEL-N129
WEL-C110	Storm Sewer	300	PVC	0.010	9.4	49.15	49.10	0.53%	51.26	51.25	WEL-N140	WEL-N130
WEL-C120	Storm Sewer	900	Concrete	0.013	81.3	49.45	49.21	0.30%	51.36	51.26	WEL-N150	WEL-N140
WEL-C130	Storm Sewer	200	PVC	0.010	5.8	59.16	59.10	1.03%	61.35	61.35	WEL-N159	WEL-N100
WEL-C139.1	*FC MH - low pipe*	*78*	*PVC*	*0.010*	*2.0*	*59.16*	*59.16*	*0.00%*	*61.35*	*61.35*	*WEL-N160*	*WEL-N159*
WEL-C139.2	FC MH - high pipe	200	PVC	0.010	2.0	60.35	59.16	59.50%	61.35	61.35	WEL-N160	WEL-N159
WEL-C140	Storm Sewer	675	Concrete	0.013	72.5	59.82	59.16	0.91%	62.60	61.35	WEL-N170	WEL-N160
WEL-C150	Storm Sewer	200	PVC	0.010	7.6	62.32	62.32	0.00%	64.26	64.20	WEL-N179	WEL-N110
WEL-C159.1	FC MH - low pipe	78	PVC	0.010	2.0	62.40	62.40	0.00%	64.26	64.26	WEL-N180	WEL-N179
WEL-C159.2	FC MH - high pipe	200	PVC	0.010	2.0	63.25	62.40	42.50%	64.26	64.26	WEL-N180	WEL-N179
WEL-C160	Storm Sewer	600	Concrete	0.013	38.5	62.60	62.40	0.52%	64.50	64.26	WEL-N190	WEL-N180

* - Culvert has 200 mm high concrete curbs (baffles) at regularly spaced intervals along its length.

NOTE: All invert elevations and surface elevations for culverts were estimated from the topographic mapping supplied by the City of Coquitlam and from the topographic information included in the "Northside Storm Sewer Relief Projects Final Report" (2002) by Dayton & Knight Ltd., provided by the City of Port Coquitlam.

CITY OF COQUITLAM / PORT COQUITLAM - HYDE CREEK IWMP
TABLE D1B: EXISTING DITCH (CREEK) INVENTORY - FROM RECORD DRAWINGS AND FIELD INVESTIGATION

NOTES: Links Modelled Together | Links Not Modelled | *Assumed Information*

DITCH I.D.	LEFT BANK SLOPE (h/v)	LEFT BANK HEIGHT (m)	LEFT BANK MANNING'S "n"	RIGHT BANK SLOPE (h/v)	RIGHT BANK HEIGHT (m)	RIGHT BANK MANNING'S "n"	BOTTOM WIDTH (m)	BOTTOM MANNING'S "n"	LENGTH (m)	INVERT ELEVATION U/S (m)	INVERT ELEVATION D/S (m)	SLOPE (%)	GROUND ELEVATION U/S (m)	GROUND ELEVATION D/S (m)	MODEL NODE CONNECTED TO DITCH U/S	MODEL NODE CONNECTED TO DITCH D/S
Alderwood Avenue																
ALD-D10	1.00	1.00	0.050	1.00	1.00	0.050	1.00	0.040	60.0	6.00	5.70	0.50%	7.00	6.70	ALD-N10	HYD-N30
ALD-D20	1.00	1.00	0.050	1.00	1.00	0.050	1.00	0.040	60.0	6.62	6.00	1.03%	7.62	7.00	ALD-N20	ALD-N10
ALD-D30	1.00	1.00	0.050	1.00	1.00	0.050	1.00	0.040	130.0	19.71	13.79	4.55%	20.71	14.79	ALD-N90	ALD-N80
Burke Mountain Creek																
BRK-D10	1.00	2.00	0.060	1.00	2.00	0.060	2.00	0.040	8.0	32.50	31.50	12.50%	34.50	33.50	BRK-N10	SML-N130
BRK-D20	1.00	5.00	0.060	1.00	5.00	0.060	2.00	0.040	120.0	48.00	32.90	12.58%	53.00	37.90	BRK-N30	BRK-N20
BRK-D30	0.50	0.75	0.070	0.50	0.75	0.070	1.00	0.050	450.0	104.00	48.00	12.44%	104.75	48.75	BRK-N40	BRK-N30
BRK-D40	0.50	0.50	0.070	0.50	0.50	0.070	1.00	0.060	1200.0	266.00	104.00	13.50%	266.50	104.50	BRK-N50	BRK-N40
BRK-D50	0.50	0.50	0.070	0.50	0.50	0.070	1.00	0.070	700.0	428.80	266.00	23.26%	429.30	266.50	BRK-N60	BRK-N50
Cedar Ditch																
CED-D10	1.00	4.00	0.050	1.00	4.00	0.050	4.00	0.030	100.0	0.90	0.89	0.01%	4.90	4.89	CED-N30	CED-N20
CED-D20	1.00	4.00	0.050	1.00	4.00	0.050	4.00	0.030	210.0	0.92	0.90	0.01%	4.92	4.90	CED-N40	CED-N30
CED-D30	0.50	4.00	0.050	0.50	4.00	0.050	4.00	0.030	40.0	0.93	0.92	0.03%	4.93	4.92	CED-N50	CED-N40
CED-D40	0.50	4.00	0.050	0.50	4.00	0.050	4.00	0.030	50.0	0.94	0.93	0.02%	4.94	4.93	CED-N60	CED-N50
CED-D50	0.00	4.00	0.050	0.00	4.00	0.050	4.00	0.030	2.0	0.94	0.94	0.00%	4.94	4.94	CED-N70	CED-N60
CED-D60	1.00	2.50	0.050	1.00	3.50	0.050	4.00	0.030	35.0	1.50	1.40	0.29%	4.00	3.90	CED-N100	CED-N90
CED-D70	1.00	2.50	0.050	1.00	3.50	0.050	4.00	0.030	12.0	1.54	1.50	0.33%	4.04	4.00	CED-N120	CED-N110
CED-D80	1.00	3.00	0.050	1.00	3.00	0.050	4.00	0.030	30.0	1.63	1.54	0.30%	4.63	4.54	CED-N140	CED-N130
CED-D90	1.00	3.00	0.050	1.00	3.00	0.050	4.00	0.030	85.0	1.64	1.63	0.01%	4.64	4.63	CED-N150	CED-N140
CED-D100	1.00	3.00	0.050	1.00	3.00	0.050	4.00	0.030	140.0	1.64	1.64	0.00%	4.64	4.64	CED-N160	CED-N150
CED-D110	1.00	3.00	0.050	1.00	3.00	0.050	4.50	0.030	160.0	1.65	1.64	0.01%	4.65	4.64	CED-N180	CED-N170
CED-D120	1.00	3.00	0.050	1.00	3.00	0.050	4.50	0.030	70.0	1.66	1.65	0.01%	4.66	4.65	CED-N200	CED-N190
CED-D130	1.00	3.00	0.050	1.00	3.00	0.050	4.00	0.030	135.0	1.67	1.66	0.01%	4.67	4.66	CED-N210	CED-N200
CED-D140	1.00	3.00	0.050	1.00	3.00	0.050	3.50	0.030	110.0	1.68	1.67	0.01%	4.68	4.67	CED-N220	CED-N210
CED-D150	1.00	2.70	0.050	1.00	2.70	0.050	3.00	0.030	150.0	1.92	1.68	0.16%	4.62	4.38	CED-N240	CED-N230
CED-D160	1.00	2.70	0.050	1.00	2.70	0.050	3.00	0.030	190.0	1.95	1.92	0.02%	4.65	4.62	CED-N260	CED-N250
CED-D170	1.00	2.70	0.050	1.00	2.70	0.050	3.00	0.030	120.0	1.96	1.95	0.01%	4.66	4.65	CED-N270	CED-N260
CED-D180	1.00	2.70	0.060	1.00	2.70	0.060	3.00	0.030	300.0	1.98	1.96	0.01%	4.68	4.66	CED-N290	CED-N280
CED-D190	1.00	2.50	0.060	1.00	2.50	0.060	2.50	0.030	130.0	2.30	1.98	0.25%	4.80	4.48	CED-N300	CED-N290
CED-D200	1.00	2.50	0.060	1.00	2.50	0.060	2.50	0.030	300.0	2.31	2.30	0.00%	4.81	4.80	CED-N310	CED-N300
CED-D210	1.00	2.00	0.060	1.00	2.00	0.060	3.00	0.030	320.0	3.27	2.31	0.30%	5.27	4.31	CED-N320	CED-N310
CED-D220	1.00	2.00	0.060	1.00	2.00	0.060	3.00	0.030	130.0	3.34	3.27	0.05%	5.34	5.27	CED-N330	CED-N320
CED-D230	1.00	2.00	0.060	1.00	2.00	0.060	3.00	0.030	320.0	4.19	3.34	0.27%	6.19	5.34	CED-N340	CED-N330
Coast Meridian (East)																
CME-D10	1.00	1.00	0.060	1.00	1.00	0.060	0.50	0.040	160.0	74.20	56.50	11.06%	75.20	57.50	CME-N20	CME-N10
CME-D20	1.00	1.00	0.050	1.00	1.00	0.050	0.50	0.040	110.0	82.00	74.40	6.91%	83.00	75.40	CME-N40	CME-N30
CME-D30	1.00	1.00	0.050	1.00	1.00	0.050	0.50	0.040	70.0	90.10	82.50	10.86%	91.10	83.50	CME-N60	CME-N50
CME-D40	1.00	1.00	0.040	1.00	1.00	0.040	0.50	0.040	20.0	90.70	90.20	2.50%	91.70	91.20	CME-N80	CME-N70
CME-D50	1.00	1.00	0.040	1.00	1.00	0.040	0.50	0.040	20.0	95.00	90.80	21.00%	96.00	91.80	CME-N100	CME-N90
CME-D60	0.50	1.50	0.070	1.00	1.50	0.050	0.50	0.040	50.0	105.60	99.10	13.00%	107.10	100.60	CME-N130	CME-N120
CME-D70	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	60.0	116.20	109.00	12.00%	117.20	110.00	CME-N160	CME-N150
CME-D80	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	25.0	117.20	116.40	3.20%	118.20	117.40	CME-N180	CME-N170
CME-D90	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	10.0	122.00	119.20	28.00%	123.00	120.20	CME-N210	CME-N200
CME-D100	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	40.0	124.80	122.80	5.00%	125.80	123.80	CME-N230	CME-N220
CME-D110	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	35.0	127.60	125.00	7.43%	128.60	126.00	CME-N250	CME-N240
CME-D120	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	50.0	132.50	128.10	8.80%	133.50	129.10	CME-N270	CME-N260
CME-D130	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	80.0	135.50	132.80	3.37%	136.50	133.80	CME-N290	CME-N280
CME-D140	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	70.0	145.50	135.80	13.86%	146.50	136.80	CME-N310	CME-N300
CME-D150	1.00	1.00	0.060	1.00	1.00	0.050	0.50	0.050	30.0	150.20	146.00	14.00%	151.20	147.00	CME-N330	CME-N320
CME-D160	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	10.0	154.60	151.60	30.00%	155.35	152.35	CME-N360	CME-N350
CME-D170	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	10.0	155.90	154.90	10.00%	156.65	155.65	CME-N380	CME-N370
CME-D180	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	28.0	157.80	156.10	6.07%	158.55	156.85	CME-N400	CME-N390
CME-D190	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	25.0	159.30	158.10	4.80%	160.05	158.85	CME-N420	CME-N410
CME-D200	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	2.5	160.51	159.50	40.40%	161.26	160.25	CME-N440	CME-N430
CME-D210	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	50.0	176.50	164.06	24.88%	177.25	164.81	CME-N470	CME-N460
CME-D220	2.00	0.75	0.060	2.00	0.75	0.060	0.30	0.050	50.0	180.30	177.10	6.40%	181.05	177.85	CME-N490	CME-N480
CME-D230	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.050	55.0	185.80	181.00	8.73%	187.30	182.50	CME-N520	CME-N510
CME-D240	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.050	50.0	194.00	186.10	15.80%	195.50	187.60	CME-N540	CME-N530
Coast Meridian (West)																
CMW-D10	1.00	1.00	0.060	1.00	1.00	0.060	1.00	0.040	50.0	64.30	60.00	8.60%	65.30	61.00	CMW-N20	WAT-N200
CMW-D20	2.00	2.50	0.050	2.00	2.50	0.050	2.50	0.040	60.0	72.30	64.40	13.17%	74.80	66.90	CMW-N40	CMW-N30
CMW-D30	1.00	1.50	0.060	1.00	1.50	0.060	0.50	0.050	30.0	77.00	73.40	12.00%	78.50	74.90	CMW-N60	CMW-N50
CMW-D40	1.00	1.50	0.060	1.00	1.50	0.060	0.50	0.050	30.0	81.00	78.10	9.67%	82.50	79.60	CMW-N80	CMW-N70
CMW-D50	2.00	1.50	0.070	2.00	1.50	0.070	0.50	0.050	80.0	87.40	81.10	7.88%	88.90	82.60	CMW-N100	CMW-N90
CMW-D60	3.00	1.50	0.060	3.00	1.50	0.060	0.50	0.050	120.0	98.30	87.60	8.92%	99.80	89.10	CMW-N120	CMW-N110
CMW-D70	0.75	1.50	0.050	0.75	1.50	0.050	0.30	0.040	20.0	101.30	98.80	12.50%	102.80	100.30	CMW-N140	CMW-N130
CMW-D80	0.75	1.50	0.050	0.75	1.50	0.050	0.30	0.040	10.0	102.70	101.80	9.00%	104.20	103.30	CMW-N160	CMW-N150
CMW-D90	0.75	1.50	0.050	0.75	1.50	0.050	0.30	0.040	15.0	104.90	103.00	12.67%	106.40	104.50	CMW-N180	CMW-N170
CMW-D100	0.75	1.50	0.050	0.75	1.50	0.050	0.30	0.040	15.0	107.70	105.00	18.00%	109.20	106.50	CMW-N200	CMW-N190
CMW-D110	0.50	8.00	0.070	2.00	10.00	0.070	6.00	0.050	520.0	180.00	123.80	10.81%	188.00	131.80	CMW-N220	HYD-N380
CMW-D120	3.00	3.00	0.070	3.00	3.00	0.070	2.00	0.050	450.0	198.50	152.50	10.22%	201.50	155.50	CMW-N230	HYD-N390
Dayton Street																
DAY-D10	1.00	1.00	0.060	1.00	1.00	0.060	0.50	0.050	300.0	190.51	158.34	10.72%	191.51	159.34	DAY-N10	HLD-N80
Glenbrook Street																
GBK-D10	1.00	1.00	0.050	1.00	1.00	0.050	1.00	0.040	50.0	104.00	94.00	20.00%	105.00	95.00	GBK-N10	HYD-N340
GBK-D20	1.00	1.00	0.050	1.00	1.00	0.050	1.00	0.040	100.0	110.54	104.00	6.54%	111.54	105.00	GBK-N20	GBK-N10
Harper Road																
HAR-D10	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.060	150.0	299.10	276.00	15.40%	300.10	277.00	HAR-N20	HYD-N420
Highland Drive																
HLD-D10	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.050	80.0	126.00	118.69	9.14%	127.00	119.69	HLD-N10	GBK-N50
HLD-D20	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.050	110.0	135.00	126.00	8.18%	136.00	127.00	HLD-N20	HLD-N10
HLD-D30	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.050	130.0	136.90	126.00	8.38%	137.90	127.00	HLD-N40	HLD-N10
HLD-D40	1.00	0.75	0.050	1.00	0.75	0.050	0.50	0.040	200.0	150.10	137.20	6.45%	150.85	137.95	HLD-N60	HLD-N50
HLD-D50	1.00	1.50	0.050	1.00	3.00	0.050	0.50	0.040	75.0	157.83	151.40	8.57%	159.33	152.90	HLD-N75	HLD-N70
HLD-D52	1.00	1.50	0.050	1.00	3.00	0.050	0.50	0.040	25.0	160.49	158.34	8.60%	161.99	159.84	HLD-N82	HLD-N80
HLD-D55	1.00	1.50	0.050	1.00	3.00	0.050	0.50	0.040	44.0	165.56	161.78	8.59%	167.06	163.28	HLD-N85	HLD-N83
HLD-D58	1.00	1.50	0.050	1.00	3.00	0.050	0.50	0.040	40.0	169.85	166.42	8.58%	171.35	167.92	HLD-N87	HLD-N86
HLD-D60	1.00	1.50	0.050	1.00	3.00	0.050	0.50	0.040	50.0	175.00	170.71	8.58%	176.50	172.21	HLD-N90	HLD-N88
HLD-D70	1.00	1.20	0.050	1.00	4.00	0.050	0.30	0.040	40.0	180.32	175.30	12.55%	181.52	176.50	HLD-N110	HLD-N100
Hyde Creek																
HYD-D10	0.00	2.00	0.040	0.00	1.50	0.040	4.00	0.030	190.0	2.60	0.94	0.87%	4.10	2.44	HYD-N10	CED-N60
HYD-D20	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	230.0	5.60	2.60	1.30%	7.60	4.60	HYD-N20	HYD-N10
HYD-D30	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	40.0	5.70	5.60	0.25%	7.70	7.60	HYD-N30	HYD-N20
HYD-D40	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	180.0	6.15	5.70	0.25%	8.15	7.70	HYD-N40	HYD-N30
HYD-D50	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	160.0	6.50	6.15	0.22%	8.50	8.15	HYD-N50	HYD-N40
HYD-D60	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	370.0	7.55	6.50	0.28%	9.55	8.50	HYD-N60	HYD-N50
HYD-D70	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	110.0	7.90	7.55	0.32%	9.90	9.55	HYD-N70	HYD-N60
HYD-D80	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	350.0	10.20	7.90	0.66%	12.20	9.90	HYD-N80	HYD-N70
HYD-D90	2.00	2.00	0.040	2.00	2.00	0.040	3.00	0.030	140.0	11.40	10.20	0.86%	13.40	12.20	HYD-N90	HYD-N80
HYD-D100	5.00	1.00	0.050	1.00	1.50	0.040	3.00	0.030	100.0	12.35	11.70	0.65%	13.35	12.70	HYD-N130	HYD-N120
HYD-D110	0.00	1.50	0.030	1.50	1.50	0.060	2.00	0.030	45.0	12.70	12.35	0.78%	14.20	13.85	HYD-N140	HYD-N130
HYD-D120	1.00	1.50	0.060	2.00	1.50	0.050	3.00	0.040	50.0	13.00	12.70	0.60%	14.50	14.20	HYD-N150	HYD-N140
HYD-D130	1.00	1.50	0.060	2.00	1.50	0.050	3.00	0.040	70.0	13.75	13.00	1.07%	15.25	14.50	HYD-N160	HYD-N150
HYD-D140	3.00	1.00	0.040	1.00	1.50	0.060	2.00	0.040	95.0	16.00	14.10	2.00%	17.00	15.10	HYD-N190	HYD-N180
HYD-D150	2.00	1.00	0.060	1.50	1.50	0.060	3.50	0.040	90.0	17.60	16.00	1.78%	18.60	17.00	HYD-N200	HYD-N190
HYD-D160	2.00	1.00	0.060	1.50	1.50	0.060	3.50	0.040	60.0	18.60	17.60	1.67%	19.60	18.60	HYD-N210	HYD-N200
HYD-D170	2.00	1.50	0.060	1.50	3.00	0.060	2.00	0.040	70.0	20.85	19.55	1.86%	22.35	21.05	HYD-N240	HYD-N230
HYD-D180	2.00	1.50	0.060	1.50	1.50	0.060	3.00	0.040	200.0	27.30	20.85	3.23%	28.80	22.35	HYD-N250	HYD-N240
HYD-D190	2.00	1.50	0.060	1.50	1.50	0.060	3.00	0.040	100.0	30.75	27.30	3.45%	32.25	28.80	HYD-N260	HYD-N250
HYD-D200	2.00	1.50	0.060	1.50	1.50	0.060	3.00	0.040	90.0	33.00	31.10	2.11%	34.50	32.60	HYD-N280	HYD-N270
HYD-D210	1.00	1.00	0.050	1.00	0.75	0.050	4.00	0.040	80.0	34.45	33.00	1.81%	35.20	33.75	HYD-N290	HYD-N280
HYD-D220	0.75	20.00	0.070	1.50	20.00	0.070	4.00	0.050	420.0	52.00	34.50	4.17%	72.00	54.50	HYD-N310	HYD-N300
HYD-D230	0.75	20.00	0.070	1.50	20.00	0.070	4.00	0.050	420.0	73.00	52.00	5.00%	93.00	72.00	HYD-N320	HYD-N310

NOTES: Links Modelled Together | Links Not Modelled | *Assumed Information*

CULVERT I.D.	GENERAL INFORMATION DESCRIPTION	SIZE (mm)	MATERIAL	MANNING'S "n"	LENGTH (m)	INVERT ELEVATION U/S (m)	INVERT ELEVATION D/S (m)	SLOPE (%)	SURFACE ELEVATION U/S (m)	SURFACE ELEVATION D/S (m)	MODEL NODE CONNECTED TO CULVERT U/S	MODEL NODE CONNECTED TO CULVERT D/S
HYD-C104	Circular Culvert	1500	CSP	0.024	*10.0*	166.00	165.00	*10.00%*	205.00	205.00	HYD-N394	HYD-N392
HYD-C106	Circular Culvert	2000	CSP	0.024	*10.0*	173.00	172.00	*10.00%*	205.00	205.00	HYD-N398	HYD-N396
HYD-C110	Circular Culvert	1500	SPCSP	0.030	30.0	199.70	198.00	5.67%	205.00	205.00	HYD-N410	HYD-N400
HYD-C120	Circular Culvert	1000	CSP	0.024	12.0	313.20	312.00	10.00%	317.00	316.00	HYD-N440	HYD-N430
Lincoln Avenue												
LIN-C10	Storm Sewer Outlet	750	Concrete	0.013	7.3	1.77	1.87	-1.37%	3.84	4.15	LIN-N10	CED-N180
LIN-C20	Storm Sewer	750	Concrete	0.013	61.0	2.31	1.77	0.89%	4.11	3.84	LIN-N20	LIN-N10
LIN-C30	Storm Sewer	750	Concrete	0.013	64.9	2.49	2.31	0.28%	4.57	4.11	LIN-N30	LIN-N20
LIN-C40	Storm Sewer	750	Concrete	0.013	50.6	2.63	2.49	0.28%	4.88	4.57	LIN-N40	LIN-N30
LIN-C50	Storm Sewer	750	Concrete	0.013	64.6	2.79	2.63	0.25%	5.18	4.88	LIN-N50	LIN-N40
LIN-C60	Storm Sewer	750	Concrete	0.013	21.6	2.93	2.83	0.46%	5.33	5.18	LIN-N60	LIN-N50
LIN-C70	Storm Sewer	750	Concrete	0.013	61.6	3.22	2.93	0.47%	5.64	5.33	LIN-N70	LIN-N60
LIN-C80	Storm Sewer	600	Concrete	0.013	75.6	3.80	3.46	0.45%	6.10	5.64	LIN-N80	LIN-N70
LIN-C90	Storm Sewer Inlet	525	Concrete	0.013	36.6	4.11	3.91	0.55%	6.40	6.10	LIN-N90	LIN-N80
Mansfield Crescent												
MAN-C10	Storm Sewer Outlet	600	Concrete	0.013	3.3	6.90	6.78	3.64%	8.40	7.90	MAN-N20	MAN-N10
MAN-C20	Storm Sewer	525	Concrete	0.013	7.9	5.90	5.70	2.53%	8.60	8.40	MAN-N30	MAN-N20
MAN-C30	Storm Sewer	450	Concrete	0.013	109.7	11.95	6.43	5.03%	14.90	8.60	MAN-N40	MAN-N30
MAN-C40	Storm Sewer	450	Concrete	0.013	60.1	12.51	12.03	0.80%	16.20	14.90	MAN-N50	MAN-N40
MAN-C50	Storm Sewer	375	Concrete	0.013	44.8	17.99	13.03	11.07%	19.20	16.20	MAN-N60	MAN-N50
MAN-C60	Storm Sewer	375	Concrete	0.013	95.8	20.65	18.02	2.75%	23.00	19.20	MAN-N70	MAN-N60
MAN-C70	Storm Sewer	600	Concrete	0.013	13.2	21.34	20.68	5.00%	22.90	23.00	MAN-N80	MAN-N70
MAN-C80	Storm Sewer	600	Concrete	0.013	13.0	22.13	21.34	6.08%	23.70	22.90	MAN-N90	MAN-N80
MAN-C90	Storm Sewer	600	Concrete	0.013	12.0	23.15	22.34	6.75%	24.50	23.70	MAN-N100	MAN-N90
MAN-C100	Storm Sewer	600	Concrete	0.013	14.7	25.14	23.15	13.54%	26.82	24.50	MAN-N110	MAN-N100
MAN-C110	Storm Sewer Inlet	600	Concrete	0.013	12.0	26.12	25.25	7.25%	27.30	26.82	MAN-N120	MAN-N110
MAN-C120	Circular Culvert	900	CSP	0.024	12.0	50.80	50.50	2.50%	52.00	51.80	MAN-N140	MAN-N130
Millard Avenue												
MIL-C10	Circular Culvert	750	Concrete	0.013	6.0	105.00	104.50	8.33%	107.60	107.50	MIL-N20	MIL-N10
MIL-C20	Storm Sewer Outlet	450	Concrete	0.013	2.9	105.31	105.13	6.21%	108.15	106.60	MIL-N40	MIL-N30
MIL-C30	Storm Sewer	450	Concrete	0.013	96.6	112.05	105.40	6.88%	113.60	108.15	MIL-N50	MIL-N40
Oxford Street												
OXF-C10	Storm Sewer Outlet	600	Concrete	0.013	55.4	63.87	63.68	0.34%	66.55	64.50	OXF-N19	OXF-N10
OXF-C19.1	FC MH - low pipe	150	Concrete	0.013	2.0	63.87	63.87	0.00%	66.55	66.55	OXF-N20	OXF-N19
OXF-C19.2	FC MH - high pipe	300	PVC	0.010	2.0	65.60	63.87	86.50%	66.55	66.55	OXF-N20	OXF-N19
OXF-C20	Storm Sewer	450	Concrete	0.013	99.8	68.14	64.00	4.15%	71.89	66.55	OXF-N29	OXF-N20
OXF-C29.1	FC MH - low pipe	150	Concrete	0.013	2.0	68.14	68.14	0.00%	71.89	71.89	OXF-N30	OXF-N29
OXF-C29.2	FC MH - high pipe	300	PVC	0.010	2.0	70.90	68.14	138.00%	71.89	71.89	OXF-N30	OXF-N29
OXF-C30	Flow Control MH	150	Concrete	0.013	2.0	68.15	68.15	0.00%	71.89	71.89	OXF-N31	OXF-N30
OXF-C31	Storm Sewer	450	Concrete	0.013	46.7	71.41	68.15	6.98%	74.70	71.89	OXF-N40	OXF-N31
OXF-C40	Storm Sewer	450	Concrete	0.013	54.2	73.25	71.45	3.32%	78.22	74.70	OXF-N49	OXF-N40
OXF-C49.1	FC MH - orifice	167	PVC	0.010		73.25			78.22	78.22	OXF-N50	OXF-N49
OXF-C49.2	FC MH - OvFl weir	450	PVC	0.010		74.97			78.22	78.22	OXF-N50	OXF-N49
OXF-C50	Storm Sewer	300	Concrete	0.013	20.5	76.25	74.96	6.29%	79.38	78.22	OXF-N60	OXF-N50
OXF-C60	Storm Sewer	300	Concrete	0.013	77.0	80.73	76.27	5.79%	83.76	79.38	OXF-N69	OXF-N60
OXF-C69.1	FC MH - low pipe	200	PVC	0.010	2.0	80.73	80.73	0.00%	83.76	83.76	OXF-N70	OXF-N69
OXF-C69.2	FC MH - high pipe	300	PVC	0.010	2.0	82.41	80.73	84.00%	83.76	83.76	OXF-N70	OXF-N69
OXF-C70	Storm Sewer	1200	Concrete	0.013	23.0	80.86	80.75	0.48%	84.89	83.75	OXF-N80	OXF-N70
OXF-C80	Storm Sewer	200	PVC	0.010	65.5	86.18	82.76	5.22%	88.95	84.89	OXF-N90	OXF-N80
OXF-C90	Storm Sewer	1200	Concrete	0.013	66.0	64.18	63.91	0.41%	68.28	66.55	OXF-N100	OXF-N20
OXF-C100	Storm Sewer	1050	Concrete	0.013	52.8	68.78	68.15	1.19%	72.33	71.89	OXF-N110	OXF-N30
OXF-C110	Storm Sewer	1200	Concrete	0.013	86.2	74.44	73.41	1.20%	79.40	78.22	OXF-N120	OXF-N50
Prairie Avenue												
PRA-C10	Storm Sewer Outlet	*1050*	*Concrete*	*0.013*	*64.9*	*2.99*	*1.96*	*1.59%*	*4.57*	*4.66*	PRA-N10	CED-N275
PRA-C20	Storm Sewer	900	Concrete	0.013	40.8	*3.29*	*2.99*	*0.74%*	*4.73*	*4.57*	PRA-N20	PRA-N10
PRA-C30	Storm Sewer	900	Concrete	0.013	95.0	*3.96*	*3.28*	*0.72%*	*5.43*	*4.73*	PRA-N30	PRA-N20
PRA-C40	Storm Sewer	900	Concrete	0.013	163.0	*4.52*	*3.96*	*0.34%*	*6.24*	*5.43*	PRA-N40	PRA-N30
PRA-C50	Storm Sewer	900	Concrete	0.013	94.2	5.03	4.52	0.54%	6.36	6.24	PRA-N50	PRA-N40
PRA-C60	Storm Sewer	900	Concrete	0.013	2.0	5.04	5.03	0.50%	6.30	6.36	PRA-N60	PRA-N50
PRA-C70	Storm Sewer	900	Concrete	0.013	104.0	5.27	5.07	0.19%	6.86	6.30	PRA-N70	PRA-N60
PRA-C80	Storm Sewer	450	Concrete	0.013	104.0	5.54	5.27	0.26%	6.77	6.86	PRA-N80	PRA-N70
PRA-C90	Storm Sewer	450	Concrete	0.013	31.7	5.72	5.56	0.50%	6.90	6.77	PRA-N90	PRA-N80
PRA-C100	Storm Sewer Inlet	450	Concrete	0.013	73.7	6.03	5.73	0.41%	7.32	6.90	PRA-N100	PRA-N90
Queenston Avenue												
QSN-C10	Circular Culvert	375	Concrete	0.013	14.0	128.30	127.30	7.14%	129.00	128.00	QSN-N10	CME-N250
QSN-C20	Circular Culvert	375	Concrete	0.013	6.0	131.72	131.18	9.00%	132.62	132.08	QSN-N30	QSN-N20
QSN-C30	Circular Culvert	375	Concrete	0.013	6.0	133.60	133.06	9.00%	134.50	133.96	QSN-N50	QSN-N40
QSN-C40	Footbridge	450 clearance	Natural Bottom	0.040	1.5	134.63	134.50	8.67%	134.73	134.60	QSN-N70	QSN-N60
QSN-C50	Circular Culvert	375	Concrete	0.013	4.0	136.07	135.71	9.00%	136.77	136.41	QSN-N90	QSN-N80
QSN-C60	Circular Culvert	375/400	Concrete/CSP	0.013/0.024	8.0	139.48	138.76	9.00%	140.28	139.56	QSN-N110	QSN-N100
QSN-C70	Circular Culvert	375/525	Concrete/CSP	0.013/0.024	65.0	150.69	144.86	8.97%	151.69	145.86	QSN-N130	QSN-N120
QSN-C80	Circular Culvert	375	Concrete	0.013	8.0	155.00	154.28	9.00%	155.80	155.08	QSN-N150	QSN-N140
Renton Avenue												
REN-C10	Storm Sewer Outlet	525	Concrete	0.013	167.3	38.79	27.30	6.87%	40.87	30.80	REN-N10	HYD-N250
REN-C20	Storm Sewer	600	Concrete	0.013	11.6	38.97	38.82	1.29%	40.90	40.87	REN-N20	REN-N10
REN-C30	Storm Sewer	600	Concrete	0.013	84.7	39.86	39.00	1.02%	41.36	40.90	REN-N30	REN-N20
REN-C40	Storm Sewer	600	Concrete	0.013	109.1	40.51	39.86	0.60%	42.31	41.36	REN-N40	REN-N30
REN-C50	Storm Sewer	525	Concrete	0.013	56.4	43.70	40.51	5.66%	46.02	42.31	REN-N50	REN-N40
REN-C60	Storm Sewer	525	Concrete	0.013	74.4	45.26	43.70	2.10%	47.12	46.02	REN-N60	REN-N50
REN-C70	Storm Sewer Inlet	*300*	*Concrete*	*0.013*	50.0	*45.50*	*45.34*	*0.32%*	*46.50*	47.12	REN-N70	REN-N60
Richmond Place												
RCH-C10	Storm Sewer Outlet	525	Concrete	0.013	40.8	2.00	1.68	0.78%	3.47	3.05	MIL-N20	MIL-N10
RCH-C20	Storm Sewer	525	Concrete	0.013	43.0	2.22	2.00	0.51%	3.47	3.47	MIL-N40	MIL-N30
RCH-C30	Storm Sewer Inlet	525	Concrete	0.013	14.5	2.32	2.22	0.69%	3.35	3.47	MIL-N50	MIL-N40
Smiling Creek												
SML-C10 *	Box Culvert	2400H x 1200V	Concrete	0.013	15.0	15.10	14.80	2.00%	18.00	18.00	SML-N40	SML-N30
SML-C20	Footbridge	900 clearance	Natural Bottom	0.040	1.0	20.80	20.77	3.00%	22.00	22.00	SML-N60	SML-N50
SML-C30	Bridge	1800 clearance	Natural Bottom	0.040	3.0	23.80	23.70	3.33%	26.00	26.00	SML-N80	SML-N70
SML-C40	Footbridge	900 clearance	Natural Bottom	0.040	1.0	26.80	26.77	3.00%	28.00	28.00	SML-N100	SML-N90
SML-C50	Twin Circ. Culverts	2 - 900	CSP	0.024	5.0	28.30	28.10	4.00%	30.00	30.00	SML-N120	SML-N110
SML-C60	Circular Culvert	1200	Concrete	0.013	7.0	33.60	32.80	11.43%	35.00	35.00	SML-N150	SML-N140
SML-C70	Circular Culvert	1400	CSP	0.024	12.0	127.00	126.00	8.33%	129.00	128.00	SML-N170	SML-N160
SML-C80	Circular Culvert	1200	Concrete	0.013	34.0	204.30	199.00	15.59%	206.70	204.80	SML-N200	SML-N180
SML-C100	Circular Culvert	900	CSP	0.024	8.0	244.60	243.60	12.50%	246.00	245.00	SML-N230	SML-N220
SML-C110	Circular Culvert	1000	CSP	0.024	12.0	308.70	308.00	5.83%	310.00	309.70	SML-N250	SML-N240
Unnamed Creek												
UNN-C10	Circular Culvert	900	CSP	0.024	25.0	16.10	15.30	3.20%	18.00	18.00	UNN-N20	UNN-N10
UNN-C15	Circular Culvert	900	CSP	0.024	12.0	48.50	47.50	8.33%	49.80	48.80	UNN-N24	UNN-N22
UNN-C18	Circular Culvert	750	Concrete	0.013	10.0	131.00	130.50	5.00%	132.40	132.90	UNN-N28	UNN-N27
UNN-C20	Circular Culvert	800	CSP	0.024	11.5	129.50	129.00	4.35%	131.10	130.60	UNN-N40	UNN-N30
UNN-C30	Circular Culvert	900	Concrete	0.013	31.7	164.35	161.80	8.04%	167.00	167.00	UNN-N90	UNN-N70
UNN-C50	Storm Sewer Outlet	450	Concrete	0.013	11.5	201.60	201.00	5.22%	203.40	*202.00*	UNN-N110	UNN-N100
UNN-C60	Storm Sewer	450	Concrete	0.013	59.0	206.07	201.60	7.58%	207.65	203.40	UNN-N120	UNN-N110
UNN-C70	Storm Sewer	450	Concrete	0.013	45.0	209.50	206.07	7.62%	210.90	207.65	UNN-N130	UNN-N120
UNN-C80	Storm Sewer	450	Concrete	0.013	35.0	212.80	209.50	9.43%	214.90	210.90	UNN-N140	UNN-N130
UNN-C90	Storm Sewer Inlet	450	Concrete	0.013	6.0	215.10	213.50	26.67%	*216.10*	214.90	UNN-N150	UNN-N140
UNN-C100	Circular Culvert	900	CSP	0.024	8.0	233.50	233.20	3.75%	235.00	234.70	UNN-N170	UNN-N160
UNN-C105	Circular Culvert	*600*	*CSP*	*0.024*	*12.0*	*264.80*	*263.80*	*8.33%*	*266.00*	*265.00*	UNN-N176	UNN-N173
UNN-C110	Storm Sewer Inlet	450	Concrete	0.013	7.5	215.30	213.50	24.00%	*216.10*	214.90	UNN-N180	UNN-N140
UNN-C120	Circular Culvert	600	CSP	0.024	12.0	241.00	239.80	10.00%	242.00	242.00	UNN-N200	UNN-N190
Watkins Creek												
WAT-C10	Box Culvert	1500H x 1500V	Concrete	0.013	20.0	26.60	26.30	1.50%	29.40	29.30	WAT-N30	WAT-N20
WAT-C20	Circular Culvert	1500	Riveted Steel	0.018	12.0	35.50	35.40	0.83%	37.80	37.80	WAT-N70	WAT-N60
WAT-C30	Circular Culvert	1500	CSP	0.024	7.0	35.60	35.55	0.71%	37.50	37.50	WAT-N90	WAT-N80
WAT-C40	Circular Culvert	1800	Steel	0.030	6.0	38.90	38.80	1.67%	41.00	41.00	WAT-N110	WAT-N100
WAT-C50	Circular Culvert	1600	Riveted Steel	0.018	6.0	41.25	41.20	0.83%	43.00	43.00	WAT-N130	WAT-N120

NOTES: Links Modelled Together | Links Not Modelled | *Assumed Information*

DITCH I.D.	LEFT BANK SLOPE (h/v)	LEFT BANK HEIGHT (m)	LEFT BANK MANNING'S "n"	RIGHT BANK SLOPE (h/v)	RIGHT BANK HEIGHT (m)	RIGHT BANK MANNING'S "n"	BOTTOM WIDTH (m)	BOTTOM MANNING'S "n"	LENGTH (m)	INVERT ELEVATION U/S (m)	INVERT ELEVATION D/S (m)	SLOPE (%)	GROUND ELEVATION U/S (m)	GROUND ELEVATION D/S (m)	MODEL NODE CONNECTED TO DITCH U/S	MODEL NODE CONNECTED TO DITCH D/S
HYD-D240	0.75	20.00	0.070	1.50	20.00	0.070	4.00	0.050	350.0	88.00	73.00	4.29%	108.00	93.00	HYD-N330	HYD-N320
HYD-D250	0.75	20.00	0.070	1.50	20.00	0.070	4.00	0.050	70.0	94.00	88.00	8.57%	114.00	108.00	HYD-N340	HYD-N330
HYD-D260	0.75	20.00	0.070	1.50	20.00	0.070	4.00	0.050	130.0	97.80	94.00	2.92%	117.80	114.00	HYD-N350	HYD-N340
HYD-D270	0.75	20.00	0.070	1.50	20.00	0.070	4.00	0.050	450.0	116.90	97.80	4.24%	136.90	117.80	HYD-N360	HYD-N350
HYD-D280	1.00	1.00	0.070	0.50	12.00	0.050	4.00	0.050	180.0	123.80	117.00	3.78%	124.80	118.00	HYD-N380	HYD-N370
HYD-D290	1.00	20.00	0.080	1.00	15.00	0.080	3.00	0.060	420.0	152.50	123.80	6.83%	167.50	138.80	HYD-N390	HYD-N380
HYD-D300	1.00	20.00	0.080	1.00	15.00	0.080	2.00	0.060	150.0	165.00	152.50	8.33%	180.00	167.50	HYD-N392	HYD-N390
HYD-D304	1.00	20.00	0.080	1.00	15.00	0.080	2.00	0.060	60.0	172.00	166.00	10.00%	187.00	181.00	HYD-N396	HYD-N394
HYD-D306	1.00	20.00	0.080	1.00	15.00	0.080	2.00	0.060	250.0	198.00	173.00	10.00%	213.00	188.00	HYD-N400	HYD-N398
HYD-D310	1.00	20.00	0.080	1.00	15.00	0.080	1.50	0.060	500.0	276.00	199.70	15.26%	291.00	214.70	HYD-N420	HYD-N410
HYD-D320	2.00	5.00	0.090	1.00	10.00	0.090	6.00	0.070	350.0	312.00	276.00	10.29%	317.00	281.00	HYD-N430	HYD-N420
HYD-D330	0.50	1.50	0.070	0.50	1.50	0.070	1.50	0.050	800.0	468.00	313.20	19.35%	469.50	314.70	HYD-N450	HYD-N440
Mansfield Crescent																
MAN-D10	1.00	1.00	0.070	1.00	1.00	0.070	1.00	0.050	180.0	6.78	2.60	2.32%	7.78	3.60	MAN-N10	HYD-N10
MAN-D20	1.00	1.00	0.070	1.00	1.00	0.070	1.00	0.050	350.0	50.50	26.12	6.97%	51.50	27.12	MAN-N130	MAN-N120
Millard Avenue																
MIL-D10	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.050	110.0	104.50	88.00	15.00%	105.50	89.00	MIL-N10	HYD-N330
MIL-D20	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.050	5.0	105.13	105.00	2.60%	106.13	106.00	MIL-N30	MIL-N20
Oxford Street																
OXF-D10	1.00	1.00	0.070	1.00	1.00	0.070	0.50	0.050	400.0	63.68	*45.50*	*4.55%*	64.68	*46.50*	OXF-N10	REN-N70
Queenston Avenue																
QSN-D10	1.00	1.00	0.050	1.00	2.00	0.050	0.50	0.040	25.0	131.18	128.30	11.52%	132.18	129.30	QSN-N20	QSN-N10
QSN-D20	1.00	1.00	0.050	1.00	2.00	0.050	0.50	0.040	15.0	133.06	131.72	8.93%	134.06	132.72	QSN-N40	QSN-N30
QSN-D30	1.00	1.00	0.050	1.00	2.00	0.050	0.50	0.040	10.0	134.50	133.60	9.00%	135.50	134.60	QSN-N60	QSN-N50
QSN-D40	1.00	1.00	0.050	1.00	2.00	0.050	0.50	0.040	12.0	135.71	134.63	9.00%	136.71	135.63	QSN-N80	QSN-N70
QSN-D50	1.00	1.00	0.050	1.00	2.00	0.050	0.50	0.040	30.0	138.76	136.07	8.97%	139.76	137.07	QSN-N100	QSN-N90
QSN-D60	1.00	1.00	0.050	1.00	2.00	0.050	0.50	0.040	60.0	144.86	139.48	8.97%	145.86	140.48	QSN-N120	QSN-N110
QSN-D70	1.00	1.00	0.050	1.00	2.00	0.050	0.30	0.040	40.0	154.28	150.69	8.98%	155.28	151.69	QSN-N140	QSN-N130
QSN-D80	1.00	1.00	0.060	1.00	1.00	0.060	0.30	0.050	350.0	179.87	155.00	7.11%	180.87	156.00	HLD-N130	QSN-N150
Smiling Creek																
SML-D10	1.00	1.50	0.060	1.00	1.50	0.060	2.50	0.040	200.0	10.70	5.60	2.55%	12.20	7.10	SML-N10	HYD-N20
SML-D20	1.00	1.50	0.060	1.00	1.50	0.060	2.50	0.040	30.0	11.00	10.70	1.00%	12.50	12.20	SML-N20	SML-N10
SML-D30	1.00	1.50	0.060	1.00	1.50	0.060	2.50	0.040	200.0	14.80	11.00	1.90%	16.30	12.50	SML-N30	SML-N20
SML-D40	0.50	1.20	0.050	0.50	1.20	0.050	1.50	0.040	200.0	20.77	15.10	2.84%	21.97	16.30	SML-N50	SML-N40
SML-D50	0.50	1.20	0.050	0.50	1.20	0.050	1.50	0.040	30.0	23.70	20.80	9.67%	24.90	22.00	SML-N70	SML-N60
SML-D60	0.50	1.20	0.050	0.50	1.20	0.050	1.50	0.040	20.0	26.77	23.80	14.85%	27.97	25.00	SML-N90	SML-N80
SML-D70	0.50	1.20	0.050	0.50	1.20	0.050	1.50	0.040	30.0	28.10	26.80	4.33%	29.30	28.00	SML-N110	SML-N100
SML-D80	1.00	1.50	0.060	1.00	1.50	0.060	2.00	0.040	30.0	31.50	28.30	10.67%	33.00	29.80	SML-N130	SML-N120
SML-D90	1.00	2.00	0.060	1.00	2.00	0.060	2.00	0.040	8.0	32.80	31.50	16.25%	34.80	33.50	SML-N140	SML-N130
SML-D100	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.040	750.0	126.00	33.60	12.32%	127.50	35.10	SML-N160	SML-N150
SML-D110	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.040	700.0	199.00	127.00	10.29%	200.50	128.50	SML-N180	SML-N170
SML-D120	1.00	1.00	0.060	1.00	1.00	0.060	1.00	0.040	350.0	243.60	204.30	11.23%	244.60	205.30	SML-N210	SML-N200
SML-D130	1.00	1.00	0.060	1.00	1.00	0.060	1.00	0.040	600.0	308.00	244.60	10.57%	309.00	245.60	SML-N230	SML-N220
Unnamed Creek																
UNN-D5	1.50	2.50	0.060	1.50	2.50	0.060	1.00	0.040	70.0	12.15	11.00	1.64%	14.65	13.50	UNN-N5	SML-N20
UNN-D10	1.50	2.50	0.060	1.50	2.50	0.060	1.00	0.040	130.0	15.30	12.15	2.42%	17.80	14.65	UNN-N10	UNN-N5
UNN-D20	1.50	2.50	0.070	1.50	2.50	0.070	1.00	0.040	450.0	47.50	16.10	6.98%	50.00	18.60	UNN-N22	UNN-N20
UNN-D23	1.50	2.50	0.070	1.50	2.50	0.070	1.00	0.040	500.0	113.50	48.50	13.00%	116.00	51.00	UNN-N26	UNN-N24
UNN-D26	1.50	2.50	0.070	1.50	2.50	0.070	1.00	0.040	150.0	129.00	113.50	10.33%	131.50	116.00	UNN-N30	UNN-N26
UNN-D28	1.50	1.50	0.070	1.50	1.50	0.070	1.00	0.050	180.0	130.50	113.50	9.44%	132.00	115.00	UNN-N27	UNN-N26
UNN-D30	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.040	200.0	150.00	129.50	10.25%	151.50	131.00	UNN-N50	UNN-N40
UNN-D40	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.040	60.0	152.00	150.00	3.33%	153.50	151.50	UNN-N60	UNN-N50
UNN-D50	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.040	140.0	161.80	152.00	7.00%	163.30	153.50	UNN-N70	UNN-N60
UNN-D60	1.00	1.50	0.060	1.00	1.50	0.060	1.00	0.040	350.0	201.00	164.35	10.47%	202.50	165.85	UNN-N100	UNN-N90
UNN-D70	1.00	1.00	0.080	1.00	1.00	0.080	0.50	0.050	170.0	233.20	215.10	10.65%	234.20	216.10	UNN-N160	UNN-N150
UNN-D75	*1.00*	*1.00*	*0.080*	*1.00*	*1.00*	*0.080*	*0.50*	*0.050*	320.0	263.80	233.50	9.47%	264.80	234.50	UNN-N173	UNN-N170
UNN-D80	1.00	1.00	0.080	1.00	1.00	0.080	0.50	0.050	220.0	239.80	215.30	11.14%	240.80	216.30	UNN-N190	UNN-N180
Watkins Creek																
WAT-D10	2.00	3.00	0.070	2.00	3.00	0.070	3.00	0.050	300.0	16.35	6.15	3.40%	19.35	9.15	WAT-N10	HYD-N40
WAT-D20	2.00	3.00	0.070	2.00	3.00	0.070	3.00	0.050	285.0	26.30	16.35	3.49%	29.30	19.35	WAT-N20	WAT-N10
WAT-D30	2.00	3.00	0.070	2.00	3.00	0.070	3.00	0.050	95.0	29.70	26.60	3.26%	32.70	29.60	WAT-N40	WAT-N30
WAT-D40	2.00	3.00	0.070	2.00	3.00	0.070	3.00	0.050	70.0	32.55	29.70	4.07%	35.55	32.70	WAT-N50	WAT-N40
WAT-D50	0.00	1.50	0.040	0.00	2.00	0.040	2.00	0.040	115.0	35.40	32.55	2.48%	36.90	34.05	WAT-N60	WAT-N50
WAT-D60	1.50	2.00	0.040	1.00	2.00	0.070	1.50	0.030	12.0	35.55	35.50	0.42%	37.55	37.50	WAT-N80	WAT-N70
WAT-D70	1.00	2.00	0.080	1.00	2.00	0.080	1.50	0.030	80.0	38.80	35.60	4.00%	40.80	37.60	WAT-N100	WAT-N90
WAT-D80	1.00	1.50	0.080	1.00	1.50	0.080	1.50	0.040	100.0	41.20	38.90	2.30%	42.70	40.40	WAT-N120	WAT-N110
WAT-D90	1.00	2.00	0.080	1.00	2.00	0.080	1.50	0.040	60.0	45.40	41.25	6.92%	47.40	43.25	WAT-N140	WAT-N130
WAT-D100	1.00	2.00	0.080	1.00	2.00	0.080	1.50	0.040	80.0	48.70	45.50	4.00%	50.70	47.50	WAT-N160	WAT-N150
WAT-D110	1.50	3.00	0.080	1.50	3.00	0.080	2.00	0.040	110.0	56.00	48.90	6.45%	59.00	51.90	WAT-N180	WAT-N170
WAT-D120	0.50	3.00	0.060	1.50	3.00	0.070	1.50	0.040	20.0	60.00	57.00	15.00%	63.00	60.00	WAT-N200	WAT-N190
WAT-D130	1.50	2.00	0.080	1.50	2.00	0.080	1.50	0.040	380.0	86.20	60.00	6.89%	88.20	62.00	WAT-N210	WAT-N200
WAT-D140	1.50	2.00	0.080	1.50	2.00	0.080	1.50	0.040	450.0	118.20	86.50	7.04%	120.20	88.50	WAT-N230	WAT-N220
Wedgewood Street																
WDG-D10	0.50	2.00	0.050	0.50	1.50	0.050	0.75	0.040	10.0	16.72	16.41	3.10%	18.22	18.73	WDG-N50	WDG-N45
WDG-D15	0.50	2.00	0.050	0.50	1.50	0.050	0.75	0.040	10.0	17.21	16.90	3.10%	18.71	18.40	WDG-N60	WDG-N55
WDG-D20	1.00	1.50	0.050	1.00	0.60	0.050	0.75	0.040	35.0	18.46	17.34	3.20%	19.06	17.94	WDG-N70	WDG-N65
WDG-D25	1.00	1.50	0.050	1.00	0.60	0.050	0.75	0.040	10.0	18.90	18.59	3.10%	19.50	19.19	WDG-N80	WDG-N75
WDG-D30	1.00	1.50	0.050	1.00	0.60	0.050	0.75	0.040	40.0	20.28	19.03	3.13%	20.88	19.63	WDG-N90	WDG-N85
WDG-D35	2.00	1.50	0.050	2.00	0.60	0.050	0.75	0.040	52.0	22.03	20.40	3.13%	22.63	21.00	WDG-N100	WDG-N95
WDG-D40	2.00	1.50	0.050	2.00	0.60	0.050	0.75	0.040	47.0	23.69	22.22	3.13%	24.29	22.82	WDG-N110	WDG-N105
WDG-D45	2.00	1.50	0.050	2.00	0.60	0.050	0.75	0.040	65.0	25.78	23.75	3.12%	26.38	24.35	WDG-N120	WDG-N115
WDG-D50	1.50	1.50	0.060	1.50	1.50	0.060	1.00	0.050	360.0	42.50	16.79	7.14%	44.00	18.29	WDG-N170	WDG-N40
WDG-D60	1.50	1.50	0.070	1.50	1.50	0.070	1.00	0.050	90.0	54.50	43.50	12.22%	56.00	45.00	WDG-N190	WDG-N180
Wellington Street																
WEL-D10	2.00	0.50	0.040	2.00	0.50	0.040	0.30	0.040	43.0	48.71	46.20	5.84%	49.21	46.70	WEL-N23	WEL-N20
WEL-D15	2.00	0.50	0.040	2.00	0.50	0.040	0.30	0.040	34.0	46.00	44.00	5.88%	46.50	44.50	WEL-N30	WEL-N26
WEL-D20	2.00	0.50	0.040	2.00	0.50	0.040	0.30	0.040	50.0	56.62	53.80	5.64%	57.12	54.30	WEL-N70	WEL-N60
WEL-D30	2.00	0.50	0.040	2.00	0.50	0.040	0.30	0.040	30.0	58.71	57.02	5.63%	59.21	57.52	WEL-N90	WEL-N80

NOTE: All invert elevations and ground elevations were estimated from the topographic mapping supplied by the City of Coquitlam and from the topographic information included in the "Northside Storm Sewer Relief Projects Final Report" (2002) by Dayton & Knight Ltd., provided by the City of Port Coquitlam.

MINUTES OF SEPTEMBER 30, 2003 ADVISORY COMMITTEE MEETING

APPENDIX E

MINUTES OF HYDE CREEK INTEGRATED WATERSHED MANAGEMENT PLAN ADVISORY COMMITTEE MEETING

DATE: September 30, 2003 **FILE:** 11-5280-30/HCIW/2003

TIME: 1:00 PM

LOCATION: Council Committee Room
Coquitlam City Hall

PRESENT:

John van der Eerden	Associated Engineering (BC) Ltd.
Mike MacLatchy	Associated Engineering (BC) Ltd.
Jamie Fitzgerald	Associated Engineering (BC) Ltd.
Libor Michalak	Envirowest Consultants Ltd.
Dana Soong	City of Coquitlam - Operations
Randy Chang	City of Coquitlam – Operations
Mike Iviney	City of Coquitlam - Operations
Joe Sulmona	City of Coquitlam - Planning
Sarah Dal Santo	City of Coquitlam - Environment
James Neville	City of Coquitlam - Environment
Kent Munro	City of Coquitlam - Planning
Dave Palidwor	City of Coquitlam – Leisure and Parks
Allen Jensen	City of Port Coquitlam
Mike Engelsjord	Fisheries and Oceans Canada
Erin Stoddard	Ministry of Water, Land and Air Pollution
Clara Brolese	North East Coquitlam Ratepayers
Eleanor Ward	North East Coquitlam Ratepayers
Ted Wingrove	Hyde Creek Watershed Society
Rick Skapski	Intercad Services Ltd.
Mark Bonner	Intercad Services Ltd.
David Bullus	Wesbild Holdings Ltd.
Elaine Golds	Burke Mountain Naturalists

Dana Soong introduced himself and explained this would be the last Advisory Committee meeting. The draft report will be revised with comments from this meeting. A revised draft report will be presented to Council. A Public Open House will follow to present the report and receive comments from the public.

There were general introductions made around the table. Janis Jarvis is no longer participating in this Advisory Committee, because her funding for the Habitat Conservation & Stewardship Program has ended.

DISCUSSION:

1. Review of Minutes

Dana Soong asked for comments on the previous minutes. No comments received. Audio recorders are being used in this meeting to capture minutes more accurately.

2. Planning Activities in Hyde Creek

Joe Sulmona provided an overview of planning activities in Hyde Creek. Work continues on the two neighbourhood plans – Lower Hyde Creek Plan and Upper Hyde Creek Plan. An open house was held at Victoria Hall in June, 2003. Working towards completing neighbourhood plans and incorporating the results from the Integrated Watershed Management Plan and OCP. One more Open House before we go to Council with first reading. David Bullus commented that work on neighbourhood plan is proceeding and waiting for Watershed Management Plan to be finalized.

3. Section 1 - Project Initiation

Mike MacLatchey reviewed the limits of the watershed area which includes Hyde Creek, Watkins Creek, Smiling Creek, Burke Mountain Creek and Cedar Creek. The main stem of Hyde Creek discharges to Deboville Slough and then into Pitt River. Port Coquitlam is fully developed whereas Coquitlam is largely undeveloped.

The plan addresses the impact from development in Coquitlam and the upper watershed while not degrading the environmental values of watershed, or causing any adverse impacts in the watercourse particularly between the borders of the two municipalities. Development can cause increased peak flows, more frequent high flows, erosion, sedimentation, reduction in environmental values and reduced base flows. The plan was developed to address all of these issues. Tiered approach to protect the environment and watershed values and all other negative impacts associated with development.

Tier 1 – Infiltrate as much rainfall and precipitation as possible. Goal is to infiltrate 90% of rainfall that would fall in any particular year. This is achieved primarily through Low Impact Development, LID principles. To be successful we first want to limit the impervious surfaces such as roof tops and driveways, then we want to direct the runoff to infiltration facilities. There are also things we can do within the municipal right of way such as roadways with open shoulders in some areas and curb breaks where runoff is captured by the roadway and directed into pervious areas.

Tier 2 - Control post-development flow rates to pre-development levels and associated with intermediate storm in the range of 5 to 10 year return periods. Control through stormwater diversion and detention ponds.

Tier 3 – Ensure that there is adequate flow paths for major events. The 100 year event water runoff should be contained without significant property damage and ensure public safety. Achieved through a combination of diversion and using the stream system itself.

4. GVRD Integrated Stormwater Management Plan Template

Dana Soong gave a presentation on the GVRD Integrated Stormwater Management Plan - Terms of Reference Template and a comparison to criteria used in the Hyde Creek Integrated Watershed Management Plan <attached Powerpoint presentation>. Objective of GVRD ISMP Template was to maintain existing watershed health and to achieve no net loss on a watershed basis. Hyde Creek IWMP generally follows the GVRD ISMP Template.

The GVRD ISMP website is www.gvrd.bc.ca/sewerage/pdf/ismp_template./pdf.

Question - Elaine Golds asked whether or not there would be any water quality monitoring in Deboville Slough and impact of dumping additional water into slough.

Water quality monitoring and impacts from diverting flows from Hyde Creek watershed directly into Deboville Slough has not been included in the Hyde Creek IWMP, but can be reviewed during the pre-design for the storm diversion outfall. <The City of Coquitlam has since retained Associated Engineering Ltd. to investigate the impacts of the storm diversion on Deboville Slough>

Question - Elaine Golds questioned the reported water quality monitoring program and recommends that presentations on specifics be made to stakeholders. She also asked what water quality monitoring is being done now?

The water quality monitoring program in the draft report includes benthic invertebrate sampling. It is being reviewed and will be revised for the final draft report. The City of Coquitlam is continuously monitoring stream flows at two locations - Hyde Creek @ Victoria Drive and Smiling Creek @ Victoria Drive. There is about a year of data. Port Coquitlam and Coquitlam have each purchased a water quality monitor and will be installing them in Hyde Creek.

Ministry of Water, Lands and Air Protection have some benthic invertebrate data. Any data collected by the cities will supplement their data.

Question - Elaine Golds would like to establish the original course of Hyde Creek before it was channelized for the records.

Aerial photos are available, but are fairly recent. Clara Brolese says that older generations could tell you where the original creek was before it was diverted. The Northeast Ratepayers Association may be able to identify people who have this information and if so will forward the information to Allen Jensen for follow-up.

5. Section 2 - Reconnaissance and Monitoring

Mike MacLatchy presented the work on identifying existing watershed deficiencies and constraints. Both Associated Engineering and Envirowest have completed field work in the watershed to determine existing conditions. Along the main stem of Hyde Creek there were a number of blockages in the channel. Tree jams have blocked the channel causing gravel and sediment build up. There is also associated erosion sites on the main stems. On the lesser creeks we found a lot of perched culverts which caused fish blockages. Some blocked culverts and various erosion sites were found. There are sites in Port Coquitlam with major retaining walls undermined which could topple over into the creek. There are baseload issues in Hyde Creek. On the upper portion of Hyde Creek our field crew experienced decent flow at the top and flow gradually diminished as you approached Coast Meridian which was augmented by ground water. Other creeks exhibit similar behaviour during dry periods.

Libor Michalak stated that Envirowest assessed the SHIM data which was available and identified locations for planning in the future. Field surveys identified such scenarios where enhancement could occur.

Question - Elaine Golds asked if really good spawning areas were identified and areas that were deficient of gravel and areas that could be enhanced.

Libor Michalak said that very good areas for spawning and areas that could be used for spawning were identified. The report discusses potential areas for enhancement and improvement. Tributary numbering in the report needs to be corrected.

Question - Eleanor Ward asked where fry have been released in Northeast Coquitlam. Where, when and who did it? Locations should be accurately reported. There are two locations of discrepancy.

Fish releases should be in the report, Libor Michalak will check.

Question - David Bullus understood that initially stream classifications were going to be dealt with in this report, then half way through the

process the agencies, DFO and WLAP thought classifications should be determined at the neighbourhood planning level. What is the status of this?

The Hyde Creek IWMP will identify stream classifications. If more detailed information becomes available in the future from the neighbourhood plan surveys, classifications could change. Stream setbacks would be determined at the neighbourhood planning level. The recommendation in the report is to follow Streamside Protection Regulations with the understanding that there may be trade offs within the watershed.

Mike Engesjord stated that in the very first meeting, Ian Whyte had classification list from GVRD which each municipality used. We did have discussion about this and what was appropriate.

Question - David Bullus stated that the level of detail for watercourse classification is too general and therefore some is probably inaccurate. He thinks the classification of streams should be done at neighborhood planning level where there is more accuracy.

Envirowest has walked all the streams and taken into account other people's work in setting stream classifications. Mike Engelsjord said that if tributaries are missing then they should be captured in this plan. Erin Stoddard said that setbacks should be dealt with at the neighbourhood level, but classifications must be imposed. Joe Sulmona said that OCP policy states whether the stream is on a map or not, it is recognized as a stream.

Any known discrepancies should be pointed out to Associated so they can revise the report.

David Bullus requests that stream classification can still be debated or discussed at neighbourhood planning level.

Question - Ted Wingrove asks why the streamside setbacks are not adhered to? Not just for fish but also becomes a wildlife corridor.

Mike Engelsjord says that DFO will approve the set-backs. Erin Stoddard stated that setbacks are variable with different sizes of properties, variance with headwater systems, variance with lower and more developed properties. When the size of the ravine outside the high water channel is 60 m or over, the setback is 10 m because you have such a wide corridor already. Main channel of Hyde north of David is more than 60 m.

Question - Ted Wingrove asked when construction starts, are you going to have something in place?

Erin Stoddard replied that's what the neighbourhood plans are for. He and Mike have met with the various agencies about the plans and talked about the regulations and how implementation should occur and made to maximize protection. When we developed the regulations, DFO says nothing less than 15m for a fish bearing watercourse. Looks at availability of land and if the land can handle 30 meters with the zoning that is presently on that land then it should have 30 m.

Comment - Ted Wingrove stated that they have already had problems with property owners filling in any type of watercourse within their property because they don't want setbacks on their property. They were threatened by property owners when doing SHIM mapping.

Erin Stoddard replied that enforcement problems one of the reasons why potential for riparian areas was built into the regulations. That was to avoid people going in and cutting down all the trees.

Joe Sulmona said that regardless of what the setback may ultimately be, Council has already decided there will be no development within 50m setback of all watercourses in the northeast. Reference A9 – northeast area plan.

6. Section 3 - Hydrologic Model

John van der Eerden described the hydrological modeling effort which includes a 600+ node hydrological model that goes with this report. Figures and tables in Section 3 show drainage sub-catchments, soil types, network data, existing culverts and their ability to handle pre and post development flows. Table 3.3 shows the Cedar Creek hydraulic gradelines for 5 different return period storms.

Comment – Ted Wingrove expressed concern that the rain gauge at the Burke Mountain Fire Hall is used, but no rain gauge at the top of the mountain. He also noted that there is nothing on tides in the drainage analysis.

Rainfall data was extrapolated to higher elevation in the analysis based on trends established on the North Shore mountains. The hydrological model is a fully dynamic model which takes into account tidal variations with time and the rainfall input on the watershed.

Question - Dana Soong asked if water surface profiles were calculated for Cedar Creek and the main stem of Hyde Creek. Were flooding impacts in Port Coquitlam reviewed?

Tables in the report show the hydraulic gradelines for Cedar Creek and sections of Hyde Creek. Also identifies undersized culverts based on headloss through the culverts. Allen Jensen noted that there has been some minor flooding issues in the past on Cedar Creek.

Question - Eleanor Ward asked whether the drainage system will be planned in more detail at the Neighbourhood Plan level. The developer, whether it is one person or a developing company, may need to make changes from what is in the report.

Joe Sulmona replied that Council has identified a policy that takes a "phased approach" to planning. The integrated watershed management plans for the various creeks is one component and the Neighbourhood Plan is a more detailed component. You will see changes in this report arising from the Neighbourhood Plan. Dana Soong stated that the Neighbourhood Plan will look at how each street and property will be serviced.

Rick Skapski stated that there are a lot of gaps where the plan is right now and where it is going to end up. Need to start with a lot of the background information that Associated has assembled and will have to modify it and get Planning involved to take into account the reality of development. The overall concept will remain essentially the same. In terms of guiding that process, we have an initial level of analysis by Associated on behalf of the City and the various designers will be working on parts of it and advancing that to an actual working level. The City will need to ensure that the initial objectives of the plan are being incorporated into the Neighbourhood Plan.

Comment - Ted Wingrove concerned that the report refers to "storm sewers" not "storm drains". The concept may mislead the public people dump things down storm drains, because they read storm sewer they think it goes into a sewer system. Erin Stoddard said that it is time that "sewer" reference is removed. Storm drains go into a stream. He thinks it is misleading and people think that if they dump it down there it's OK.

Common terminology in the industry is storm sewer and sanitary sewer. However, Coquitlam uses only "sewer" to define a sanitary sewer. References to "storm sewer" will be changed in the report.

7. Section 4 – Stormwater Management Alternatives

John van der Eerden introduced Section 4 which looks at the Stormwater management alternatives. The three primary alternatives:

- First one was a pure detention pond approach taking flows down to predevelopment levels.
- Second approach was a combined detention pond and stormwater diversion to Coquitlam River
- Third combined detention pond system and diversion to Deboville slough.

At a previous Advisory Committee meeting Alternative 3, diversion to Deboville Slough was selected as the preferred option. Now there are stronger, more compelling reasons why that option is recommended. Pure detention ponds alone couldn't control major event flows - 100 year event return period pond size became enormous. Diversion to Coquitlam River has some strong merits, but what prevented us from going in that direction was the issues surrounding Coquitlam River capacity level and flood protection.

Diverting to the Deboville Slough allowed the greatest area to be protected by the diversion sewer, peak flows from the watershed discharges to same receiving water body and flows can be controlled at the municipal boundary. It's recognized there is an inconsistency on how we expect the watershed to develop. The implementation of the diversion would be from the east to the west and then up the watershed, while development would likely start from the west to the east. That is a negative. Matrix and evaluation comparison put Alternative 3 ahead of the rest.

Another important aspect of Section 4 is the comparison of impacts to impervious area by implementing Low Impact Development, LID. The report shows different levels of effort regarding infiltration, disconnection of impervious surfaces, open shoulders. It provides some guidance and how much LID is appropriate and what is the practical limitation and how much you can reduce Effective Impervious Area, EIA.

Question - Mike Engelsjord asked what are the reasons for not disconnecting garage roof drainage.

There may not be adequate infiltration capacity in the soil depth. The report looked at the impervious area and ability to store runoff within the soil layer.

Comment – Erin Stoddard stated that there are other methods to infiltrate such as cisterns, underground vaults and French drains. Intention is to reduce impervious surfaces. Whether it is permeable pavers, there are lots of new technologies coming up that are quite practical and trying to meet 50% MAR on the site. You should be looking at everything.

The target in the report is for development to strive to infiltrate 50% of the mean annual rainfall MAR event in the watershed. Practical LID measures are recommended, not every possible LID measure. Some, due to the soils conditions, may not be worthwhile pursuing.

Comment - Rick Skapski stated when it gets down to actually doing the development there is opportunity to get disconnects in there even if they are not going to be effective in terms of 50% of MAR. He doesn't think that the report recommendation should be read as a directive that you don't need to try because it is not practical.

Comment - Mike Englesjord said that straight forward most effective BMP's should be done first and look at reasons for doing some of the other measures in 5 or 10 years.

The report doesn't focus on one type of development, some measures are not practical for street oriented town homes. Table 4.1 shows the effective impervious area, EIA, of the integration of all the different lot types and the right of ways when you have them altogether not just focusing on one type of development.

Comment - Mike Englesjord said it would be useful to have the reasons why we are not doing some BMPs.

Question - Clara Brolese asked for an explanation of a green roof.

John van der Eerden explained it as the ability to store and infiltrate water on a roof. Started out with roof top storage, cisterns originally and then progressed to actually putting some absorbent soil and vegetation on the roof. Erin Stoddard said that there is quite a lot of technology around green roofs. Europeans are getting into it big time. If you go to the GVRD web site you will find a report in the stormwater and drainage section and the technology around it. Questionable in some applications and there are lots of fears with regards to leaking condos. There are a lot of good examples locally such as White Rock where they are doing some work at their City hall.

Question - Elaine Golds stated that with regards to disconnection of roof tops, she does it in her yard and is amazed at how much the ground absorbs the water. Rainwater never builds up on the ground. One way to minimize impervious area is to minimize road system. She asked what is being done to minimize roads. Another way to maximize impervious areas look at greenways.

Kent Munro replied that the report takes a very integrated approach. When Catherine Berris did her analysis, we took a snapshot of where we were at with the Neighbourhood Plans. The EIA analysis is based on the actual land use plan. Table 4.3 in the report gives a sense of the EIA as applied to the new road standards, the development and the neighbourhood plans and LID's. The new road standards has about 40% less EIA then the old road standards.

Question - Elaine Golds asked what can be done to limit the number of roads.

Kent Munro replied that some specific work is being undertaken in the upper areas to examine the possibility of eliminating some roads and putting in green streets.

Joe Sulmona stated that Kent is providing expertise in what is called New Urbanism. Ensures how an area can be developed in a sustainable manner. There is more of a grid system in the northeast than you would see in more traditional suburban development. Highly recognized as having better connectivity and is a better solution. There may be room for improvement in terms of reducing the amount of pavement.

Comment - Rick Skapski said that the plans have more roads than your more traditional cul-de-sac. The cul-de-sac is the minimum amount of road for the amount of development. There is a lot of pavement out there even with the narrow road surfaces.

The traditional cul-de-sac is not a favoured approach of the City.

Suggestion was made to use pervious lanes. Erin Stoddard said that there are plenty of examples of that happening locally.

Comment - Rick Skapski doesn't think catchbasins have to go directly into the storm drain. It can go into a French drain and then overflow into the storm drain. Should look at disconnecting garage roofs from the storm drains to runoff back into the ground.

John van der Eerden said that maybe just a perforated base on the catch basins is needed. There should be a standard drawing in the municipal bylaw created.

Question - Elaine Golds asked when the roads will come back for public comment. She wants to make sure that the roads are being minimized. And also wants to look at stream crossings.

Kent Munro said that they are only three quarters through the neighbourhood plan process. There are still a number of opportunities for comment before being finalized. Joe Sulmona added that they have already heard feedback from residents in the northeast of the pros and cons of stream crossings. That will be a challenge and something that Council will need to hear at a public hearing about how the road system must meet the needs of everybody.

Comment - Mike Englesjord noted that page 4-28 of the report states "none of the scenarios result in an overall watershed EIA below 20%, at which point impact to fisheries are generally considered to be "slight" rather than "significant"". Most relationships are based on total impervious area, TIA and he is not sure how valid it is to use EIA. Erin Stoddard said that 10 to 12% TIA results in impacts to the stream.

The approach of the watershed management plan is to lower the total impervious area to an effective impervious area. The objective is to minimize the increase in EIA for the overall watershed from pre to post development. <Estimates of existing EIA are 6% for Coquitlam and 37% for Port Coquitlam. The estimated average overall existing EIA for the Hyde Creek watershed is 20%.>

8. Section 5 – Model Analysis of Preferred Alternative

John van der Eerden discussed Section 5 which looks at the preferred alternative in detail. Figure 5.1 shows schematically how the system works. All pre-development flow rates go to the creeks. For areas served by the diversion sewer, all pre-development flow rates, for any return period, are going to the creeks represented by the green and yellow lines. The reason we split the yellow and green lines is to show flows through the stormwater quality ponds before draining to the creeks, and bypass flows directly to creeks. If all predevelopment flow rates from major storms went through the ponds it would cause flushing of the captured sediment into the stream. The difference between post-development flow rates and pre-development flow rates go to the diversion sewer and then to Deboville Slough and that is represented by the blue line. For areas not served by the diversion sewer we have full stormwater detention ponds that are capturing the 10 year flow. In this case we have the blue line which is the post-development flow rate going into the pond and exiting is the pink line which is the flow attenuated to pre-development levels. The red line represents the major events that bypass the ponds. Anything in excess of the 10 year event will be bypassed.

Figure 5.2 is the recommended alternative. It shows the diversion extending from the Deboville Slough upstream initially along Victoria Drive and then jogging up along the Roxton Avenue right of way. Following the B.C. Hydro right of way was reviewed, but property issues and the need for an agreement with B.C. Hydro made this alignment less attractive. Stream crossings could go underneath the stream or be suspended by a bridge. The decision would be a detailed design issue. Ponds in the upper area above Roxton Avenue, except for pond no. 1, are all water quality ponds to capture the pre-development flow rates before the discharge to the creek to provide some water quality improvements primarily capturing sediment and any pollutants associated with the sediment. Pond nos. 1, 4, 7, 9 and 10 are stormwater detention ponds that are designed for 10 year storm events. They will be wet ponds which provide water quality improvements and various benefits over other types of detention ponds.

Comment - Erin Stoddard said that every development site should have a comprehensive sediment control plan which shouldn't allow anything to come off the development site. Traditional development relies on ponds as the only means of sediment control instead of doing a comprehensive plan for the development site. Recently came across a development site on Pinetree Way in Coquitlam that was discharging sediment.

David Bullus said that in Coquitlam you have to provide comprehensive sediment control drawings so there is process already established and not just a reliance on ponds. John van der Eerden said that there may be an opportunity to use the permanent ponds as a construction pond and then have cleaned out and put in its final configuration before it comes on line.

Dana Soong said that the Pinetree Way site is likely an enforcement issue. He also stated that the use of permanent ponds for construction sediment control is not desirable as the ponds will likely be maintained by the City.

Erin Stoddard wants words in the report that explains comprehensive sediment control plans are required above and beyond the use of ponds.

Question - Elaine Golds asked how the outfall is going to be engineered at Deboville Slough. Will probably be getting most of the flows in the fall when salmon will be returning. Fish are going to have more water to fight against than normal. She is also concerned that fish may have difficulty finding their way into Partington Creek when water is taken from the upper part of Hyde Creek and put into the outfall. It will smell like Hyde Creek water.

John van der Eerden replied that the outfall design needs a lot of thought for erosion control protection at Deboville Slough. He was not sure what the impacts to the upstream migration of fish would be.

<The City of Coquitlam has since retained Associated Engineering Ltd. to investigate the impacts of the storm diversion on Deboville Slough>

Mike McLatchy referred to Figure 5.5A which shows the hydrographs for Hyde Creek and includes diversion flows. Black hydrograph is runoff that enters Deboville Slough under existing conditions without any development , the lighter colour hydrograph color, which is slightly lower than the black hydrograph, is the post development flow that will be entering Deboville Slough from Hyde Creek and the very small, light grey hydrograph is the flow coming out from the diversion under a twice per year storm. For the smaller storm events there is very little flow coming down the diversion and that is for a short period of time. That is 2 cubic metres per second going through the diversion as compared to 24 cubic metres per second at Hyde Creek itself. For small storms that occur frequently the diversion is only going to be functioning for a very minor degree. For a 100 year storm event as shown in Figure 5.5D you will have a more significant flow that is coming down the diversion, but for a very short period of time. That is when all kinds of other things will be taking place in the watershed during the 100 year storm event.

Most of the time, the diversion is not greatly exaggerating the flows to Deboville Slough. Even for the 5 year storm, shown in Figure 5.5B, the pre-development hydrograph puts in 33 cubic metres per second into Deboville Slough, while the post-development flow is 29 from Hyde Creek plus 8 from the diversion for a total of 37 cubic metres per second flow. This is only about a 12 percent increase in flow. There will be an impact from this, but it should be manageable and needs to be explored in more detail.

Comment - Eric Stoddard said that for Coho, small increases in flow can affect their upstream migration. If you don't know what the effects will be, you should be looking at minimizing those effects through whatever means you can.

Mike MacLatchy replied that the Deboville Slough is very wide compared to the other streams and ditches so the velocity is very low to begin with. On the issue of mixing Partington and Hyde Creek water and the chemical coding of water, all water going through the diversion is runoff from urban areas, not water that has been taken out of streams into the diversion.

Question - Ted Wingrove asked if there is a possibility for the diversion pipe to be moved farther north and discharged into a lake and controlled by a pump house instead of dumping into something that is controlled by the tide and we have no control over in terms of freshet and backup water flow. If we get a big storm at the top and we have to dump that excess water, that may be the straw that breaks the camel's back. There are GVRD lands north of the Deboville Slough that may accommodate a man-made lake.

Mike MacLatchy replied that technically it could be made possible, but there would definitely be extra costs. The extra flow into Deboville Slough is not likely going to be a problem.

Question - Eleanor Ward does not think the diversion should only go to Deboville Slough, some of it should go to Coquitlam River. The Diking Commission may be concerned with the additional flow. They should be asked for their comments.

The City of Coquitlam is represented on the Fraser River Estuary Management Program and the report will be presented to them. A copy of the report will also be sent to the Inspector of Dikes for review and comments.

Question - Eleanor Ward asked that the alignment of the diversion pipe be reviewed. She does not agree with the route along Roxton Avenue. Others routes should be reviewed. David Bullus also asked if there are any other practical alternatives. Clara Brolese expressed concern about building a

2.4 m concrete pipe down the middle of her street. How will this be accommodated and how do you deal with ravine crossings?

<The City of Coquitlam has initiated an alignment study of the diversion sewer that looks at different routes in more detail with refined cost estimates>

Question - Elaine Golds asked what flexibility is built into the plan if flows in the diversion are not what was anticipated. She doesn't want Hyde Creek to be robbed of those important functions.

John von Eerden replied that it is mandatory that this system is adaptable. Control manholes often have a steel plate so you can adjust the opening based on the pre and post development flow monitoring.

Erin Stoddard asked that the report include a requirement for adjustable structures.

Comment - Allen Jensen said that it is important to decide on the alignment because it will affect the sizing of the ponds. The ponds below the diversion are sized to one in 10 years so if you move that diversion up, need more ponds or bigger ponds below the diversion. Clara Brolese stated that neighbourhood plans will have to be put on hold until a decision is made on the ponds.

<The diversion sewer alignment analysis results will be used to update the Hyde Creek IWMP report>

Question - Rick Skapski asked whether some level of development could proceed before the diversion is in place. Water quality ponds are not very big.

The ponds would accommodate some level of development that has not yet been determined. Timing of the diversion sewer also needs to be determined.

Comment - Clara Brolese notes that in the upper parts of Hyde Creek the diversion pipe will have an affect on the Hyde Creek neighbourhood.

Rick Skapski stated that the diversion pipe would be adapted into the neighbourhood plan.

9. Section 6 – Recommendations

John van der Eerden discussed Section 6 – Recommendations. Need to include recommendations for existing deficiencies. Cleanup of omissions, statements and comments received earlier. LID recommendations will be made more definitive.

Question - Ted Wingrove noted that for Cedar Drive creek, the report recommends reducing water levels by upgrading culverts. Could the pump house be upgraded?

Upsizing the culverts would improve the hydraulic gradeline in the creek. Allen Jensen said that there are diversion options downstream. Mike McLatchy said that upgrading the pump house would have benefits, but according to a previous study, it wasn't the preferred option.

Question - Mike Engelsjord asked if enough information was available to plan higher density developments in areas with low infiltration potential and lower density developments in areas with good infiltration potential.

The Piteau hydro-geological investigation was based on 10 test holes across the whole watershed, so it gives the general potential for infiltration, but does not specifically say in one area. Additional investigation would be required at the neighbourhood planning level.

Rick Skapski believes the area, as far as development potential, is really very similar with not a lot of variation in it. Figure 2 in the Piteau report shows the locations and variations in the impermeable areas.

Question - Elaine Golds asked for clarification on the statement in section 6.2.3, "An alternative to detention ponds that provides similar, and often superior, environmental benefits is a diversion sewer". She thought that detention ponds were for tier 2 storms and diversion for tier 3 storms, and that one was not an alternate for the other.

The purpose of the detention ponds is to detain stormwater runoff such that creek flow rates are maintained at pre-development levels up to a 10 year storm, tier 2. Excess flows caused by development, that would normally be evapotranspirated, is released back into the creeks. It is unpractical to size detention ponds for larger storms.

A diversion pipe has the same purpose of a detention pond. It diverts the excess flow caused by development and maintains pre-development flow rates in the creeks. The advantage over a detention pond is that pre-development flow rates up to a 100 year storm event can be maintained in the creeks. For example, during a 25 year storm, excess flows caused by development would be diverted and the creek flows would remain at pre-development levels for a 25 year storm.

10. Section 7 – Cost Estimates and Implementation

John van der Eerden reviewed Section 7 - Costs Estimates and Implementation. The current draft has a $16.5 M program and we still have to add in the costs of current deficiencies.

Question - Mike Iviney asked if this includes monitoring costs as well.

Mike MacLatchy replied that we don't have those costs right now.

Question - Erin Stoddard asked if something will be put in with respect to implementation of LID's.

The report will include recommendations for LIDs.

Question - Dana Soong asked if the environmental cost allowance is 5% as stated on page 7.1 or 10% as listed in Table 4.2.

Mike MacLatchy said it should be 10%.

Comment - Mike Iviney said that when the facilities are designed he expects a full maintenance manual on how to operate them.

11. Concluding Remarks

The comments from the Advisory Committee will be used to update the draft Hyde Creek IWMP report. Any outstanding concerns will be captured in the minutes of this meeting.

A revised draft will be presented to the Councils of Coquitlam and Port Coquitlam. A public open house is planned after the respective Councils have received the report.

1940 AERIAL PHOTOGRAPH OF LOWER HYDE CREEK WATERSHED

APPENDIX F