Report

Jacques Whitford AXYS

Associated Engineering

GLOBAL PERSPECTIVE. LOCAL FOCUS.

City of Surrey

Erickson Creek Integrated Stormwater Management Plan

September 2010

ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF
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September 23, 2010
File: 20062802.00.E.03.00

Ms Jane Umpleby
Project Coordinator
City of Surrey
Engineering Department
14245 - 56 Avenue
2nd Floor Reception
Surrey, BC
V3X 3A2

Re: ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN FINAL REPORT

Dear Ms Umpleby:

We are pleased to provide three complete hard copies of our final report for the Erickson Creek ISMP. A complete PDF of the report is provided on the enclosed CD.

We greatly enjoyed working with you on this challenging assignment and trust that this final report meets your expectations. Please contact myself or John van der Eerden should you have any questions or concerns.

Yours truly,

Prepared by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA M.R. MacLATCHY 24939

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Senior Water Resources Engineer

Reviewed by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. H. Van der Eerden

John van der Eerden, M.Eng., P.Eng.
Manager – Water Resources Group

MM/JV/lp

Enclosure

Executive Summary

1 PROJECT OVERVIEW

The Erickson Creek watershed encompasses agricultural lowlands and partially developed upland areas. Drainage flows generally northward from the upland areas northward through the lowlands to the Nickomekl River. There are two distinct upland areas in the watershed, Grandview Heights in the southwest, and Campbell Heights along the eastern margin. Refer to Figure 2-1 for a map of the Erickson Creek watershed.

The Grandview Heights area is the subject of the Grandview Heights General Land Use Plan, which extends beyond the watershed boundaries. Residential and commercial developments are planned for this area of the watershed. In the future, Campbell Heights is expected to be intensively developed as a business park with commercial and light industrial activities (Campbell Heights Local Area Plan Review, City of Surrey, 2000). A very high level of impervious cover is expected as a result of this land use.

An important aim of this Erickson Creek ISMP is to bring together an integrated understanding of existing functioning of the Erickson watershed and to identify management processes that the City of Surrey can use to guide land development that maintains a healthy and safe watershed from an environmental and hydrological perspective. This plan will foster an integrated approach to stormwater management that promotes public safety, protects life, property, and environmental values, and allows for economic land use.

2 ERICKSON CREEK WATERSHED OVERVIEW

The Erickson Creek watershed encompasses 1454 ha in South Surrey, BC. The main current land uses in the watershed are agricultural (in the lowlands and along the north slope), wood lots and low density residential. Industrial areas are being or will be developed along the eastern fringe. Further urban and suburban development in upland areas is anticipated.

2.1 AQUATIC HABITAT

Upstream of 32nd Street, Erickson Creek and its tributaries have been described as containing fish habitat (Envirowest 1995, 2005), with reports of salmonids (coho salmon, cutthroat trout, rainbow trout) and other species in the creeks. A number of ponds offer excellent rearing habitat for salmonids and habitat for wildlife, waterfowl and amphibians. Most tributaries and ditches in the Erickson drainage are designated Class A fish habitat (City of Surrey 1995), indicating year-round presence of salmonids, as illustrated in Figure 3-1.

2.2 TERRESTRIAL HABITAT

The Erickson watershed has been developed with a mix of highly agricultural areas (in the lowlands and along the northern slope), wood lots and low density residential land use, with industrial areas being developed along the eastern fringe. Vegetation in undeveloped areas consists of deciduous and coniferous woodland and old-field habitats.

Wildlife using the watershed are likely to include small mammals (e.g., mice and voles), skunks, racoons, red fox, coyotes and a wide range of birds. Anticipated uses of existing natural habitat include nesting by songbirds and hunting, foraging, shelter and migratory stopovers by other animals. Many remaining patches of natural habitat are small and fragmented. This limits the watershed's ability to support mammals with large home ranges, such as black-tailed deer, and supports the presence of tolerant species such as raccoon and coyote.

Recent environmental assessments for the Grandview Heights Plan Area (which includes part of the Erickson watershed) indicate the occurrence or potential occurrence of habitat suitable for eight species of conservation concern (provincially or federally-listed wildlife species), including red-legged frog, western toad, Great Blue Heron, Western Screech Owl, Barn Owl, Band-tailed Pigeon, Pacific water shrew and Trowbridge's shrew.

2.3 HYDROGEOLOGY

Soils in most of the Erickson watershed are typically low in permeability, although the upland areas in Campbell Heights have significantly more permeable soils than the lowland areas. An unconfined aquifer under the Campbell Heights area, extending into Langley, provides base flow for many streams along the plateau, including Erickson Creek.

Based on the results of the hydrogeological assessment, opportunities for infiltration of stormwater on a mid- to large-scale are expected to be limited to the mid- and upland areas of the Erickson Creek watershed.

2.4 WATERSHED HEALTH

The preliminary watershed health assessment was prepared using total impervious area (TIA) and riparian forest integrity (RFI), following the Watershed Health Tracking System described in the GVRD ISMP template (GVRD 2005). TIA and RFI are considered key physical performance measures that correlate strongly with watershed health. Values shown in Table 3-8 for existing conditions were overlain on the template chart (Figure 3-8).

The upland areas of the Erickson Creek watershed, the main focus of this ISMP, are considered to have moderate watershed health, based on 10% TIA and 41% RFI under current conditions. These values would be expected to move toward poorer health as TIA increases with future development, unless mitigated.

2.5 STREAM SETBACKS

The importance of adequate setbacks for maintenance of watershed health, protection of fish habitat, wildlife corridors, access for maintenance, geotechnical and flood plain concerns, as well as for protection of property cannot be overemphasized. Encroachment leads to loss of riparian vegetation, with associated degradation of fish habitat and loss of wildlife habitat and migration corridors. Setbacks should be determined based on geotechnical and geomorphological values, in conjunction with existing and proposed flow regimes, as well as fisheries and wildlife values. Recommended setbacks are discussed in Section 9.3.1.

2.6 HYDRAULIC INVENTORY

Hydraulic structures and other features are indicated in Figures 3-6a and 3-6b. During our field reconnaissance, our staff noted all hydraulically significant features in the creek channel and adjacent tributaries. These features included:

- Culverts and bridges, including special conditions
- Debris blockages
- Erosion areas
- Channel obstructions
- Fish passage restrictions
- Pump stations.

3 STORMWATER MANAGEMENT STRATEGIES

3.1 CAMPBELL HEIGHTS STORMWATER MANAGEMENT

Due to the high infiltration capacity of the soils underlying the Campbell Heights area the primary mechanism for stormwater management will be extensive application of infiltration based LID approaches. **The recommended target for stormwater infiltration is to ensure that the entire runoff volume from the five-year return period design storm of 24 hours and shorter durations be detained and infiltrated**.

Specific LID measures are recommended as candidates for application in the Campbell Heights area of the watershed in Section 9 of this ISMP. All exfiltration facilities must be designed by a qualified professional in consideration of site specific conditions.

A comprehensive program for the maintenance and inspection of LID facilities is required to ensure the viability and effectiveness. These measures are also presented in Section 9.

Excess runoff arising from large events must be routed safely to the lowland drainage system, as indicated on Figure 7-1. Required improvements are indicated on Figures 8-24A and 8-24B.

3.2 GRANDVIEW HEIGHTS STORMWATER MANAGEMENT

Peak Flow Management

For the Grandview Heights area primary stormwater management will be provided by eight detention ponds to attenuate peak flows according to the City of Surrey's peak flow criteria. These ponds and their service areas are illustrated in Figure 7-1.

Some drainage components, primarily culverts, of the upland drainage system will require upgrading to ensure safe conveyance of the 100-year design flow. These deficient components are highlighted on Figure 8-24A and 8-24B. Lowland drainage upgrades were identified in the previous lowland drainage strategy.

Our capital cost estimate for the stormwater management infrastructure related to the ISMP recommendations in the Grandview Heights area is $16,670,000 (2010 dollars). This estimate includes capital costs associated with the detention ponds, as well as the required culvert and conveyance upgrades. Our capital cost estimate does not include any allowance for environmental mitigation or enhancement projects. A breakdown of the estimated capital costs is included in Table 9-1.

Low Impact Development Measures

LID measures are required to maintain the hydrological regime of the Grandview Heights area. Our WBM analysis indicated that retention of existing forest cover and enhancement of vegetation is generally more effective than relying on infiltration based approaches.

Our recommended candidate LID measures favour retention or enhancement of vegetation, and are detailed in Section 9. Application of any of these measures to a particular development site should be confirmed by a qualified professional and be subject to review by the City. Overall, maximization of evapotranspiration through retention of forest cover and other vegetation should be a priority.

Requirements to Protect Stream Health

In completing the assessment of LID measures for use in the Grandview Heights area, we assessed the level of effort that would be required to fully protect stream health by maintaining the current hydrology of the watershed (Section 8).

We recommend the following performance criteria to ensure protection of stream health:

- Infiltration or evapotranspiration of 50% of the rainfall volume from the 24-hour, 2-year return period design storm.
- Maximum flow release of 0.5 L/s/impervious hectare during the 24-hour, 2-year return period design storm.

- Maximum effective impervious area (EIA) within any given catchment of 20% of the catchment area, as indicated by runoff during the 24-hour, 2-year return period design storm.
- Maximum total impervious area on any identifiable watercourse limited to 40% of the catchment area.
- Total long-term runoff volumes controlled to 29% of the long-term rainfall volume
- All surface runoff originating from developed lands routed to peak flow detention systems for events up to and including the 5-year return period, at all durations.

These criteria imply that effective LID measures will need to be applied extensively within the Grandview Heights area. The primary LID mechanism will be maximization interception and evapotranspiration of water by vegetation. During upcoming detailed NCP processes for Grandview Heights, clustering of development to retain existing forest cover should be a priority.

3.3 WATER QUALITY BMPS

Water quality BMPs are recommended for application as a function of land use activities (i.e. parking lots, vehicle servicing areas), otherwise water quality inlets can be widely applied in catch-basins to trap sediment and debris. The recommended water quality BMPs include:

- Water quality inlet (sediment and debris trapping catch basins).
- Oil-water separator (proprietary or generic).
- Water quality swales for parking areas, road runoff (where grade and space allow).

3.4 ENVIRONMENTAL QUALITIES

In addition to the stormwater management recommendations discussed above, we recommend a number of environmental measures be implemented to minimize development impact on the creek systems. These are discussed in detail in Section 9, and include:

Riparian Setbacks
The importance of adequate setbacks for maintenance of watershed health, protection of fish habitat, wildlife corridors, access for maintenance, geotechnical and flood plain concerns, as well as for protection of property cannot be overemphasized. The City of Surrey currently requires a 15 m to 30 m riparian setback for fish-bearing streams. It is strongly recommended that these setbacks not be relaxed in the Erickson Creek watershed. Riparian setbacks should be the widest provided in existing municipal and provincial legislation to protect fisheries, wildlife, geotechnical and property values.

Environmental Enhancements
The following recommendations are made as ways in which the City may continue to protect and enhance riparian, stream and forest habitat in the watershed, maintain biodiversity and protect or restore habitat reservoirs, patches and corridors:

- Establishing a park and natural area network that preserves valuable habitat.
- Establishing fenced corridors, dedicated as parkland, to protect riparian habitat.
- Ensuring that land use zoning protects natural areas including valuable terrestrial habitat.
- Maintaining existing natural features such as ponds that provide habitat.
- Conserving or restoring native riparian habitat, as identified in Section 3.1.5 and **Table 3-4**.
- Encouraging landscaping with native plants.
- Removing barriers to fish migration.
- Consult the provincial Draft Environmental Management Practices for Urban and Rural Land Development (Polster and Cullington 2004) prior to development to ensure that relevant BMPs are incorporated.

Existing forested lands provide important connectivity for terrestrial wildlife. Therefore a high priority must be placed on avoiding disturbance to this forest cover.

Environmental Monitoring Program

Through the ISMP process we identified a number of environmental concerns and opportunities. To identify and mitigate future environmental concerns and to act on the environmental recommendations, we recommend ongoing monitoring activities for the watershed, including:

- Periodic water quality monitoring to assess impacts of development within the watershed.
- Benthic invertebrate monitoring, on a three year cycle.
- Periodic watercourse field reconnaissance to assess physical stream conditions.

Adaptive Management

Consistent with the objectives of this Erickson Creek ISMP, the City of Surrey should adopt an adaptive management approach in order to ensure the overall health of the watershed is maintained, and no net loss of habitat occurs at the watershed scale.

Monitoring data should be compiled and reviewed periodically in a systematic and consistent manner, to determine whether overall watershed health is impaired, and to recommend mitigative actions. Depending upon identified impacts, an adaptive management response could include:

- Adjustment of BMP requirements and standards.
- Implementation of specific mitigative works.
- Adjustment to subsequent development planning and implementation.

3.5 BYLAWS AND POLICIES

The City of Surrey has a number of bylaws and policies that relate to watershed health and stormwater management. To incorporate our findings into these bylaws and policies we recommend the following additions:

- Revise existing City development standards to incorporate the LID recommendations of this ISMP for application to development within the Erickson Creek watershed.
- Develop zoning classifications that reflect the recommended TIA and EIA limits.
- Ensure that TIA and EIA limits incorporated in zoning classifications are enforceable.
- Ensure that bylaws protect LID facilities from removal or modification.
- Implement ongoing surveillance, measurement and reporting protocols, as well as compliance enforcement activities at both the municipal and provincial level.
- Require annual monitoring, maintenance, and reporting for “hot-spot” BMP applications.
- Incorporate annual monitoring and maintenance activities for City owned and operated BMP / LID systems into regular City operations.
- Require tree removal permits and maintain maximum native vegetation during development.
- Require minimal removal and compaction of surficial soil during development.
- Maintain any areas with reasonable infiltration capacity for siting of LID / BMP facilities.

Although the Erickson Creek ISMP process commenced prior to the development of the City of Surrey’s Sustainability Charter, with the Draft ISMP document submitted in July of 2008, the recommendations of this ISMP are consistent with the overall vision and objectives of the Sustainability Charter.

Stormwater Operation and Maintenance Requirements

Systematic operation and maintenance procedures are required in order to ensure proper long-term operation of detention systems, LID measures and water quality BMPs. Recommended measures and practices for incorporation into the City’s regular operations and maintenance activities within the watershed are detailed in Section 9.

3.6 IMPLEMENTATION STRATEGY

Implementation of this Erickson Creek Integrated Watershed Management Plan requires both physical works and institutional measures. The following listing indicates the relative priority for implementation of these measures:

.1 Construct the recommended stormwater infrastructure, to keep pace with development activities.
.2 Revise the City’s development standards to achieve rainfall capture and runoff targets.
.3 Correct identified capacity deficiencies related to culverts and channel constrictions.
.4 Implement the environmental enhancements identified in this plan.
.5 Develop an adaptive management strategy.
.6 Develop an ongoing education/public awareness program to minimize the removal or disturbance of LID measures on private property.

Table of Contents

1 Introduction

1.1 PROJECT OVERVIEW

The Erickson Creek watershed encompasses agricultural lowlands and partially developed upland areas. Drainage flows generally northward from the upland areas through the lowlands to the Nickomekl River. There are two distinct upland areas in the watershed, Grandview Heights in the southwest, and Campbell Heights along the eastern margin.

Overall, Grandview Heights is currently lightly developed with scattered single family housing. In the future Grandview Heights will be subject to extensive development of single and multi-family housing, and a neighbourhood commercial core. The Grandview Heights area is the subject of the Grandview Heights General Land Use Plan, which extends beyond the watershed boundaries. Within the Erickson Creek watershed no Neighbourhood Community Plans are in progress, pending the completion of this Integrated Stormwater Management Plan (ISMP).

Within the Erickson Creek watershed, current Campbell Heights land uses include agriculture related industry and gravel extraction. Most tree cover has been removed in Campbell Heights, but notable localized pockets of forest remain. The steep escarpment that separates Campbell Heights from the lowlands remains largely forested. The Brookswood Aquifer lies under Campbell Heights, and extends to the east and south, well beyond the watershed boundaries. This aquifer supports several small watercourses that rise on the escarpment and flow into the lowlands.

In the future, Campbell Heights is expected to be intensively developed as a business park with commercial and light industrial activities (Campbell Heights Local Area Plan Review, City of Surrey, 2000). A very high level of impervious cover is expected as a result of this land use.

Previously, drainage of the agricultural lowlands was the focus of the Erickson Creek and Burrows Ditch Functional Plan (UMA, 2002). This plan investigated present and future drainage conditions in the lowlands and prescribed improvements to the lowland drainage system. Potential increases in runoff entering the lowlands as a result of development in the upland areas were considered in that functional plan. The main focus of this Erickson Creek ISMP is the upland areas of Grandview Heights and Campbell Heights; however, this ISMP will ensure that increases in runoff volume are compatible with the earlier lowland drainage study.

An important aim of the Erickson Creek ISMP is to bring together an integrated understanding of existing functioning of the Erickson watershed and to identify management processes that the City of Surrey can use to guide land development that maintains a healthy and safe watershed from an environmental and hydrological perspective. The ISMP will establish a vision for the Erickson Creek Watershed that manages development and promotes sustainability. The plan will foster an integrated approach to stormwater management that promotes public safety, protects life, property, and environmental values, and allows for economic land use. To address the commitments to the GVRD Liquid Waste Management Plan, the Erickson Creek ISMP will:

- Facilitate orderly land development and redevelopment within the subject watershed.
- Protect aquatic and wildlife habitat.
- Protect private and public property from flood and erosion damage.
- Maintain public safety through stormwater management.
- Ensure that excessive runoff from upland development does not adversely impact the agricultural lowlands.

The goal is to achieve the above in a manner that is:

- Cost effective,
- Scientifically defensible,
- Supported by the public, and
- Endorsed by the senior regulatory agencies.

1.2 PROJECT PARTICIPANTS

The consulting team was comprised of personnel from Associated Engineering and Jacques Whitford. Key team members were:

- John van der Eerden — Project Manager
- Michael MacLatchy — Senior Water Resources Engineer
- Nazmun Nahar — Assistant Water Resources Engineer
- Karen Munro — Senior Aquatic Biologist, Facilitator
- Nigel Denby — Senior Geotechnical Engineer
- Shelley Norum — Biologist: Aquatic and Terrestrial Habitat

City of Surrey staff involved over the course of the project included:

- Jane Umpleby — City Project Manager/Groundwater Supply Coordinator
- Ted Uhrich — Parks
- Cari St. Pierre — Parks
- Jeff Welch — Operations
- Lynn Guilbault — Long Range Planning & Policy Development
- Bargav Parghi — Long Range Planning & Policy Development
- Mira Petrovic — Utilities/Transportation
- Carrie Baron — Utilities/Drainage & Environment
- Remi Dube — Utilities/Drainage Planning

Stakeholder participants were:

•	Phillip Milligan	Semiahmoo Fish & Game Club
•	Ron Meadley	Semiahmoo Fish & Game Club
•	David Riley	Little Campbell Watershed Society
•	Margaret Cuthbert	Friends of Semiahmoo Bay Society
•	Glen Carlson	A Rocha Canada
•	Dennis Fung	Surrey Dyking District
•	Mike Bose	Agricultural Advisory Committee
•	Bill Stillwell	Environmental Advisory Committee
•	Rob Knight	Ministry of Environment
•	Alan Jonsson	Department of Fisheries & Oceans
•	Kathleen Zimmerman	Ministry of Agriculture, Fisheries & Food
•	Drew Waska	Nicomekl Enhancement Society
•	Hugh Carter	Grandview Developer Group
•	John Northey	Grandview Developer Group
•	Ken Beck Lee	Grandview Developer Group
•	Dr. Roy Strang	Sunnyside Acres Heritage Society
•	Inderjeet Gill	Fraser Health

We gratefully acknowledge the contribution of the community stakeholders who provided insightful discussion and knowledge of the Erickson Creek watershed.

2 Erickson Creek Watershed Overview

The Erickson Creek watershed encompasses 1454 ha in South Surrey, BC and is bordered by the Burrows Creek watershed to the west, the Little Campbell River watershed to the south, the Unwin watershed to the east, and the Nicomekl River to the north. The main current land uses in the watershed are agricultural (in the lowlands and along the north slope), wood lots and low density residential. Industrial areas are being or will be developed along the eastern fringe. Further urban and suburban development in upland areas is anticipated. Refer to Figure 2-1 for a map of the Erickson Creek watershed.

Erickson Creek is a short (5.7 km long) third order tributary of the Nicomekl River, with a confluence approximately 15.5 km upstream of the Nicomekl outlet into Mud Bay. The creek has been fragmented over the years by a series of agricultural ditches. A number of headwater tributaries originate near 24th Avenue and 184th Street and flow northward. At 32nd Avenue and 180th Street, the creek flows into a ditch running alongside 180th Avenue. Many of the headwater tributaries are named locally and are known as Justin Brook, Breaks Creek, Dall Brook, Vandrish Brook, Laura Brook and Clover Brook. According to DFO's online mapping program, Erickson Creek and associated tributaries include approximately 12 km of "natural" channel (DFO 2005), 6 km of main ditched channels (along 180th and 184th Streets) and additional irrigation ditches.

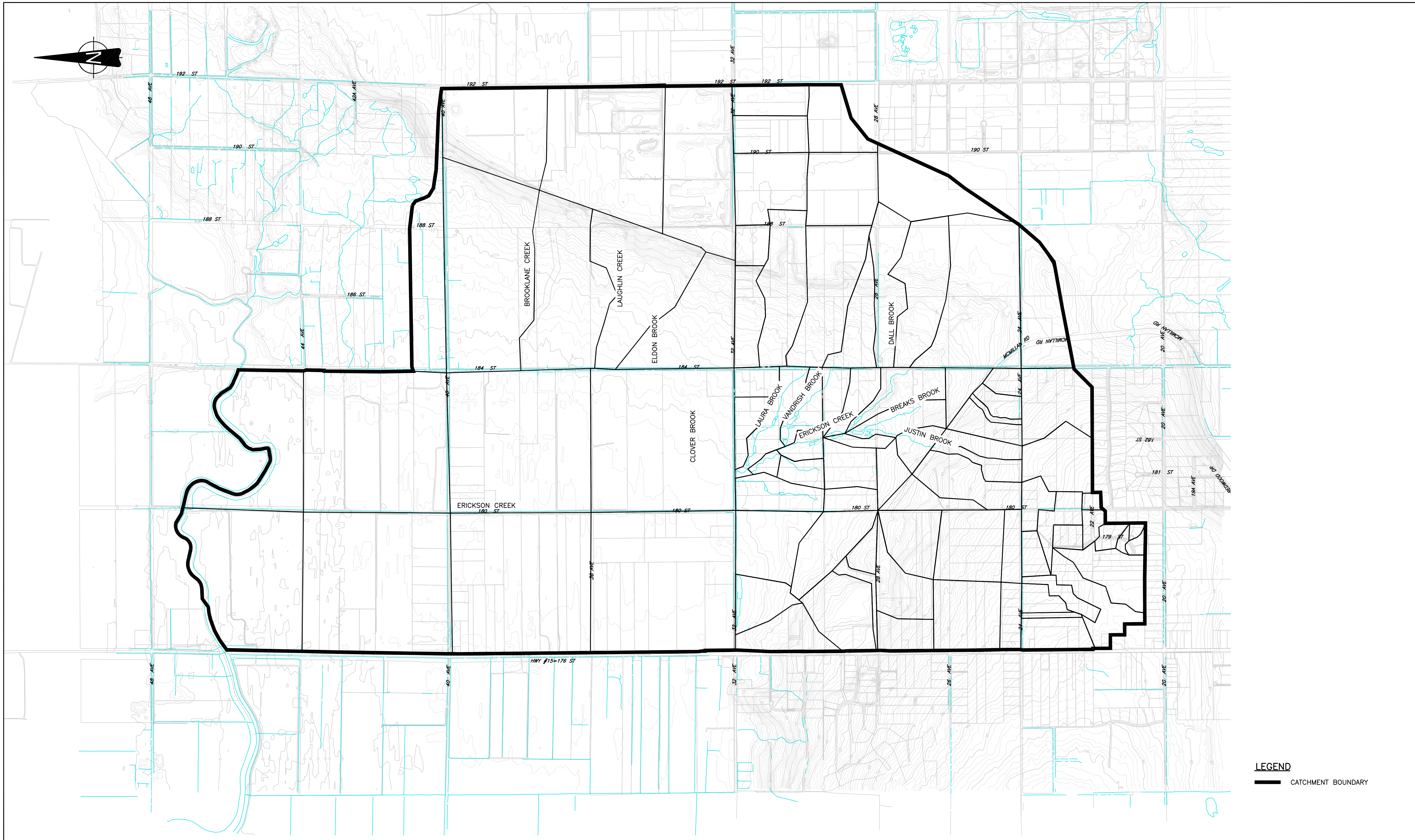
Upstream of 32nd Street, the creek and its tributaries have been described as containing fish habitat (Envirowest 1995, 2005), with reports of salmonids (coho salmon, cutthroat trout, rainbow trout) and other species in the creeks.

Agriculture practices in the lowlands place a high irrigation demand on this creek and low summer flows, with high water temperatures, are common as are bank erosion and instability, where pastures extend to the banks of the creek. Water levels in Erickson Creek are controlled at the outlet to the Nicomekl River by three floodgates and two Archimedes screw pumps in order to provide flood protection to the surrounding agricultural lands. Both the floodgates and the pumps allow fish passage without increasing the risk of fish mortality (Envirowest 1992).

Erickson Creek was not included in watershed health assessments conducted by the GVRD (1999), which provided predictions of change associated with population growth, although assessments were made for the Nicomekl River and several of its tributaries.

The total length of Erickson Creek and its major tributaries, estimated at 9.3 km based on GIS data provided by the City of Surrey, includes:

- 5.7 km for the Erickson Creek
- 0.8 km for Laura Brook
- 0.6 km for Vandrish Brook
- 0.6 km for Justin Brook
- 0.8 km for Dall Brook



Associated Engineering

REVISIONS	DESCRIPTION	BY	DATE	APPROVED
5				
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SURREY CITY OF PARKS

ENGINEERING DEPARTMENT

BENCH MARK – S.M. # ELEV.

TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN GENERAL WATERSHED PLAN

SEAL

SCALE: HOR. 1:10000 VERT. 1:10000	DATE JUNE 2006	PROJECT NUMBER 4806–705	
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Xrefs: 2802R101, 2802R103, 2802R104, 2802R102

F-87 PRODUCED BY CAD/CAM

3 Field Reconnaissance

3.1 AQUATIC HABITAT

3.1.1 Fish Species

Upstream of 32nd Street, Erickson Creek and its tributaries have been described as a significant feature for fish and fish habitat (Envirowest 1995). A number of ponds offer excellent rearing habitat for salmonids and habitat for wildlife, waterfowl and amphibians. Documented species of fish in the Erickson system are listed in Table 3-1 (Freshwater Fisheries Society of BC 2005). The cutthroat trout listed in Table 3-1 is likely coastal cutthroat trout (*O. clarkii clarkii*), a species of special conservation concern, i.e., blue-listed species provincially (BC CDC 2005).

Table 3-1
Fish Species Reported in Erickson Creek and Tributaries

Salmonid Species	Other Fish Species
coho salmon (*Oncorhynchus kisutch*)	brown catfish (*Ameiurus nebulosus*)
cutthroat trout (*O. clarkii*)	carp
rainbow trout (*O. mykiss*)	redside shiner (*Richardsonius balteatus*)
	sculpin (*Cottus sp.*)
	stickleback (*Gasterosteus sp.*)
	threespine stickleback (*Gasterosteus aculeatus*)
	western brook lamprey (*Lampetra richardsoni*)

Source: Freshwater Fisheries Society of BC (2005)

3.1.2 Surrey Stream Classification

In 1995, the City of Surrey developed a watercourse classification system that colour-coded the value of streams to fish (Table 3-2). Class A (red) indicates year-round presence of salmonid species, Class AO (dashed red) indicates fish presence mainly over winter, Class B (yellow) indicates non-fish bearing streams that contribute substantial amounts of food and nutrients to downstream waters and Class C (green) indicates no fish presence and no significant food and nutrient value (mainly ditches). Most tributaries and ditches in the Erickson drainage were designated Class A (City of Surrey 1995), as illustrated in Figure 3-1.

Figure 3-1 shows existing stream classifications for Erickson Creek and its tributaries, based on City mapping. These classifications were updated as a result of the 2006 fisheries habitat assessment, which recognized some inconsistencies in the previous classification map. For example, field assessments identified realigned drainage ditches on some properties, areas that did not provide spawning or rearing habitat, and reaches with ephemeral rather than year-round flow. Recommendations for consistency in classification of various tributaries and drainage ditches resulted in some ditches being upgraded from Class C to Class B or AO.

Table 3-2
City of Surrey Stream Classification System

Class[1]	Map Colour	Definition
A	Red	Inhabited by salmonids year round or potentially inhabited year round.
AO	Red dashed	Inhabited by salmonids primarily during the over-wintering period or potentially inhabited during the over-wintering period with access enhancement.
B	Yellow	Significant food/nutrient value. No fish present.
C	Green	Insignificant food/nutrient value. No fish present.

[1](source: City of Surrey) – 'The phrase "No fish present" for stream classifications B and C implies that fish presence is unknown. However, based on habitat characteristics such as stream gradient, access and proximity to known fish-bearing waters (and limited sampling results) in most cases it may be interpreted, as "No Fish are Present". The distinction must be made between fish-bearing and non-fish-bearing waters in order for the City to apply the appropriate mitigation and compensation procedure with respect to instream works for both "scheduled" and "emergency" project types.'

3.1.3 Stream Habitat Assessment Methods

A field level habitat assessment for Erickson Creeks was conducted from April 10 to April 12, 2006. Inventory methods generally followed those established by the Resource Inventory Standards Committee (RISC) in the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (v. 2.0; RIC April 2001). Much of Erickson Creek and its tributaries were walked from 32nd Avenue to its headwaters on the first two days of assessment. Difficulty in accessing certain properties, due to landowner restrictions, prevented the assessment of Laura Brook on the third day. As a result, remaining creek assessments were performed at road crossings. Tributaries east of 184th Street were surveyed in July and additional confirmatory surveys were conducted in October 2006.

Physical habitat data were recorded on appropriate RIC cards. The following habitat characteristics were assessed:

- Fish migration obstructions (culverts, falls, instream debris and structures).
- Fisheries sensitive zones (tributaries, side-channels, flood channels).
- Areas suitable for fish rearing, spawning and overwintering or that provide cover for species known or suspected to occur in a particular reach.
- Width (bankfull and wetted).
- Depth (bankfull, residual pool).
- Stream stage.
- Percentage cover (woody debris, boulder, cutbank, deep pool, over-stream vegetation and instream vegetation).
- Bank shape and texture.
- Turbidity.
- Substrate (dominant and sub-dominant bed materials).
- Channel morphology, channel pattern, islands, bars, coupling, and confinement.
- Disturbance indicators, flood signs, erosion, deposition of sediment from construction areas.
- Riparian vegetation community and crown closure.

Reaches were defined to encompass areas of consistent habitat characteristics, with reach breaks established at tributary confluences, significant changes in gradient and barriers to fish passage. Reaches are shown in Figure 3-2 and were named based on the watercourse names provided by the City of Surrey's COSMOS mapping system, and subsequent discussions with the City of Surrey to clarify naming anomalies on Erickson Creek and Breaks Brook.

3.1.4 Stream Habitat Features

Fish habitat features are summarized in Table 3-3 (following this section) and photographs are provided in Appendix A. The overall salmonid productive capacity is rated moderate, based primarily on good rearing habitat but with a lack of adequate spawning gravels and presence of migration barriers. The lack of deep pools and riffles in some areas also limits overwintering and rearing habitat.

3.1.5 Barriers to Fish Migration

Gradients in the upper reaches are less than 20%, not steep enough to create a velocity barrier to fish migration as defined in the Forest Practices Code (1998). Barriers to fish migration are summarized in Table 3-4 and shown on Figure 3-3. Barriers encountered include a berm, lake inlet and outlet structures, underground flow and a falls. Some of the barriers (BB-3, BB-4, EC-1) are passable during high flows. It will be useful to survey reaches upstream of barriers to determine if there are resident fish populations and to describe the completeness of the barrier.

Table 3-4
Barriers to Fish Migration

Reach	Barrier	Photo
EC-3	Wooden berm in creek; possible barrier if fish cannot pass around berm; may be passable at high flow	7
EC-4	Metal grate over culvert; additional culverts only accessible in high flows	10
VB-1	Pipe inlet of lower pond	25
VB-1	Pipe inlet of second pond	26
VB-1	Three outlets to third pond	27
VB-4	Falls an obstacle or barrier; resident fish reported in pond upstream	32
VB-5	Channel flows underground	-
EC-4	Wooden box culvert at outlet of lake (barrier at low flow)	11

3.1.6 Water Quality

Streams in urban, residential and agricultural areas often show evidence of periodic or chronic water quality problems, related to stormwater runoff and human activities in the watershed. Water quality is currently a concern in Erickson Creek, given the current land uses and, if unmitigated, may become more of an issue with increased development in the watershed.

Several parameters can provide evidence of degraded water quality due to human activities. These include physical parameters, bacteria, metals and nutrients. Metals, pesticides, nitrate, ammonia and phosphate can be transported to the stream via stormwater runoff, and reflect vehicle use and commercial, residential and agricultural practices. The presence of coliform bacteria can indicate contamination with fecal material (coliforms are a group of bacteria that live in soil, water and the intestinal tracts of cold- and warm-blooded animals, with fecal coliforms, including Escherichia coli, specific to warm-blooded animals, including humans).

Baseline water chemistry was assessed during the 2006 field investigations for the ISMP. Water samples were collected at two locations (upper and mid watershed) twice during the low flow period to reflect base flows and in situ characteristics were also assessed during the field reconnaissance. Information about coliforms and nutrients are useful in documenting effects of runoff from agricultural as well as residential areas.

In situ water quality data (temperature, dissolved oxygen, conductivity, pH and turbidity) were collected at select reaches during the April 2006 field reconnaissance. Results are shown in

Table 3-5. Temperature and pH were within the range expected for streams in the Lower Mainland. However, dissolved oxygen levels of 35% to 68% did not meet provincial guidelines and may reflect the low gradient of the streams or addition of organic matter in agricultural areas. The optimum dissolved oxygen guideline for salmonids is ≥ 90% and the minimum optimum concentration is ≥8 mg/L (Chilibeck et al. 1993). Turbidity was low (<10 NTU) at most sites, although higher levels were reported at the 32nd Avenue ditch (24.6 NTU). Conductance provides a cursory measure of concentrations of ionic strength of the water; it ranged from 89 to 238 µS and was highest at the 180th Street ditch where streams from the entire watershed had converged.

Table 3-5
***In Situ* Water Quality, April 10 to 12, 2006**

Reach	Temp (°C)	DO (%)	DO (mg/L)	Specific Conductance (µS)	pH	Salinity (ppt)	Turbidity (NTU)
32 Ave. Ditch	8.9	54	6.3	168	7.7	0.1	24.6
EC-1	9.8	58	6.7	200	7.5	0.1	12.7
EC-3	10.1	35	3.6	89	6.8	0.0	-
VB-1	11.4	57	6.0	160	7.4	0.1	4.8
VB-2	10.1	63	6.9	157	7.5	0.1	6.1
VB-3	10.5	57	6.4	111	7.5	0.1	6.8
VB-5	9.9	51	5.7	99	7.5	0.0	<5
EC-4	7.6	64	7.4	114	7.6	0.1	<5
JB-1	8.5	54	6.1	105	7.8	0.0	<5
EC-4	9.0	55	7.3	147	8.1	0.1	<5
EC-4	9.8	60	7.3	136	7.9	0.1	<5
EC-5	10.4	66	7.3	125	7.7	0.1	<5
180 St. Ditch	10.5	68	7.1	238	7.6	0.1	6.3

A more detailed water sampling program was conducted during June 2006 to provide information about metals, coliforms and nutrients at two locations in the watershed:

- Site E1 on Erickson Creek, in the lower watershed (the ditch along 180th Street, just downstream of 32nd Avenue, where benthic invertebrate samples were collected in April 2006); and
- Site E2 in the upper watershed on Vandrishe Brook, just upstream of 29A Avenue.

Samples were collected on June 28 and July 21, following at least five days of dry weather. Two travel blanks (one per trip) and one field duplicate sample were collected. Samples were preserved as required, kept in a cooler at 4°C and submitted to ALS Environmental Laboratory (Vancouver, BC) within 24 hours. Results for water chemistry were compared with Ministry of Environment (2006) water quality guidelines for protection of aquatic life and results for bacterial analyses were compared with guidelines for recreation / primary contact for microbiological parameters (coliforms), as these are the most protective guidelines.

Analytical results are presented in Appendix C, with the following trends noted:

- Higher temperature and conductivity at the upstream (E2) than the downstream site (E1).
- Low turbidity and total suspended solids levels at both sites on both dates.
- Elevated *E.coli* levels at both sites on both dates (800 to 1700 mean probable number per 100 mL), considerably higher than the provincial guideline of 77 mean probable number per 100 mL for primary contact recreation and for irrigation of ready-to-eat crops (note: the guideline is meant to be calculated for five samples over a 30 day period, rather than the two samples collected here).
- Notable levels of nitrogen, as ammonia (0.011 to 0.040 mg/L), nitrite (0.023 to 0.038 mg/L) and nitrate (3.40 to 4.37 mg/L) at both sites, with higher nitrate levels at E1 than E2.
- Notable levels of phosphorus (total phosphate of 0.0268 to 0.0839 mg/L, mainly in the dissolved form), with higher levels at E2 than E1; levels of ortho phosphate in unpolluted streams are approximately 0.01 mg/L and can increase to 0.05 to 0.1 mg/L in areas receiving additional inputs (Wetzel 2001).
- Metals levels within BC water quality guidelines, with the exception of iron, which ranged from 1.1 to 1.3 mg/L at site E1 (three to four times higher than provincial guideline).

Baseline surveys at the two Erickson Creek sites indicated elevated levels of coliforms, nutrients and iron during the low flow period of 2006 suggestive of poor water quality. Agricultural runoff is a likely source of the fecal coliforms, phosphate, nitrate and ammonia to the creek. The elevated nitrate and iron levels, particularly at E1 in the lower watershed, may also come from groundwater, which would be particularly noticeable during the low flow period. Times of low dissolved oxygen (April) and high temperature (summer) compared to guidelines for protection of salmonids also indicate periodic stresses on coho and trout in Erickson Creek.

Although elevated *E. coli* levels were reported in irrigation ditches, Erickson Creek and tributaries and addressed in the past (Payette 2006), results for 2006 suggest there may be ongoing compliance issues at some properties, notably with some hobby farms in upland reaches of the watershed. There may be an ongoing need for education and compliance monitoring on coliform and nutrient management.

If unmitigated, changes associated with increased residential and commercial development in the Erickson watershed could include higher levels of metals (associated with road runoff), nutrients (associated with fertilizer use in landscaping), and temperature (associated with loss of riparian habitat).

3.2 TERRESTRIAL HABITAT

This section describes wildlife and terrestrial habitat within the Erickson Creek watershed. Maintenance of wildlife corridors and protection of habitat for species of conservation concern (species listed under the federal Species at Risk Act, red or blue listed species) have been identified as important objectives of the ISMP. Characteristics, opportunities and constraints of the watershed are discussed.

There is limited literature concerning wildlife and terrestrial habitat conditions within the Erickson Creek watershed, although information about riparian habitat obtained in previous fish and fish habitat surveys provides some information about riparian areas. Professional knowledge of the natural landscape in the lower mainland, a review of information available from the BC Conservation Data Centre, City of Surrey (policies, Campbell Heights City Lands Servicing Study, aerial photographs), and results of site visits in April 2006 provide the basis for this section. The site visits were designed to document conditions in areas of interest and to locate rare or uncommon flora and fauna.

The City of Surrey provides direction for land development through various policies, plans and bylaws. The Department of Parks, Recreation and Culture has developed a Natural Areas Management Plan, which covers approximately 60% of the existing parkland in the City. The plan is based on the principles of sustainability, access and communication among stakeholders and balances environmental protection with recreational access and safety issues. It addresses vegetation, fauna, access and recreation, tree hazard, fire, coarse woody debris and yard waste and refuse management. Vegetation and pest problems on city-owned lands are managed through an Integrated Pest Management Policy.

3.2.1 Erickson Creek Watershed

The Erickson watershed is located primarily within the Coastal Western Hemlock Zone (CWH xm1) biogeoclimatic zone with the southernmost portion of the watershed in the Coastal Douglas-fir (CDF mm) biogeoclimatic zone.

The CWH xm1 zone is characterized by warm, dry summers and moist, mild winters with relatively little snowfall. This zone is the wettest zone in BC and extends over the majority of Vancouver Island, the Queen Charlotte Islands and the Coast Mountains from the Alaskan Panhandle south to the Lower Mainland, at elevations between sea level and approximately 700 m. This zone extends up the south side of the Fraser River to Chilliwack (Green and Klinka 1994). Natural forests within the CWH xm1 sites are dominated by Douglas fir (*Pseudotsuga menziesii*), accompanied by western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Major understory species include salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*) and red huckleberry (*Vaccinium parvifolium*) (Green and Klinka 1994).

The CDF mm zone is found only at low elevations (<150 m) on southeast Vancouver Island, the Gulf Islands south of Cortes Island, the Sunshine Coast and the extreme southeastern tip of the mainland. It is characterized by warm, dry summers and mild, wet winters with very long growing seasons and water deficits at zonal and drier sites. It is considered to have the mildest climate in Canada (Green and Klinka 1994). Natural forests are dominated by Douglas-fir, accompanied by grand fir (*Abies grandis*) and western red cedar. Dominant understory species include salal, dull Oregon-grape and oceanspray (*Holodiscus discolor*).

The Erickson watershed has been developed with a mix of highly agricultural areas (in the lowlands and along the northern slope), wood lots and low density residential land use, with industrial areas being developed along the eastern fringe. Vegetation in undeveloped areas consists of early seral stages of deciduous and coniferous woodland and old-field habitats, with tree species such as western red cedar and red alder, and lesser amounts of Douglas-fir, grand fir, paper birch (*Betula papyrifera*) and black cottonwood (*Populus trichocarpa*) present. Predominant understory shrubs are Himalayan blackberry (*Rubus discolor*), salmonberry (*Rubus spectabilis*), Indian-plum (*Oemleria cerasiformis*), red elderberry (*Sambucus racemosa*), vine maple (*Acer circinatum*) and sitka mountain-ash (*sorbus sitchensis*).

Wildlife using the watershed are likely to include small mammals (e.g., mice and voles), skunks, racoons, red fox, coyotes and a wide range of birds. Anticipated uses by existing natural habitat include nesting by songbirds and hunting, foraging, shelter and migratory stopovers by other animals. Given that much of the watershed has been altered, many remaining patches of natural habitat are small and fragmented. This limits the watershed’s ability to support mammals with large home ranges, such as black-tailed deer, and supports the presence of tolerant species such as raccoon and coyote. Existing patches do provide habitat for smaller mammals, such as voles, shrews, rodents and songbirds, although the small areas lead to a high proportion of edge habitat, which is typically inhabited by nest predators (e.g., crows and jays) or opportunistic species (e.g., starlings), further limiting the suitability of the area to native, more desirable songbird species (Paton 1994, Flaspohler 2001, Deng and Gao 2005).

Habitat assessments were conducted in May 2006 at locations indicated on Figure 3-4. Riparian habitat along many areas of Erickson Creek provides the main migration corridors within the watershed. Parks also provide larger areas of undeveloped habitat for wildlife. Maintaining these linkages will be important considerations for land use planning, and provide the basis for recommendations made in Section 3.2.3 regarding opportunities for the watershed as a whole.

3.2.2 Species of Conservation Concern

Provincial and federal legislation provides for protection of plant and animal species, or their habitat, which are of conservation concern. These species are listed by the BC Conservation Data Centre (BCCDC) as either blue-listed (ecological communities, and indigenous species and subspecies of special concern in British Columbia) or red-listed (ecological communities, and indigenous species and subspecies that are extirpated, endangered or threatened in British Columbia). There is also a yellow list, which includes all remaining wildlife species. Although these species are not considered at risk, the BCCDC maintains a watch list of yellow-listed taxa that have a small range or low abundance in the province, have shown provincial declines, or are susceptible to perceived long-term threats. To track the status of species at risk, the BCCDC maintains a database of rare vertebrates for each Forest District in British Columbia.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is the federal equivalent of the BCCDC. COSEWIC is a committee of experts that assesses and designates wild species that are in some danger of disappearing from Canada. COSEWIC ratings for species are defined as follows:

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.
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.

A COSEWIC designation of Extirpated, Endangered, Threatened or Special Concern makes a species potentially eligible for listing on Schedule 1 of the Species at Risk Act (SARA). The SARA provides special protection for Extirpated, Endangered and Threatened species and their critical habitats, and it mandates the development of management plans for species of Special Concern. When SARA received royal assent in December 2002, Schedule 1 contained 233 plant and animal species. This list grows larger every year.

Changes to the British Columbia Wildlife Act were passed in 2004 (the Wildlife Amendment Act, 2004). Changes include greater protection for species at risk, and will be brought into force through regulation. Changes that may affect land development include prohibitions respecting species at risk and specific legislation stating that no compensation is to be paid for reduced land values or damages/losses resulting from the new legislation, including :

"6.1 (1) A person must not do any of the following:

a) kill, harm, harass, capture or take a species individual of a species at risk, except as authorized by regulation or by a permit or agreement under this section;

(b) damage or destroy a species residence of a species at risk, except as authorized by regulation or by a permit or agreement under this section;"

Under the amendments, "species residence" is defined as:

"a place or area in, or a natural feature of, the habitat of the species at risk, or a class of such a place, area or natural feature that is habitually occupied or used as a dwelling place by one or more species individuals of the species at risk".

In effect, lands occupied by rare, threatened or endangered species on a regular basis will be protected from development under these provisions.

The BCCDC has sixteen records for blue-listed or red-listed species (four animal and twelve plant species) within approximately 5 km of the Erickson watershed, registered over the past 100 years:

- 1992 record of two blue-listed Trowbridge's Shrews (*Sorex trowbridgii*) along Fergus Creek.
- 1992 record of a red-listed Pacific Water Shrew along Fergus Creek.
- 1984 report of a blue-listed American Bittern (*Botaurus lentiginosus*) observed in Campbell Valley Regional Park.
- 1969 poorly documented report of a red-listed mountain beaver (*Aplodontia rufa rufa*) in Langley.
- 1996 record of blue-listed western mannagrass (*Glyceria occidentalis*) in Campbell Valley Regional Park.
- 1990 observation of blue-listed false-pimpernel (*Lindernia dubia var. anagallidea*) on the shore of Latimer Lake.
- 1990 observation of blue-listed large Canadian St. John's-wort (*Hypericum majus*) in an old gravel pit near Latimer Pond.
- 1989 observation of blue-listed field dodder (*Cuscuta pentagona*) at the mouth of the Little Campbell River.
- 1978 record of false-pimpernel in a gravel pit in Langley at the end of 197A Street.
- 1975 record of blue-listed California-tea (*Rupertia physodes*) in Brookswood at 196th Street and 32^{nd} Avenue.
- 1972 record of blue-listed water-pepper (*Polygonum hydropiperoides*) in Hazelmere.
- 1955 record of Henderson's checker-mallow (*Sidalcea hendersonii*) in Grandview, 3 km north of the US border on Pacific Highway.
- 1954 poorly documented report of blue-listed western St. John's-wort (*Hypericum scouleri ssp. nortoniae*).
- 1954 poorly documented report of blue-listed mountain sneezeweed (*Helenium autumnale var. grandiflorum*) in a roadside ditch in Langley.

- 1906 poorly documented record of western pearlwort (*Sagina decumbens ssp. occidentalis*) in Douglas.

Recent environmental assessments for the Grandview Heights Plan Area (which includes part of the Erickson watershed) indicate the occurrence or potential occurrence of habitat suitable for eight species of conservation concern (provincially or federally-listed wildlife species), including red-legged frog, western toad, Great Blue Heron, Western Screech Owl, Barn Owl, Band-tailed Pigeon, Pacific water shrew and Trowbridge's shrew. A summary of the wildlife species of conservation concern that may occur in parts of the Erickson watershed, and their preferred habitat, is described in Table 3-6.

Table 3-6
Potential Wildlife Species of Conservation Concern in the Erickson Watershed

Species	Preferred Habitat	Potential locations in Erickson Watershed
red-legged frog (*Rana aurora*) Special Concern (COSEWIC 2006) Blue-listed (BC CDC 2006)	Occurs in southwestern BC in moist forests and treed wetlands. Adults can be found on land at a distance from water if weather is damp and logs or other debris are available for shelter. Breed in ponds or slow moving streams during late winter or early spring. In winter, aestivate in small burrows in moist vegetation and leaf litter close to the water.	Riparian forested areas in the watershed
western toad (*Bufo boreas*) Special Concern (COSEWIC 2006)	Occurs in BC from sea level to 3660 m. Breeds in a variety of natural and artificial aquatic habitats, with or without tree or shrub canopy cover, coarse woody debris, or emergent vegetation. During non-breeding season, occupies forest, wet shrublands, avalanche slopes and subalpine meadows; appears to favour dense shrub cover, to protect from desiccation and predation (COSEWIC 2002a).	Riparian areas for breeding, and forested areas during the fall and winter

Species	Preferred Habitat	Potential locations in Erickson Watershed
Pacific water shrew (*Sorex bendirii*) Threatened (COSEWIC 2006); Red-listed (BC CDC 2006)	Limited to lowland riparian forests and marshes (usually below 600 m) and prefers habitat containing a moderate amount of ferns, mosses and rocks, a low amount of grass and exposed soil and a high percentage of fine litter (Environment Canada 2006). Heavily dependant on freshwater organisms for food (RIC 1998), most individuals have been caught within 25 m of a stream.	Well vegetated riparian areas throughout the watershed, creeks must provide a source of benthic invertebrates
Trowbridge's shrew (*Sorex trowbridgii*) Blue-listed (BC CDC 2006)	Occurs in the Lower Mainland to Boston Bar. The most abundant shrew in the lower Fraser Valley (Cannings *et al.* 1999), found in coastal stands to 1820 m, prefers habitat with dry loose leaf litter or swampy woods, feeds on insects, worms, centipedes and vegetation.	Forested areas in the watershed
Great Blue Heron (*Ardea herodias fannini*) Special Concern (COSEWIC 2006) Blue-listed (BC CDC 2006)	The fannini subspecies of the Great Blue Heron occurs along the Pacific coast. Breeds in forested locations close to wetland feeding areas. Forages in freshwater and saltwater environments, feeds on insects, fishes, crustaceans, amphibians, reptiles and mammals (Gebauer and Moul 2001).	Riparian areas throughout the watershed
American Bittern (*Botaurus lentiginosus*) Blue-listed (BC CDC 2006)	Breeds in wet areas with dense growths of tall emergent vegetation or tall grasses adjacent to freshwater sloughs, marshes, swamps, protected sections of lakes. Forages in marshes, sloughs, lake edges, swamps, river banks, sewage ponds and fields, feeds on insects, fish, crustaceans, amphibians, snakes and small mammals (Fraser *et al.* 1999).	Riparian areas throughout the watershed
Band-tailed Pigeon (*Columba fasciata*) Blue-listed (BC CDC 2006)	In coastal BC, from sea level to 1,830 m elevation. Frequents a wide range of habitats, including railway yards, rail lines, farmland, coniferous and deciduous forests, residential areas, mineral springs and intertidal flats and golf courses (Campbell *et al.* 1990).	Anywhere in the watershed

Species	Preferred Habitat	Potential locations in Erickson Watershed
Barn Owl (*Tyto alba*) Special Concern (COSEWIC 2006) Blue-listed (BC CDC 2006)	Nests in agricultural areas, occasionally along the edges of open woodlands and in urban areas. Most nests are built in man-made structures. Winter habitat is primarily agricultural areas and may include grasslands and river bottom meadows where they feed almost entirely on small mammals.	In agricultural areas of the watershed
Western-screech Owl (*Megascops kennicottii kennicottii*) Special Concern (COSEWIC 2006) Blue-listed (BC CDC 2006)	Occurs along the coast of BC at lower elevations generally in wooded environments, often in riparian zones. Also found in treed urban and suburban environments, and at the edge of forested habitats close to open wetlands or fields (COSEWIC 2002b).	Riparian and forested upland areas, though not likely present in the watershed

There is potential for some of the species listed in Table 3-7 to be present in agricultural areas and for Trowbridge's shrew, Band-tailed Pigeon and Western-Screech Owl to be present in the upland residential areas.

3.2.3 Field Assessments

Wildlife habitat within agricultural and low density residential lands was assessed during visits to 18 locations in April 2006. Sites were selected to reflect the variety of land uses and habitat types present. Sites are shown in Figure 3-4 and plant species observed at each site are listed in Table 3-13, at the end of this section.

3.2.3.1 Agricultural Lands

The majority of the watershed is used for agricultural purposes, which has resulted in removal of the majority of the natural vegetation in this area. However, some relatively large areas of forest remain, mostly within the riparian zone of Erickson Creek and its tributaries, and in McKeery Park and a large woodlot on provincially owned land in the northeast corner of the watershed. An example of forested habitat in the agricultural area is shown in Photo 1. During the April 2006 site visit, American robin (*Turdus migratorius*), winter wren (*Troglodytes troglodytes*), white-crowned sparrow (*Zonotrichia leucophrys*), an unidentified hummingbird, black-capped chickadee (*Poecile atricapilla*), pileated woodpecker (*Dryocopus pileatus*) and bald eagle (*Haliaeetus leucocephalus*) were observed. Mammals identified within this area include gray squirrel (*Sciurus carolinensis*) and black-tailed deer (*Odocoileus hemionus*).

There is suitable habitat for and potential for the presence of most species of conservation concern listed in Table 3-6 to be found within the agricultural lands.

Photo 1
Representative Deciduous Forest Found Within the Agricultural Lands

3.2.3.2 Residential Lands

The southwest portion of the watershed contains low density residential development. A significant amount of natural vegetation has been removed; however, some smaller areas of forested habitat remain. This forest provides suitable habitat for song birds and small mammals, although, due to its isolation, likely does not provide habitat for mammals with large home ranges, such as deer. More tolerant mammals, such as raccoon and coyote, may be present. Wildlife species observed within this area during the April 2006 survey include red-breasted nuthatch (*Sitta canadensis*), winter wren, black-capped chickadee and white-crowned sparrow. Typical habitat is shown in Photo 2.

There is the potential for Trowbridge's shrew, Band-tailed Pigeon and Western Screech Owl, species of conservation concern listed in Table 3-6 to be found within residential areas.

Photo 2
Representative Mixed Forest Found Within the Residential Lands

3.2.3.3 Industrial Lands

All land within the Erickson watershed that is zoned for industrial use is completely developed, with no remaining natural vegetation, so no wildlife habitat assessments were conducted within the area. Band-tailed pigeon is the only species of conservation concern that may use habitat within the industrial areas.

General Habitat and Migration Corridor Considerations
Wildlife corridors connecting habitat fragments play an important role in maintaining wildlife populations because they facilitate local and regional wildlife movement. In a fragmented

landscape, as occurs in the Erickson Creek Watershed and surrounding area, corridors are especially important to ensure that various wildlife species can move between seasonally important breeding, over-wintering and other habitats (Beier, 1998) and to maintain genetic population viability (Saxena et al. 1997). Many species indigenous to the Coastal Western Hemlock biogeoclimatic zone require connectivity between suitable habitat patches within their ranges. The Erickson Creek Watershed exists in a matrix of mainly agricultural land use, low density residential areas, and some natural habitat, connected mainly through riparian habitat and woodlots. As a result, wildlife using the area have adapted to using creeks and ravines, woodlots, edges, and cultivated fields for travelling.

Five potential wildlife movement corridors were identified within the Erickson Watershed (Figure 3-4), including three riparian areas in conjunction with woodlots, deactivated roads, and low residential development, one large area of intact forest, and agricultural lands. These corridors will support wildlife movement to varying levels of success, depending on their connectivity to other natural areas, their size and width, and the level of disturbance in and around the corridor. If these corridors are adequately protected or enhanced, wildlife within the Erikson watershed can continue to use them successfully.

The potential wildlife movement corridors within the Erickson Creek Watershed and surrounding area include:

- Corridor 1, which facilitates north-south movement through Breaks and Justin Creek, in conjunction with an overgrown abandoned rail line and agricultural fields, eventually meeting up with Twin Creeks and the Little Campbell River.

- Corridor 2, which follows Erickson Creek, facilitating north-south movement for wildlife and connecting to a large forested area in the southeast portion of the watershed and Twin Creeks, and eventually connecting with Little Campbell River.

- Corridor 3, which facilitates east-west movement, following Vandrishe or Laura Creeks, which both pass through some small residential areas and the edge of Keery Park, before connecting to the same large wooded area located in the southeast of the watershed.

- Corridor 4, which consists of a relatively large area of intact forested habitat in the northeast portion of the watershed, facilitating north-south movement for wildlife. It links with several other creeks including Ross and Armstrong Creek in the northern section of the watershed, eventually leading toward the Nicomekl River.

- Corridor 5, which consists of agricultural lands throughout the northern portion of the watershed, which provide both east-west and north-south movement for wildlife, through mostly unforested habitat but also along windrows, roads, fences, and ditches.

The five wildlife corridors were evaluated qualitatively, based on a number of criteria to access their ecological function within an urban setting, and each criterion was ranked high, moderate or low (Table 3-7).

Table 3-7
Habitat Evaluations for Identified Potential Wildlife Corridors Within the Erickson Creek Watershed

Criterion	Corridor 1 (Breaks and Justin Creek)	Corridor 2 (Erickson Creek)	Corridor 3 (Vandrishe and Laura Brooks)	Corridor 4 (Large Intact Forest)	Corridor 5 (Agricultural Lands)
Connectivity – Linkages to other urban natural areas such as woodlots, watercourse corridors and wetlands provide corridors for movement and assist in maintaining the health of natural communities including diversity; also considers restoration potential and opportunities for site and feature renewal and enhancement.	Moderate	High	High	High	Moderate
Regeneration - The extent of natural regeneration of canopy trees is indicative of a healthy, self-sustaining urban natural area.	Moderate	High	High	High	Low
Disturbance - Physical disturbance within habitats significantly reduces native biodiversity and the quality of ecological functions and ecological integrity within natural habitats.	Moderate	Low	Low	Low	High
Size and Shape - The area of the urban natural area (natural feature such as a patch of forest or a wetland within an urban environment) often affects the diversity and value of the ecological functions that the urban natural area can support. The shape of the urban natural area is also considered in this factor, as shape determines the extent of wooded edge relative to potential interior.	Low	Moderate	Moderate	High	High

Criterion	Corridor 1 (Breaks and Justin Creek)	Corridor 2 (Erickson Creek)	Corridor 3 (Vandrishe and Laura Brooks)	Corridor 4 (Large Intact Forest)	Corridor 5 (Agricultural Lands)
Habitat Maturity - Although optimal conditions include a good distribution and mixture of habitats at various ages, more mature habitats are generally less common, less disturbed and contain a greater number of more valuable functions.	Moderate	Moderate	Moderate	High	Low
Natural Communities - A greater number of natural community types should result in more diverse and ecologically important natural heritage functions.	Moderate	High	High	High	Low
Representative Flora - Species that have a lower tolerance to disturbances are generally good indicators of areas with fewer disturbances, greater biodiversity and more ecological functions.	Moderate	High	High	High	Low
Significant Flora and Fauna - Ecologically important species are generally found in less disturbed urban natural areas or areas with greater rehabilitation potential. These species are excellent indicators of a high level of naturalness and natural diversity.	Moderate	High	High	High	Low
Wildlife Habitat - Areas supporting exceptional numbers of particular wildlife species constitute rare natural features within urban landscapes and provide an important ecological contribution.	Moderate	High	High	High	Mod

3.2.4 Common Watershed Opportunities

The following recommendations are ways in which the City may continue to protect and enhance riparian, stream and forest habitat in the watershed, maintain biodiversity and protect or restore habitat reservoirs, patches and corridors:

- Establish a park and natural area network within the context of existing planning documentation.
- Establish fenced covenants to protect riparian habitat (30 m from the top-of-bank or high water mark), with backyard landscaping not extending into the covenanted areas.

- Ensure that land use zoning reflects natural area covenants.
- Conserve or restore native riparian habitat by removing exotic species and replanting with native species, where possible.
- Encourage landscaping with native plants in high density and low density residential areas.
- Retain natural features in the remaining larger tracts of undeveloped land in the watershed.
- Encourage owners of agricultural areas to retain existing wildlife habitat on their land.

3.2.5 Common Watershed Constraints

The major constraint to environmental enhancement opportunities is that many areas are on private property, so landowner cooperation will be required for access to and enhancement of suitable areas. Because most of the land is privately held, establishment of natural covenants or parks would require significant land purchases by the City of Surrey or private land donations for green space preservation. As discussed in Section 3.2.1, the small size of natural habitat patches is a limiting factor for mammals with large home ranges.

The provincial Draft Environmental Management Practices for Urban and Rural Land Development (Polster and Cullington 2004) should be consulted prior to development to ensure that relevant best management practices (BMPs) are incorporated. There are BMPs for protection of habitat for several species, including nesting raptors, Pacific water shrew, amphibians and reptiles, which should be applied to development applications within the Erickson watershed. A buffer of undisturbed natural vegetation for a distance of 1.5 tree lengths should be established around raptor nest sites (Demarchi and Bentley 2005). The draft BMP for Pacific water shrew (Craig and Vennesland 2005) should be consulted with respect to riparian protection.

For indigenous amphibians and reptile conservation (including red-legged frogs, which could occur around ponds and slow flowing streams), the provincial BMPs (Ovaska et al. 1994) recommend the following:

- Locate developments and roads away from key habitats for amphibians and reptiles.
- Maintain buffers of undisturbed native vegetation around and adjacent to key amphibian and reptile habitats.
- Provide suitable landscape linkages to allow movements of animals between important seasonal habitats.
- Minimize road kill of animals migrating between seasonal habitats by locating roads and infrastructure away from these areas or consider special road-crossing structures where this is unavoidable.
- Control the spread of non-native animals and plants.
- Encourage residents to take an interest in protecting these species.

The riparian setbacks described in Section 3.4.5 for protection of fish habitat also protect habitat for many of the listed species in Table 3-6.

3.3 HYDROGEOLOGY

The hydrogeology assessment is described in Appendix B. The report describes soils underlying the watershed, aquifers, precipitation, recharge areas, and potential for infiltration of stormwater. A follow-up assessment of infiltration potential at specific locations in the Erickson watershed is also contained in Appendix B.

Soils in the Erickson watershed are typically low in permeability, although the upland areas have more permeable soils than the lowland areas. Geology in the upper reaches of Erickson Creek is reported to consist of a raised proglacial sand and gravel deposit, while the mid-reaches consist of a thin (1 to 5 m) raised beach deposit of fine to medium-grained sands and lowland soils are comprised of peat underlain by fine grained and low permeability and oftentimes saturated, clay deposits. Sand and gravel underlying the Campbell Heights area provide higher permeability. An unconfined aquifer under the Campbell Heights area, extending into Langley, provides base flow for many streams along the plateau, including Erickson Creek.

Based on the results of the hydrogeological assessment, opportunities for infiltration of stormwater on a mid- to large-scale are expected to be limited to the mid- and upland areas in the southeast and eastern portions of the Erickson Creek watershed. This conclusion is based on the expected moderate to high hydraulic conductivity and significant depth to groundwater from current grades in materials underlying these areas. The geologic materials underlying the lowland and plain regions of the catchment are expected to have significantly lower hydraulic conductivities and shallow water tables (1 to 2 m below grade) thus limiting storage capacity through most of the year. Heavy precipitation through the fall, winter and early spring season are expected to maintain moisture contents in the shallow soils, specifically of the topographically low areas, near saturation for the majority of the year. This leaves little buffer for the accommodation of stormwater recharge in these areas.

Site assessments of infiltration capacity were made at two locations in the Campbell Heights area (188 Street and 28 Avenue at Kerry Park and 192 Street and 36 Avenue at a commercial aggregate supply operation). Test pits were dug and percolation tests conducted using standard methods. Results, described in Appendix B, confirm the desktop survey and previous studies, with a hydraulic conductivity greater than 10^{-4} m/s. Thus, the hydrogeologic conditions in the mid and upland sections of Campbell Heights are considered suitable for infiltration of stormwater on a mid- to large scale.

3.4 WATERSHED HEALTH

The GVRD ISMP template provides guidance on preparing watershed health assessments using two physical characteristics: total impervious area and percent riparian integrity (Kerr Wood Leidal 2002, 2005). Watershed health ratings are then calculated and compared to biological assessments obtained from measurements of benthic invertebrate communities (EVS 2003).

The riparian integrity assessment describes the proportion of riparian corridor (habitat within 30 m of each bank of the stream, a total of 60 m) that contains natural forest habitat. Natural forest vegetation within this corridor provides many ecological benefits to stream and watershed health, including shade, nutrients, bank stability, stable soils that promote infiltration and purification of water, and habitat for many species of birds and wildlife. Restrictions on developing property within this riparian corridor are regulated through the provincial Fish Protection Act (Riparian Area Regulations) and/or municipal bylaws and BMPs.

Total impervious area (TIA) provides an estimate of the paved and hard surface areas in the watershed. Impervious areas (e.g. roads, buildings, parking areas, patios, etc.) restrict the amount of land available for natural infiltration of precipitation. Increases in impervious area result in changes to stream hydrology (higher high flows, lower base flows), which have been correlated to reduced ability of streams to support salmonids and other species. The TIA calculation is based on the assumption that paved and hard surface areas do not provide any infiltration. Current practice is to use effective impervious area (EIA), the impervious area that produces surface runoff that enters a watercourse or storm drain, and accounts for the use of BMPs to reduce the volume of stormwater runoff. EIA and TIA are likely to be similar in the Erickson watershed under current conditions.

This section discusses the watershed health assessment conducted in 2006.

3.4.1 Riparian Corridor Assessment

The riparian assessment corridor is a 30 m buffer on either side of the stream (total width of 60 m). The riparian corridors for Erickson Creek and its tributaries were delineated in Arc GIS, based on available TRIM data and orthophotos taken in 2005. Buffers were measured from the stream centreline, given that top-of-bank data are not available. In creeks where top-of-bank data are available, the riparian corridor width would be 60 m plus the bankfull width.

The Erickson Creek riparian corridor extends from its confluence with the Nickomekl River upstream through agricultural ditches to headwaters north of 32nd Avenue and also extends along all tributaries, a distance of approximately 12 km. The watershed contains a mix of agricultural and rural residential land uses, with areas of intact forest vegetation. Figure 3-5 shows the extent of the riparian corridor used for the assessment.

Riparian forest integrity (RFI) is one of two key factors the GVRD ISMP template uses to characterize watershed health. RFI is calculated as the proportion of intact forest cover within the entire riparian corridor and includes culverted and other developed areas (assessed as 0% forest cover), and drainage ditches in agricultural areas (Kerr Wood Leidal 2002).

A desktop assessment of RFI was performed using AutoCAD and 2005 orthophotos to identify current watershed conditions. RFI was calculated for the watershed as a whole and for the lowland and upland areas (using 32nd Avenue to distinguish the areas). The total intact riparian area is

610,000 m^2 and the total riparian assessment area is 3,100,000 m^2, resulting in an RFI of 20%. As indicated in Table 3-8, riparian integrity is considerably lower in agricultural areas (3.4%) than in upland areas (41%); however, the value of 41% is used for this assessment, given that the ISMP deals with development in the uplands. Figure 3-5 illustrates that several tributaries have lost significant amounts of riparian habitat, mainly around Class B streams but also around some Class A and AO streams.

Table 3-8
Riparian Forest Integrity and Total Impervious Area Calculations for Erickson Creek and its Tributaries

Watershed Zone	% RFI	Estimated % TIA / EIA
Uplands (upstream of 32nd Avenue)	41%	5% to 10% (estimate) for whole watershed
Lowlands (downstream of 32nd Avenue)	3.4%	
Whole Watershed	20%	

3.4.2 Total Impervious Area Assessment

Total impervious area (TIA) is the second of two key watershed health indicators identified by the ISMP template (Kerr Wood Leidal 2002, 2005), and provides an estimate of the paved area in the watershed. With mitigation measures in place or planned, it is more appropriate to assess EIA, the impervious area directly connected to a storm drain than TIA. However, as noted above, EIA and TIA are likely to be similar in the Erickson watershed under current conditions.

The preliminary estimate of TIA for the watershed as a whole is 5% to 10% TIA, based on typical impervious cover associated with agricultural and low density residential land uses (Table 3-8). Although TIA values were not calculated separately for upland and lowland areas, upland areas will be at the upper end of the range and lowland areas will be at the lower end. At this stage of development in the watershed, the total and effective impervious areas are likely to be similar. The estimate will need to be confirmed by flow monitoring and model calibration. Impervious cover is up to 20% in conventional residential areas around 24th Avenue, which comprises a small proportion of the watershed.

3.4.3 Watershed Health Assessment

The preliminary watershed health assessment was prepared using TIA and RFI, and following the Watershed Health Tracking System described in the revised ISMP template (Kerr Wood Leidal 2005). TIA (or EIA) and RFI are considered key physical performance measures that correlate strongly with watershed health. Values shown in Table 3-8 for existing conditions were overlain on the template chart (Figure 3-8). For watershed health tracking purposes, the more conservative value of 10% TIA was used.

The upland area of the Erickson Creek watershed, the main focus of this ISMP, is considered to have moderate watershed health, based on 10% TIA and 41% RFI under current conditions. These values would be expected to move toward poorer health as TIA increases with future development, unless mitigated. Development of land within the 30 m riparian assessment corridor, while potentially compliant with the City of Surrey's riparian setback regulations, would reduce the %RFI and contribute to a decline in watershed health.

3.4.4 Benthic Invertebrate Communities

Results of benthic invertebrate community monitoring are used to augment preliminary watershed health assessments, as recommended by the ISMP template (Kerr Wood Leidal 2002) and GVRD Benthic Invertebrate Index of Biotic Integrity (B IBI) guide (EVS 2003). Benthic surveys provide a biologically based performance measure of the effectiveness of watershed planning and implementation processes because these organism, which inhabit the cobble and gravel substrates of the stream, experience the ambient conditions and stressors of the watershed (e.g., changes in flow regime and instream habitat, sediment and toxic substances that enter through storm drains and other runoff).

The B-IBI assessment incorporates environmental and community characteristics (taxon richness and composition, pollution tolerance vs. sensitivity, feeding ecology, population structure) and index scores have been shown to correlate with TIA and RFI (Kerr Wood Leidal 2005). Values range from 10 (very poor) to 50 (excellent), although a maximum of 40 has been observed for pristine streams within Metro Vancouver (Kerr Wood Leidal 2005). The stream condition rating system used in Metro Vancouver is described in Table 3-9.

Table 3-9
Stream Condition Ratings Based on B-IBI Scores (EVS 2003)

10-metric B-IBI Score	Stream Condition Rating
46 to 50	Excellent
38 to 44	Good
28 to 36	Fair
18 to 26	Poor
10 to 16	Very Poor

A benthic invertebrate survey of Erickson Creek was made in April 2006 at one site immediately downstream of 32nd Avenue along the 180th Street ditch (Dillon 2006). Samples were collected using the East Clayton Monitoring Program Protocol. This protocol differs from the GVRD protocol (EVS 2003) in the collection of one rather than four samples in each riffle area, given that Surrey streams often have smaller or fewer riffle areas than do other streams in the GVRD. Also, samples are collected during spring because many Surrey streams have low flow during late summer. A Surber sampler with 250 µm mesh was used at each site to collect samples from three riffle areas, with samples preserved and identified by a taxonomic laboratory. Substrate in this area was mainly clay (hardpan) with a thin veneer of clay peds (coarse gravel size), sand and fine gravel (Dillon 2006), rather than the gravel and cobble substrate preferred for benthic sampling and used to develop the B-IBI ratings.

Results of the benthic survey indicated B-IBI scores ranging from 10 to 20, with a mean B-IBI score of 14 for the three replicates and a pooled score of 20 (all replicates considered together). These results place Erickson Creek in the “poor” to “very poor” classification used by Metro Vancouver (EVS 2003), and are similar to results obtained for other Surrey streams, including Latimer, Hyland, North, Fergus, Delta, Cougar and McLellan Creek and Burrows Ditch, all of which had mean B-IBI scores less than 20 in the 2006 surveys (Dillon 2006).

The low scores were attributable mainly to the substrate type, given that the B-IBI approach was developed for typical riffle habitat with cobble-gravel substrate. In addition, results may be influenced by the timing of sampling in relation to emergence of the pollution intolerant insects (Environment Canada 2002 and 2006, EVS 2003). Individual metrics of the score were consistent with substrate characteristics, with a lack of pollution intolerant species such as mayflies, stoneflies, caddisflies and the predominance of pollution tolerant organisms (chironomid larvae, aquatic worms). Pollution intolerant benthic invertebrate species are sensitive to siltation, excess nutrients and toxic compounds, as are salmonids (Dillon 2006), and are not common in sand and clay substrate. Aquatic worms and chironomids are common inhabitants of sandy and silty substrates, and would be expected to predominate in such areas. Although testing of Erickson Creek water indicates the presence of elevated nutrients and coliforms, the lack of suitable substrate is probably the over-riding determinant of benthic community composition. Observations made during the fish habitat survey also indicated that many upland areas of the stream also do not contain gravel – cobble substrate.

The B-IBI score can also be calculated using a linear regression against %TIA or EIA (Kerr Wood Leidal 2005), which is useful for comparing with current conditions and for predicting changes when the watershed is fully developed. As shown in Figure 3-8, the mean B-IBI score of 14 is considerably lower than the value of 27 (poor to fair) calculated under current EIA levels, i.e., based on current development levels in the watershed, benthic communities would be expected to be healthier than observed. As noted above, the field results are likely influenced by the fine substrate available for sampling. Future conditions for %/EIA are discussed in Section 9, where a recommendation is made for a maximum EIA of 20% in the watershed, based on maximum use of Low Impact Development strategies. The calculated B-IBI value decreases from 27 (for 10% EIA) to 21 (for 20% EIA), within the “poor” range.

The measured and calculated values for B-IBI are plotted against % riparian forest integrity in the Watershed Health Tracking chart (Figure 3-8), and support the observation that current measured benthic community health is lower than would be expected based on existing amounts of riparian forest and impervious cover.

3.4.5 Stream Classification Map and Stream Setbacks

Most of the streams in the Erickson Creek watershed are fish bearing (A or AO) or provide significant food and nutrient value (B), as indicated in Figure 3-1. Drainage ditches in the agricultural lowlands are ranked as AO (seasonal fish presence).

The importance of adequate setbacks for maintenance of watershed health, protection of fish habitat, wildlife corridors, access for maintenance, geotechnical and flood plain concerns, as well as for protection of property cannot be overemphasized. Encroachment leads to loss of riparian vegetation, with associated degradation of fish habitat and loss of wildlife habitat and migration corridors. Setbacks should be determined based on geotechnical and geomorphological values, in conjunction with existing and proposed flow regimes, as well as fisheries and wildlife values. Recommended setbacks are discussed in Section 9.3.1.

3.5 HYDRAULIC INVENTORY

Hydraulic structures and other features are indicated in Figures 3-6a and 3-6b. During our field reconnaissance, our staff noted all hydraulically significant features in the creek channel and adjacent tributaries. These features included:

- Culverts and bridges, including special conditions
- Debris blockages
- Erosion areas
- Channel obstructions
- Fish passage restrictions
- Pump stations.

Erickson Creek begins on the south side of 24th Avenue just west of the 188th Street right-of-way. It has three major crossings, these being the 32nd Avenue culverts, the 40th Avenue culverts and the 184th Street culvert. In addition to these crossings there are four pedestrian bridges, one vehicle bridge, seven shorter culvert crossings, and a fish ladder. Erickson Creek has six major tributaries, these being Laura Brook, Vandrish Brook, Justin Brook, and Dall Brook that join Erickson upstream of 32nd Avenue. Additionally, Clover Brook and the 40th Avenue ditches join Erickson downstream of 32nd Avenue. Descriptions for these tributaries are provided below. Details of the Erickson Creek culverts and other creek features were obtained during our field reconnaissance and are provided in Tables 3-11 and 3-12.

The owner of 3011 - 184th Street has water rights to Laura Brook. Water is withdrawn through a concrete channel and then treated. According to discussions with the owner, the source of Laura Brook is a spring on the east side of 184th Street. The owner currently utilizes Laura Brook for drinking water and plans to use it for agricultural purposes. Laura Brook also has four private ponds whose water levels are controlled by culverts. The confluence of Laura Brook and Erickson Creek is located on 18106 - 32nd Avenue.

Vandrish Brook begins on the east side of 184th Street just north of 28th Avenue. It has two major crossings, these being the 184th Street and 29A Avenue culvert crossings. In addition to these crossings there are four shorter culvert crossings, three pedestrian bridges, one vehicle bridge and seven private ponds. During our field reconnaissance we were unable to access 2942 and 2916 - 184th Street due to uncooperative owners. The confluence of Vandrish Brook and Erickson Creek is located on 18171 - 29A Avenue.

Justin Brook begins on the south side of 24th Avenue east of 180th Street. It has four short culvert crossings and two private ponds. The confluence of Justin Brook and Erickson Creek is located on the property at 18222 - 29A Avenue.

Dall Brook begins on the south side of 28th Avenue east of 184th Street. One major culvert crosses underneath 184th Street. The confluence of Dall Brook and Erickson Creek is located just south of East Kensington Elementary School.

The Clover Brook sub-catchment begins on the west side of 188th Street north of 28th Avenue Clover Brook has two major crossings, these being the 184th Street and 32nd Avenue culvert crossings. In addition to these crossings there are three shorter culvert crossings that are located on the east side of the 184th Street ditch at private driveways. The confluence of Clover Brook and Erickson Creek is located on 18227 - 32nd Avenue.

Sub-catchment areas flowing to the 40th Avenue ditches begin on 184th Street north of 32nd Avenue. These ditches have two major crossings, these being underneath 184th Street and underneath 40th Avenue. Both of these crossings are located at the intersection of 184th Street and 40th Avenue. These ditches have 27 shorter culvert crossings and one vehicle bridge located at private driveways.

A general summary of the features is contained in Table 3-10, below. Detailed information for culverts, bridges and obstructions can be found in Table 3-11, while other features including erosion sites and confluences can be found in Table 3-12. The field report sheets are located in Appendix D. Figures 3-6a and 3-6b indicates the locations of features detailed in Tables 3-11 and 3-12. Figure 3-7 provides channel profiles for the four creek main stems originating in the Grandview Heights area.

Table 3-10
Hydraulic Summary for Erickson Creek

Description	Erickson Creek
Drainage Area (ha)	1454
Boundary	Burrow's to the west, Little Campbell to the south, Unwin to the east and the Nicomekl River to the North.
Stream Structure	Erickson creek has six major tributaries that join Erickson upstream of 32nd Avenue.
Topography	Erickson creek ranges from EL 90 m to sea level with an average gradient of 17% upstream of 32nd Avenue and 6% downstream of 32nd Avenue.
Land Use	The main current land uses in the watershed are agricultural (in the lowlands and along the north slope), wood lots and low density residential. Industrial areas are being or will be developed along the eastern fringe. Further urban and suburban development in upland areas is anticipated.
Drainage	Storm sewers range in size from 150 mm to twin 1800 mm.
Channel Characteristics	Total length of significant channels is 9.3 km (Based on City of Surrey GIS Mapping).
Hydraulic Structures	76 culverts identified in field reconnaissance. Likely more on small tributaries and in lowland area. Seven vehicle and pedestrian bridges. One fish ladder and one weir.
Erosion	Three erosion sites were observed along Erickson Creek main stem.
Debris Blockage	Five sites with debris blockages were observed.
Confluence	28 confluences were identified.

Table 3-3 Fish Habitat by Reach (also see Figure 3-2)

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
Unnamed Creek (UC)								
UC-1 Unnamed Creek upstream from 18000 block of 32nd Ave	A to 29A Ave. alignment and B upstream	1%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	0.7 – 1.3 m 0.1 – 0.3 m 0.2 – 0.3 m < 0.1 m None	Channelized and natural banks, passable to fish at confluence with 32nd Ave ditch. Flows through blueberry farm and open horse pastures. Impoundment in lower section, wet swale with reduced definition upstream of pond.	Grassy swale with ephemeral flow. Lacks spawning gravels and riparian vegetation, so is not considered to provide good spawning and rearing habitat.	1, 2
Erickson Creek (EC)								
EC-1 Mainstem from 32nd Ave to Vandrishe Brook	A	2%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	1.5 – 2.3 m 1.7 – 2.0 m 1.0 – 1.1 m 0.2 – 0.5 m Moderate	Creek runs through the front yard of a property. Signs of erosion are present. Braided stream upstream of front yard.	Good rearing habitat. Undercut banks and overhead vegetation provide cover – no canopy through front yard.	3, 4
EC-2 Unnamed tributary to Erickson Creek	A for 125 m and B upstream	2%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	0.9 – 1.0 m 0.4 – 0.7 m 0.2 – 0.3 m none Moderate	Channel unconfined and lacks complexity, minimal flow originates from a stagnant pool.	Potentially good amphibian habitat but does not provide good fish habitat (no spawning gravels, low dissolved oxygen in April).	5, 6
EC-3 Mainstem between EC-2 and 29A Ave	A	2%	Fines and some gravel	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	2.3 – 3.2 m 1.3 – 2.1 m 1.4 – 1.6 m 0.2 – 0.5 m Trace	Exposed roots, failing banks indicate erosion; landowner has placed riprap in areas to stabilize bank. Riparian cover and canopy is present close to 29A Ave but sparse just downstream (landowner plans to plant ornamental trees). Bittersweet (*Solanum dulcamara)* apparently covers creek in summer.	Good rearing habitat (riffle-pool morphology) and some spawning gravels. Wood berm (1.3 m high) may be a barrier and could be improved with a fish ladder. Fish access to side pond likely limited by perched culvert (1.1 m). "Stickleback" reportedly inhabit stream.	7, 8

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
EC-4 Mainstem from 29A Ave to 184th St	A	5%	Fines and some gravel	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	1.1 – 2.0 m 1.0 – 1.7 m 0.3 – 0.8 m 0.3 – 0.5 m Moderate	Pond and fish ladder near 29A Ave. in a semi-forested area, close to open fields. Upstream of pond, the creek flows through marshy area and small pond. Channel is gullied alongside East Kensington Elementary School. Orange iron bacteria present in backwater areas.	Ponds and channel provide moderate to good rearing habitat; spawning gravel present at upper end; swampy areas provide more marginal habitat. Metal grate covering culvert is a barrier to fish but other culverts passable during high water. Wood box outlet to upper pond (0.94 m drop) may be barrier to fish passage at low flow.	9, 10, 11, 12, 13, 14
EC-5 Tributary to EC-4	B			Not assessed			Does not provide fish habitat - channel flows underground through residential properties.	
EC-6 Mainstem upstream of 184th St to 24th Ave.	A	5%	Gravel and fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	1.2 – 1.9 m 1.1 – 1.7 m 0.2 – 0.5 m 0.3 – 0.4 m Moderate	Channel flows through a forested area, partially gullied. Ravine banks show signs of erosion from human and animal traffic.	Excellent rearing habitat throughout EC-6. Gravels in lower portion of EC-6 provide excellent spawning habitat.	15
EC-7 tributary to EC-6	None			No defined channel		Tributary to EC-6 from east. Channel not flowing in April.	No fish habitat. Not classified by Surrey.	16
EC-8 tributary to EC-6	None			No defined channel		Tributary to EC-6 from east. Channel not flowing in April.	No fish habitat. Not classified by Surrey.	17
EC-9 tributary to EC-6	A			No defined channel		Tributary to EC-6 from west. Channel has minimal flow in April, no flow in July.	No fish habitat.	18

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
Breaks Brook (BB)								
BB-1 tributary to Justin Brook	A for 140 m and B upstream	3%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	4.0 – 6.0 m 0.5 – 1.0 m 2.0 – 3.0 m 0.1 m Moderate	Channel moderately gullied, indicating historic high flow. Dry almost immediately upstream of pond at Justin Brook in April.	This reach provides no fish habitat, as it is limited by lack of flow.	19
Laura Brook (LB)								
LB-1 Ponds tributary to Erickson Cr.	A	2%	Fines	Not surveyed due to landowner restrictions		Series of four semi-forested ponds in residential yards		20
LB-2 Downstream of 184 St	A	2%		Not surveyed due to landowner restrictions		Flows through open fields from ponds to 184th St (poor riparian cover). Upstream area flows underground.	.	
LB-3 Upstream of 184th St	A			Roadside assessment		Channel is undefined and swampy above 184th St	Not good spawning and rearing habitat.	21
LB-4 Old tributary to Laura Brook (south branch)	A for 130 m, B upstream			Roadside assessment		Originates in undeveloped area, mostly heavily forested. Former residents reported to have dug this ditch to drain their field and prevent flooding in neighbour's basement.	Confluence with 184th St ditch is accessible to fish. Poor fish habitat near road (no cover or gravel). Upstream, the channel flows through forest and habitat may improve.	22
LB-5 Old tributary to Laura Brook (mid branch)	A for 270 m, B upstream			Roadside assessment		Originates in undeveloped area, mainly heavily forested.	Good salmonid rearing habitat but spawning habitat limited due to insufficient substrate.	23

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
LB-6 Old tributary to Laura Brook (north branch)	A for 170 m, B upstream			Roadside assessment		Originates in forested area, flows through agricultural field with riparian buffer most of its length. Grassy swale without canopy at 184th St confluence.	Poor spawning and rearing habitat at confluence with 184th St. ditch, but habitat may improve upstream.	24
Vandrishe Brook (VB)								
VB-1 Series of four ponds	A	2%	Fines			Series of four ponds in open fields and semi-forested residential yards. Some minor bank erosion in creek leading to ponds, riprapped to stabilize banks.	Ponds have potential for excellent rearing habitat but pipes leading to ponds are barriers to fish migration.	25, 26, 27, 28
VB-2 Between ponds and 29A Ave	A	2%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	0.7 – 1.3 m 0.9 – 1.3 m 0.2 – 0.3 m 0.2 – 0.3 m Moderate	Creek flows through forested marshy area. Cows have access to creek, causing bank erosion and potential water quality degradation.	Riffle-pool morphology and undercut banks provide good rearing habitat. Lack of gravels limits spawning potential.	29
VB-3 29A Ave to 184th St	A	3%	Gravel and fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	2.5 – 3.2 m 0.9 – 2.5 m 0.4 – 0.5 m 0.2 – 0.3 m Moderate	Short length of stream with mature riparian cover.	Riffle-pool morphology provides excellent rearing habitat. With improved access, localized gravels will provide potential spawning habitat.	30
VB-4 184th St to top of three ponds	A	3%		Assessed from roadside due to landowner restrictions.		A short length of creek leading to a series of three ponds.	Ponds provide excellent rearing habitat (“coho” reportedly in ponds). Falls (~0.8 m) at outlet of lowest pond may be a barrier.	31, 32
VB-5 Upper Vandrishe Brook	A for 50 m, B upstream	4%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	1.3 – 1.4 m 0.3 – 0.4 m 0.5 – 0.8 m 0.1 – 0.2 m Moderate	Near headwaters of Vandrishe Brook. Flows underground in some areas.	Underground flow is a barrier to fish migration. Spawning substrate is absent. Overall fish habitat is poor.	33

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
Justin Brook (JB)								
JB-1	A for 450 m, B upstream	3%	Fines and some gravel	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	2.1 – 3.0 m 0.8 – 1.6 m 0.2 – 0.4 m 0.2 – 0.4 m Moderate	Flows through forested riparian area within open agricultural fields.	Good rearing habitat with moderate gravels for spawning, abundant cover.	34, 35
JB-2 Tributary to Justin Brook	B	1%	Fines and some gravel			Channel is straight and runs through an agricultural field.	Poor spawning, rearing habitat (lack of complexity, unsuitable substrate).	
Dall Brook (DB)								
DB-1 Tributary to Erickson Creek	A	5%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	1.0 – 1.5 m 0.7 – 1.0 m 0.2 – 0.3 m 0.1 – 0.2 m Abundant	Channel is gullied and flows through forested riparian areas. Partial stream walk completed due to access issues.	DB-1 provides low to moderate rearing habitat. Lack of gravels limit spawning habitat.	36
Eldon Brook (EB)								
EB-1	B					not assessed		
Laughlin Creek (LC)								
LC-1 Mainstem	A	1%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	- 0.4 m 0.7 m 0.07 m none	Poor riparian cover near 184th St. Abundant cover in young forest near confluence with LC-2.	Moderate rearing habitat, limited by cover. Poor spawning habitat (lack of substrates).	37, 38
LC-2 Connects with LC-1	B	1%	Fines			Abundant cover from alder, blackberries and salmonberries. Channel is defined but dry in July.	Moderate rearing habitat, limited by water flow. Poor spawning habitat (lack of substrates).	39
LC-3 LC-1 Tributary	B					Channel is dry in July		
LC-4	A							

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
Brooklane Creek (BC)								
BC-1	A	1%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	2.7 m 1.3 m 1.1 m 0.18 m trace	Riparian vegetation sparse through agricultural field but increases with distance upstream. Cows have access to the stream. Fish were seen in this reach.	Moderate rearing habitat, limited by cover and potentially turbid water. Poor spawning habitat (lack of substrates).	40, 41
BC-2 Adjacent tributary to BC-1	AO, with B upstream							
BC-3 Unmapped tributary to BC-1	Not mapped	1%	Fines			Ephemeral swale tributary to Brooklane Creek.	Poor habitat for salmonids at all life stages. Contributes to downstream flow and nutrients.	
Roadside Ditches								
32nd Ave Ditch (south side)	AO Between 180th and 184th St, C East of 180th St	1%	Fines	Bankfull width Wetted width Bankfull depth Residual pool depth LWD	3.8 – 4.1 m 1.8 – 2.3 m 0.8 – 1.0 m 0.1 m none	Ditch draining south side of 32nd Ave. Assessed from 184th St to 180th St.	Moderate rearing habitat, limited by cover and potentially turbid water. Poor spawning habitat (lack of substrates).	42
32nd Ave Ditch (north side)	C Between 180th and 184th St							
184th St Ditch (east side)	A, AO, B, and C	2%	Fines and gravels			Most of ditch on east side of 184th St. is grassed. Recent excavation and laying of gravel in 3100 block. Banks mostly exposed soil, some new grass emerging. Bank erosion evident.	Moderate rearing habitat in ditch but productivity limited by lack of cover. Spawning may occur in newly placed gravels but the ditch is heavily silted.	43, 44

Reach	Surrey Stream Class	Grad-ient	Sub-strate	Physical characteristics		Description	Habitat Quality	Photo
Agricultural Ditches								
180th St Ditch (east side, from 32nd Ave to Serpentine R.	A			Bankfull width Wetted width Bankfull depth Residual pool depth LWD	5 m 2.5 m 1.1 m n/a Trace	Agricultural ditch running parallel to 180th St. Evidence of bank erosion.	Moderate rearing habitat, poor spawning habitat due to unsuitable substrates. Sparse riparian cover.	45, 46, 47

ERICKSON CREEK

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Erickson Ditch	Pump Station	ERK-010	Inlet		Pump station at Nicomekl River.
Erickson Ditch	Pedestrian Bridge	ERK-050		Wooden	Pedestrian bridge that also anchors an irrigation pump inlet. Bridge has 2 piers and is approximately 0.5 m above the surveyed water surface elevation.
Erickson Ditch	Culvert	ERK-060	Outlet	CSP	Twin 2000 mm diameter culverts with concrete headwall and wingwalls built under 40th Avenue.
		ERK-061	Inlet		Twin 2000 mm diameter culverts with concrete sandbag headwall and wingwalls. Access is restricted by private fence.
Erickson Ditch	Culvert	ERK-080	Outlet	CSP	Twin 1800 mm diameter culverts with concrete sandbag headwall and wingalls. The crown of the culvert on the east side is sagging.
		ERK-081	Inlet		Twin 1800 mm diameter culverts with concrete sandbag headwall and wingalls. Culverts built underneath a driveway to private gated property.
Erickson Ditch	Pedestrian Bridge	ERK-150		Wooden	Pedestrian bridge forms a weir whose elevation is controlled by a gate. An inlet for an irrigation pump is located upstream from the weir.
Erickson Ditch	Culvert	ERK-180	Outlet	CSP	Twin 1500 mm diameter culverts with concrete headwall and concrete sandbag wingwalls built underneath 32nd Avenue.
		ERK-181	Inlet		Twin 1500 mm diameter culverts with concrete headwall and concrete sandbag wingwalls built underneath 32nd Avenue.
Erickson Creek	Culvert	ERK-190	Outlet	CSP	1200 mm culvert with concrete headwall built underneath a private driveway to a dog kennel.
Erickson Creek		ERK-191	Inlet		1200 mm diameter culvert with concrete headwall built underneath a private driveway to a dog kennel.
Erickson Creek	Culvert	ERK-200	Outlet	Concrete	1300 mm diameter culvert with cinder block headwall built underneath a private driveway.
Erickson Creek		ERK-201	Inlet		1300 mm diamter culvert with cinder block headwall built underneath a private driveway.
Erickson Creek	Culvert	ERK-220	Outlet	Concrete	One 1000 mm diameter driveway culvert on private property with a 600 mm high flow concrete culvert.
Erickson Creek		ERK-221	Inlet		One 1000 mm diameter driveway culvert on private property with a 600 mm high flow concrete culvert.
Erickson Creek	Culvert	ERK-280	Outlet	CSP	1200 mm diameter culvert built underneath a vehicle access (less than 300 mm of cover) on private property. Outlet is armored with 300 mm diameter rip rap. There is visual evidence of the creek overtopping the culvert.
		ERK-281	Inlet		1200 mm culvert built underneath a vehicle access (less than 300 mm of cover) on private property. Outlet is armored with 300 mm diameter rip rap.
Erickson Creek	Vehicle Bridge	ERK-300		Wooden	Vehicle bridge built on private property at the crest of the creek. Owner has installed rip rap downstream of bridge.
Erickson Creek	Weir	ERK-330		Wooden	V-Notch weir built downstream of 29A Avenue. Rip rap has been installed downstream of the weir.
Erickson Creek	Culvert	ERK-340	Outlet	Wood Stave	1500 mm diameter culvert built underneath 29A Avenue with a concrete lock block retaining wall.
Erickson Creek		ERK-341	Inlet		1500 mm diameter culvert built underneath 29A Avenue with a concrete lock block retaining wall.
Erickson Creek	Fish Ladder	ERK-350		Wooden	Fish ladder drains an ornamental pond built on private property. Stages of the fish ladder may be too high for fish passage.
Erickson Creek	Pedestrian Bridge	ERK-360		Wooden	Two pedestrian bridges meet join an island in the middle of an ornamental pond to either side of the pond. West bridge is approximately 0.2 m above the surveyed water level. East bridge is approximately 1.5 above the surveyed water level and is built on a log crib abutment.
Erickson Creek	Culvert	ERK-380	Outlet	Concrete	900 mm culvert built underneath private driveway that drains an ornamental pond.
		ERK-381	Inlet		900 mm culvert built underneath private driveway that drains an ornamental pond. Flow is controlled by a notched weir and a 300 mm high flow culvert.
Erickson Creek	Pedestrian Bridge	ERK-390		Wooden	Pedestrian bridge that spans across an ornamental pond. The bottom side of the bridge is approximately 600 mm above the surveyed water surface level
Erickson Creek	Log Debris	ERK-400			A tree has fallen across the creek channel.
Erickson Creek	Culvert	ERK-420	Outlet	Concrete	900 mm diameter culvert built underneath 184th Street with cinder block headwall and wingwalls.
		ERK-421	Inlet		900 mm diameter culvert built underneath 184th Street with cinder block headwall and wingwalls.
Erickson Creek	Log Debris	ERK-430			Fallen logs and other wood debris present in creek channel.
Erickson Creek	Log Debris	ERK-440			Fallen logs and other wood debris present in creek channel.
Erickson Creek	Log Debris	ERK-450			Fallen logs and other wood debris present in creek channel.
Erickson Creek	Weir	ERK-490			A broken and plugged 600 mm diameter culvert has created a weir in the creek channel.

TABLE 3-11 - HYDRAULIC STRUCTURE INVENTORY

LAURA BROOK

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Laura Brook	Culvert	LAU-010	Outlet	Concrete	Outlet of two 450 mm diameter culverts that drain a private pond. One of the culverts is for high flow conditions.
		LAU-011	Inlet		Inlet of two 450 mm diameter culverts that drain a private pond. One of the culverts is for high flow conditions.
Laura Brook	Culvert	LAU-020	Outlet	Concrete	Property owner has water rights to Laura Brook. Laura Brook is routed through a concrete spillway that is connected to a water treatment shed. Outlet is located below a wood deck built on concrete piers.
		LAU-021	Inlet		Inlet of 600 mm diameter culvert and is also at a confluence of west side ditch along 184th Street
Laura Brook	Culvert	LAU-030	Outlet	Concrete	Outlet of 600 mm diameter culvert. Adjacent signs indicate that Laura Brook is used for potable water.
		LAU-031	Inlet		Inlet of 600 mm diameter culvert built underneath 184th Street.

VANDRISH BROOK

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Vandrish Brook	Culvert	VAN-010	Outlet	PVC	200 mm diameter culvert that drains an ornamental pond on private property. Water velocity seems high and an erosion area has formed around the culvert outlet. The culvert outlet is located at the confluence of Vandrish Brook and Erickson Creek.
		VAN-011	Inlet		200 mm diameter culvert that drains an ornamental pond on private property. The inlet is clogged by small floating debris.
Vandrish Brook	Culvert	VAN-020	Outlet	PVC	200 mm diameter culvert that drains an ornamental pond into another ornamental pond. There is a 45 degree angle in the culvert.
		VAN-021	Inlet		200 mm diameter culvert that drains an ornamental pond into another ornamental pond. The inlet is controlled by a concrete weir with a mesh gate.
Vandrish Brook	Pedestrian Bridge	VAN-030		Wooden	Pedestrian bridge that spans the upstream end of an ornamental pond.
Vandrish Brook	Pedestrian Bridge	VAN-040		Wooden	Pedestrian bridge built on concrete vertical walls at downstream end of ornamental pond. Bridge is approximately 200 mm above the surveyed water level.
Vandrish Brook	Vehicle Bridge	VAN-050		Wooden	Vehicle Bridge spans narrow point between two ornamental ponds. Flow is channelized between wood abutment walls. Bridge is approximately 400 mm above the surveyed water level.
Vandrish Brook	Pedestrian Bridge	VAN-060		Wooden	Pedestrian bridge built at the upstream end of an ornamental pond.
Vandrish Brook	Culvert	VAN-070	Outlet	PVC	450 mm diameter culvert built underneath possible vehicle access road.
		VAN-071	Inlet		450 mm diameter culvert built underneath possible vehicle access road.
Vandrish Brook	Culvert	VAN-080	Outlet	Concrete	600 mm diameter culvert built underneath 29A Avenue with minimal erosion around outlet.
		VAN-081	Inlet		600 mm diameter culvert built underneath 29A Avenue with minimal erosion around inlet.
Vandrish Brook	Culvert	VAN-090	Outlet	Concrete	600 mm diameter culvert build underneath 184th Street with concrete headwall. Possible sediment issue as the culvert invert is below channel bottom.
		VAN-091	Inlet		600 mm diameter culvert build underneath 184th Street and a confluence with the 184th Street east ditch.
Vandrish Brook	Culvert	VAN-210	Outlet	PVC	150 mm diameter culvert and a 300 mm diameter high flow culvert draining anornamental pond into side channel.
		VAN-211	Inlet		150 mm diameter culvert and a 300 mm diameter high flow culvert draining an ornamental pond into side channel. Inlet is controlled and surrounded by a wire mesh.

JUSTIN BROOK

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Justin Brook	Culvert	JUS-010	Outlet	Concrete	750 mm diameter culvert with a log headwall. Outlet is clogged by vegetation.
		JUS-011	Inlet		750 mm diameter culvert with a log and concrete headwall and trash rack. The culvert drains a large pond.
Justin Brook	Culvert	JUS-020	Outlet	Concrete	300 mm diameter culvert adjacent to a 750 mm diameter high flow culvert draining into pond.
		JUS-021	Inlet		300 mm diameter culvert adjacent to a 750 mm diameter high flow culvert draining pond.
Justin Brook	Culvert	JUS-030	Outlet	Concrete	750 mm diameter high flow culvert discharges into a pond. Could not locate outlet 600 mm diameter low flow concrete culvert.
		JUS-031	Inlet		750 mm diameter high flow culvert discharges into a pond. Adjacent to 600 mm diameter low flow concrete culvert.
Justin Brook	Log Debris	JUS-040			Log has fallen across creek channel. Branches have built up and clog the creek channel.
Justin Brook	Culvert	JUS-050	Outlet	Concrete	CSP outlet connected to a 900 mm diameter concrete culvert built underneath a vehicle access road.
		JUS-051	Inlet		900 mm diameter concrete culvert built underneath a vehicle access road.

TABLE 3-11 - HYDRAULIC STRUCTURE INVENTORY

DALL BROOK

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Dall Brook	Culvert	DAL-010	Outlet	CSP	600 mm diameter culvert with no headwall built underneath 184th Street.
		DAL-011	Inlet		600 mm diameter culvert with cinder block headwall built underneath 184th Street. Inlet is partially submerged which may indicate obstruction in the culvert.

CLOVER BROOK

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Clover Brook	Culvert	CLV-020	Outlet	Concrete	450 mm diameter culvert with a concrete headwall and wingwalls and a trash rack. Culvert is built underneath 184th Street. Outlet is armored with rip rap.
		CLV-021	Inlet		450 mm diameter culvert with a concrete headwall and wingwalls and a trash rack. Culvert is built underneath 184th Street. Inlet is armored with rip rap.
Clover Brook	Culvert	CLV-030	Outlet	Concrete	600 mm diameter culvert with concrete headwall and wingwalls and a trash rack. Culvert is built underneath 32nd Avenue. Outlet is armored with rip rap. Confluence with west side 184th Street ditch at a manhole at the north east corner of the 184th Street and 32nd Avenue intersection.
		CLV-031	Inlet		600 mm diameter culvert with concrete headwall and wingwalls and a trash rack. Culvert is built underneath 32nd Avenue. Inlet is armored with rip rap.
Clover Brook	Culvert	CLV-050	Outlet	Concrete	450 mm diameter culvert with no headwall built underneath a private driveway. Outlet is armored with gravels.
		CLV-051	Inlet		450 mm diameter culvert with no headwall built underneath a private driveway. Inlet is armored with gravels.
Clover Brook	Culvert	CLV-060	Outlet	PVC	300 mm diameter culvert with no headwall built underneath a private driveway. Confluence with a small ditch from the east.
		CLV-061	Inlet	Concrete	300 mm diameter culvert with no headwall built underneath a private driveway. Concrete inlet is connected to a PVC outlet.
Clover Brook	Culvert	CLV-070	Outlet	Concrete	300 mm diameter culvert with a cinder block headwall built underneath a private driveway.
		CLV-071	Inlet		300 mm diameter culvert with a cinder block headwall built underneath a private driveway.

28th AVE

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
28th Ave South	Culvert	28E-020	Outlet	Concrete	300 mm diameter culvert outlet is at a manhole located at the south east corner of the intesection between 28th Avenue and 184th Street.
		28E-021	Inlet		300 mm diameter culvert with cinder block headwall.
28th Ave South	Culvert	28E-030	Outlet	Concrete	300 mm diameter culvet with no headwall built underneath a driveway access to a school parking lot.
		28E-031	Inlet		300 mm diameter culvet with no headwall built underneath a driveway access to a school parking lot.
28th Ave East	Culvert	28S-010	Outlet	Concrete	300 mm diameter culvert with no headwall built underneath a private driveway.
		28S-011	Inlet		300 mm diameter culvert with no headwall built underneath a private driveway.
28th Ave East	Culvert	28S-020	Outlet	Concrete	300 mm diameter culvert with cinder block headwall.
		28S-021	Inlet		300 mm diameter culvet with cinder block headwall. Culvert connects to same manhole as 28E-020.

32nd AVE

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
32nd Ave North	Culvert	32N-020	Outlet	Concrete	600 mm diameter culvert with concrete headwall and wingwalls with trashrack built underneath 32nd Avenue.
		32N-021	Inlet		600 mm diameter culvert with concrete headwall and wingwalls with trashrack built underneath 32nd Avenue.
32nd Ave North	Culvert	32N-030	Outlet	Concrete	600 mm diameter culvert built underneath a private driveway.
		32N-031	Inlet		600 mm diameter culvert built underneath a private driveway. Inlet slightly obstructed by vegetation.
32nd Ave North	Culvert	32N-040	Outlet	CSP	600 mm diameter culvert with timber headwall built underneath a private driveway
		32N-041	Inlet		600 mm diameter culvert with timber headwall built underneath a private driveway
32nd Ave North	Culvert	32N-050	Outlet	CSP	600 mm diameter culvert with timber headwall built underneath a private driveway
		32N-051	Inlet		600 mm diameter culvert with timber headwall built underneath a private driveway
32nd Ave North	Culvert	32N-060	Outlet	Concrete	450 mm diameter culvert with concrete sandbag headwall.
		32N-061	Inlet		450 mm diameter culvert with concrete sandbag headwall.

TABLE 3-11 - HYDRAULIC STRUCTURE INVENTORY

40th AVE

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
40th Ave North	Culvert	40N-010	Outlet	CSP	750 mm diameter culvert with concrete sandbag headwall and wingwalls.
		40N-011	Inlet		750 mm diameter culvert with concrete sandbag headwall and wingwalls. Inlet is plugged with debris and garbage.
40th Ave North	Culvert	40N-020	Outlet	CSP	1200 mm diameter culvert with timber headwall built underneath 184th Street.
		40N-021	Inlet		1200 mm diameter culvert with timber headwall built underneath 184th Street. Confluence with partial flow from east side ditch on 184th Street.
40th Ave South	Culvert	40S-010	Outlet	CSP	900 mm diameter culvert with concrete sandbag headwall. Outlet is also a confluence with Erickson ditch.
		40S-011	Inlet		900 mm diameter culvert with concrete sandbag headwall.
40th Ave South	Culvert	40S-020	Outlet	Wood Stave	750 mm diameter culvert with concrete sandbag headwalls built underneath a private driveway. Some sandbags in the headwall are damaged or have been replaced
		40S-021	Inlet		750 mm diameter culvert with concrete sandbag headwalls built underneath a private driveway. Some sandbags in the headwall are damaged or have been replaced
40th Ave South	Culvert	40S-030	Outlet	Wood Stave	1000 mm diameter culvert built underneath a private driveway.
		40S-031	Inlet		1000 mm diameter culvert with a concrete sandbag headwall built underneath a private driveway. Inlet is plugged by debris.
40th Ave South	Culvert	40S-040	Outlet	Wood Stave	1000 mm diameter culvert with a concrete sandbag headwall built underneath a private driveway. Sandbag headwall is bulging outwards and some sandbags have been replaced at the upper portion of the headwall.
		40S-041	Inlet		1000 mm diameter culvert with a concrete sandbag headwall built underneath a private driveway. Sandbag headwall is bulging outwards and some sandbags have been replaced at the upper portion of the headwall.
40th Ave South	Culvert	40S-050	Outlet	Wood Stave	750 mm diameter culvert with concrete sandbag headwall built underneath a private driveway.
		40S-051	Inlet	Concrete	750 mm diameter culvert with concrete sandbag headwall built underneath a private driveway. Some debris collected at concrete inlet.
40th Ave South	Culvert	40S-060	Outlet	Wood Stave	1000 mm diameter culvert with concrete sandbag headwall built underneath a private driveway.
		40S-061	Inlet		1000 mm diameter culvert with concrete sandbag headwall built underneath a private driveway.
40th Ave South	Culvert	40S-070	Outlet	CSP	1200 mm diameter culvert with timber headwall built underneath 184th Street. Confluence with west side ditch on 184th Street.
		40S-071	Inlet		1200 mm diameter culvert with timber headwall built underneath 184th Street. Confluence with partial flow from east side ditch on 184th Street.

184th ST

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
184th St West	Culvert	184W-010	Outlet	Concrete	900 mm diameter culvert with timber headwall and built underneath a vehicle access to a private field.
		184W-011	Inlet		900 mm diameter culvert with concrete sandbag headwall and built underneath a vehicle access to a private field.
184th St West	Culvert	184W-020	Outlet	Concrete	900 mm diameter culvert with concrete sandbag headwall and built underneath a vehicle access to a private field.
		184W-021	Inlet		900 mm diameter culvert with concrete sandbag headwall and built underneath a vehicle access to a private field.
184th St West	Culvert	184W-030	Outlet	PVC	450 mm diameter culvert with concrete headwall built underneath a private driveway. The headwall is bulging outwards.
		184W-031	Inlet		450 mm diameter culvert with concrete headwall built underneath a private driveway. The headwall is bulging outwards.
184th St West	Culvert	184W-040	Outlet	Concrete	450 mm diameter culvert with concrete sandbag headwall built underneath a private driveway. The headwall is bulging outwards.
		184W-041	Inlet		450 mm diameter culvert with concrete sandbag headwall built underneath a private driveway. The headwall is bulging outwards.
184th St West	Culvert	184W-050	Outlet	Concrete	600 mm diameter culvert with cinder block headwall build underneath a private driveway. The headwall is bulging outwards.
		184W-051	Inlet		600 mm diameter culvert with cinder block headwall build underneath a private driveway.
184th St West	Culvert	184W-060	Outlet	Concrete	450 mm diameter culvert with cinder block headwall build underneath a private driveway. The headwall is bulging outwards.
		184W-061	Inlet		450 mm diameter culvert with cinder block headwall build underneath a private driveway.
184th St West	Culvert	184W-070	Outlet	Concrete	450 mm diameter culvert with no headwall. The outlet is plugged with gravel that has sluffed off from the private driveway.
		184W-071	Inlet		450 mm diameter culvert with no headwall.
184th St West	Vehicle Bridge	184W-080	Wooden		Wooden vehicle bridge providing access to a private property. The bridge is 2 m wide and 3 m long and is approximately 600 mm above the channel invert.
184th St West	Culvert	184W-090	Outlet	Concrete	450 mm diameter culvert with concrete headwall built underneath a private driveway.
		184W-091	Inlet		450 mm diameter culvert with concrete headwall built underneath a private driveway.
184th St West	Culvert	184W-100	Outlet	Concrete	300 mm diameter culvert with concrete headwall built underneath a private driveway. Outlet is obstructed by light vegetation
		184W-101	Inlet		300 mm diameter culvert with concrete headwall built underneath a private driveway. Inlet is obstructed by light vegetation

184th St West	Culvert	184W-110	Outlet	Concrete	300 mm diameter culvert with concrete cylinder headwall built underneath a private driveway.
		184W-111	Inlet		300 mm diameter culvert with concrete cylinder headwall built underneath a private driveway.
184th St West	Culvert	184W-120	Outlet	Concrete	300 mm diameter culvert with cinder block headwall built underneath a private driveway. Upper part of headwall has been replaced with concrete sandbags.
		184W-121	Inlet		300 mm diameter culvert with cinder block headwall built underneath a private driveway. Inlet is obstructed by debris.
184th St West	Culvert	184W-130	Outlet	Concrete	300 mm diameter culvert with no headwall. Outlet is obstructed by light vegetation.
		184W-131	Inlet		300 mm diameter culvert with no headwall. Inlet is obstructed by small debris.
184th St East	Culvert	184E-010	Outlet	CSP	1200 mm diameter culvert with timber headwall built underneath 40th Avenue.
		184E-011	Inlet		1200 mm diameter culvert with timber headwall built underneath 40th Avenue.
184th St East	Culvert	184E-020	Outlet	CSP	1200 mm diameter culvert with timber headwall and built underneath a private driveway. Outlet is armored with rip rap.
		184E-021	Inlet		1200 mm diameter culvert with timber headwall and built underneath a private driveway.
184th St East	Culvert	184E-040	Outlet	Concrete	900 mm diameter culvert with no headwall built underneath a private driveway.
		184E-041	Inlet		900 mm diameter culvert with concrete headwall built underneath a private driveway. Headwall is bulging outwards.
184th St East	Culvert	184E-050	Outlet	Concrete	900 mm diameter culvert with cinder block headwall built underneath a private driveway.
		184E-051	Inlet		900 mm diameter culvert with cinder block headwall built underneath a private driveway.
184th St East	Culvert	184E-060	Outlet	Concrete	900 mm diameter culvert with concrete headwall built underneath a private driveway.
		184E-061	Inlet		900 mm diameter culvert with concrete headwall built underneath a private driveway. Inlet is obstructed with vegetative debris.
184th St East	Culvert	184E-090	Outlet	Concrete	900 mm diameter culvert with cinder block headwall built underneath a private driveway. Outlet is submerged and headwall is bulging outwards and backfilled with gravel.
		184E-091	Inlet		900 mm diameter culvert with cinder block headwall built underneath a private driveway. Outlet is submerged and headwall is bulging outwards.
184th St East	Culvert	184E-100	Outlet	Concrete	750 mm diameter culvert with concrete sandbag headwall and confluence with ditch from the east.
		184E-101	Inlet		750 mm diameter culvert with cinder block headwall and confluence with ditch from the east. Concrete is damaged behind headwall and flow from east is bypassing inlet.
184th St East	Culvert	184E-110	Outlet	Concrete	600 mm diameter culvert with concrete sandbag headwall.
		184E-111	Inlet		600 mm diameter culvert with cinder block headwall.
184th St SW	Culvert	184SW-010	Outlet	Concrete	450 mm diameter culvert with concrete sandbag headwall built underneath 184th Street. Confluence with south east 184th Street ditch and Erickson Creek.
		184SW-011	Inlet		450 mm diameter culvert with cinder block headwall built underneath 184th Street. A notched weir has been built north of the inlet and is armored with rip rap.
184th St SW	Culvert	184SW-020	Outlet	Concrete	600 mm diameter culvert with cinder block headwall and wingwalls built underneath a private driveway. Outlet is armored with rip rap.
		184SW-021	Inlet		600 mm diameter culvert with cinder block headwall and wingwalls built underneath a private driveway.
184th St SW	Culvert	184SW-030	Outlet	PVC	600 mm diameter culvert with no headwall built underneath a private driveway. Outlet is damaged but flow is not obstructed.
		184SW-031	Inlet		600 mm diameter culvert with no headwall built underneath a private driveway.
184th St SW	Culvert	184SW-050	Outlet	Concrete	600 mm diameter culvert with cinder block headwall and wingwalls. Outlet is armored with rip rap.
		184SW-051	Inlet		600 mm diameter culvert with cinder block headwall and wingwalls.
184th St SW	Culvert	184SW-060	Outlet	Concrete	600 mm diameter culvert with concrete headwall and wingwalls. Inlet location was not found in the field.
184th St SE	Culvert	184SE-020	Outlet	Concrete	450 mm diameter culvert with cinder block headwall underneath a private driveway.
		184SE-021	Inlet		450 mm diameter culvert with cinder block headwall underneath a private driveway.
184th St SE	Culvert	184SE-030	Outlet	CSP	600 mm diameter culvert with cinder block headwall underneath a private driveway.
		184SE-031	Inlet		600 mm diameter culvert with cinder block headwall underneath a private driveway. Confluence with a small ditch to the east.

UNNAMED TRIBUTARIES

Watercourse	Structure Type	Point_ID	Inlet/Outlet	Material	Comment
Tributary 1	Culvert	TRIB1-010	Outlet	Concrete	600 mm diameter culvert with concrete headwall and wingwalls and trash rack. Built underneath 32nd Avenue and is a confluence with the north side 32nd Avenue ditch.
		TRIB1-011	Inlet		600 mm diameter culvert with concrete headwall and wingwalls and trash rack. Built underneath 32nd Avenue.
Tributary 2	Culvert	TRIB2-010	Outlet	Concrete	200 mm diameter culvert with no headwall. Outlet is overgrown.
		TRIB2-011	Inlet		200 mm diameter culvert with no headwall. Inlet is overgrown.

TABLE 3-12 - INVENTORY OF MISCELLANEOUS CREEK FEATURES

Watercourse	Observation Type	Point_ID	Comment
Erickson Creek	Confluence	ERK-040	Confluence with ditch draining field to the east with some erosion of the channel banks.
Erickson Creek	Confluence	ERK-070	Confluence with ditch draining field to the east with some erosion of the channel banks.
Erickson Creek	Confluence	ERK-090	Confluence with ditch draining field to the east. Channel banks composed of grass.
Erickson Creek	Confluence	ERK-100	Confluence with ditch draining field to the west via a culvert.
Erickson Creek	Confluence	ERK-110	Confluence with ditches draining field from both east and west. Channel banks composed of grass.
Erickson Creek	Confluence	ERK-120	Confluence with ditches draining field from both east and west. Channel banks composed of grass.
Erickson Creek	Confluence	ERK-130	Confluence with ditch draining field to the west. Channel banks are steep sided and heavily vegetated.
Erickson Creek	Confluence	ERK-140	Confluence with ditch draining field to the west. Channel banks are steep sided and heavily vegetated.
Erickson Creek	Confluence	ERK-160	Confluence with Clover Brook channel banks are heavily vegetated.
Erickson Creek	Erosion	ERK-170	East bank undercut with roots exposed. Erosion section is approximately 10 m long.
Erickson Creek	Confluence	ERK-210	Confluence with south side 32nd Avenue ditch. Channel banks composed of grass.
Erickson Creek	Confluence	ERK-230	Confluence with Laura Brook with channel banks composed of grass.
Erickson Creek	Erosion	ERK-240	Erosion area undercuts slope adjacent to work shed. Erosion area is approximately 5 m long and 2 m high.
Erickson Creek	Erosion	ERK-260	Erosion areas on both sides of the channel. Erosion area is approximately 10 m long and 2 m high.
Erickson Creek	Confluence	ERK-270	Confluence with Tributary 2.
Erickson Creek	Erosion	ERK-290	Erosion on both sides of the channel, grass has started to grow back. Erosion area approximately 5 m long and 1.5 m high.
Erickson Creek	Confluence	ERK-370	Confluence with Breaks Creek. Channel is not well defined and possibly meanders.
Erickson Creek	Confluence	ERK-410	Confluence with Dall Brook. Channel is not well defined and possibly meanders.
Erickson Creek	Confluence	ERK-460	Confluence with unidentified channel to the west.
Erickson Creek	Confluence	ERK-470	Confluence with unidentified channel to the east.
Erickson Creek	Confluence	ERK-480	Confluence with unidentified channel to the west.
Laura Brook	Confluence	LAU-040	Laura Brook joins east side ditch on 184th Street.
Vandrish Creek	Confluence	VAN-200	Confluence with Erickson Creek and a side channel that drains an ornamental pond in high flow conditions.
Vandrish Creek	Side Channel	VAN-100	Cross-section of Vandrish Creek upstream of 184th Street crossing.
Breaks Creek	Confluence	BRK-010	Confluence with Justin Brook at upstream side of pond.
Breaks Creek	Side Channel	BRK-020	Cross-section of Breaks Creek upstream of confluence some erosion evident on east bank.
Clover Brook	Side Channel	CLV-015	Cross-section downstream of 184th Street crossing. Channel banks are well vegetated.
Clover Brook	Confluence	CLV-040	Confluence with ditch coming from the east.
176th St Ditch	Pump Station Outlet	176-010	Private pump station that services an agricultural field. Outflow is directed to the Nicomekl River.
180th St Ditch	Confluence	180-010	Confluence with farm ditch draining field to the west.
180th St Ditch	Confluence	180-020	Confluence with small creek draining from the north.
184th St East Ditch	Confluence	184E-030	Confluence with ditch draining field to the east.
184th St East Ditch	Confluence	184E-070	Confluence with ditch draining field to the east. Channel banks are well vegetated.
184th St East Ditch	Confluence	184E-080	Confluence with ditch draining field to the east. Channel banks are well vegetated.
184th St SW Ditch	Confluence	184SW-040	Confluence with ditch draining field to the west. Channel banks composed of grass.
Tributary 1	Side Channel	TRIB1-020	Well defined side channel in farm field. Channel banks are well vegetated.
Tributary 1	Side Channel	TRIB1-030	Well defined side channel in farm field. Channel banks are well vegetated.
Tributary 2	Side Channel	TRIB2-020	Undefined side channel upstream of 300 mm concrete culvert.
Tributary 3	Confluence	TRIB3-010	Confluence with Erickson Creek at 32nd Avenue. Channel is well defined and banks are composed of grass.
Tributary 3	Side Channel	TRIB3-020	Side channel is well defined and banks are composed of grass.
Tributary 3	Side Channel	TRIB3-030	Side channel is well defined and banks are heavily vegetated.

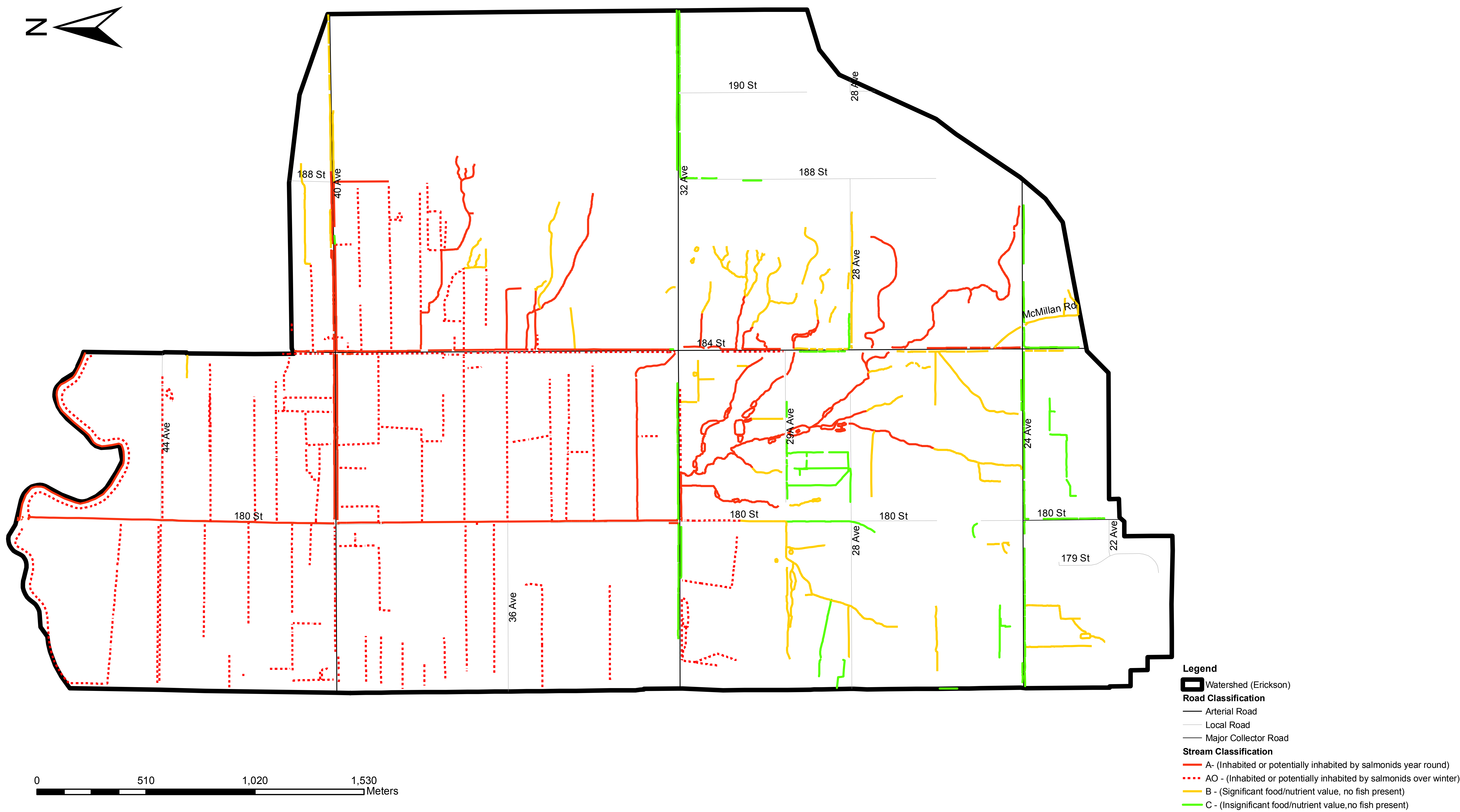
Table 3-13

Plant Species Identified During the April 2006 Field Survey

	Site																	
	E01	**E02**	**E03**	**E04**	**E05**	**E06**	**E07**	**E08**	**E09**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**	**E18**
Trees																		
bigleaf maple								X				X		X				X
bitter cherry					X	X												X
black cottonwood	X		X	X	X					X	X			X				
cascara			X		X		X					X	X					X
paper birch	X		X	X	X		X				X	X	X	X				
red alder	X		X	X		X	X	X	X	X	X			X	X	X	X	X
Douglas-fir		X				X	X		X		X	X	X		X		X	
grand fir										X								
Sitka spruce	X	X																
western hemlock	X	X					X											
western redcedar	X	X					X	X	X	X	X	X	X		X		X	X
Shrubs and Herbs																		
beaked hazelnut	X																	
black gooseberry									X		X							
black twinberry					X											X		
bracken fern	X		X					X						X				
cleavers																	X	
common snowberry						X	X											
dull Oregon-grape		X					X				X	X	X					
false lily-of-the-valley	X		X						X									
hardhack				X		X							X					
Himalayan blackberry		X	X		X	X									X	X	X	X
horsetail														X				

Table 3-13
Plant Species Identified During the April 2006 Field Survey

	Site																	
	E01	**E02**	**E03**	**E04**	**E05**	**E06**	**E07**	**E08**	**E09**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**	**E18**
Indian-plum			X		X	X	X		X	X	X		X				X	X
lady fern	X					X		X		X	X			X	X		X	
licorice fern									X			X						
Nootka rose							X											
Pacific bleeding heart			X					X	X						X			X
red elderberry	X			X	X	X		X	X	X	X		X	X	X	X	X	
red huckleberry	X	X					X	X				X						
Robert’s geranium							X											
salal	X	X																
salmonberry	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X
Saskatoon		X											X					
Sitka mountain-ash							X							X				X
skunk cabbage														X	X		X	
sphagnum moss											X							
spiny wood fern	X	X									X	X						
stinging nettle											X							
sword fern	X	X					X	X	X	X	X	X			X		X	X
thimbleberry						X											X	
trailing blackberry													X					
vanilla leaf											X	X						
vine maple	X		X			X	X		X	X	X	X	X		X			X
western trillium	X							X	X		X	X						
western trumpet honeysuckle													X					
willow					X	X				X						X	X	



Jacques Whitford AXYS Ltd.
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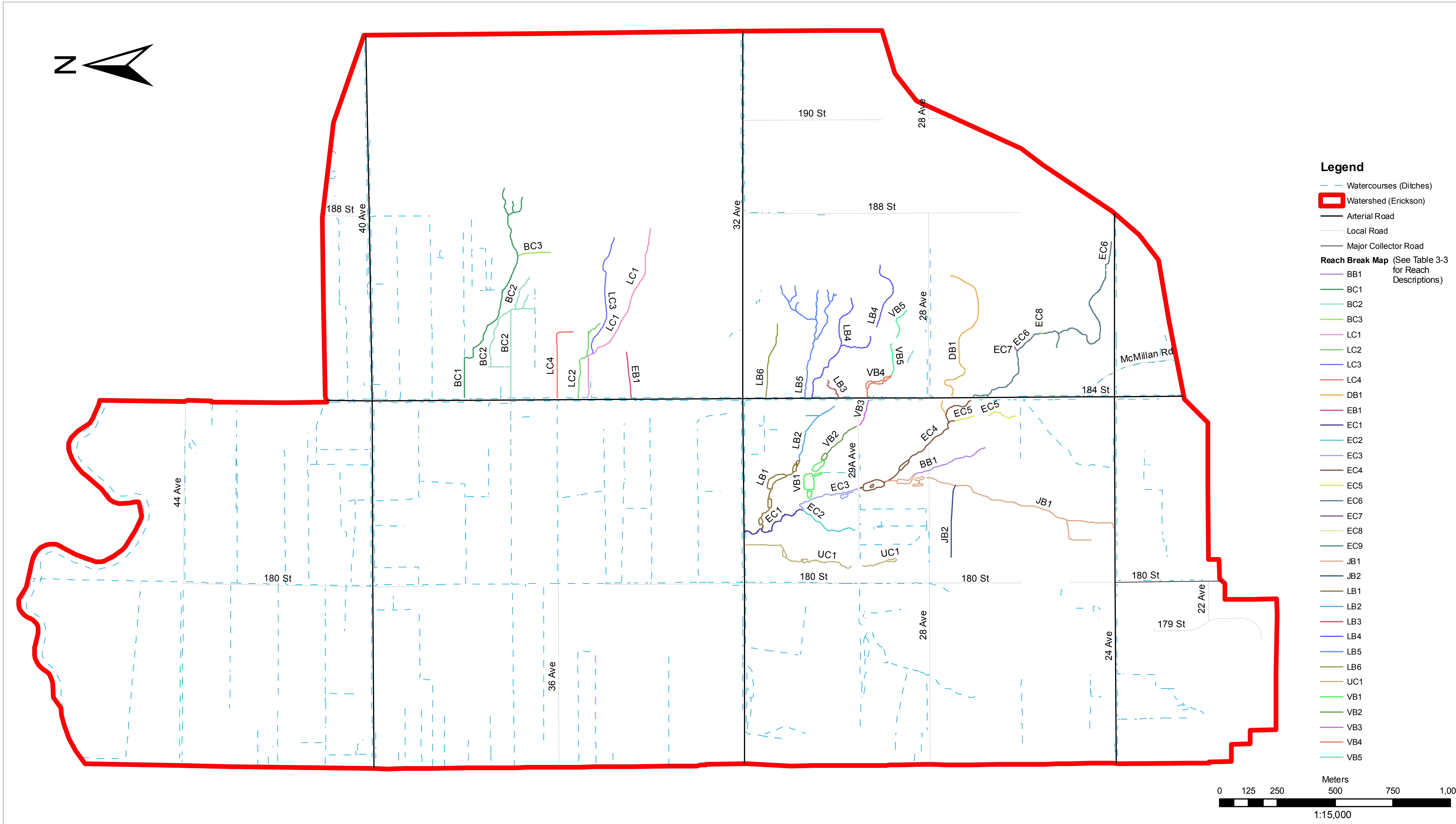
Fax. (604) 436 3752

CITY OF SURREY

SURREY STREAM CLASSIFICATION

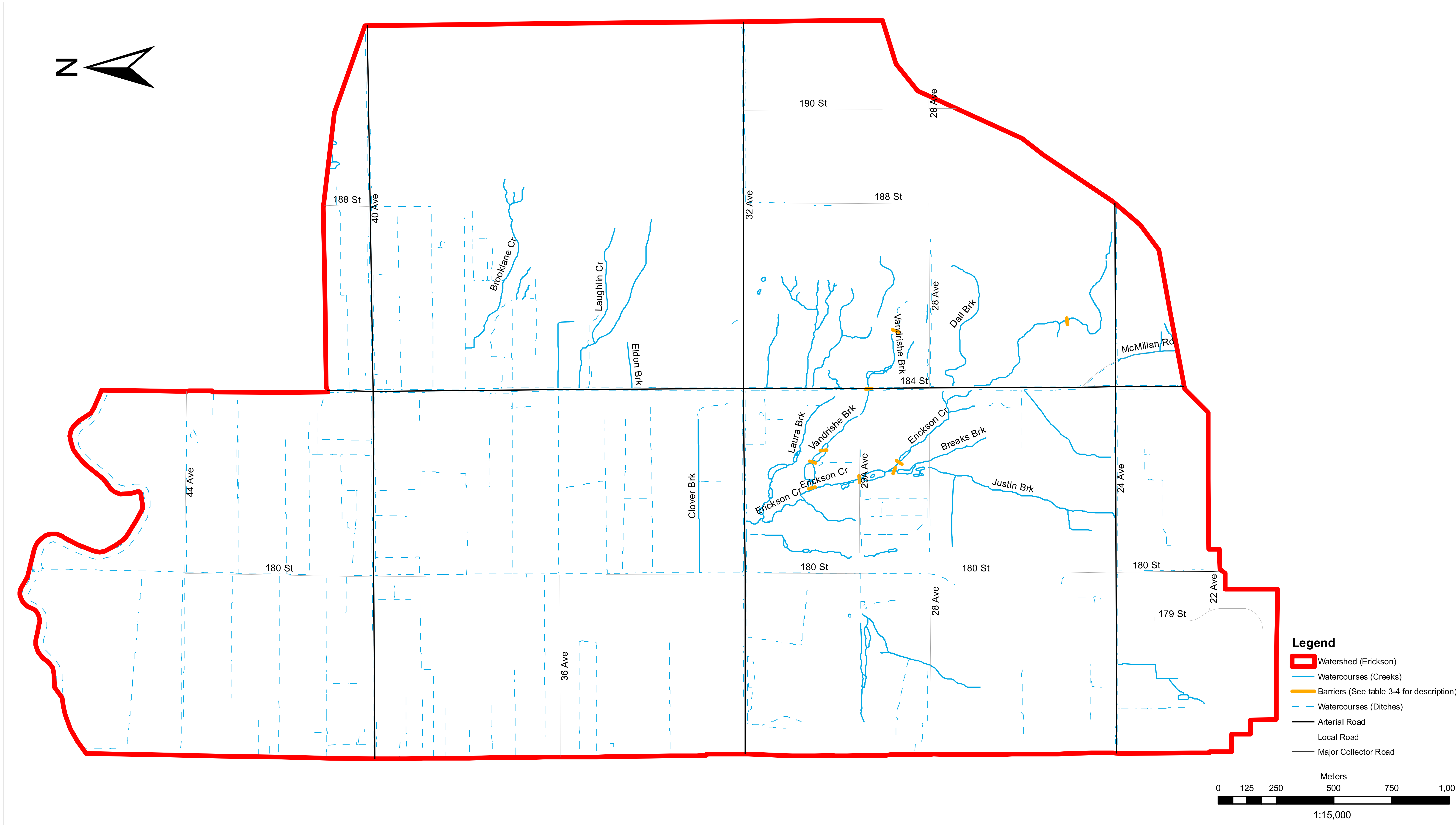
PROJECTION	DRAWN BY
UTM - ZONE 10	SS
DATUM: NAD 83	CHECKED BY: KM
DATE: 02-July-08	FIGURE NO.: 3-1

R:\2008\Fiscal\1010673\Erickson\ISMP\GIS\Report_Issued_June 27, 2008\1010673 Fig3-1 Surrey Stream Classification.mxd



PROJECT: ERICKSON CREEK ISMP	CLIENT:	TITLE:	DATE: 16-Oct-06	PROJECTION: UTM
LOCATION: ERICKSON CREEK, SURREY, BRITISH COLUMBIA	ASSOCIATED ENGINEERING (BC) LTD.	**REACH BREAKS** ERICKSON CREEK WATERSHED	AUTHOR: MC / APPROVED: KM	DATUM: NAD 83 - ZONE 10
PROJECT No: 1010673				FIGURE No. 3-2

Jacques Whitford



Jacques Whitford

PROJECT: ERICKSON CREEK ISMP

LOCATION: ERICKSON CREEK, SURREY, BRITISH COLUMBIA

PROJECT No: 1010673

CLIENT: ASSOCIATED ENGINEERING (BC) LTD.

TITLE: **OBSTACLES & BARRIERS TO SALMONID MIGRATION**

ERICKSON CREEK WATERSHED

DATE: 07-Aug-06

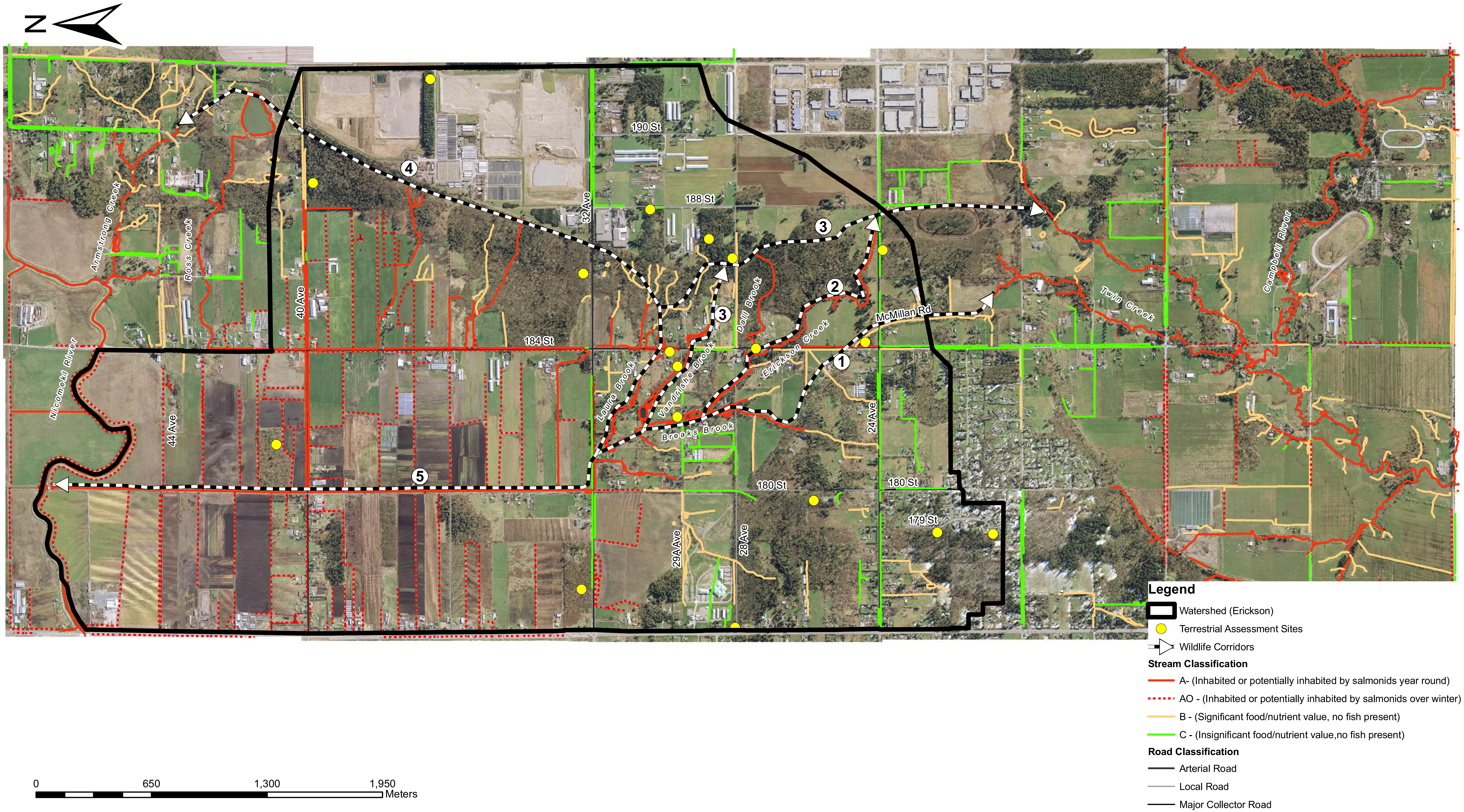
PROJECTION: UTM

FIGURE No. **3-3**

AUTHOR: MC

APPROVED: KM

DATUM: NAD 83 - ZONE 10



Jacques Whitford AXYS

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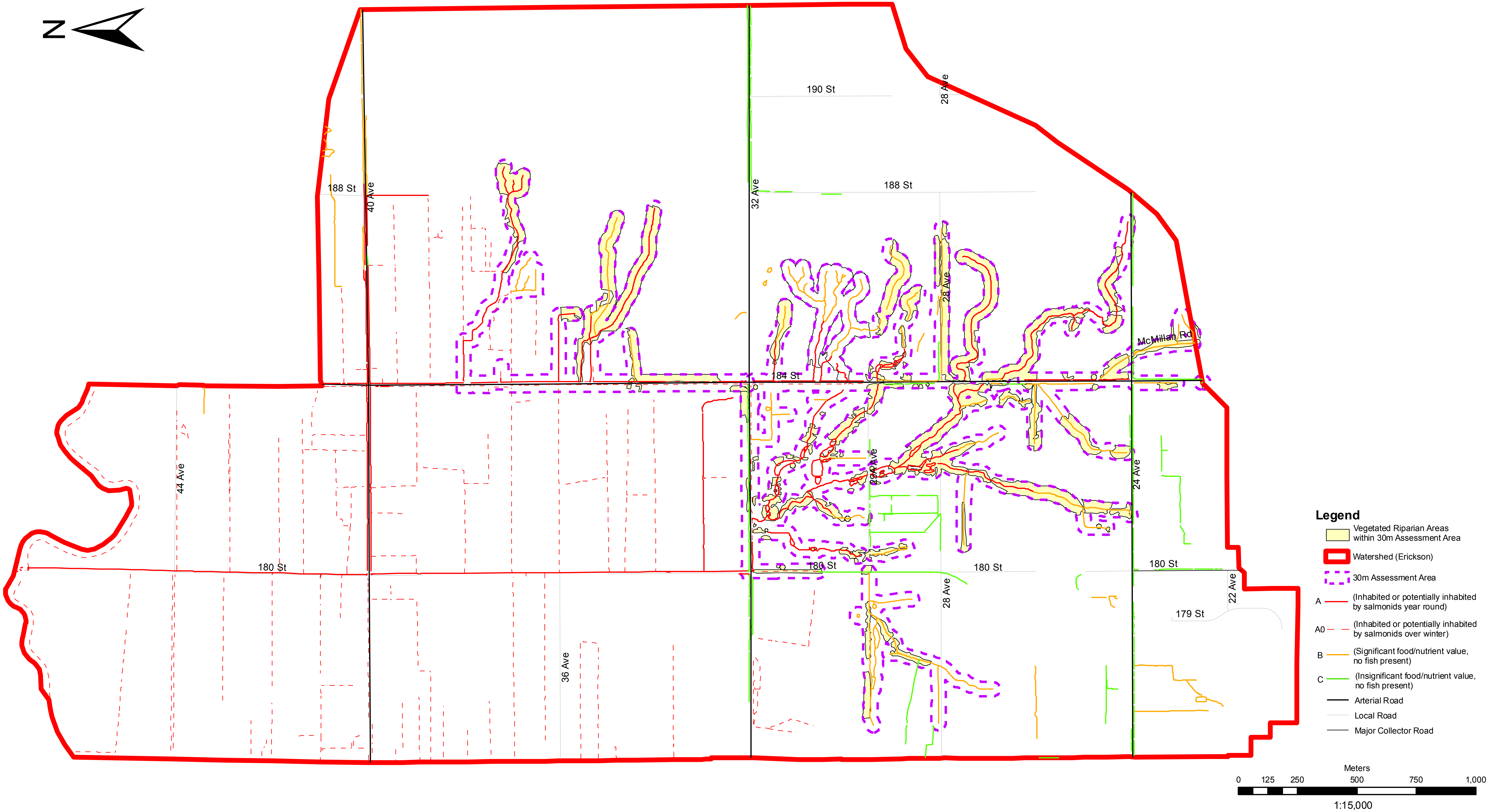
CITY OF SURREY

WILDLIFE CORRIDORS AND TERRESTRIAL HABITAT ASSESSMENT SITES

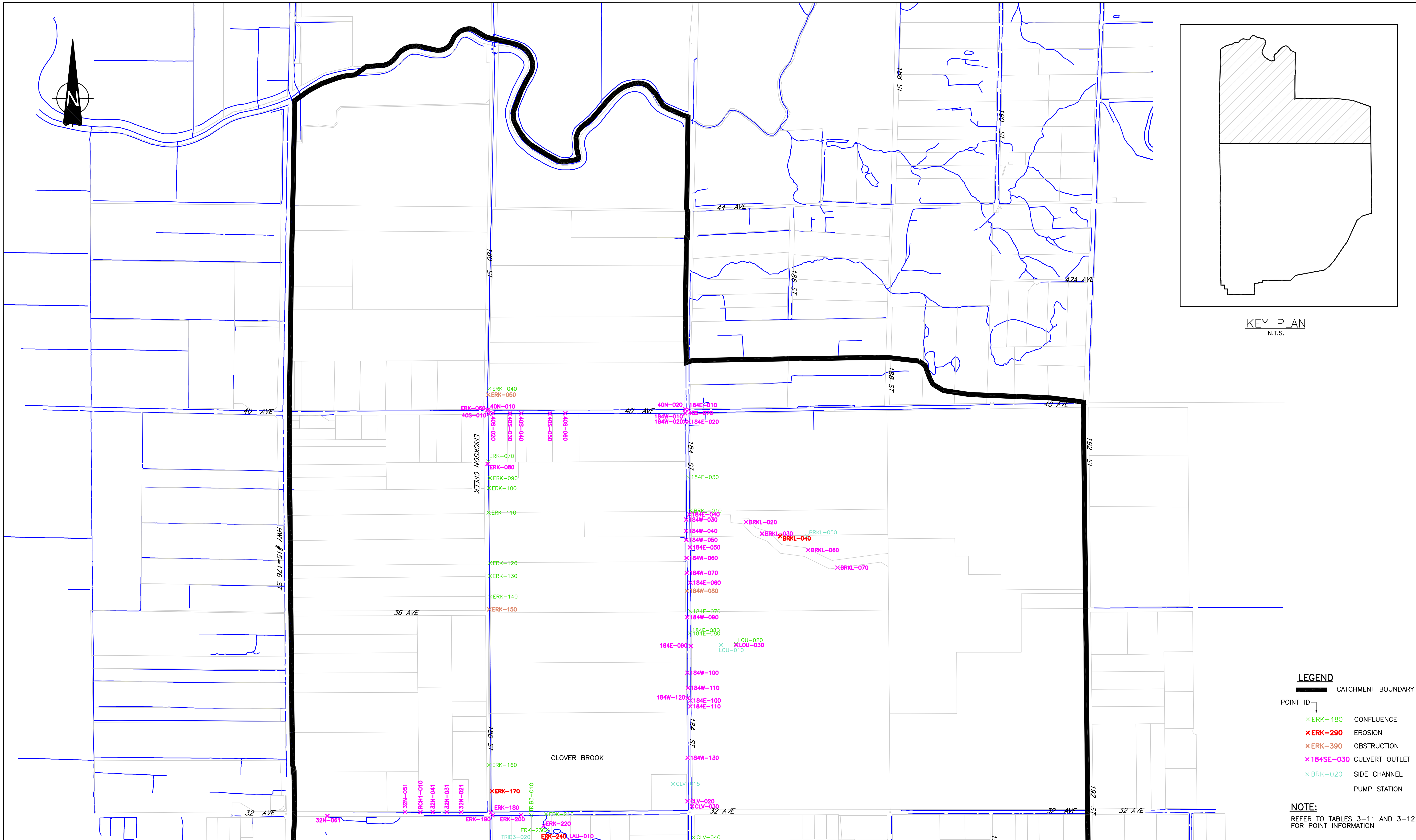
PROJECTION: UTM - ZONE 10	DRAWN BY: SS
DATUM: NAD 83	CHECKED BY: KM
DATE: 02-July-08	FIGURE NO. 3-4

R:\2008\Fiscal\1010673Erickson\SMP\GIS\Report_Issued_June 27, 2008\1010673 Fig3-4WildLifeCorridors&TerrestrialHabitatAssessment.mxd



Jacques Whitford	PROJECT: ERICKSON CREEK ISMP	CLIENT:	TITLE:
	LOCATION: ERICKSON CREEK, SURREY, BRITISH COLUMBIA	ASSOCIATED ENGINEERING (BC) LTD.	**RIPARIAN (STREAMSIDE) CORRIDOR ASSESSMENT** ERICKSON CREEK WATERSHED
	PROJECT No: 1010673		

DATE:	PROJECTION:	FIGURE No.
07-Aug-06	UTM	3-5
AUTHOR: MC / APPROVED: KM	DATUM: NAD 83 - ZONE 10	



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AutoCAD File: P:\20052802\00_STUDY\WORKING_DWGS\100_CIVIL\FIGURE 2B.DWG (G2)
Xrefs: 2802R103, 2802R102, 2802R104

F-87 PRODUCED BY CAD/CAM

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5				
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3				
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CITY OF PARKS

ENGINEERING DEPARTMENT

BENCH MARK - S.M. # ELEV.

SEAL

TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN INVENTORY

SCALE: HOR. N.T.S. VERT. N.T.S.

DATE JUNE 2006

PROJECT NUMBER 4806-705

DRAWN G.Q. CHECKED L.B.

DESIGNED J.G. CHECKED

CONTRACT

DRAWING NUMBER FIGURE 3-6a

P.W. P.U.

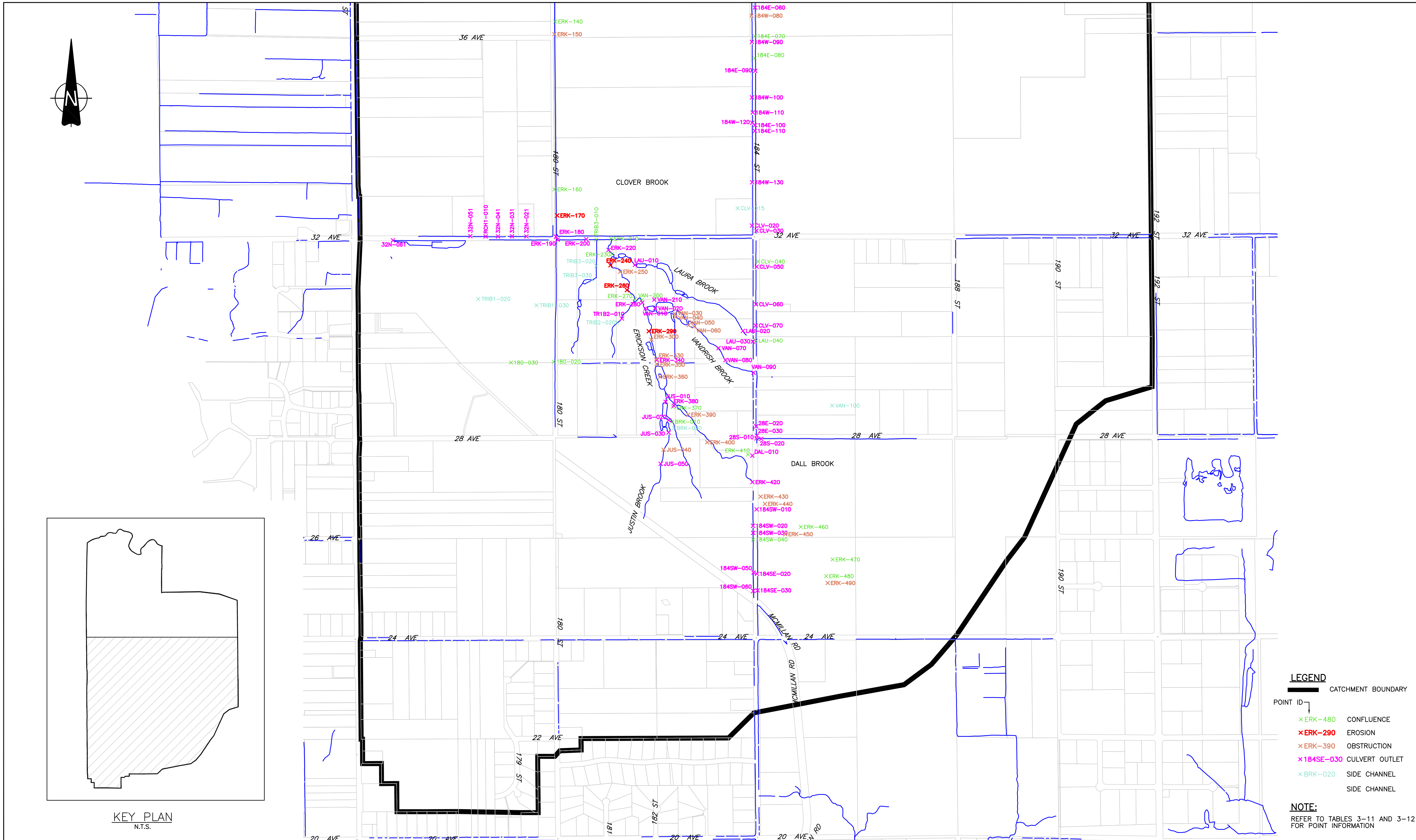
AS BUILT

SHEET OF

APPROVED

DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS

REVISION



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SEAL

TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN INVENTORY

SCALE: HOR. N.T.S. VERT. N.T.S.

DATE JUNE 2006

PROJECT NUMBER 4806–705

DRAWN G.Q. CHECKED L.B.

DESIGNED J.G. CHECKED

CONTRACT

DRAWING NUMBER FIGURE 3–6b

P.W. P.U.

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Date: 2008/7/2
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AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\JULY 02 DRAFT\FIGURE 3-6B.DWG (GQ)
Xrefs: 2802R103, 2802R102, 2802R104

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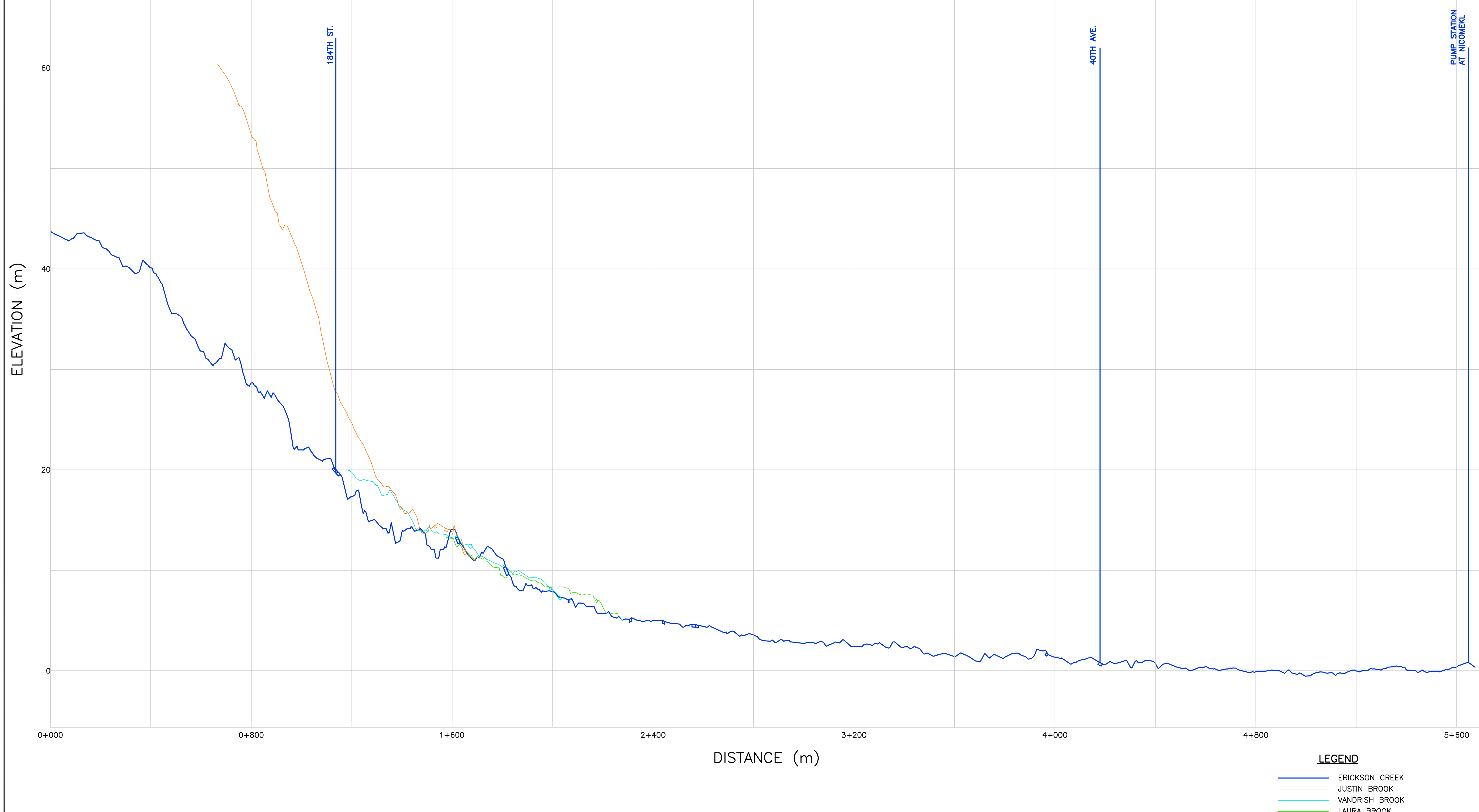

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BENCH MARK – S.M. # ELEV.

TITLE
ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN PROFILE

SEAL

SCALE: HOR. 1:10000 VERT. 1:20	DATE JUNE 2006	PROJECT NUMBER 4806–705
DRAWN G.Q. CHECKED	L.B.	DRAWING NUMBER FIGURE 3–7
DESIGNED J.G. CHECKED	CONTRACT	
P.W. P.U.	AS BUILT	SHEET OF
APPROVED	DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS	REVISION

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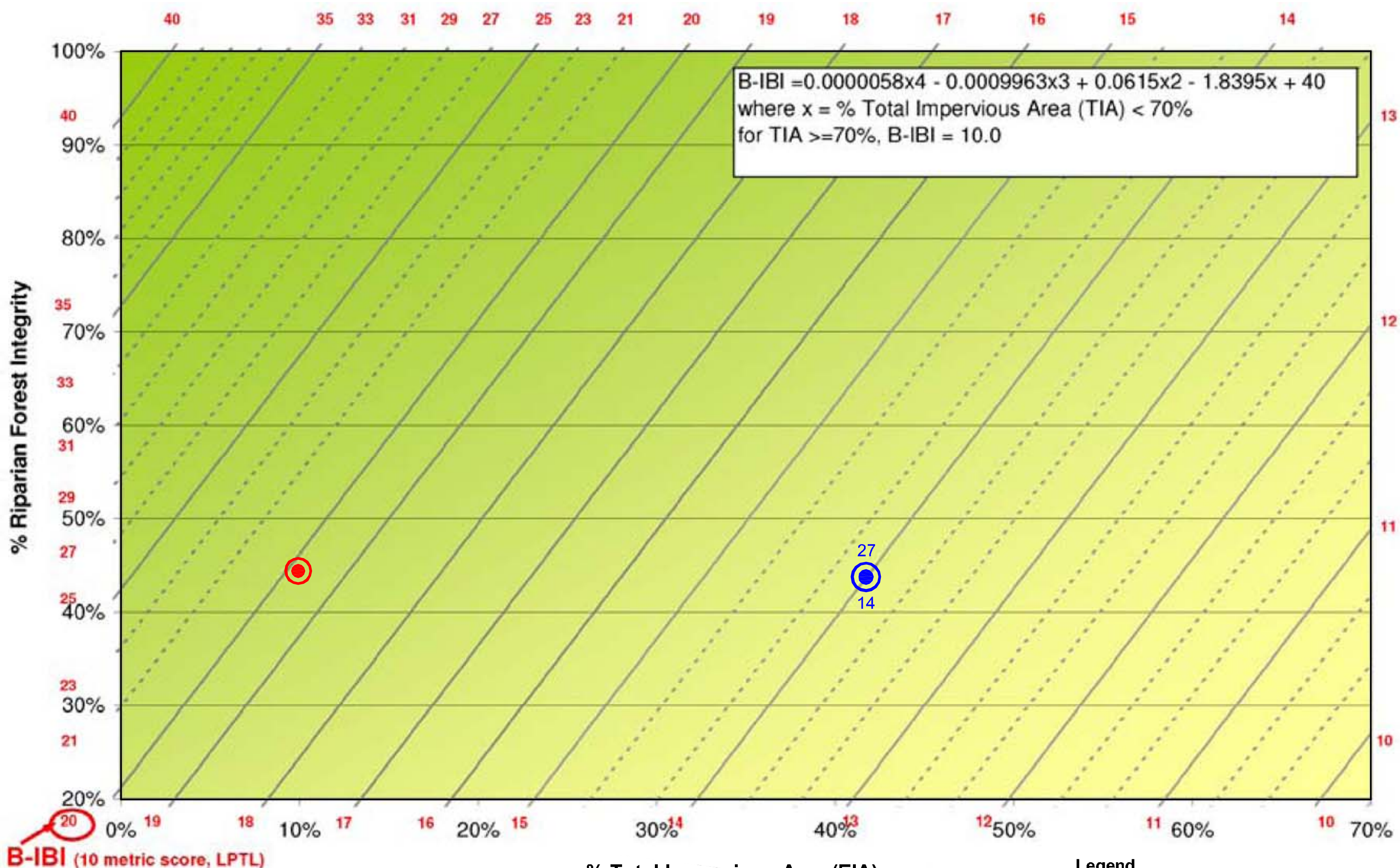
Time: 15:51 Date: 2006/7/2 Plot Scale: 1=1 (Paper Space) AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\JULY 02 DRAFT\FIGURE 3-7.DWG (GQ)

R:\2006Fiscal\1010673EricksonISMP\GIS\Report_Issued_June 27, 2008\1010673 Fig3-8 Watershed Health Tracking.dwg PRINTED: Jul 13, 2010



Source: Kerr Wood Leidal Associates Ltd. 2005

Legend

Watershed health (RFI vs EIA) in ISMP Area shown in Figure 3-5

Watershed health (B-IBI Score)

Note: Lower Number = Mean Measured B-IBI
Upper Number = B-IBI Caculated using Linear Regression with TIA

ERICKSON CREEK UPLAND AREAS OUTSIDE THE AGRICULTURAL LAND RESERVE
GVRD WATERSHED HEALTH TRACKING SYSTEM - PERMANENT FLOW CREEKS

Job No.:	1010673
Scale:	N.T.S.
Date:	27-June-2008
Dwn. By:	SS
App'd By:	KM

Dwg. No.: 3-8

Jacques Whitford AXYS

Client: CITY OF SURREY

4 Hydrologic Model Development

4.1 BASE MODEL ASSEMBLY

During Phase 1 of the study, we carried out a field inventory/assessment of the drainage network in the watershed. This inventory located the majority of important hydraulic features in the watershed, and collected basic parameters necessary to the assembly of the hydraulic model. In addition, the City provided its database on existing drainage features in the watershed, primarily local sections of enclosed storm sewer and some culvert locations. The database included with the UMA report on lowland drainage "Erickson Creek and Burrows Ditch Functional Plan" (UMA, 2002), a lowland drainage and irrigation water study, which also provided supplemental information on the drainage system.

We merged the three data sources to produce one database for model assembly. In general we followed a hierarchy where data from our more recent field program superseded conflicting information in the other two databases. The UMA database was primarily useful for indicating the presence of structures on secondary drainages that we had not inventoried. Subsequently, a supplemental field investigation was undertaken to resolve discrepancies and fill missing data.

Due to the accuracy of the GPS data obtained during the field work, and near absence of invert elevations in the other databases, we estimated elevations from the City provided digital elevation model (DEM). For upland structures that are likely to be inlet controlled, this is sufficiently accurate for modelling. In the lowlands, inverts were estimated from the DEM and channel profiles from the UMA study where available.

Creek and ditch cross-sections and other parameters were developed from the field inventory data sheets. Channel inverts and slopes were again estimated from the DEM and inverts at key points, such as junctions and culverts.

Given that the primary focus of this plan is to investigate and mitigate the impacts of upland development, we modelled the trunk lowland drainage system only, and omitted secondary channels and branches downstream (north) of 32nd Avenue. The trunk system we modelled includes the main ditches along 180th and 184th Streets and 32nd and 40th Avenues.

We developed hypsometric (area-elevation) curves to model the lowland drainage storage cells. As we were modelling the lowland areas on a simplified basis, these cells were treated as large lumped storage units and not divided into small storage cells distributed over a detailed drainage system. Simplified overland storage routing was included in our model for the lowland areas to link flood cells. Elevations for our overland routing, and the hypsometric curves, were obtained from the DEM.

We delineated sub-catchments to account for current drainage patterns, as interpreted from topographic mapping and drainage structures, but also adjusted these to allow for future general development patterns and boundaries. For example, as a boundary between future development and the agricultural areas, the GNR right-of-way was used to divide sub-catchments, as were most major roads.

Our model configuration is shown in Figures 4-1A, B, and C, which indicate model sub-catchments and modelled hydraulic features. The model was assembled in XPSWMM, Version 9.51. This is a fully dynamic model environment appropriate to this assignment.

We note that stream flow data is unavailable for the Erickson Creek watershed, and therefore we were not able to calibrate the estimated hydrologic parameters used in the model.

4.2 EXISTING DEVELOPMENT CONDITION EVALUATION

The lowland areas of the Erickson Creek watershed are largely agricultural, with roads, rural/farm homes and agriculture related structures representing most of the impervious coverage. Nominally, the state of development indicated on the aerial photographs suggests a low EIA. In actuality, the soils are generally saturated in the winter, with the result that the effective imperviousness of the lowland areas of the watershed is high, and most rainfall produces runoff during sustained winter wet weather. In addition, little forest cover remains in the lowlands, so interception and evapotranspiration, which can account for more than 30% of the rainfall volume of an average frequently occurring storm, has been nullified.

The upland areas of the watershed are currently lightly developed, with rural residential areas to the south and west of the former Great Northern Railway (GNR) right-of-way, and light industrial and extractive activities on the Campbell Heights on the eastern boundary of the watershed, west of 192nd Street. A general map of the watershed is provided as Figure 4-2.

In the upland residential areas (Grandview Heights), the majority of properties are larger rural residential lots with low total impervious cover relative to the lot size. We infer that a significant percentage of the existing impervious cover of these lots is not directly connected to the drainage system, and does not act as effective impervious area.

The Campbell Heights industrial lands in the eastern area of watershed generally exhibit low impervious cover, with gravel pits, storage yards and open fields. Some concentrated pockets of high impervious coverage are apparent in the aerial photography, composed of large structures such as greenhouses and processing plants. Given the identified high infiltration capacity of the underlying soils the overall existing EIA in this area is likely considerably lower than the TIA. Our estimates of existing condition runoff parameters are provided in Table 4-1.

Table 4-1
Estimated Existing Condition Runoff Parameters

Sub-Area	Estimated TIA (%)		Estimated EIA (%)	
	Maximum	Typical	Maximum	Typical
Grandview Heights	10	5	5	2
Campbell Heights	60[2]	10	40[2]	5
Transition	5	2	2	1
Agricultural Lowlands[1]	5	2	2	1

Notes: [1]Given high water table and saturated soils during winter, TIA and EIA may not reflect actual proportions of surface runoff.
[2]High TIA & EIA associated with localized structures/paved surfaces.

4.3 FUTURE DEVELOPMENT CONDITION EVALUATION

Future land uses south and west of the former GNR right-of-way (McMillan Road) will follow the concepts presented in the Grandview Heights General Land Use Plan (Surrey, 2005). This plan indicates that most of the future development that falls within the Erickson Creek watershed is to become urban residential lands with 4 to 16 units per acre. We interpret urban residential to include compact lot single-family and multi-family housing types, both with relatively high EIAs. The southernmost fringe of the watershed will be "transitional density", with more dispersed housing and lighter development to transition to the adjacent rural properties. The GNR right-of-way will become a trail and buffer strip separating urban development from the agricultural lowlands.

Riparian corridors along well defined creeks and other green spaces will be retained, interspersed with the developed lands. For the purposes of estimating EIAs, we assumed a simplified, and conservative, 30 m buffer strip is retained along significant mapped streams in the development areas. Actual riparian buffers could differ from this assumed width and may be less extensive.

A commercial node is indicated for the northwest corner of 176th Street and 24th Avenue. Our assumed future land-use proportions and EIA for the Grandview Heights portion of the watershed are summarized in Table 4-2 below. We assume conventional stormwater management and development practices in these estimates, and therefore no low impact development (LID) measures are incorporated. We note that detailed land-use projections were not available; the Grandview Heights Land-Use Plan deals only in general concepts.

EIAs were selected consistent with documented values as provided by the City of Surrey for comparable developments in the City (Review of Runoff Coefficients, McElhanney (2002)). Our estimates generally assume the high end of the density projections, and hence high associated EIA. We note that a specific zoning is not identified for the likely predominant land-use (urban residential) in the Grandview Heights area at this time.

Table 4-2
Grandview Heights Assumed Future Condition Land-use and Impervious Cover

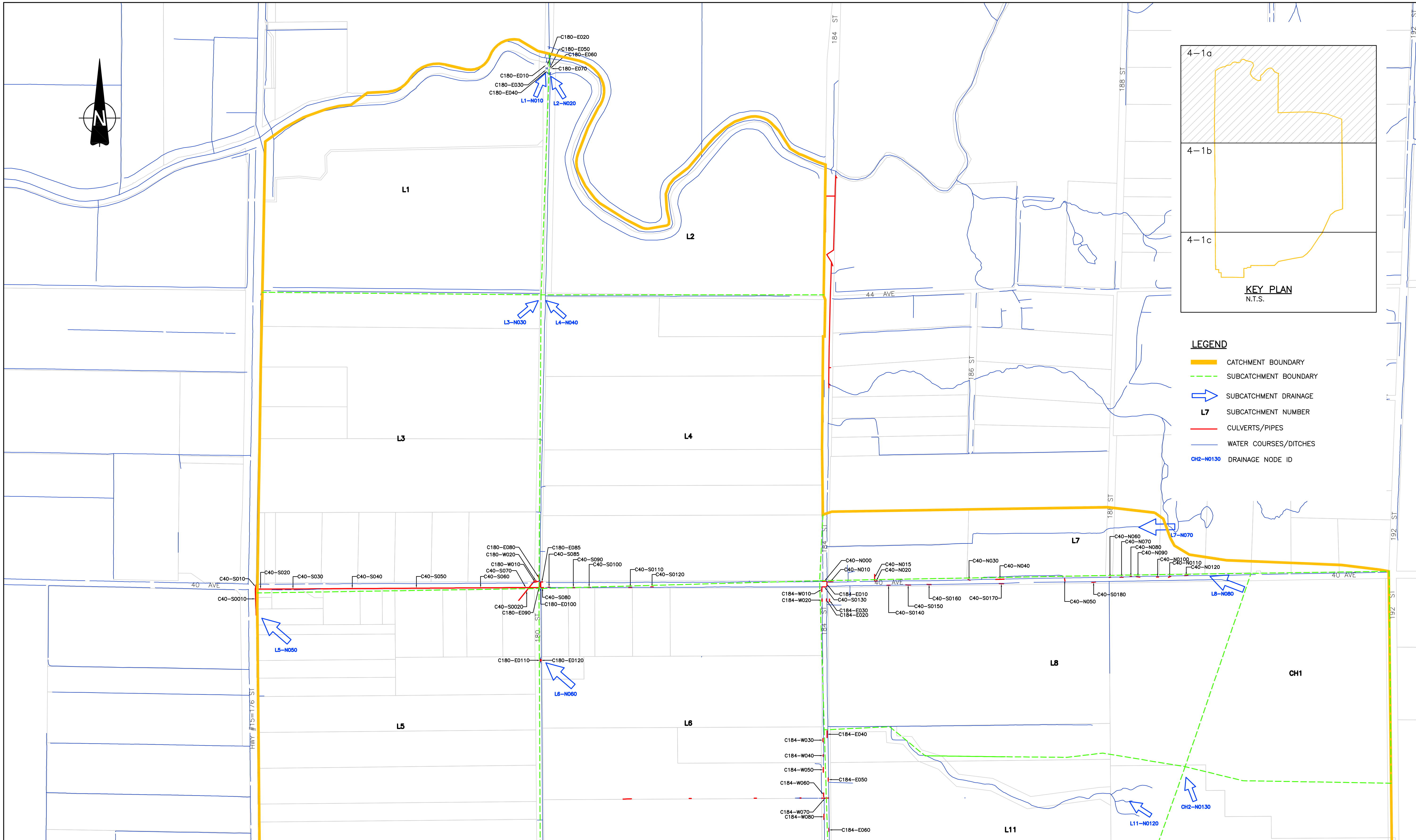
Land-Use	Percent of Land-Base	Land-Use EIA	Area EIA
Forest/Riparian Buffer	10%	5%	0.5%
Other Green Space	10%	10%	1%
Urban Residential (12 UPA)	55%	75%	41%
Transitional Density (4 UPA)	18%	60%	11%
Commercial	7%	95%	7%
Total	100%	Estimated Overall Approx. 61%	

Along the eastern escarpment in the Campbell Heights area, light industrial, business and technology park land uses are anticipated, but these are only in the early stages of planning. The various land-uses proposed for the Campbell Heights area include a significant degree of landscaping, including street setbacks and buffer strips, which will act to decrease TIA and EIA, and indirectly encourage infiltration of a portion of the rainfall volume. Even so, in the absence of extensive LID measures to disconnect impervious surfaces and encourage infiltration, the EIA of the proposed developments will likely remain relatively high. Generally, we assume an EIA of 90% for future conditions in the Campbell Heights area.

However, the Campbell Heights area has the highest identified infiltration potential, allowing for possible mitigation of impacts using various LID approaches, discussed in Section 6.5.

We assumed that land-use and EIA within the agricultural lowlands remain unchanged in the future.

We developed future condition EIAs for the model analysis based on the distribution of proposed future land use types. These were applied to the model sub-catchments as appropriate.



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TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN MODEL SCHEMATIC

SEAL

SCALE: HOR. 1:10000 VERT. 1:10000	DATE JAN. 2007	PROJECT NUMBER	
DRAWN M.P./G.Q. CHECKED	L.B.	DRAWING NUMBER	
DESIGNED N.N. CHECKED	CONTRACT	FIGURE 4–1a	
P.W. P.U.	AS BUILT	SHEET OF	
APPROVED	DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS		REVISION

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Xrefs: 2802R102

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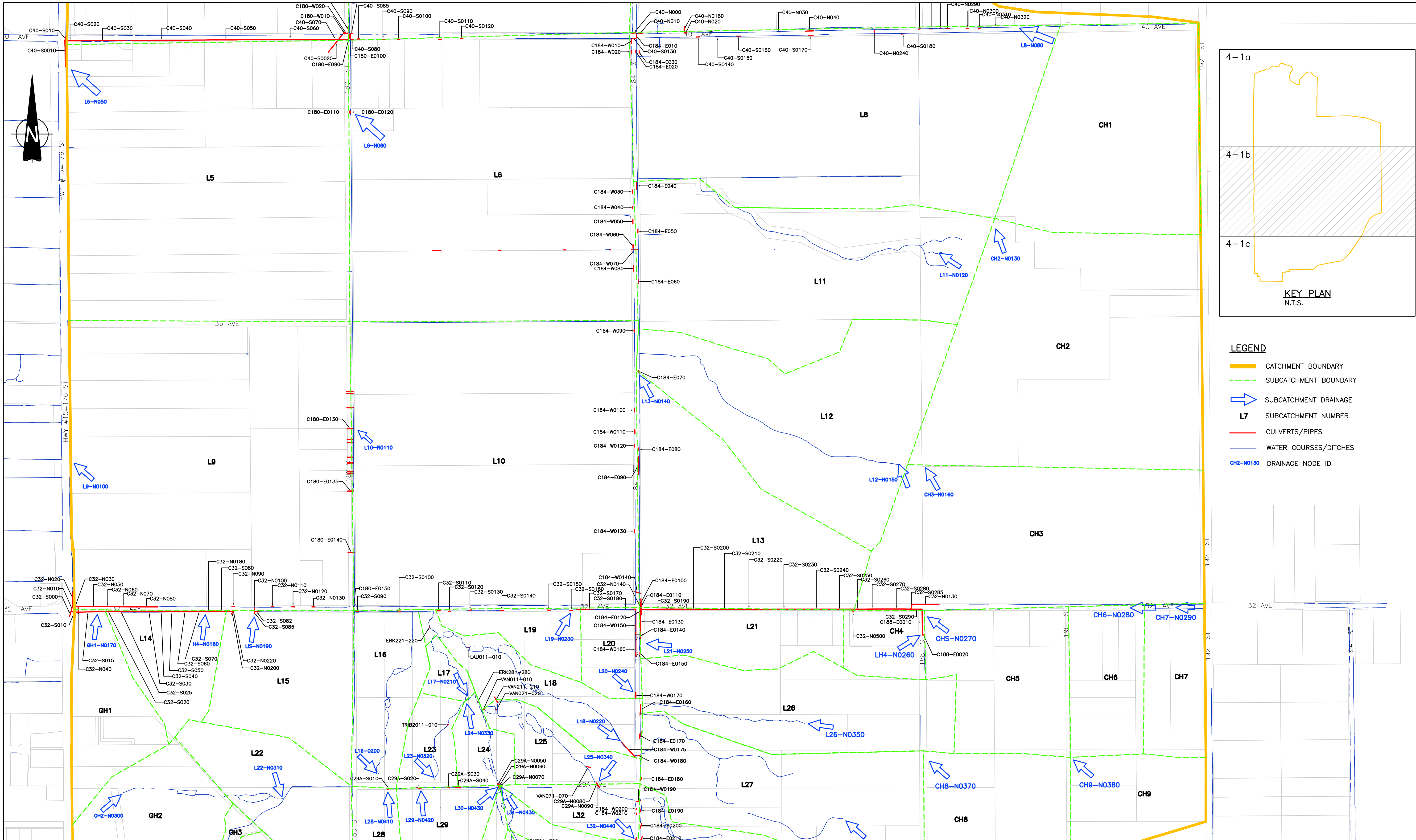

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Xrefs: 2802R102, 2802R103

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ENGINEERING DEPARTMENT

BENCH MARK - S.M. #
ELEV.
SEAL

TITLE
ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN
MODEL SCHEMATIC

SCALE: HOR. 1:10000 VERT. 1:10000
DATE JAN. 2007
PROJECT NUMBER
DRAWN M.P./G.Q. CHECKED L.B.
DRAWING NUMBER FIGURE 4-1b
DESIGNED N.N. CHECKED
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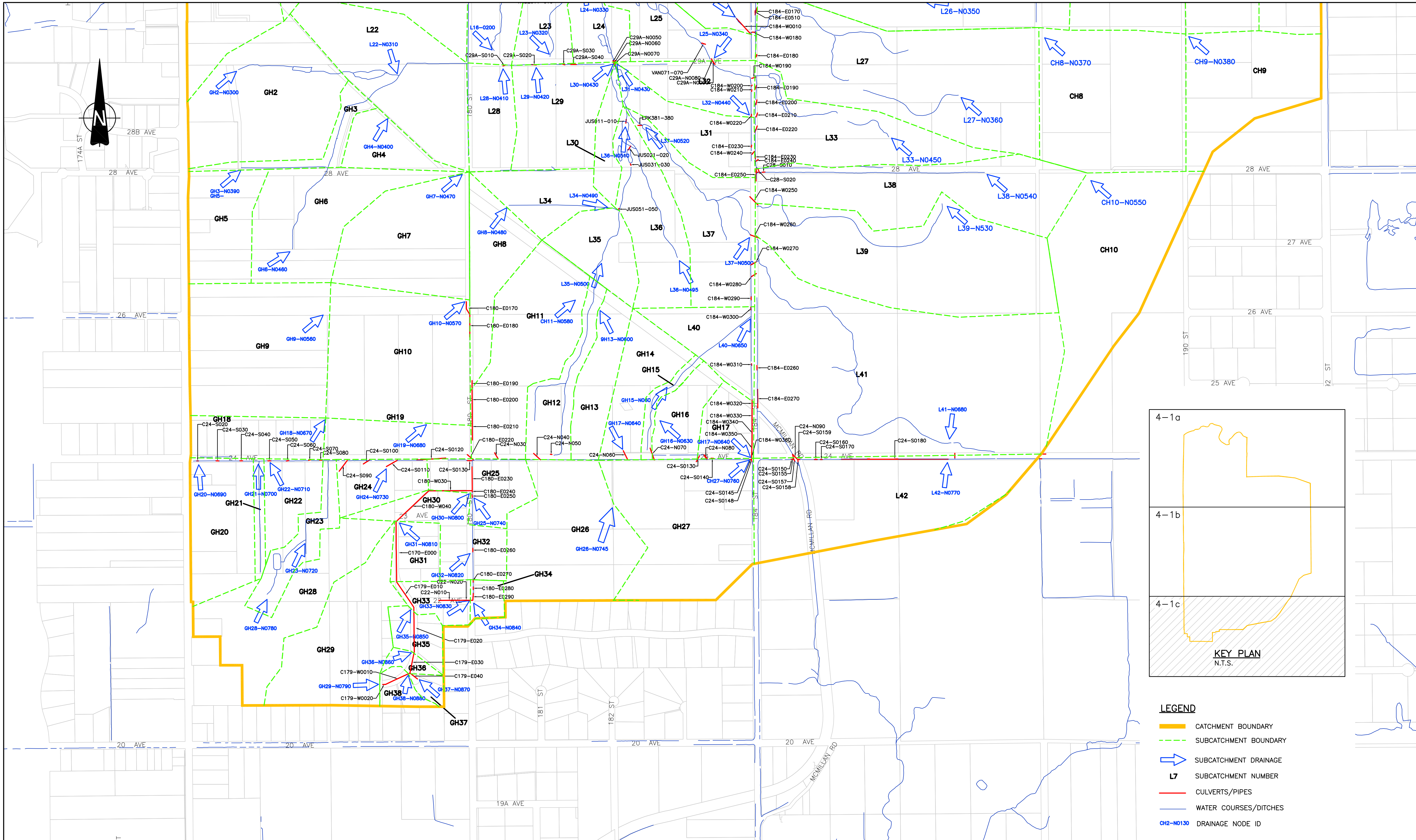

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TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN MODEL SCHEMATIC

SEAL

SCALE: HOR. 1:10000 VERT. 1:10000
DATE JAN. 2007
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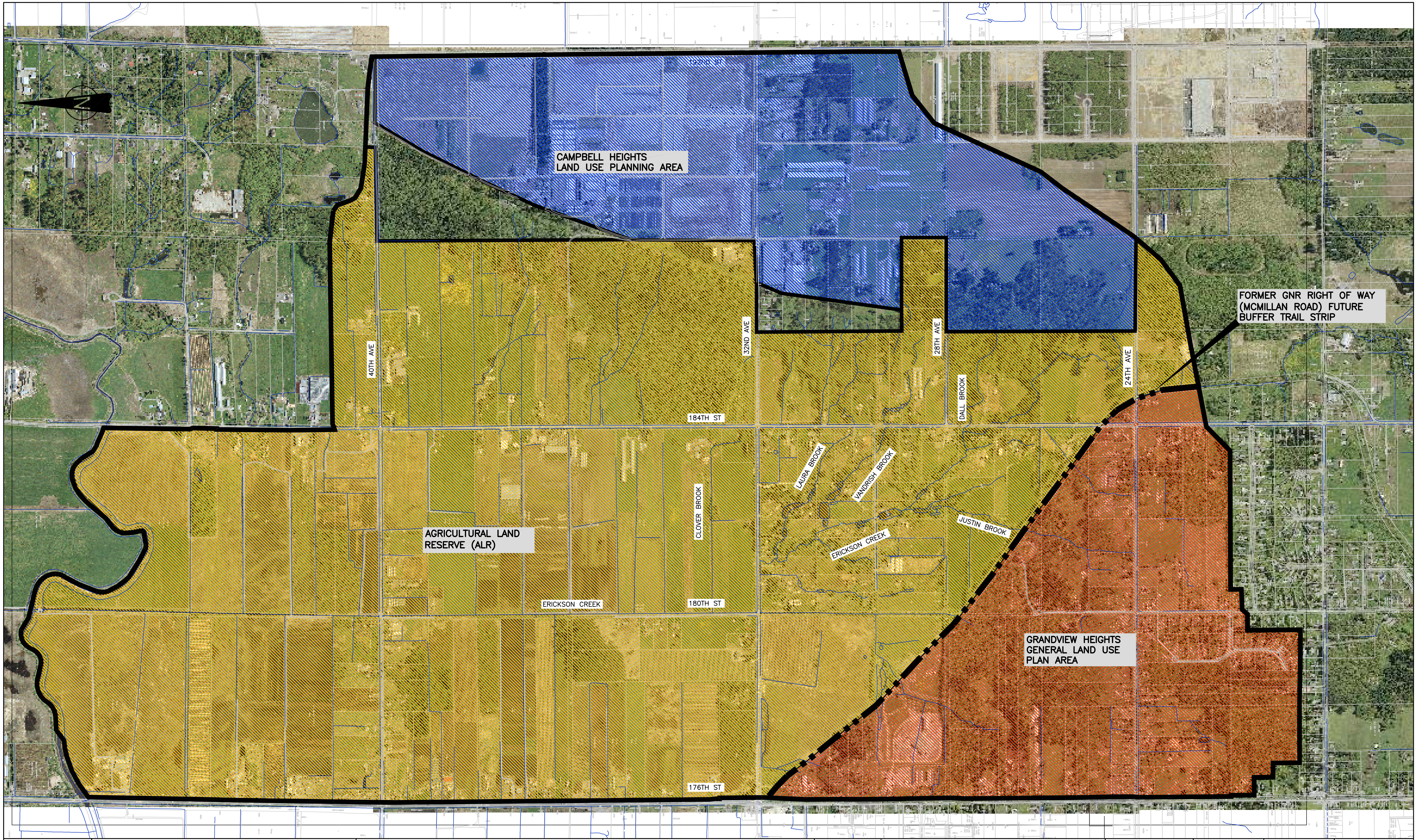
FIGURE 4–1c
SHEET OF
DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS
REVISION

F–87 PRODUCED BY CAD/CAM



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AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\FIGURE 4-2.DWG (GQ)
Xrefs: 2802R104(old), 2802R102, 2802R103

Associated Engineering

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SURREY
CITY OF PARKS

ENGINEERING
DEPARTMENT

BENCH MARK – S.M. #
ELEV.

TITLE

ERICKSON CREEK WATERSHED
GENERAL LAND USE PLANNING AREAS

SEAL

SCALE: HOR. 1:7500
VERT. 1:7500

DATE JAN. 2007

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FIGURE 4–2

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5 Assessment of Potential Impacts

In the previous section, we indicated that significant land-use changes are primarily confined to the upland areas of the watershed, in the Campbell and Grandview Heights Areas. Assessment of the potential impacts of development on the watershed can initially focus on flow hydrographs at locations where the drainage system discharges from the upland areas to the lowlands. Both peak flows and total runoff volumes are a concern.

In the upland areas, changes in the flow duration spectrum are of importance. These changes include increased peak flows and the duration for which high flows are maintained, of primary importance in determining the potential for erosion damage to the stream system. A second consideration is at the low end of the flow duration spectrum, where base flows are potentially reduced by development and the duration of low flow conditions may be increased. Assessment of flow duration impacts is contained in Section 8.

In the lowland drainage system, increased total runoff volumes may result in longer flooding durations when they interact with boundary condition constraints at the Nicomekl River. Potentially, ARDSA criteria (refer to Appendix E) governing duration of winter and summer flooding of agricultural lands may be violated, and agricultural productivity impacted. However, the previous lowland drainage study undertaken by UMA (UMA, 2002) included an allowance for upland development impacts, and identified lowland conveyance system upgrades to achieve compliance with ARDSA criteria.

Using the hydrologic model, we analyzed both existing and future conditions in the watershed. From these we are able to estimate the potential impacts on the watershed as a result of development, prior to the implementation of mitigative measures such as detention storage, LID and conveyance improvements. For our initial assessment of impacts we utilized a 48-hour synthetic storm to stress the drainage system. In Section 8, when confirming the appropriateness of various mitigation strategies, we will utilize the appropriate City of Surrey design storms for both urban areas and to confirm that ARDSA criteria are being met.

In Figures 5-1 to 5-11, we provide existing and future condition hydrographs for seven key locations at the upland and lowland interface in the watershed. The locations that these hydrographs correspond to are indicated on Figure 5-12. Peak flow rates, and total runoff volumes for both existing and post-development conditions are summarized in Table 5-1.

Table 5-1
Comparison of Pre- and Post-Development Runoff Volumes and Peak Flow Rates From Preliminary Hydrologic Analysis

	Runoff Volume (m^3)			Peak Flow Rate (m^3/s)		
Discharge Location	**Pre-development**	**Post-development**	**Ratio**	**Pre-development**	**Post-development**	**Ratio**
Campbell Heights						
CHD10	11700	27700	2.4	0.14	1.2	8.6
CHD20	17700	39600	1.7	0.76	1.0	1.3
CHD30	16600	38900	2.4	0.18	1.1	6.2
CHD40	10000	16100	1.6	0.10	0.12	1.2
CHD50	16400	41000	2.5	0.09	0.86	9.2
Weighted Average			2.1			
Grandview Heights						
GHD10	16800	17900	1.1	1.2	1.7	1.4
GHD20	18700	21200	1.1	1.0	1.9	1.9
GHD30	11400	13900	1.2	0.83	1.1	1.3
GHD40	4240	5050	1.2	0.34	0.44	1.3
GHD50	6960	13700	2.0	0.12	0.21	1.7
GHD60	23300	32000	1.4	0.31	0.34	1.1
Weighted Average			1.3			

Significant impacts are indicated in the runoff hydrographs for the five major discharges from the Campbell Heights area, plotted in Figures 5-1 to 5-5. Peak flows increase by factors of up to 9 depending on the particular originating sub-catchments. Total runoff volumes increase by factors of up to 2.5, with an overall increase from the Campbell Heights area by a factor or 2.12. These magnitudes of changes in runoff are due to the very high post-development EIA of the proposed commercial and light industrial developments in the area, in contrast to the low-runoff/high infiltration potential of existing conditions in this the area.

Without mitigation, the increased peak flow rates and extended duration of runoff from developed areas will destabilize creek channels, resulting in additional sediment accumulating in lowland drainage channels. The impact will be particularly severe on creeks that originate in the escarpment below Campbell Heights, where peak flow rates and total runoff increase significantly over current conditions.

Figures 5-6 to 5-11 present existing and post-development hydrographs for major discharges from the Grandview Heights area of the watershed. This area will primarily become urban residential developments, with associated institutional, neighbourhood commercial and green space land-use components included. Peak flow rates increase by up to 90% as a result of the change in land-use. However, total runoff volumes and the duration of flows also increase significantly, as apparent in the hydrographs and Table 5-1. Overall, total runoff volume from the Grandview Heights area increases by almost 30% over existing conditions.

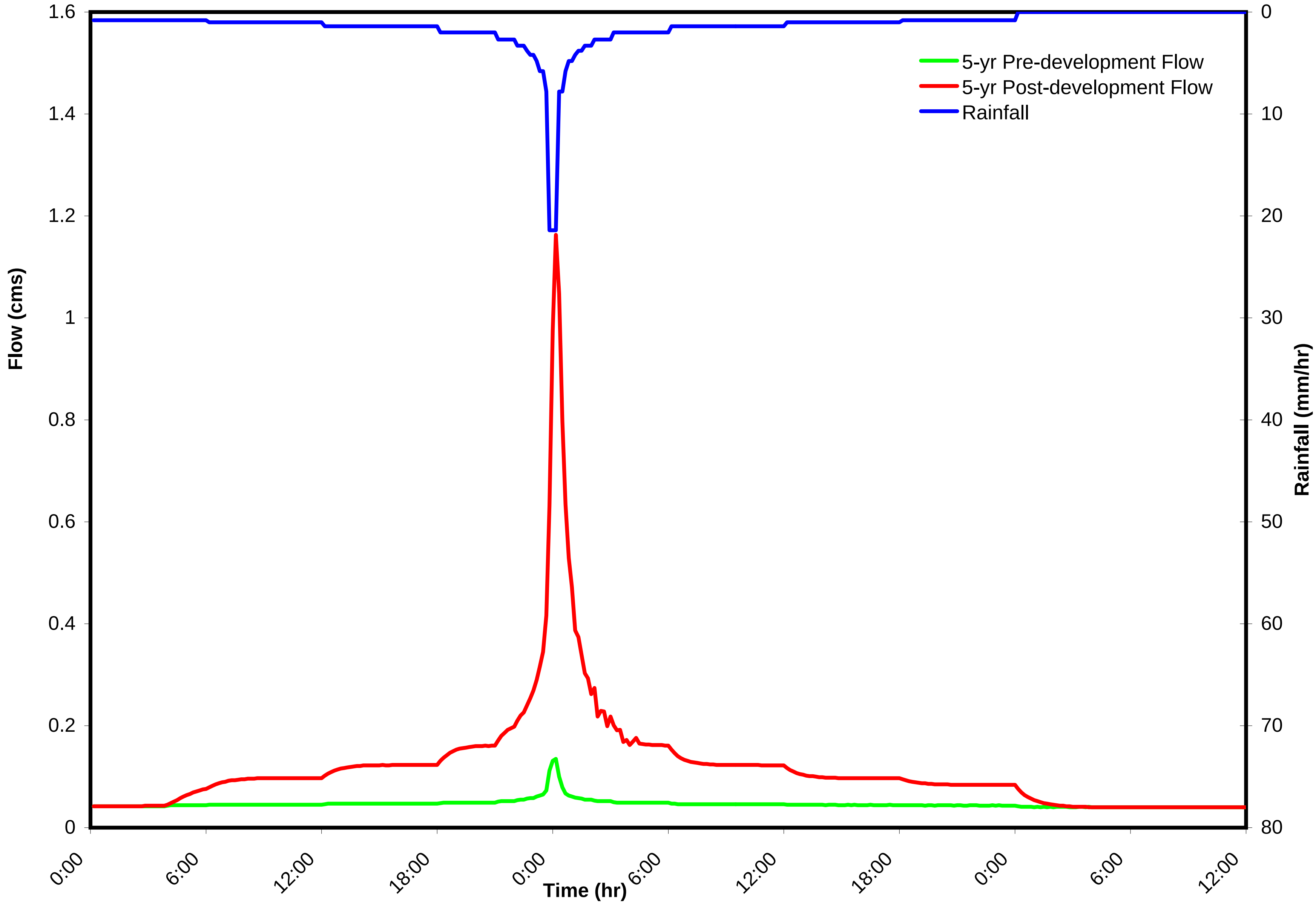

Figure 5-1
Existing and Post-Development Hydrographs for Discharge Location CHD10

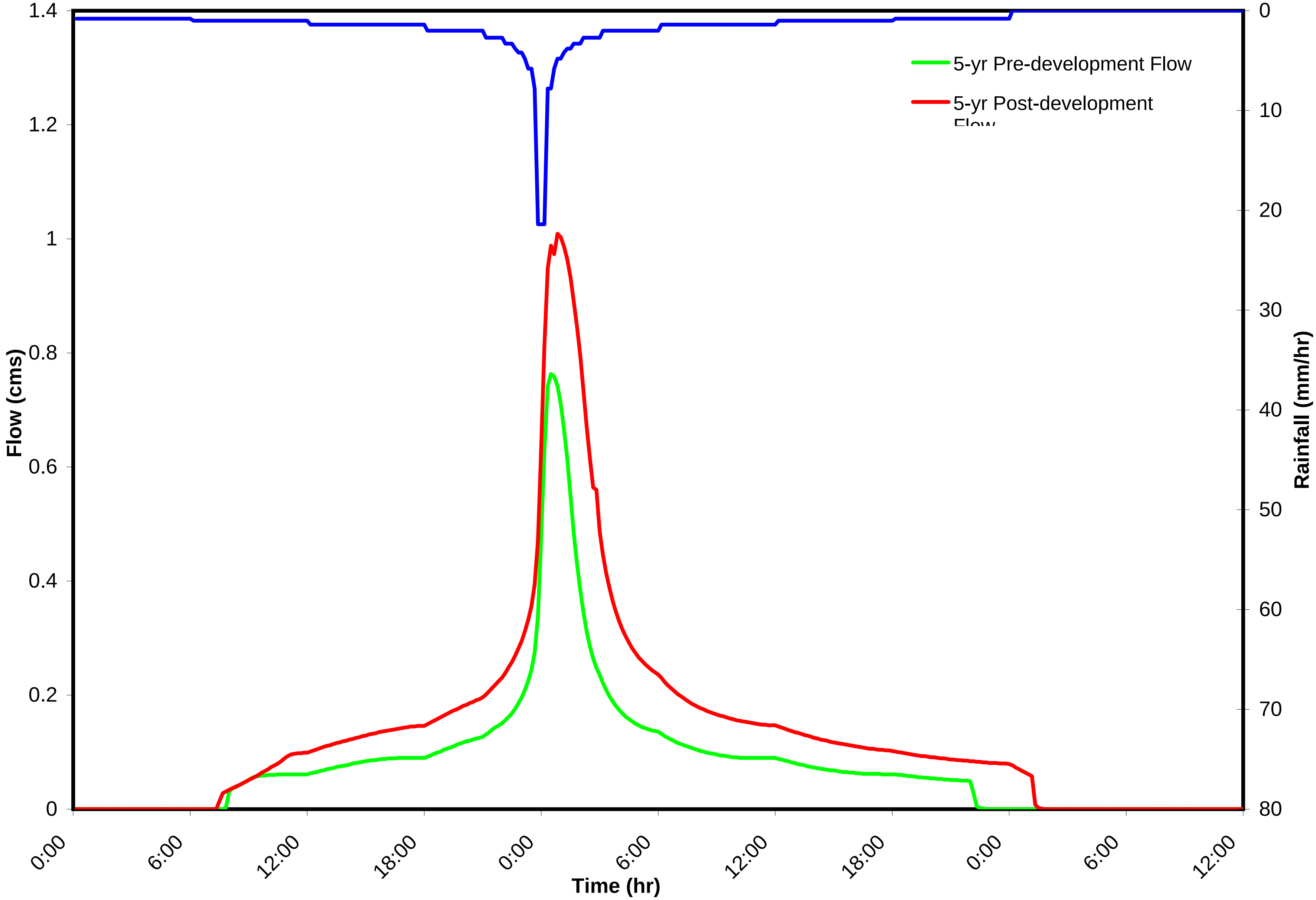

Figure 5-2
Existing and Post-Development Hydrographs for Discharge Location CHD20

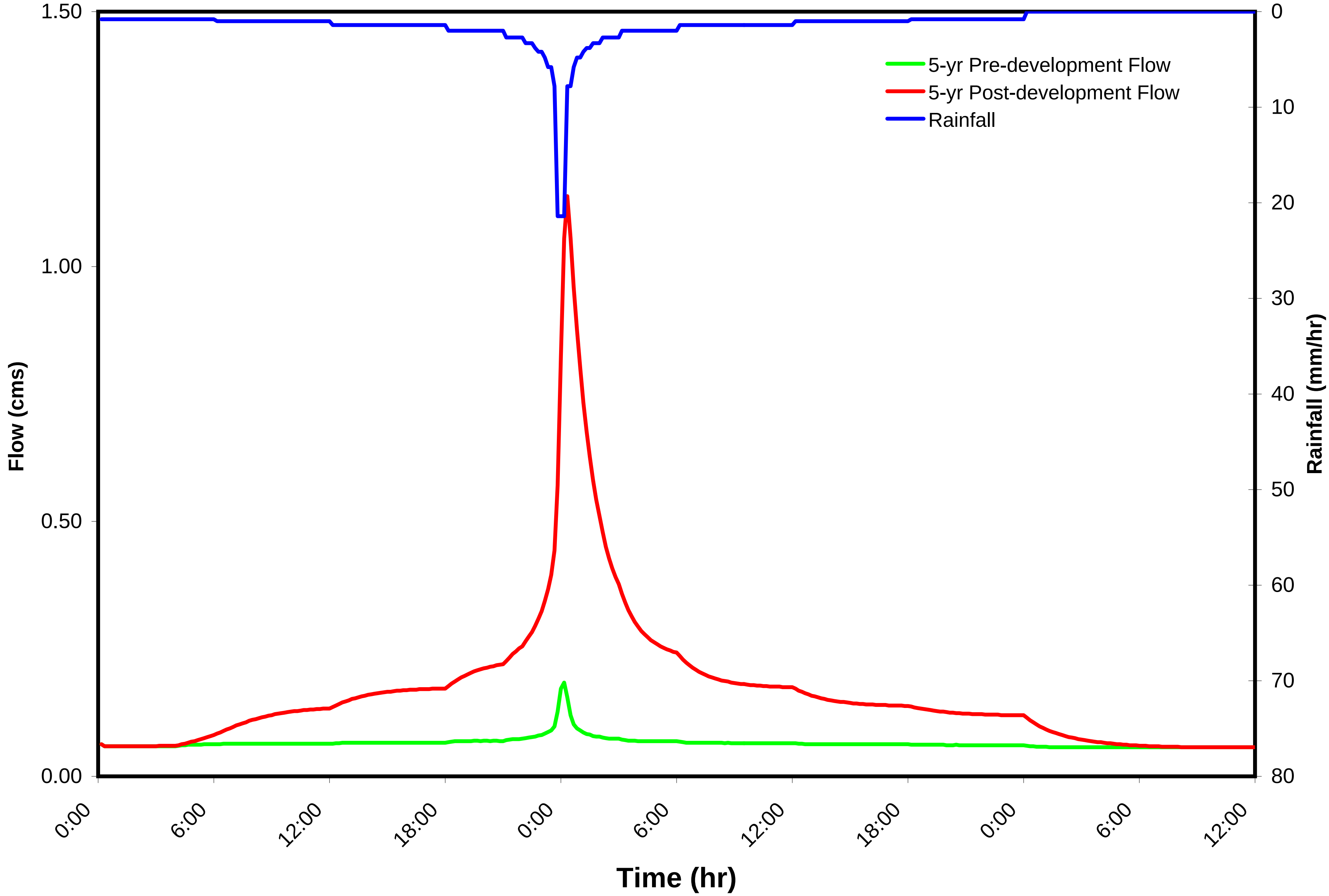

Figure 5-3
Existing and Post-Development Hydrographs for Discharge Location CHD30

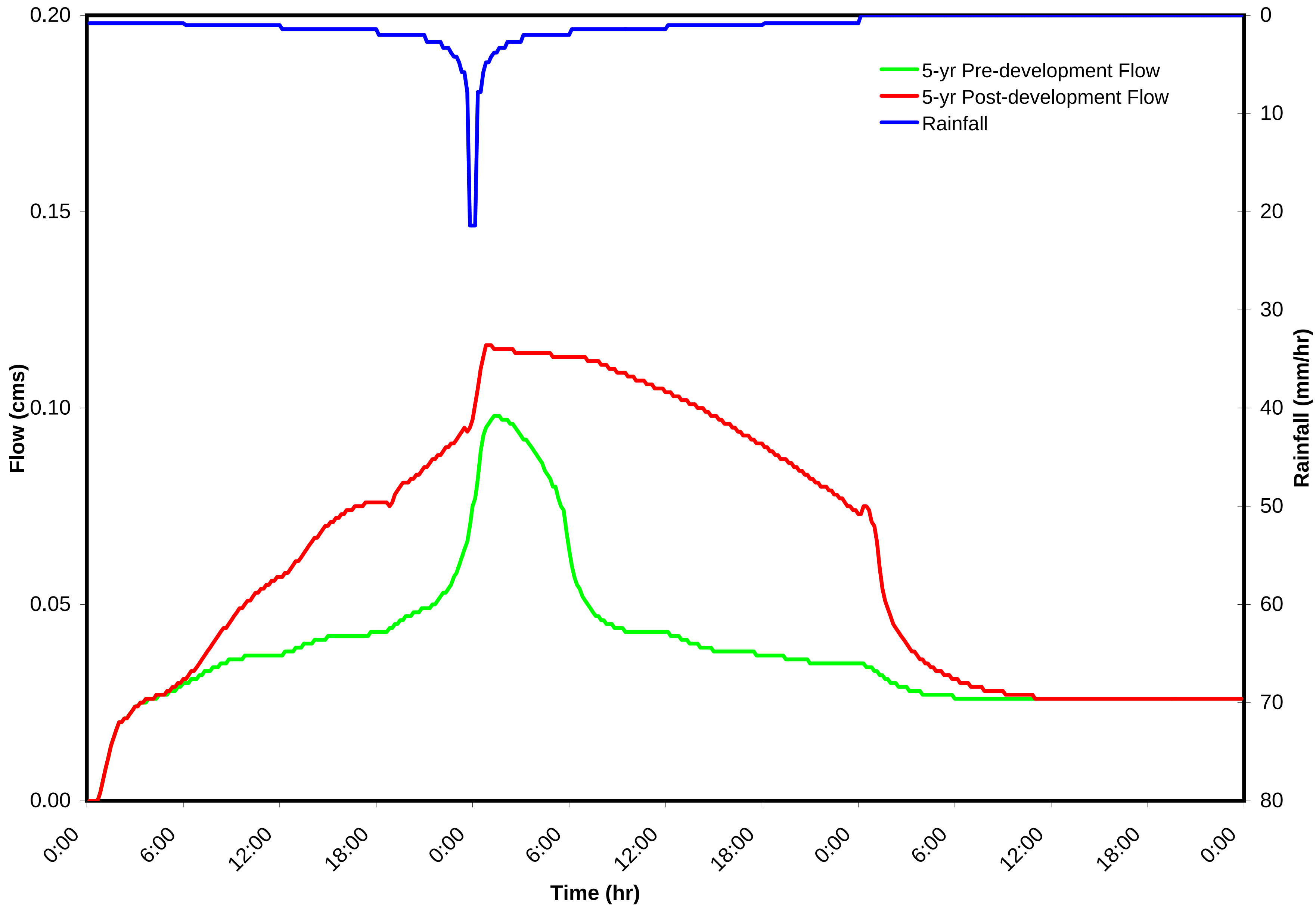

Figure 5-4
Existing and Post-Development Hydrographs for Discharge Location CHD40

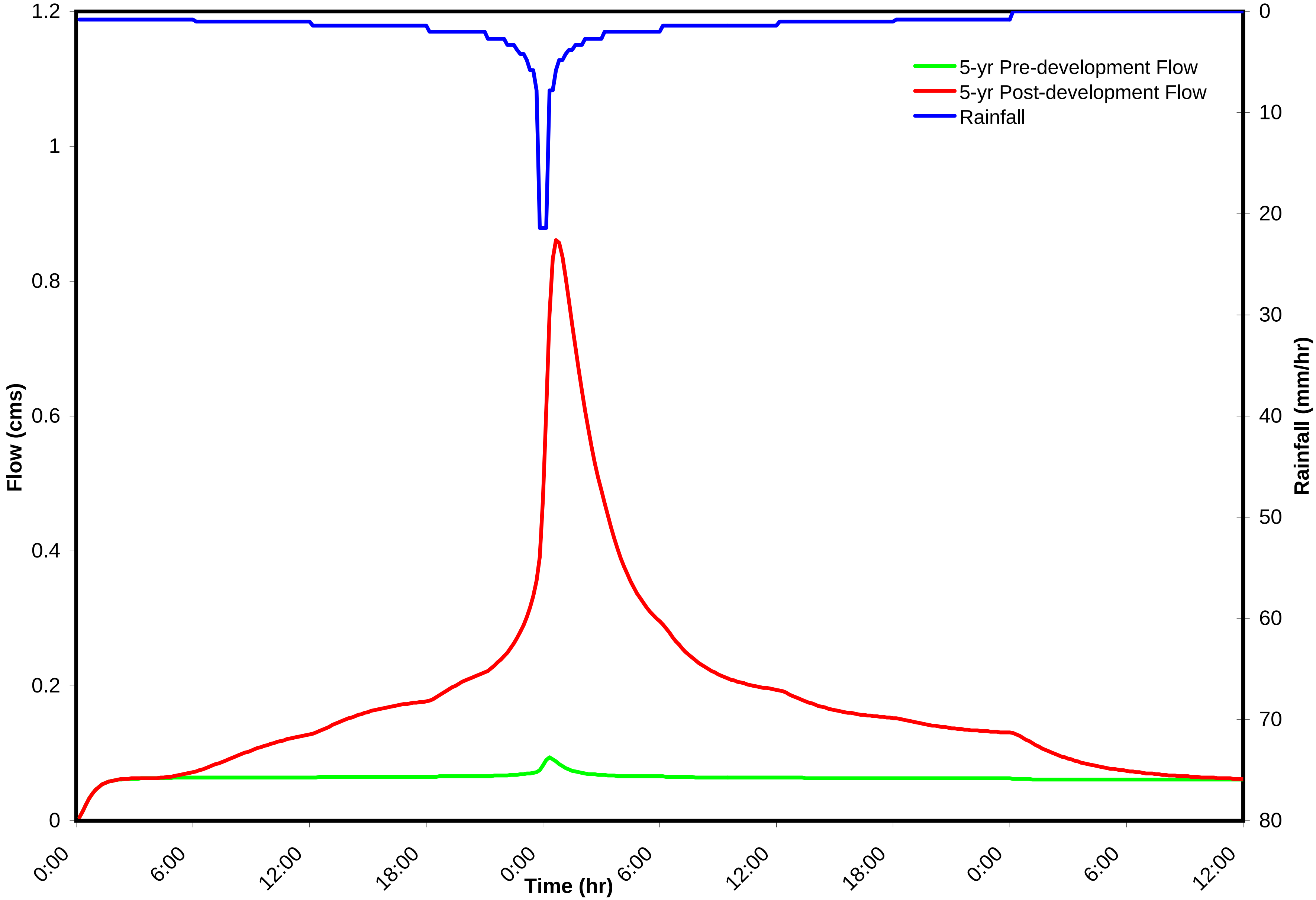

Figure 5-5
Existing and Post-Development Hydrographs for Discharge Location CHD50

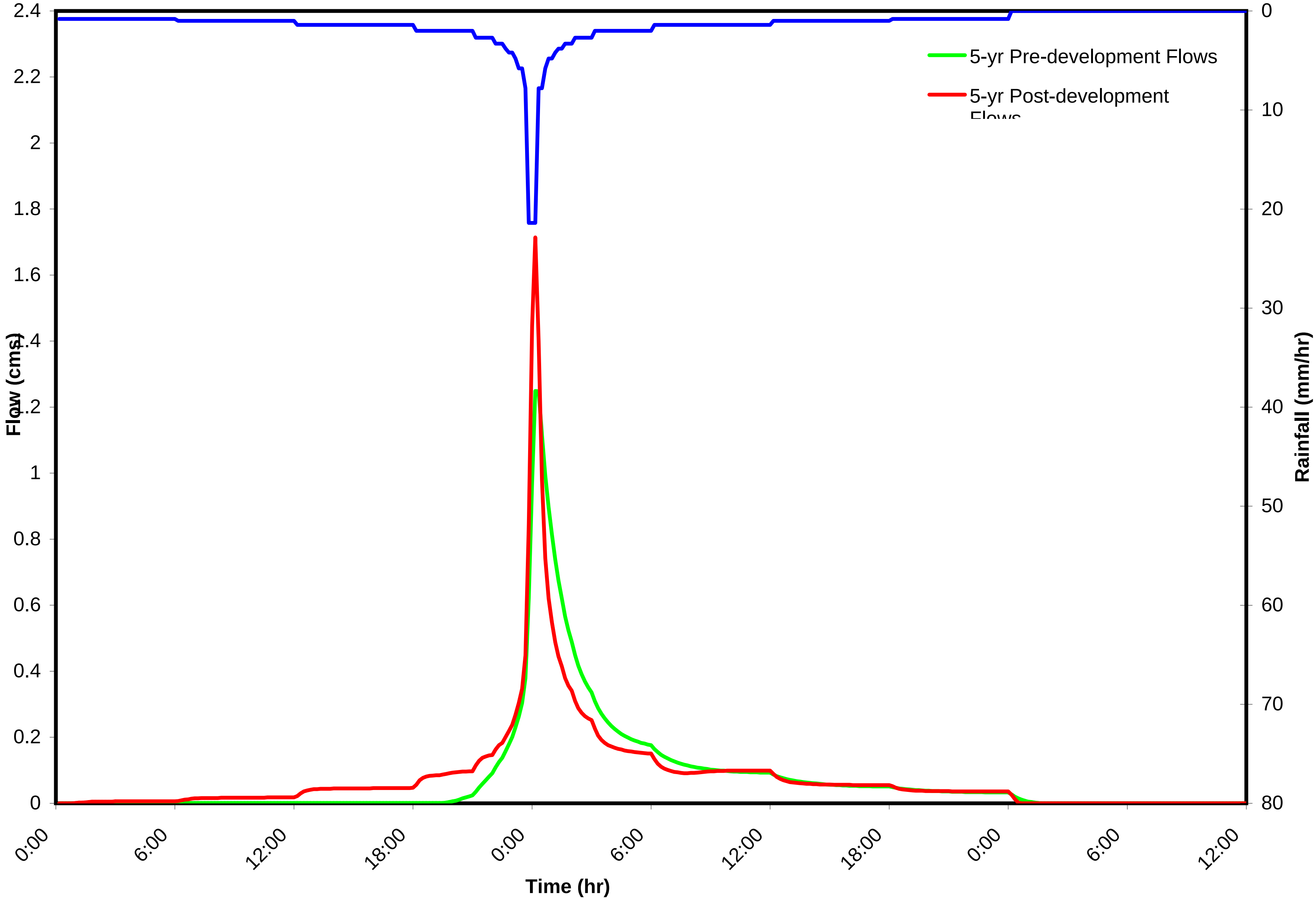

Figure 5-6
Existing and Post-Development Hydrographs for Discharge Location GHD10

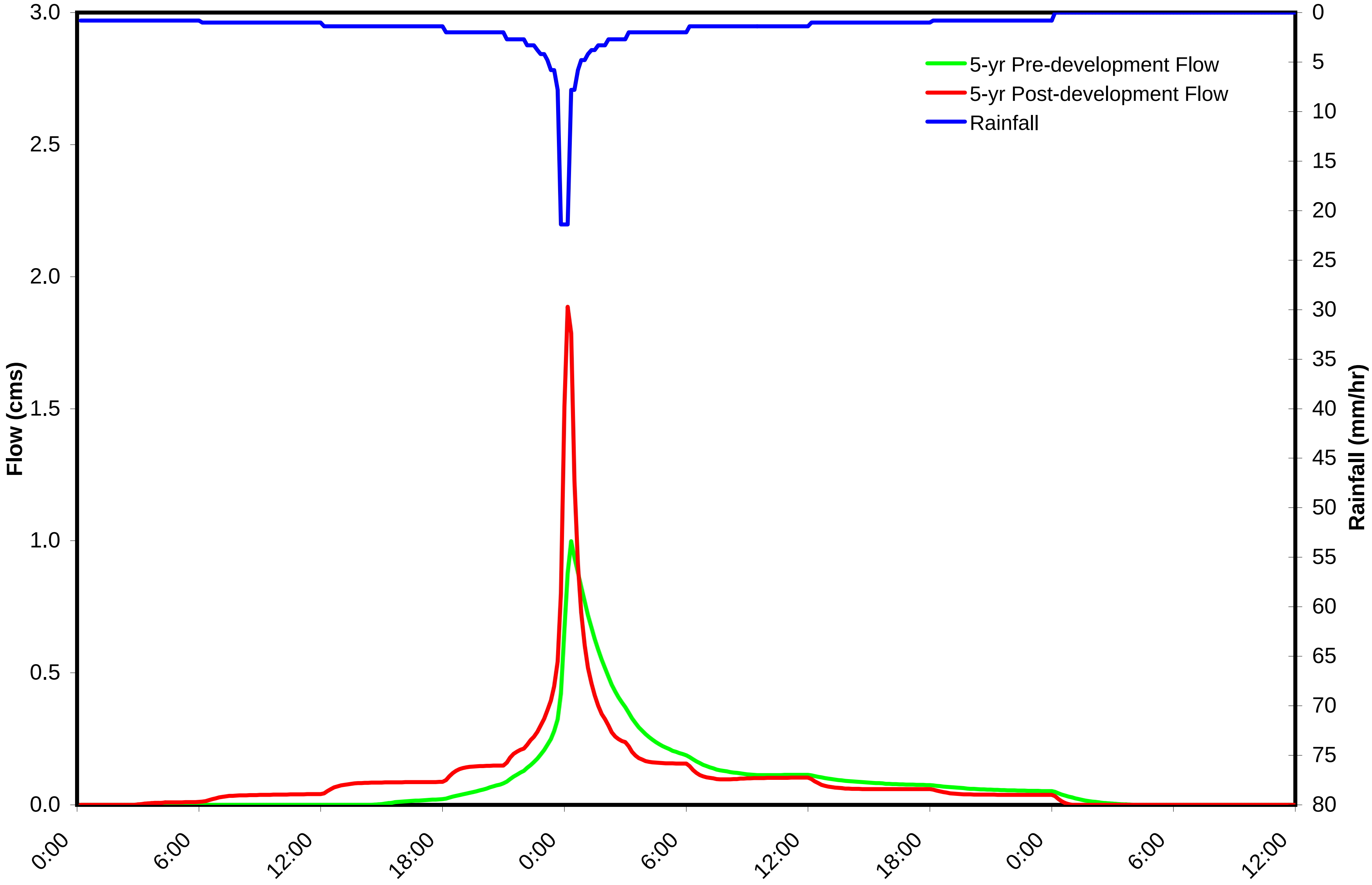

Figure 5-7
Existing and Post-Development Hydrographs for Discharge Location GHD20

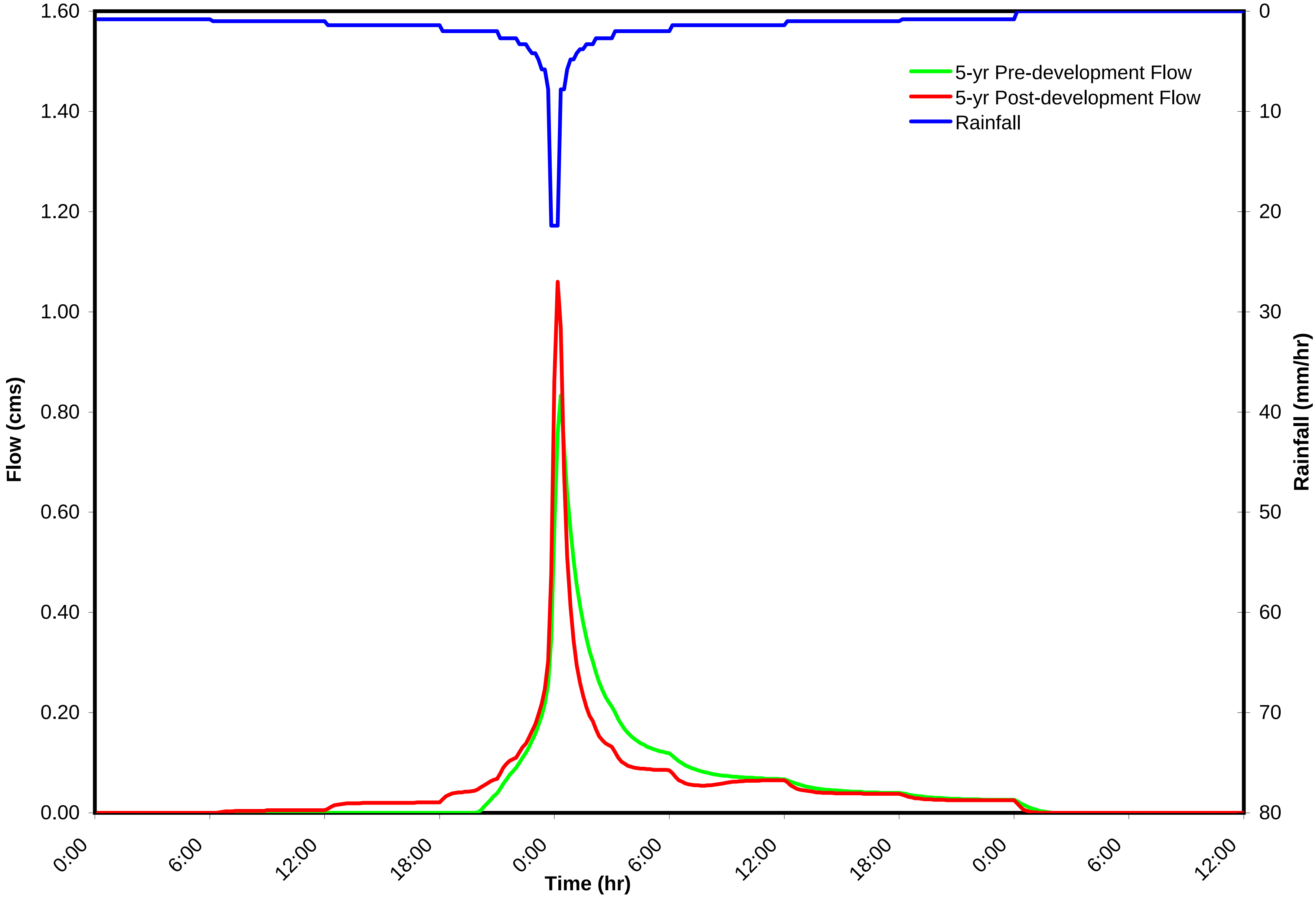

Figure 5-8
Existing and Post-Development Hydrographs for Discharge Location GHD30

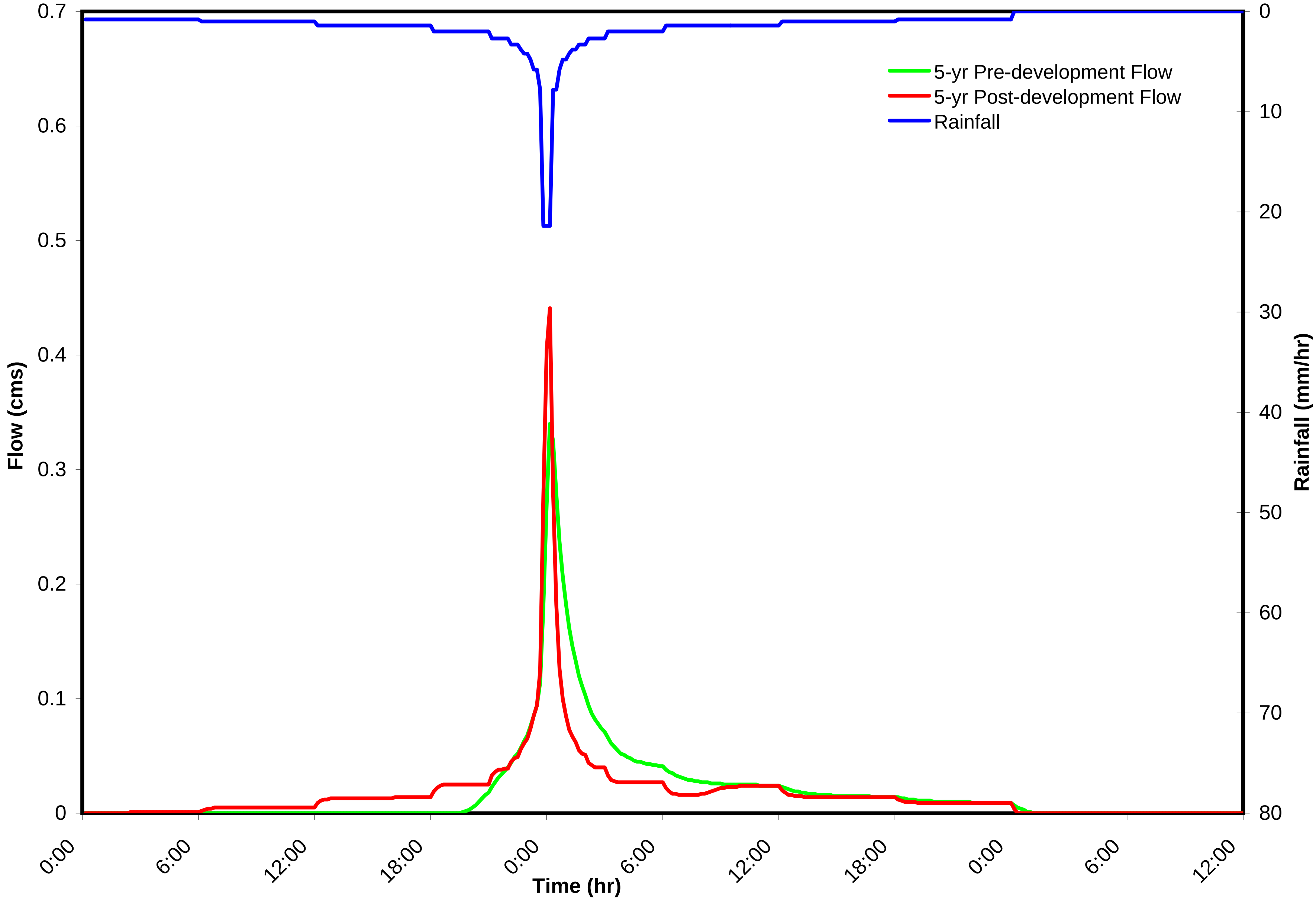

Figure 5-9
Existing and Post-Development Hydrographs for Discharge Location GHD40

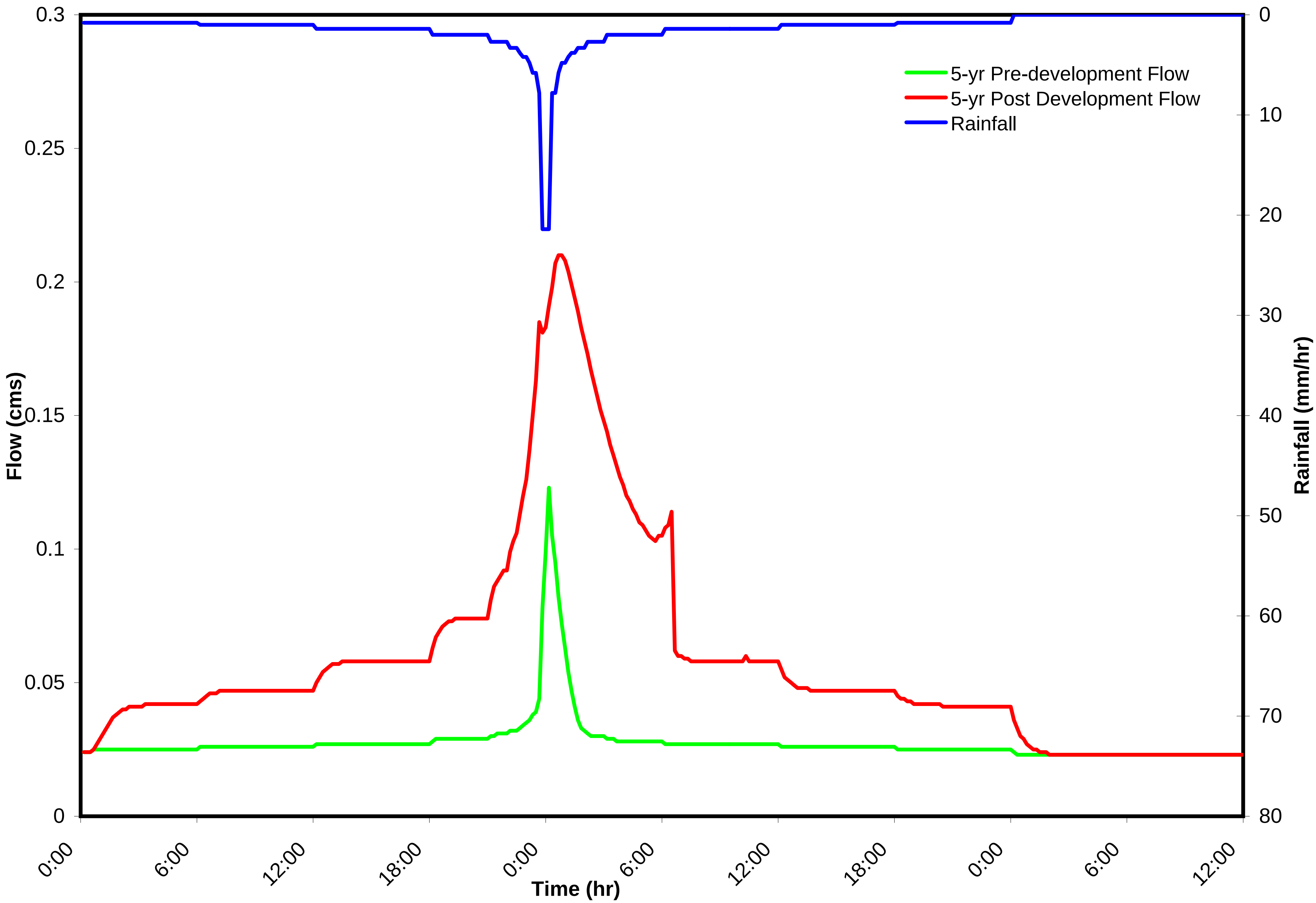

Figure 5-10
Existing and Post-Development Hydrographs for Discharge Location GHD50

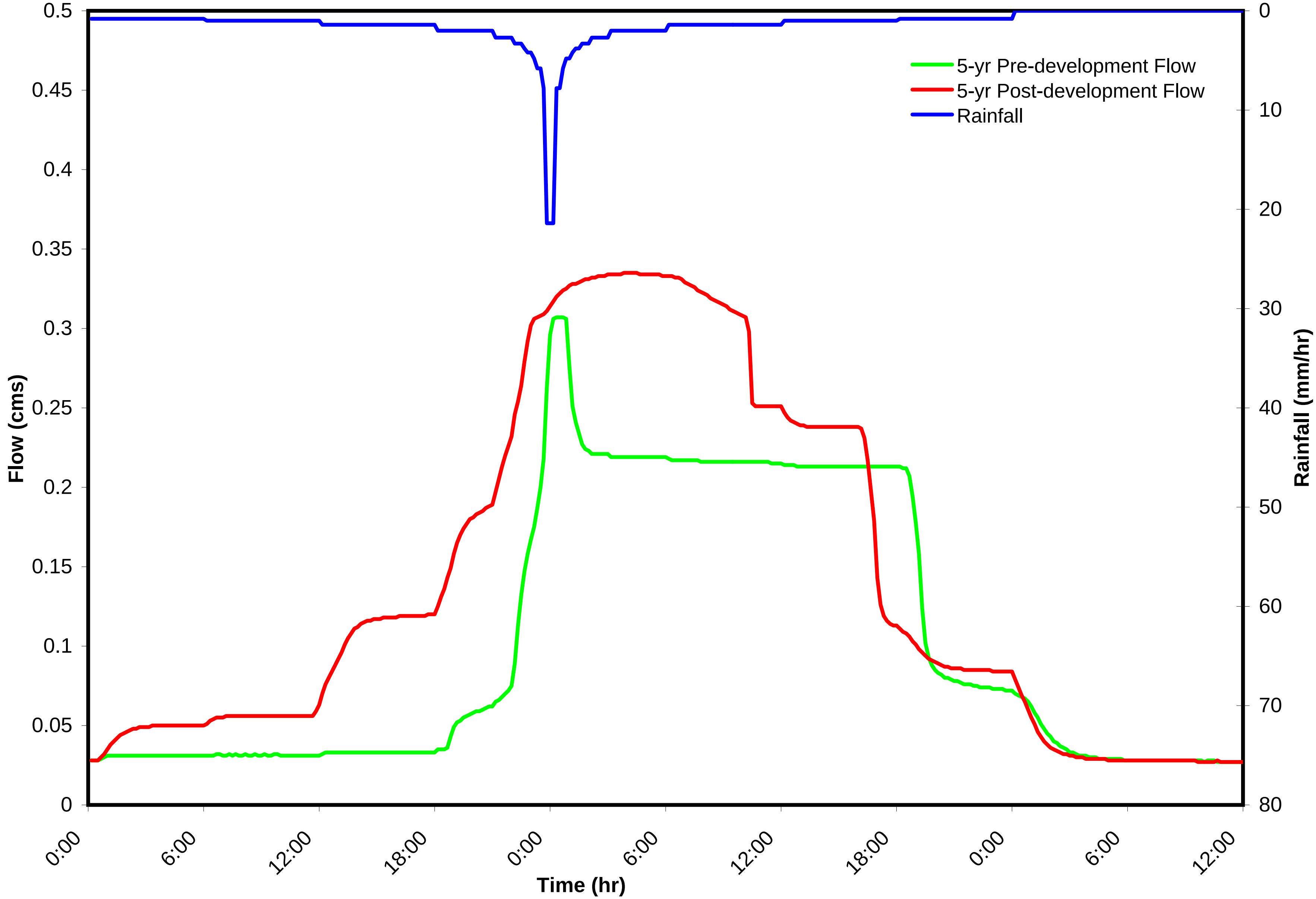

Figure 5-11
Existing and Post-Development Hydrographs for Discharge Location GHD60

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AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\JULY 02 DRAFT\FIGURE 5-12.DWG (GQ)
Xrefs: 2802R102, 2802R103

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SURREY
CITY OF PARKS

ENGINEERING DEPARTMENT

BENCH MARK – S.M. # ELEV.

SEAL

TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN HYDROGRAPH LOCATION

SCALE: HOR. 1:10000 VERT. 1:10000	DATE JAN. 2007	PROJECT NUMBER	
DRAWN G.Q. CHECKED	L.B.	DRAWING NUMBER FIGURE 5-12	
DESIGNED N.N. CHECKED	CONTRACT		
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APPROVED	DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS	REVISION	

6 Candidate BMPs

As discussed in previous sections, comprehensive development will occur in two distinct areas of the watershed, portions of Grandview Heights and Campbell Heights. Within each the form of development will be different, and will interact with significantly different surficial geology and near surface soils. As a result, we propose different approaches to manage rainfall volumes and control runoff for each development area.

6.1 CAMPBELL HEIGHTS LID

While this area is intended to host high value industrial, business and technology park developments that include significant landscaping, it will still represent a significant increase in TIA, to approximately 90%. To what degree this high TIA becomes EIA depends on the extent to which LID measures are able to be implemented in this area.

A portion of the Campbell Heights area, to the south and outside of the Erickson Creek Watershed is already undergoing development. It is our understanding that extensive infiltration based source controls have been implemented in developing this area. Anecdotal reports indicate the infiltration facilities seldom overflow and produce direct runoff (pers. comm. City Staff). This, combined with the infiltration capacities reported for the deep sands and gravels of the Sumas Drift sediments underlying this portion of the watershed, indicates that LID measures should be able to significantly reduce the EIA from the potential maximum indicated by the TIA.

The following candidate LID measures are proposed for the Campbell Heights portion of the watershed:

- Infiltration chambers receiving runoff from majority of impervious surfaces.
- Absorbent landscaping, including central medians in boulevards.
- Pervious pavers on light duty driveways, pathways and sidewalks.
- Grassed or vegetated buffer strips.
- Disconnection of impervious areas, sidewalks separated from curbs by buffer strips.
- Infiltration swales and galleries in buffer strips and property perimeters.
- Exfiltration pipes for in-road City drainage systems.

Also, we note that green roofs could be applied to the large structures proposed for the area to provide an additional layer or runoff reduction or to offset infiltration requirements, but this measure is not directly incorporated in our analysis.

To support the LID measures and minimize maintenance problems, the following measures should be implemented:

- Oil/water separators for runoff from large parking areas, to protect water quality.
- Sediment/grit settling for road and parking area runoff, to protect infiltration capacity and prevent sediment “blinding” by fines.

- Isolation of activities that may lead to significant contamination of stormwater, for example equipment maintenance areas and fuelling pads.

The majority of streams in the Erickson Creek watershed rise on the escarpment slopes below the Campbell Heights area. Infiltration of rainfall in the Campbell Heights area is likely crucial to maintaining base flows in Erickson Creek watershed. A reduction in groundwater recharge, as would result from high impervious areas that route runoff directly to the surface drainage system, would severely reduce base flows in the streams.

To provide a qualitative analysis, we employed the WBM to assess the Campbell Heights area WBM. We simulated existing conditions, future conditions without LID, and future conditions with LID. Our future conditions with LID assumed that the majority of impervious surfaces route runoff to infiltration facilities modelled as infiltration swales with underdrains or decants. These results are presented in Figure 6-1.

Under existing conditions, direct runoff accounts for approximately 17% of the annual rainfall, with 55% infiltrating and 28% dissipated by interception and evapotranspiration. Unmitigated future conditions result in direct runoff increasing to 77% of annual rainfall with infiltration and evapotranspiration reduced to 14% and 9% respectively. This high level of direct runoff would result in significant erosion damage to the creek system, increased peak flows and flooding, and reduced base flows. The conceptual LID scenario essentially mimics current conditions with 15% direct runoff. However, less evapotranspiration occurs, 17%, with infiltration, favoured by the modelled LID measures, increasing to 68%.

By comparison, under assumed forested pre-development conditions, only an estimated 6% of the annual rainfall volume becomes direct runoff, with 33% dissipated by evapotranspiration and 59% infiltrating.

6.2 CAMPBELL HEIGHTS CONVENTIONAL BMPS

In the Campbell Heights area the intent is to maximize infiltration of stormwater into the underlying permeable soils. However, the WBM conceptual analysis indicates that approximately 15% of the annual rainfall volume could become direct runoff.

Provisionally, peak flows associated with the small degree of direct runoff could be attenuated and controlled using detention ponds or constructed wetlands. However, given the experiences in other parts of Campbell Heights and based on more detailed hydro-geological investigation, it may be possible to infiltrate rainfall from a larger proportion of the annual rainfall volume. Then only a portion of very large storm events would be discharged to the drainage system, and attenuation may not be required.

As previously discussed, oil/water separators and sediment removal should be implemented to protect infiltration facilities from blinding, and to reduce the likelihood of groundwater contamination arising from infiltration of stormwater.

6.3 GRANDVIEW HEIGHTS LID

In the south/southwest corner of the watershed, the primary land-use advanced by the Grandview Heights General Land Use Plan involves urban residential development. As discussed in Jacques Whitford's Preliminary Hydrogeology Assessment, contained in Appendix B, the Grandview Heights area has two main underlying soil types. Jacques Whitford indicates that both the Vashon Drift and Capilano Sediments have very low infiltration capacities (hydraulic conductivities), with a median value of 1 X 10^{-8} m/s (0.036 mm/hr) suggested for both. These surficial soils vary between 1 and 5 m in depth with fairly impermeable soils underneath. As a result the area is subject to lateral or telluric seepage, with little or no deep groundwater recharge potential. These soil conditions limit the extent to which infiltration based LID measures can be applied to manage the annual rainfall volume.

Using the water balance model (WBM), we investigated several concepts for managing rainfall volume for urban residential development on both soils types. We assessed existing conditions as a baseline, future conditions without any LID and future conditions with implementation of LID measures. Refer to Figure 6-2 for the water balance results in the Grandview Heights area.

Our existing condition WBM analysis assumed that an average of 35% of the modelled catchment has intact forest canopy on an absorbent organic soil layer. Disturbed areas account for the remainder of the catchment, including 37% grass lands, 14% other types of vegetation and a TIA of 14% representing roads, driveways and buildings. Our assumed hydraulic conductivity for the underlying soils was 0.05 mm/hr.

Based on our interpretation of current conditions in this area, the WBM estimates that approximately 15% of the rainfall volume is able to infiltrate, as an average over the area, and nearly 56% is dissipated by interception and evapotranspiration. The remaining 29% produces direct runoff. These results reflect the current, dispersed and lightly developed conditions over most of this part of the watershed, however soil conditions and the reduced forest cover result in relatively high runoff rates.

As only 15% of the long term rainfall volume is able to infiltrate, as compared to 56% dispersed by interception and evapotranspiration, it is apparent that the existing vegetative cover is particularly important for the current hydrologic state of the watershed. By extension, significant removal of the remaining vegetation will result in a substantial increase in runoff that is unlikely to be successfully mitigated by promotion of infiltration, given that the soil conditions do not appear conducive to receiving increased water volumes.

We developed an illustrative future condition scenario assuming the following distribution of impervious surfaces within the urban residential developments (note that this does not include specifically designated commercial, institutional and park areas):

Urban residential lot accounting for 75% of land area, and configured as:

- Impervious roof surface 45% of urban residential lot.
- Driveways, patios and pathways 15% of urban residential lot.

- Lawns or gardens on the remaining 40% of urban residential lot.

The City of Surrey's existing single family urban zoning types incorporate limits on impervious lot coverage varying between 40% and 50%. These zoning types include: RF (40%), RF-SS (40%), RF-G (45%), and RF-12 (50%). Three single family zoning types have allowable impervious lot cover exceeding 50%, RF-9, RF-9C and RF-12C, where impervious cover can be up to 60% of the lot depending on total lot size and configuration. The future development lot scenario described above has a total impervious area of 60%, greater than most City of Surrey single family zoning types except for some RF-9, RF-9C, and RF-12C.

However, a review of actual developments in the City by McElhanney Consulting ("Review of Runoff Coefficients, McElhanney Consulting Services Ltd., 2002) indicates that impervious lot coverage often exceeds nominal limits as set forth in the City's zoning standards. Some RF zoned areas have lot coverage exceeding the nominal limits by up to 8%. The same report indicates similar occurrences in multi-family housing types and commercial developments.

Therefore, a higher than allowed impervious lot coverage may better represent future development conditions in the Grandview Heights area, in the absence of stricter enforcement of impervious coverage limits by the City. Higher than allowed impervious lot coverage can be expected to partially or completely negate many of the benefits achieved by implementing LID measures to mimic current hydrological conditions.

In addition to the residential lot land-use, our WBM analysis included residential streets and roadways accounting for 15% of land area in our representative unit area:

- 70% impervious coverage for roadway and sidewalk;
- 30% pervious shoulder, grassed areas.

The remaining 10% of land area was assumed to be forest and riparian buffer zones, and all was assumed to be pervious and vegetated. Our modelled estimates include allowances for riparian corridors and green spaces (as indicated in Table 6-1).

Under future development conditions, without LID measures, the WBM indicates that approximately 8% of the rainfall volume infiltrates and 20 % is dissipated through interception and evapotranspiration. Direct runoff increases to nearly 70% of the rainfall volume. The increased proportion of runoff, to 72%, reflects the expected increase in EIA, and reduced tree cover in the future urban residential areas. Notably, the greatest proportion in the increase in runoff is shifted away from evapotranspiration, which is down from 56% under existing conditions to 20% under the hypothetical future development conditions. This reinforces the supposition that vegetative cover is more effective at maintaining hydrologic conditions than is infiltration.

We identified several LID measures that appear appropriate given the soil conditions and proposed development. Given the soils limitations, and application to urban residential development, the candidate measures favour vegetation based approaches:

- Absorbent landscaping and lawns with 300 mm organic soil depth.
- Sidewalks separated from roads by buffer strips.
- Roadways and sidewalks draining to vegetated infiltration swales via curb cuts or other means.
- Building roofs draining to absorbent landscaping and rain gardens with underdrains.
- Retention and enhancement of natural vegetated areas, particularly forest cover.
- Minimize use of buried and piped stormwater conveyance in favour of well maintained vegetated ditches.
- Centralized rain gardens in multifamily housing.
- Pervious paving on paths and driveways, underlain with 300 mm coarse pervious material.

On residential lots, our LID analysis (LID Scenario 1) using the WBM model provided for 100% of the impervious roof surface being routed to an onsite infiltration facility. We also assumed that 33% of the impervious paving would be converted to pervious pavers with the remaining 67% also routed to the onsite infiltration facility. Of the assumed 40% of a residential lot occupied by “conventional” lawn area, 40% now becomes absorbent landscaping with an assumed 300 mm absorbent organic soil depth, with 60% remaining conventional lawn. However, the onsite infiltration facility would occupy a portion of the remaining lawn area. This scenario represents a significant level of LID implementation on a residential lot. Table 6-1 summarizes the distribution of surface area for a nominal 1 ha (10,000 m^2) “unit catchment” area.

Table 6-1
LID Scenario 1 Assumed Surface Conditions and LID measures in Grandview Heights Urban Residential Developments

<table>
<tr><th></th><th></th><th>Area</th><th colspan="3">Surface Sub-Area</th><th>% Routed</th><th>LID Measure</th><th>Area</th></tr>
<tr><td>Forest Buffer</td><td>10%</td><td>1000 m^2</td><td>Forest</td><td>100%</td><td>1000 m^2</td><td colspan="3">None Required</td></tr>
<tr><td rowspan="2">Road/Street</td><td rowspan="2">15%</td><td rowspan="2">1500 m^2</td><td>Paving</td><td>70%</td><td>1050 m^2</td><td rowspan="2">100%</td><td rowspan="2">Infiltration Swale</td><td rowspan="2">225 m^2</td></tr>
<tr><td>Grass</td><td>30%</td><td>450 m^2</td></tr>
<tr><td rowspan="4">Urban Residential</td><td rowspan="4">75%</td><td rowspan="4">7500 m^2</td><td>Roof</td><td>45%</td><td>3375 m^2</td><td>100%</td><td rowspan="2">Infiltration Facility[1]</td><td rowspan="2">750 m^2</td></tr>
<tr><td rowspan="2">Paving</td><td rowspan="2">15%</td><td rowspan="2">1125 m^2</td><td>67%</td></tr>
<tr><td>33%</td><td>Pervious Paving</td><td>371 m^2</td></tr>
<tr><td>Lawn/Landscaping</td><td>40%</td><td>3000 m^2</td><td>40%</td><td>Absorbent Landscaping</td><td>1200 m^2</td></tr>
</table>

Note:
[1]Common infiltration facility for roof and paved surfaces.

Our WBM analysis assumed performance consistent with older (degraded) facilities, available as a performance option within the WBM. These features will be most successful where the Capilano Sediments are deeper, and will tend to saturate and produce runoff more readily in Vashon Drift sediments.

The WBM results for this combination of LID measures (Figure 6-2) indicate that direct runoff can be controlled to approximately 39% of long term rainfall volume, but does not achieve the same proportion of runoff as existing conditions. However, an additional 24% occurs as underflow from the assumed infiltration facilities, and is therefore not truly infiltrated or dispersed, though some degree of attenuation is achieved. Under this particular LID scenario, evapotranspiration increases to 27%, with true infiltration increasing by only 2% to 10%. Given these results for our assumed density (EIA) of development and uncertainty regarding the long-term performance of some LID measures, it is not realistic to attempt to control runoff to existing conditions using infiltration based approaches.

The above conceptual results indicate that it will not be possible to achieve current runoff conditions through the application of source control strategies alone, if overall TIA/EIA is not limited. We revised our WBM analysis with a greater proportion of forest cover retained (now 20%), and with overall TIA reduced to 40% (LID scenario 2, Table 6-2). Impervious road coverage was reduced, and the residential infiltration facility was now assumed to be a combination infiltration facility and rain garden. Under this configuration, direct runoff reduced to 22%, but underflow remained at 24%. Evapotranspiration approached 40% and infiltration increased to 13%. These results are a significant improvement and suggest that upper limits on TIA/EIA with retention of the maximum proportion of existing vegetation possible will be the most feasible way to retain the existing hydrologic regime.

Table 6-2
LID Scenario 2 Assumed Surface Conditions and LID measures in Grandview Heights Urban Residential Developments

		Area	Surface Sub-Area			% Routed	LID Measure	Area
Forest Buffer	20%	2000 m^2	Forest	100%	2000 m^2	None Required		
Road/Street	15%	1500 m^2	Paving	50%	750 m^2	100%	Infiltration Swale	375 m^2
			Grass	50%	750 m^2			
Urban Residential	65%	6500 m^2	Roof	38%	2470 m^2	100%	Rain Garden/Infiltration Facility[1]	650 m^2
			Paving	12%	780 m^2	66%		
						33%	Pervious Paving	257 m^2
			Lawn/Landscaping	50%	3250 m^2	60%	Absorbent Landscaping	1950 m^2

Note:
[1]Common infiltration facility for roof and paved surfaces.

Retention of a higher proportion of existing vegetation, particularly forest canopy, will help to boost evapotranspiration. Further implementation of vegetated landscaping will help to reduce underflow from the infiltration facilities and rain gardens. However, without an exhaustive analysis of all possible combinations of source controls and development patterns, it appears that the maximum watershed TIA for which existing hydrological conditions can be maintained is approximately 40%.

Given the above results, and the current state of the Grandview Heights area, it is unlikely that LID strategies could be identified that would achieve the idealized target of 10% runoff identified by the GVRD ISMP Template (GVRD, 2005).

We did not carryout a parallel WBM analysis for the commercial node proposed for the north east corner of 24th Avenue and 176th Street. Absorbent landscaping and pervious pavers can be applied to a commercial development and can achieve a significant degree of runoff reduction. We are aware of local applications where pervious pavers were combined with a coarse gravel subgrade to provide a large underground storage and infiltration facility that receives flow from both the parking surface and adjacent commercial buildings. This appears to be a successful application and similar approaches could be applied in the commercial node. Proprietary systems are also available that can achieve the same aims.

We note that the Capilano and Vashon Drift soils exist in surficial layers of varying thickness, and are confined by underlying soils that are essentially impervious, as reported in the Preliminary Hydrogeology Assessment. These conditions create a Telluric or lateral seepage pattern where groundwater moves downgrade roughly parallel to the ground surface. As a result, retention times in these soils are relatively short, with groundwater discharging to the drainage network quickly. This situation may be aggravated as a result of development activities such as site grading and excavation of utility trenches and road cuts that will tend to short circuit groundwater movement. However, these impacts are difficult to quantify. Development activities should attempt to preserve as much of the surficial soil layers as possible, and maintain downgrade connectivity.

We anticipate that all LID measures would be provided with fail-safe overflows or decants that would route excess flow to the drainage network. These features are required to address saturated soil conditions that could arise during sustained wet weather and/or large events leading to nuisance conditions and/or property damage.

6.4 GRANDVIEW HEIGHTS CONVENTIONAL BMPS

As discussed in the previous section, several LID measures appear promising for the Grandview Heights area to reduce direct runoff, particularly for small frequently occurring storms. However, under sustained wet weather and during large events, the majority of rainfall will become surface runoff. Management of peak flows during larger events will require implementation of conventional structural BMPs.

We expect that the conventional, community based BMPs that will be applied in the Grandview Heights area will be:

- Detention ponds
- Constructed wetlands or wet ponds
- Underground storage in commercial areas

Water quality BMPs such as grit chambers and oil water separators may be applied in relation to concentrated sources of contaminants, such as commercial parking lots, service stations or parking facilities related to high density multi-family developments. In single-family residential areas most contaminants will be too diffuse for these measures to be effective. Also, LID measures that redirect road and impervious surface runoff will assist in addressing first flush issues. Downstream wetlands and wet ponds will also play a role in improving water quality.

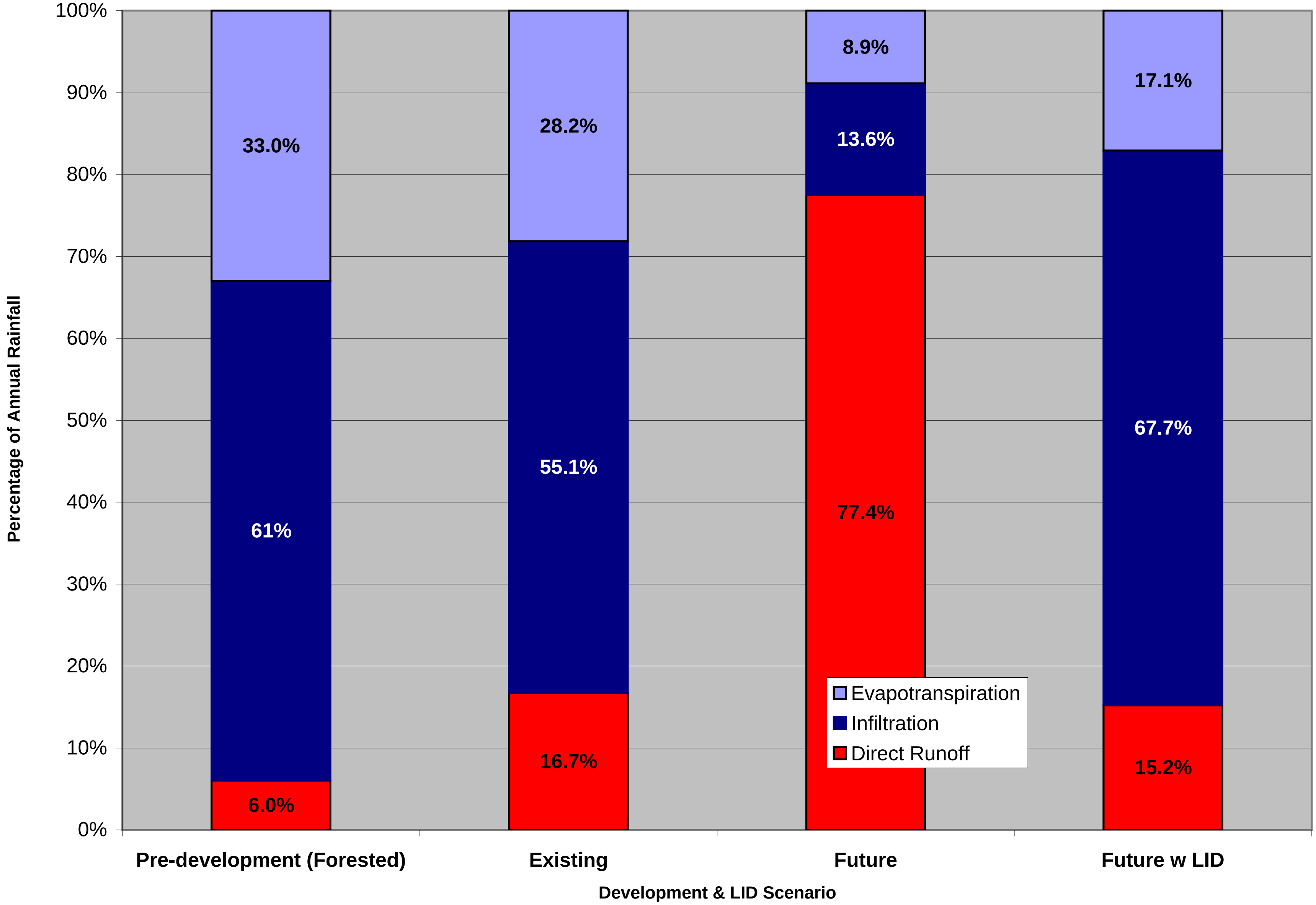


Figure 6-1
Comparison of Water Balance Conditions For Campbell Heights Area
Erickson Creek Watershed

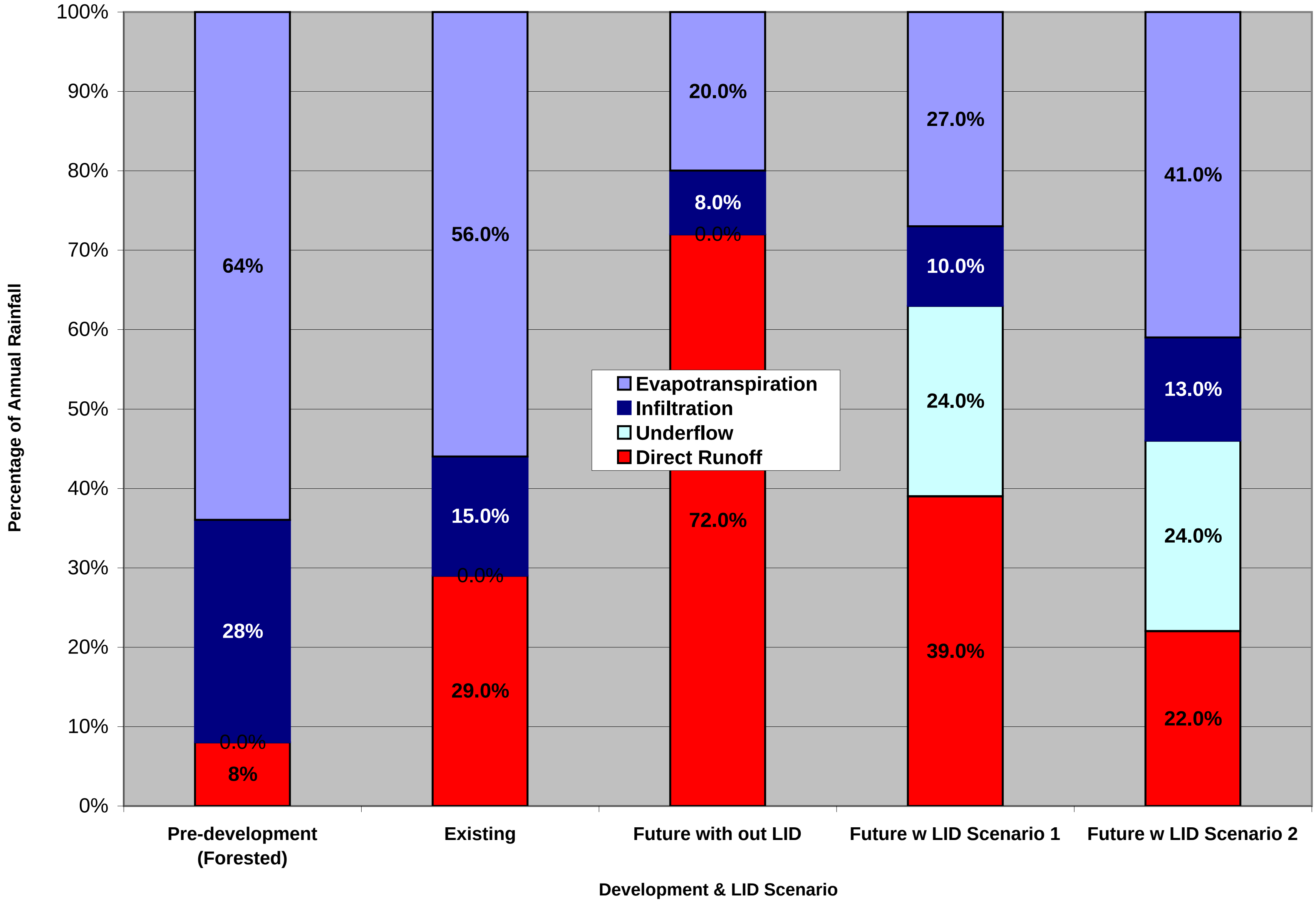


Figure 6-2
Comparison of Water Balance Conditions for Grandview Heights Area
Erickson Creek Watershed

7 Stormwater Management Strategies

In this section, we develop in detail and evaluate the proposed management strategies and discuss their effectiveness in controlling runoff from development areas. We investigated the potential for disturbance of the creek systems, and identified deficiencies in hydraulic structures using the City of Surrey's prescribed storm events (as per Surrey's design criteria) for the upland urban drainage.

In Section 6, we identified candidate BMPs that can be applied in the Erickson Creek watershed to manage stormwater. These included the potential to apply LID in both the Campbell Heights and Grandview Heights areas of the watershed. These BMPs are incorporated in our overall strategy and our evaluation using the XPSWMM model of the watershed.

7.1 STORMWATER DRAINAGE CRITERIA AND RAINFALL DATA

To address erosion and minor system conveyance capacity concerns, the City of Surrey's drainage standards require controlling the five-year post-development flow from urban development to either 50% of the two-year post-development flow or the five-year pre-development flow; whichever is most stringent. These standards are applicable to the creek system upstream of the agricultural lowlands.

The lowland areas within the Erickson Creek Watershed are designated as part of the Agricultural Land Reserve (ALR). In order to provide appropriate drainage ARDSA (Agrifood Regional Development Subsidiary Agreement) criteria are usually followed. These criteria primarily govern the acceptable duration of flooding of agricultural lands. Under these criteria, the total time it takes to drain agricultural lands and return water levels to their respective base flow conditions is not to exceed five days during the winter and two days during the summer as a result of a ten-year five-day storm and ten-year two-day storm respectively.

Surrey's urban design storms were developed using Intensity-Duration-Frequency data from the Surrey Municipal Hall rain gauge. Storm shapes and durations followed the Surrey Design Storms with durations of 1, 2, and 6 based on AES Short duration coastal storm distributions and 12 and 24 hours based on SCS 1a storm distributions. These storms superseded the synthetic all-duration storm event that we used in the preliminary evaluations of Phase 2 of this process. In evaluating our strategies' compatibility with UMA's 2002 lowland drainage strategy ("Erickson Creek and Burrows Ditch Functional Plan, UMA, 2002), we obtained and used the same long duration rainfall events (i.e. ARDSA criteria storms as required by the City) that were used in that study.

We developed and evaluated several conceptual stormwater management alternatives for the Erickson Creek ISMP. We applied different strategies in the Grandview Heights and Campbell Heights areas of the watersheds. These reflect the differing soils conditions and form of future development that will exist in these two areas. This issue was discussed in detail in Section 6 of this ISMP report. Section 6 also contains a preliminary identification and evaluation of Candidate BMPs for the Grandview and Campbell Heights areas.

7.2 CAMPBELL HEIGHTS MANAGEMENT STRATEGY.

Underlying soils in the Campbell Heights areas are generally identified as comprised of sand and gravel up to 40 m in depth with high permeability. The Campbell Heights area is situated above a portion of the Brookswood/Langley aquifer. This aquifer supplies base flow to various Erickson Creek tributaries that rise below the Campbell Heights escarpment. This same aquifer also provides groundwater flows to the Little Campbell River system to the southeast and Anderson Creek to the northeast. Mapping contained in the Piteau Associates evaluation of stormwater infiltration for New East Consulting ("Assessment of Options for Infiltration of Stormwater", Campbell Heights, Surrey, BC, Piteau Associates, 2000) indicates that the Erickson Creek watershed potentially receives groundwater from a significant distance outside the nominal watershed boundaries indicated by topography and surface flow patterns.

As discussed in Sections 4 and 6, the anticipated high infiltration potential in Campbell Heights allows LID measures to play the central role in stormwater management in this area. In fact, because of the critical role that groundwater recharge to the underlying aquifer plays in supporting stream flows in the watershed, it is advisable to retain the existing groundwater regime to the greatest extent possible.

We propose the following LID measures for the Campbell Heights portion of the watershed:

- Infiltration chambers or other facilities receiving runoff from majority of impervious surfaces.
- Absorbent landscaping.
- Pervious pavers on light duty driveways, pathways and sidewalks.
- Grassed or vegetated buffer strips, positioned to receive runoff from adjacent impervious surfaces.
- Disconnect impervious areas, sidewalks separated from curbs by buffer strips.
- Infiltration swales and galleries in buffer strips and property perimeters.
- Exfiltration pipes for in-road City drainage systems.

Green roofs remain a viable alternative to offset infiltration requirements, or to reduce loading on infiltration systems.

To support the LID measures and minimize maintenance problems, the following measures should be implemented:

- Oil/water separators to protect water quality.
- Sediment/grit settling for road and parking area runoff, to protect water quality and prevent "blinding" of the receiving soils by fines.

7.2.1 Major Flow Routing

Even with successful utilization of the infiltration capacity of the Campbell Heights area, there will be large storm events that produce sufficient runoff volumes that discharges from Campbell Heights to the lowlands will occur. We note that the exfiltration system concepts described in Piteau's 2000 report are intended to infiltrate runoff volumes resulting from a 5-year return period event. Assuming this target is achieved, larger events will be considerably reduced in volume, but the excess will need to be discharged in a controlled manner. Confirmation of LID feasibility is discussed in Section 8.

New East Consulting Services developed a servicing plan for the Campbell Heights Area in 2000 ("Campbell Heights Servicing Study – Technical Report"). An addendum to this plan was developed in December 2005 and submitted to the City. Figure 9.3A of the Addendum indicates that the majority of the future Campbell Heights development that falls within the Erickson Creek watershed will be directed to stormwater exfiltration systems.

New East's Figure 9.3A indicates that runoff in excess of a five-year return period event will be discharged to the lowlands at 40th Avenue, 32nd Avenue and 24th Avenue, as indicated on our Figure 7-1. These discharges will be routed to the lowland drainage system in road side ditches. Given that flows currently originating from the Campbell Heights area are relatively small, improvements to these ditches will be required to provide adequate capacity to route major flows. These improvements are discussed further in Section 8.

Campbell Heights Servicing Plan Addendum also indicates that a small area east of 190th Street, between 28th and 32nd Avenues will be serviced by a conventional storm drainage system that will drain southeast to Latimer Pond and ultimately the Little Campbell River. This represents a diversion of a small parcel of land out of the Erickson Creek Watershed to the Little Campbell River. We do not expect that this small diversion will significantly alter the hydrologic regime in the Erickson Creek watershed.

7.2.2 Campbell Heights Alternative Strategy

If infiltration of stormwater in the Campbell Heights area was not viable, or more limited in capacity, then the alternative would be conventional conveyance and detention of runoff volumes. The anticipated form of development for this area will result in a significant increase in impervious area, from a current average of approximately 10% to 90% or higher. Without infiltration, very large volumes of runoff will need to be managed.

Stormwater detention facilities are unlikely to achieve the long term flow attenuation benefits that groundwater recharge provides. In particular, storage of runoff as groundwater to provide dry season base flow to the creek system will not be provided by any reasonably sized detention storage facility. Given the high runoff volumes that we expect, providing sufficient detention storage to provide flow attenuation over a period of days to ensure ARDSA criteria are met in the lowlands would be challenging. Conventional detention storage attenuates runoff over a relatively short period of time, typically 24 hours to 48 hours. ARDSA requires that flooding durations be limited to five days during the winter. For upland storage to effectively address lowland flooding conditions as defined by ARDSA, would require much slower release rates, and consequently larger storage volumes.

We anticipate the following issues in connection with use of conventional conveyance and detention storage:

- Land requirements for detention ponds reduce developable land base.
- Costly construction due to flat topography of Campbell Heights area, requiring deep excavations to maintain pipe slopes.
- Deep detention ponds intersecting the groundwater table.
- Additional conveyance improvements required in lowland area.

Underground storage tanks in place of detention ponds could mitigate the footprint issues. They are potentially suitable for development where space is a constraint, or property values make surface detention ponds undesirable. However, large buried structures are usually more costly to engineer, construct (excluding land costs), and maintain. Selection of an underground detention facility in place of a surface detention pond requires evaluation on a site specific basis to weigh the benefits versus challenges.

Also, roof top storage on larger commercial buildings may partially makeup the required total detention storage volume. However roof top storage must be considered during structural engineering, and will not be able to attenuate flows generated at ground level, for example from parking surfaces.

7.3 GRANDVIEW HEIGHTS MANAGEMENT STRATEGY

Section 6 identifies LID measures that appear applicable to the Grandview Heights area to reduce direct runoff, particularly for small frequently occurring storms. However, due to the limited infiltration capacity of the surficial soils in the Grandview Heights areas these measures will not successfully manage peak flows and runoff volumes during sustained wet weather and larger storm events. As such, detention ponds or other storage units that attenuate runoff will play a major role in stormwater management for Grandview Heights.

Our servicing plan for Grandview Heights, illustrated on Figure 7-1, divides the Grandview Heights area into eight service areas. Within each service area, the detention pond (or other facility) will be located as far down slope as possible to allow routing of all runoff from that service area through the pond. Surface or underground storage facilities can be utilized as appropriate to specific land uses.

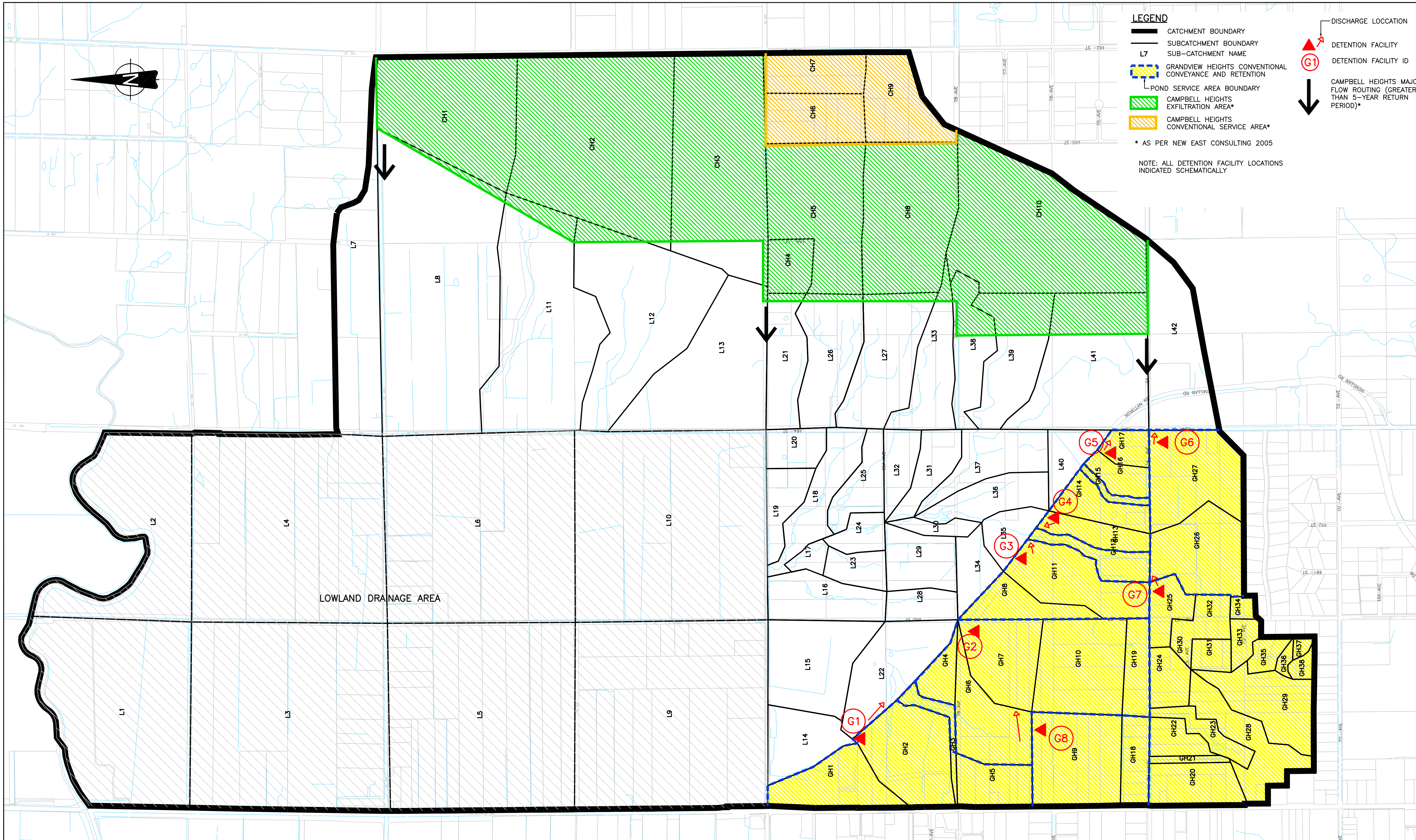
Five of the proposed detention ponds (G1 to G5) will be located on the north edge of the Grandview Heights portion of the watershed, in proximity to the interface between urban development and the agricultural lowlands. The exact location of these ponds requires further consultation with the development and agriculture communities, but they could be positioned so as to provide a buffer between urban developments and agricultural lands. A conceptual layout for Pond G4 is provided as Figure 7-2. Notably, intrusions on to agricultural lands and other conflicts between urban residential areas and agricultural activities are of great concern to the agriculture industry. Use of the former railway right-of-way for a public use trail may exacerbate these concerns.

We propose LID measures in order to mimic existing hydrologic conditions in Grandview Heights as much as possible. Groundwater storage, as limited as it appears to be in Grandview Heights, is essential for provision of dry period base flows in the creek system. Candidate LID measures were identified and assessed using the WBM in Section 6. The LID Scenario 2 results indicate that LID measures, if extensively applied combination with limits on TIA and retention of vegetation, could maintain the proportion of direct runoff at approximately 22%, with an additional underflow volume of 24%. For comparison, WBM analysis of existing conditions indicated that the current proportion of direct runoff is approximately 29% of the total rainfall volume; however, no underflow occurs with existing conditions.

However, given the soil conditions, existing state of the watershed, the relatively high EIA expected with development and uncertainty regarding the long-term performance of some LID measures, it is difficult to identify LID strategies that would achieve the generalized ideal target of 10% runoff advanced in the GVRD ISMP Template (GVRD, 2005) in the Grandview Heights area. Moreover, it is unlikely that this generalized target is achievable in this watershed given the current state of development and underlying soils. It is likely more reasonable to set a goal to maintain or mimic existing hydrological conditions rather than return the watershed to a hypothetical pre-disturbance condition.

Therefore, for the Grandview Heights area, we recommend the following LID measures be employed wherever practical:

- Absorbent landscaping and lawns with 300 mm organic soil depth.
- Pervious paving on paths and driveways, underlain with 300 mm coarse pervious material.
- Sidewalks separated from roads by buffer strips.
- Roadways and sidewalks draining to vegetated infiltration swales via curb cuts.
- Building roofs draining to absorbent landscaping or infiltration trenches.
- Infiltration swales.
- Centralized rain gardens in multifamily housing.
- Minimize use of piped drainage systems in favour of open swales or naturalized channels wherever possible.



REVISIONS	DESCRIPTION	BY	DATE	APPROVED
5				
4				
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2	PHASE 4	G.Q.	MAR. 2008	M.M.
1	PHASE 3	G.Q.	MAR. 2007	M.M.

Associated Engineering

SURREY CITY OF PARKS

ENGINEERING DEPARTMENT

BENCH MARK – S.M. # ELEV.

SEAL

TITLE

ERICKSON CREEK ISMP MANAGEMENT PLAN

CONCEPTUAL STORMWATER MANAGEMENT PLAN

SCALE: HOR. 1:10000 VERT. 1:10000	DATE JAN. 2008	PROJECT NUMBER	
DRAWN G.Q. CHECKED	L.B.	DRAWING NUMBER FIGURE 7-1	
DESIGNED M.M. CHECKED	CONTRACT		
P.W. P.U.	AS BUILT	SHEET OF	
APPROVED	DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS	REVISION 1	

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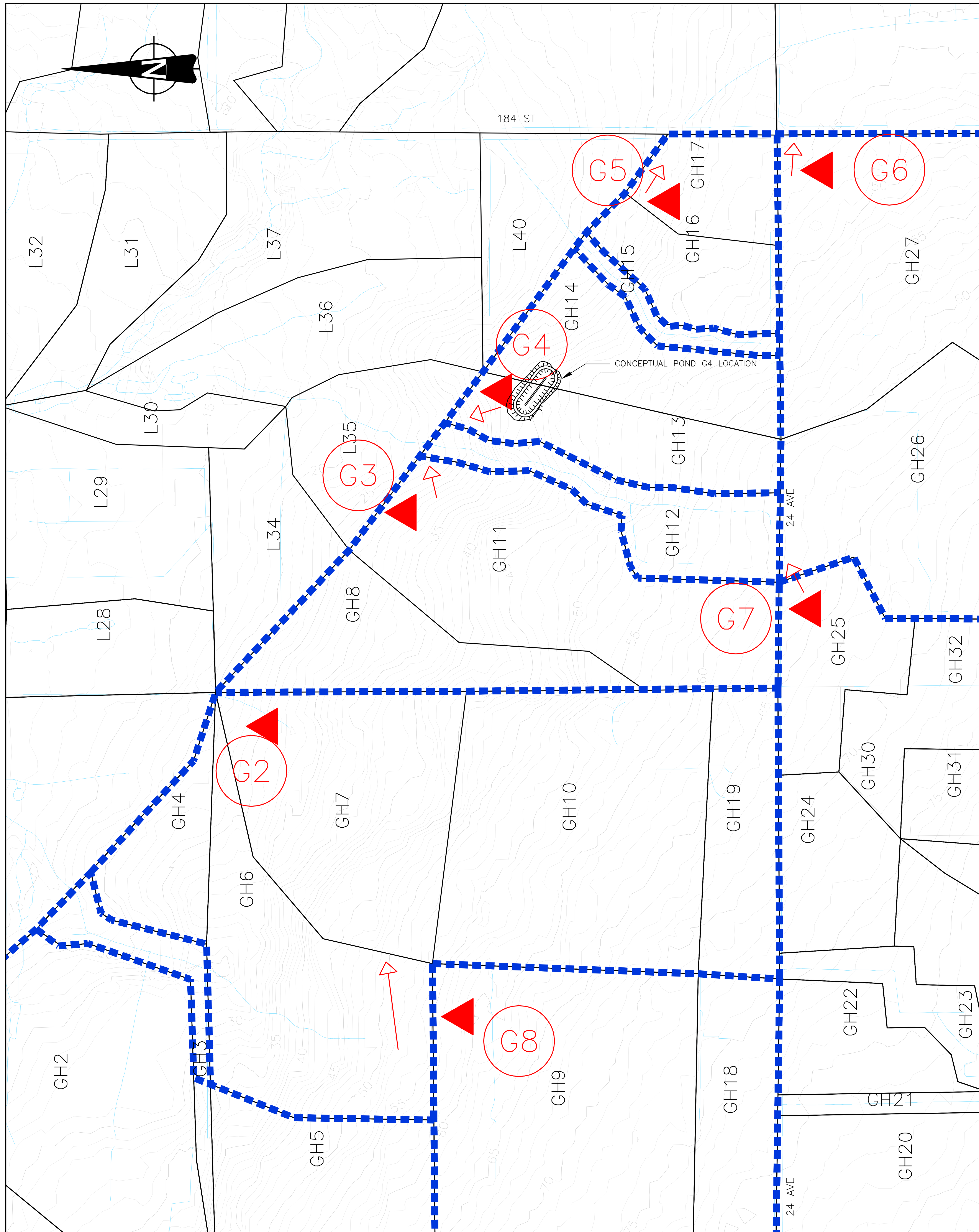
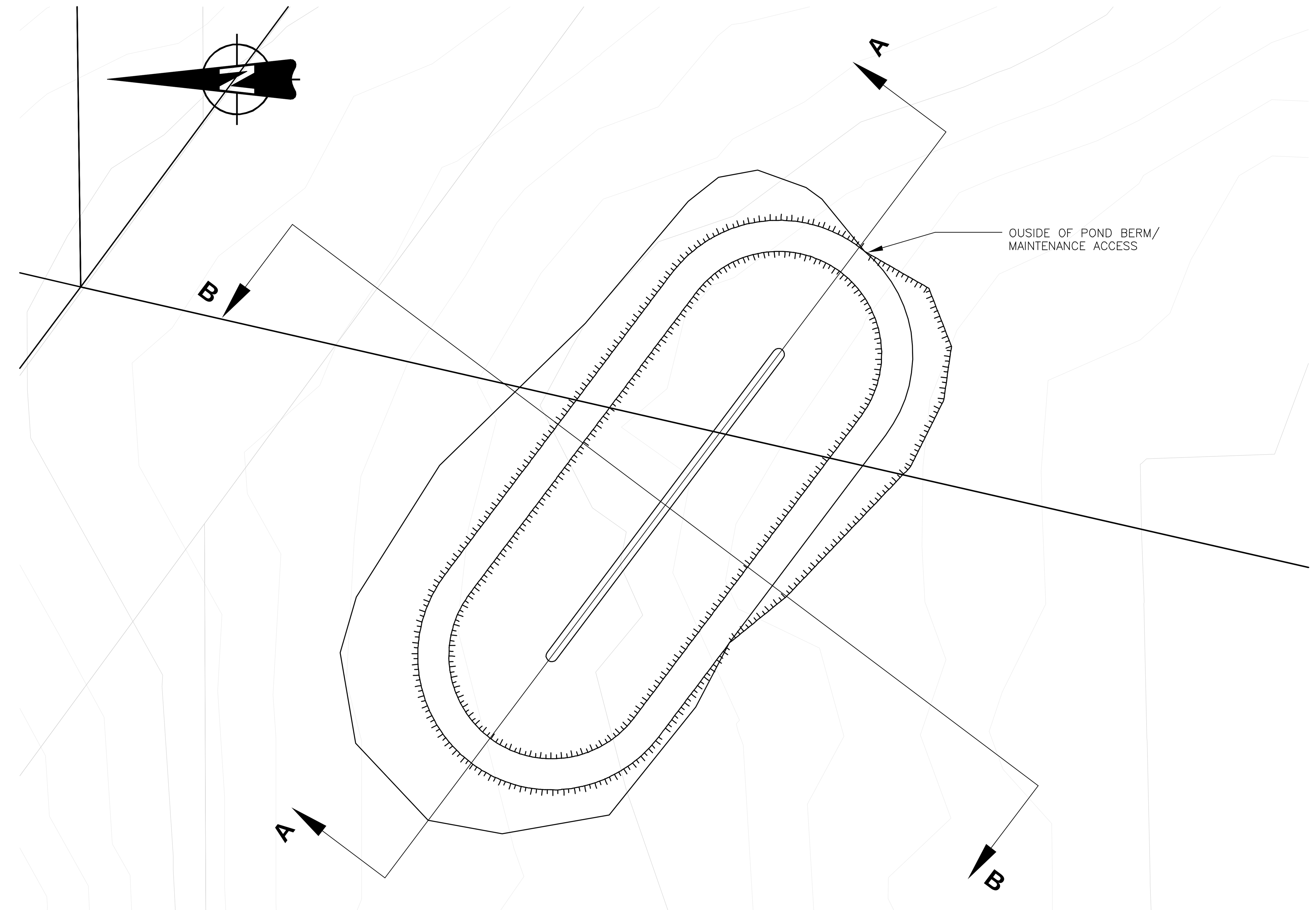


POND G4 LOCATION
SCALE 1:4000

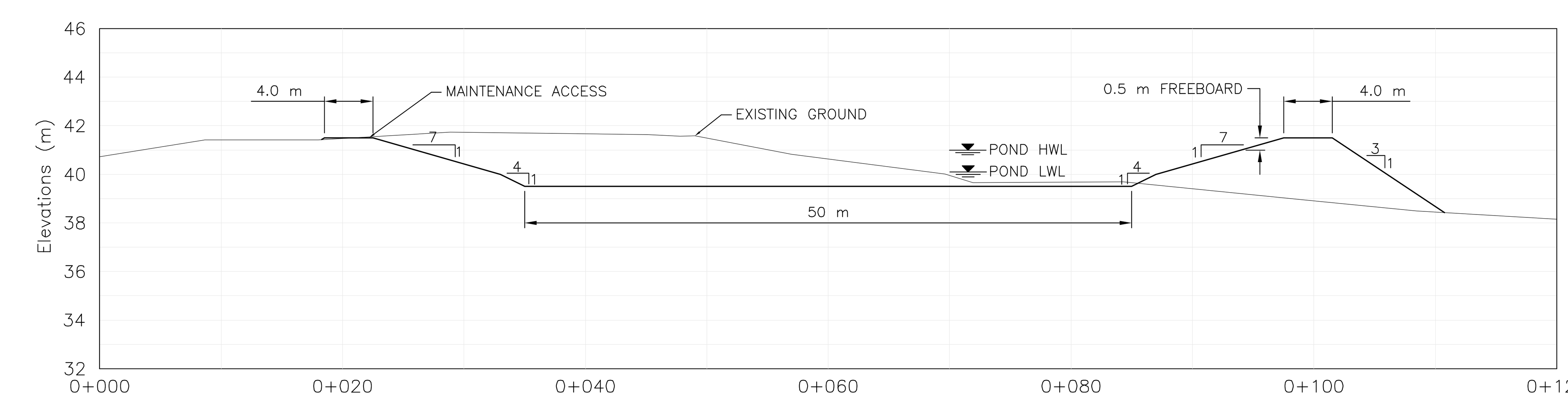


POND G4 FOOTPRINT
SCALE 1:500

LEGEND

- CATCHMENT BOUNDARY
- SUBCATCHMENT BOUNDARY
- L7 SUB-CATCHMENT NAME
- GRANDVIEW HEIGHTS CONVENTIONAL CONVEYANCE AND RETENTION
- POND SERVICE AREA BOUNDARY
- DISCHARGE LOCCATION
- DETENTION FACILITY
- G1 DETENTION FACILITY ID

NOTE: ALL DETENTION FACILITY LOCATIONS INDICATED SCHEMATICALLY



SECTION A–A
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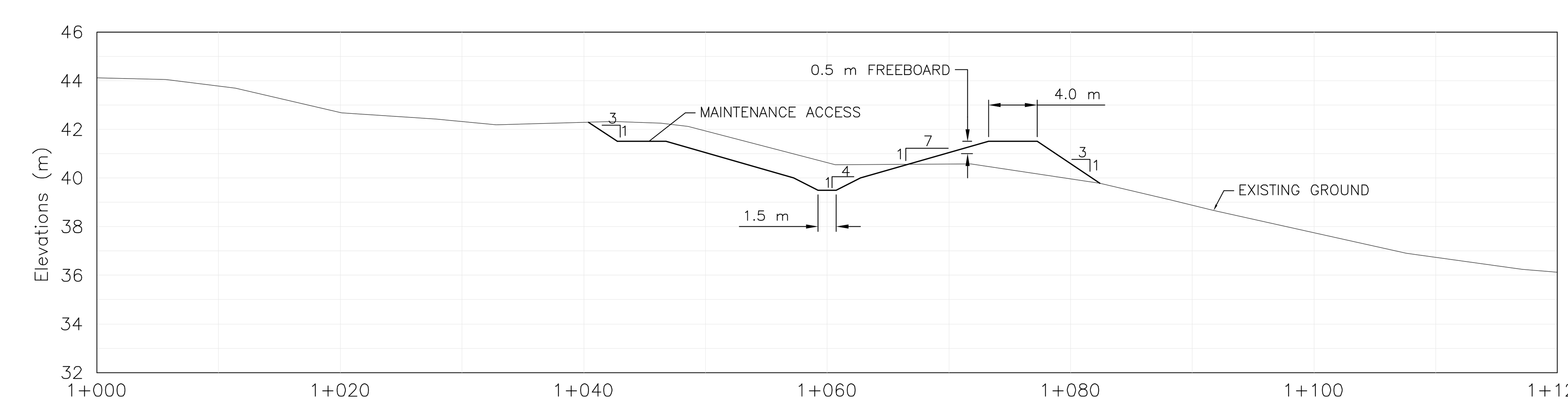
VERTICAL SCALE: 1:200



SECTION B–B
HORIZONTAL SCALE: 1:400
VERTICAL SCALE: 1:200

REVISIONS	DESCRIPTION	BY	DATE	APPROVED
5				
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SEAL

TITLE
ERICKSON CREEK ISMP
GRANDVIEW HEIGHTS EXAMPLE
CONCEPTUAL POND LAYOUT (POND G4)

SCALE: HOR. AS SHOWN VERT. AS SHOWN	DATE JUL. 2010		PROJECT NUMBER
DRAWN M.P. CHECKED	L.B.		DRAWING NUMBER FIGURE 7–2
DESIGNED M.P. CHECKED M.M.	CONTRACT		
P.W. P.U.	AS BUILT		SHEET OF
APPROVED	DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS		REVISION 1

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8 Evaluation of Stormwater Management Strategies

In combination, the differing strategies for Grandview Heights and Campbell Heights form the overall stormwater management plan for the future developments areas of the watershed. Using the XPSWMM model, we conducted an evaluation of the effectiveness of our stormwater management plan in:

- Meeting the City of Surrey's requirements for controlling peak flows from developed areas to protect creek systems.
- Managing total runoff volumes to ensure consistency with the earlier lowland drainage study (UMA, 2002), and compliance with ARDSA criteria.
- Mimicking existing hydrological conditions to maintain stream health, as indicated by maintaining flow-duration characteristics on natural water courses.
- Assessing the effectiveness of the overall strategy in maintaining stream health as expressed by the flow-duration distribution of stream discharge.

8.1 CAMPBELL HEIGHTS STORMWATER MANAGEMENT STRATEGY

8.1.1 Volume Balance LID Validation

As proposed, the LID based Campbell Heights stormwater management strategy represents maintenance of the existing groundwater discharge regime that limits surface runoff and provides sustaining baseflows to the creeks that rise below the Campbell Heights escarpment. Therefore, pre- and post-development runoff condition should be nearly identical for the five-year return period event.

To assess the effectiveness of relying entirely upon LID measures for the Campbell Heights area, we selected sub-catchment CH10 to perform a detailed volume analysis using the WBM. We selected sub-catchment CH10 as it has the greatest contrast between current and future development conditions. Based on our GIS data, we identified CH10 as having a current EIA of 5%. This value will increase dramatically based on values contained in the City of Surrey's Design Criteria Manual, which specify the TIA for Industrial Development as 90%.

Using orthographic photos provided by the City, we developed a detailed representation of sub-catchment CH10, shown in Figure 8-1. The existing surface cover consists of the following:

- 40% Agriculture
- 38% Grass and Pervious Cover
- 20% Forest
- 1% Impervious Paving
- 1% Rooftop (Building)

Using the WBM we determined that 5.6% of the total annual rainfall volume translates into direct runoff under existing conditions. Refer to Figure 8-2 for a graphical representation of the partitioning of total rainfall volume between infiltration, evapotranspiration, and surface runoff.

Sub-catchment CH10 is classified as IB-1 Zoning (Business Park) in the City of Surrey's OCP. As indicated previously, the City's Design Criteria Manual specifies a value of 90% TIA for Industrial areas. In developing a WBM scenario for future development conditions, we assumed 10% of the surface cover will be arterial roads (a combination of impervious paving and grass shoulder) with the remaining 90% allocated to Industrial development (a combination of landscaping, impervious paving and rooftop). In aggregate, the future surface cover of the entire CH10 catchment is then:

- 89% Impervious Paving and Rooftop
- 11% Grass

Under these future development conditions, the WBM indicates that 90.2% of the total annual rainfall volume will translate into direct runoff, if no LID measures are implemented.

To evaluate the effectiveness of LID measures as the primary means of stormwater management, we modelled the following features in the WBM:

- 100% of the grass within the Industrial Development Area (900 m^2) modelled as absorbent landscaping.
- 100% of the rooftop area and 90% of the impervious paving within the Industrial Development Area was routed to a 250 m^2 infiltration chamber with a depth of 1.0 m. In effect, all of the impervious surface area is routed to this infiltration chamber.
- 10% of the previously impervious paving within the Industrial Development Area (450 m^2) was now modelled as pervious paving, representing emergency access lanes, pathways etc. that are not subjected to ongoing heavy vehicle loading.
- 100% of the grass shoulder within the Arterial Road Area (200 m^2) modelled as a vegetated swale with underdrain.

We note that the WBM we developed is based on a 10,000 m^2 lot, representative of development conditions. Figure 8-3 shows a schematic representation of the various types of surface cover under future development conditions and the areas allocated to LID measures.

Using the WBM we determined that, by incorporating the above LID measures into the future development conditions, the amount of total annual rainfall volume that will translate into direct runoff can be reduced to 3.4%, which is less than surface runoff indicated for existing conditions. This scenario is also included in Figure 8-2. Further, we note that by incorporating the above LID measures, the WBM indicates a 20% increase in the amount of annual rainfall that is infiltrated, compared to existing conditions.

The proportion of total rainfall volume that infiltrates is higher than existing conditions (78% for future as compared to 58% for existing), this is in part due to the reduction in evapotranspiration capacity that results from reduced vegetation cover with development. The “engineered” infiltration systems represented in the future condition LID scenario appears to compensate for this effect. However, a likely consequence is that the attenuated groundwater discharge to the lowland creeks and drainage system will increase as more groundwater is stored over the winter. We do not expect this to present a problem in terms of stream erosion, as the additional groundwater discharge will be most prevalent during low surface runoff periods, and is highly attenuated by the storage effect. In terms of summer baseflows, increased groundwater discharge appears to be a positive effect.

The results of this volume based assessment of the proposed LID measures indicates that the existing hydrological regime of the Campbell Heights area should be maintained. However, while this result confirms that overall volume balances are maintained, confirmation of the ability to successfully infiltrate the City’s design storm is desirable. We undertook a conceptual model exercise as described in the following section to assess the ability to infiltrate runoff volumes associated with the design storm events.

8.1.2 Design Storm Infiltration System Evaluation

The WBM model analysis discussed above provides a general indication of the feasibility of our infiltration based stormwater management plan proposed for the Campbell Heights area of the Erickson Creek watershed. However, it does not explicitly take into account considerations such as the depth to the water table (top of aquifer), and total aquifer depth. In order to ensure the viability of exfiltration of stormwater as the primary management mechanism, more detailed analysis to identify system constraints is required. Also, and notably, the Water Balance Model is unable to model specific design storms to ensure that the City’s runoff control criteria are met.

We developed a spreadsheet model of a hypothetical exfiltration facility, into which we routed runoff from a 1 ha “unit” catchment generated by various five-year return period storm events. Storm durations of 3, 6, 12, 24 and 48 hours were investigated using the spreadsheet model. In order to be conservative, we assumed 100% runoff from the 1 ha area, and neglected all rainfall volume losses due to initial surface wetting, depression storage, evapotranspiration and potential presence of other LID features.

The generated runoff hydrograph was routed to our hypothetical infiltration facility. The exfiltration process was modeled using an online simulation tool based on Hantush’s (Hantush, 1967) method for calculating the mounding of water above the receiving aquifer. Mounding or surcharging is a necessary mechanism to provide the driving head for the infiltrated water to enter the aquifer, and is a function of the recharge rate, duration of the recharge, hydraulic conductivity of the aquifer and overall depth (height from bottom to free surface) of the aquifer. When the height of the surcharge above the receiving aquifer is sufficient to intersect the exfiltration facility, then exfiltration of stormwater is hindered and the resulting exfiltration rates are lower than indicated by the straight hydraulic conductivity.

Again, to be conservative, the aquifer was assumed to be 4 m deep. We note that in most areas of Campbell Heights the indicated height of the aquifer is greater than 4 m, as shown in Piteau's report. The bottom of the exfiltration facility was assumed to be only 1 m above the aquifer, consequently the mounding effect interferes with stormwater exfiltration from the facility at relatively low recharge rates. The exfiltration facility was assumed to be circular, with a recharge area of 250 m^2, the same size as used in the WBM analysis above.

Various hydraulic conductivities were used in this analysis, with similar orders of magnitude to those reported in the Piteau report and in Jacques Whitford's hydrogeology assessments as contained in Appendix B. Hydraulic conductivity values used were 360, 720, 1060 and 1440 mm/hour (0.5, 1.0. 1.5 and 2.0 x 10^{-4} m/s respectively). Jacques Whitford's minimum estimated hydraulic conductivity for the Campbell Heights areas was 360 mm/hour or 1 x 10^{-4} m/s.

The spreadsheet model relates inflow volume to the outflow rate, with the volume difference allocated to storage. The degree of surcharge in the exfiltration facility provides the driving head for exfiltration of stormwater, and is also an expression of the volume of runoff stored in the facility. The volume in storage is the product of the area of the exfiltration facility and the surcharge in excess of 1 m (i.e. above the bottom of the facility). As the storage volume increases, the driving head for exfiltration to the underlying aquifer increases.

The maximum mounding height represents the maximum depth of storage required for the facility to successfully exfiltrate the entire storm volume under the given conditions of hydraulic conductivity. We assumed that storage volume was 30% of the surface area of the exfiltration facility, based on the assumption that the storage volume of the facility would be filled with open graded coarse angular gravel, similar to railway ballast, with a porosity of 30%. An open tank type of exfiltration facility, as is found in some proprietary systems, would have a different governing head to volume relationship and would therefore produce differing surcharging for a given stored volume.

Our estimates of required detention storage to ensure infiltration of the five-year return period runoff volume is summarized in Table 8-1 below. These results confirm, at a conceptual level, the exfiltration facilities can be implemented that will be able to completely exfiltrate the runoff volume resulting from a five-year return period event.

Table 8-1
Required Storage Volume for Campbell Heights Exfiltration Facility as a Function of Hydraulic Conductivity

Hydraulic Conductivity (mm/hr)	Required Storage Volume (m^3)	Maximum Depth of Surcharge (m)
360	155	2.1
720	103	1.4
1080	77	1.0
1440	62	0.8
Note: Storage capacity for exfiltration based on 1 ha service area, 250 m^2 exfiltration facility with 30% void space.		

Obviously, as hydraulic conductivity increases, less detention storage is required to ensure that the total runoff volume can be exfiltrated. For greater hydraulic conductivities than those reported above, for example the upper value identified by Jacques Whitford, 1950 mm/hour ($5.43 * 10^{-4}$ m/s), little or no detention storage would be required.

8.1.3 Campbell Heights LID Constraints

However, we note the following constraints and uncertainties that must be considered in the application of LID measures as the primary mechanism of stormwater management in the Campbell Heights area of the Erickson Creek watershed:

1. For storm events that result in greater volumes of runoff than the governing five-year return period storm, safe routing of the excess runoff is required. This includes allowances for overflows from the underground exfiltration and detention facilities to the City's storm drainage networks, and safe overland routing of flow from very large events (i.e. 100-year return period), along streets. Major flow discharge locations from Campbell Heights are indicated on Figure 7-1.

2. Portions of the Campbell Heights area have been or are being mined for gravels. If an insufficient height of coarse granular material above the top of the aquifer remains, then reliance on exfiltration of storm water may be invalid. We estimate that a minimum of 2 m depth of pervious granular material is required to allow for successful implementation of exfiltration facilities in the Campbell Heights area.

3. In the event that insufficient depth of pervious cover over the aquifer is available, then other approaches would then need to be investigated, analyzed and designed, such as

conventional detention ponds. However, any excavated facility that intersects the groundwater table will present challenges.

4. Different exfiltration facility configurations, or different orientations with respect to the predominant groundwater flow may result in varying performance of the facility. Also, local soil conditions may result in substantially different performance. All facilities will require analysis and design by qualified ground water professionals.

5. An appropriate factor of safety should be employed to allow for degraded performance over time. Also, exfiltration facilities should be situated to allow them to be maintained and/or rehabilitated without disturbance to significant infrastructure.

8.2 GRANDVIEW HEIGHTS STORMWATER MANAGEMENT STRATEGY

8.2.1 Grandview Heights Peak Flow Management

In the Grandview Heights area, eight detention facilities are proposed, as indicated on Figure 7-1. These Grandview Heights stormwater detention facilities were evaluated with the specified City design storms. We developed hydrographs for each key discharge location comparing the five-year return period pre-development and post-development hydrographs, and 50% of the two-year return period hydrograph, all without detention storage. Key discharge locations are indicated on Figure 8-4. Figures 8-5 to 8-10 illustrate the hydrographs for Grandview Heights.

Note that only the hydrographs for the critical storm duration are provided for each discharge location, generally short duration storms. The hydrograph indicating the cumulative attenuation provided by our conceptual detention storage facilities is also provided on these respective figures to indicate that the City's criteria are being achieved.

Our peak flow management strategy assumes that all surface runoff from developed lands within a service area would be routed to the appropriate detention facility. Runoff from all storm events up to and including a five-year storm event would be attenuated at the proposed detention facilities. Flows in excess of those from a five-year return period will be discharged to existing watercourses by overflow mechanisms at each detention facility. Table 8-2 provides the estimated detention facility volume to achieve these targets.

The City's requirements for attenuating peak flows recognize that channel forming flows are usually found in the two-year to five-year return period storms. These events occur frequently enough, and are also large enough, to influence erosion and deposition processes. Larger and less frequent storms are important for design of conveyance systems and an issue in terms of protection of life and property, but are not targeted by the City's attenuation criteria.

We evaluate the flow-duration characteristics of the stormwater management strategy in Grandview Heights in the following section. The extended period simulation (EPS) evaluation addresses changes in flow characteristics across the entire flow spectrum beyond the consideration of only peak flow rates from design storms that are managed with the proposed detention ponds.

8.2.2 Evaluation of Flow Duration Spectrum

Within the field of stormwater management, it is now well understood that relying solely on conventional BMPs (such as detention ponds and diversions) that only manage peak flows is not sufficient to maintain the health of a watercourse. While such BMPs may sufficiently limit peak flows and prevent downstream flooding, the watercourse is still subjected to a larger volume of runoff than occurs naturally, due to increased impervious surface runoff and reduced evapotranspiration. Therefore, the overall volume of stream discharge increases, and the cumulative time over which the stream is subjected to intermediate flows increases despite management of the peak flow rates. This change in the flow-duration spectrum increases the erosive power of the watercourse, resulting in increased channel disturbance and sediment movement, often with detrimental impacts on fish habitat and the riparian corridor.

The increased stream discharge resulting from increased impervious area associated with development also reduces the volume of water that infiltrates and is then available to support dry period base flows. Detention facilities are generally ineffective at addressing this impact due to their short retention times, so the ability of the watercourse to support fish, such as salmon fry, or to ensure that spawning areas remain wetted, is negatively impacted by the reduction in groundwater discharge. The degree of this impact is also apparent when changes in the flow duration characteristics at the low flow end of the spectrum are examined. The existing flow regime should be preserved if stream health is to be adequately protected by the proposed stormwater management plan, (i.e. the existing long-term flow duration spectrum will be mimicked by post development stormwater management).

To assess changes in the flow duration spectrum, an extended period model simulation is carried out using an appropriately configured hydrologic model. Through this effort, a better assessment of how effectively a stormwater management plan is addressing both the occurrence of sustained intermediate flows that lead to erosion and in the maintenance of dry period base flows, is provided.

We conducted an extended period simulation of both the existing conditions in the watershed (to provide a baseline for comparison), future conditions without LID, and future conditions incorporating our proposed stormwater management, plan including the recommended level of LID.

In addition, extended period simulations were used to estimate the level of effort required to fully retain the existing hydrology of the Grandview Heights area of the watershed. Primarily, this investigation considered whether upper limits on the extent of TIA or EIA are required to ensure that stream health is fully preserved. Conceptually, this can be achieved by imposing more rigorous LID requirements and/or limiting the total impervious cover within the development areas, if stormwater management practices are insufficient on their own.

8.2.2.1 Extended Period Simulation Methodology

As the term implies, extended period simulations require computationally intensive model analysis to simulate the behaviour of the watershed over a long period of time, and require extensive high quality weather data records from a location proximate to the watershed. For this ISMP we identified the weather station located on Surrey City Hall. This station is located within the same lowland valley system (Nicomekl - Serpentine) as the Erickson Creek watershed, and provides a reasonably long period of record.

Often, extended period simulations will encompass a time span of 30 years or more, to account for climatic cycles and weather variability and to obtain stable estimates of watershed behaviour. However, the Surrey City Hall gauge has a continuous period of record spanning only 14 years. We believe that this data record is sufficient for the purposes of this extended period analysis, and our results appear stable and consistent, as indicated by the results presented in the following sections.

We simplified the existing Erickson Creek model to remove the detailed hydraulic components and include only those necessary for the evaluation of hydrologic performance of the Grandview Heights area. Therefore, the lowland area downstream of 32nd Avenue, the Campbell Heights area, and most hydraulic details were eliminated from the model. Simplified hydraulic links were substituted to ensure that the connectivity of the creek system was properly represented.

However, the proposed stormwater management plan incorporates detention ponds to provide peak flow control and attenuation. These detention ponds are important to the flow-duration response of the watershed during larger rainfall events, and resulting peak flows in the creek system, and must be retained for the extended period analysis. These features were simplified to ensure stable model results.

8.2.2.2 Flow Duration Performance

We selected five reference locations in the creek system downstream of Grandview Heights for analysis of flow-duration performance of the watershed. These represent the most significant creek channels and the transition from the upland areas of Grandview Heights into the lowland agricultural areas. These locations are indicated on Figure 8-4.

We provide plots of the flow duration response at these five locations in Figures 8-11 to 8-15. Flow duration results for existing development conditions, post-development without LID measures, and post-development with the recommended (denoted Base) LID measures of the proposed stormwater management plan are all plotted on these figures. These figures also contain the flow-duration curves representing the application of enhanced LID required to ensure full preservation of the watershed's hydrology and stream health, these results are discussed in the following section.

In Table 8-3 we summarize the flows at the 25th, 50th, 80th and 95th percentiles for pre-development, post-development without LID, and post-development with recommended (Base) LID at each of the five reference locations. As in Figures 8-11 to 8-15, these results indicate the increase in peak flows and decrease in base flows without LID as compared to pre-development conditions, and the positive benefit of LID in returning peak flows and base flows closer to pre-development hydrology. We also indicate the percentile at which 1.0 L/s falls for each case, to more clearly illustrate the changes in base flows. Implementation of LID is effective at reducing the percentile ranking of 1.0 L/s closer to the existing (or pre-development) condition.

In comparing the results for existing development conditions to post development without LID it is evident that the lack of LID results in reduced base flows during drying conditions, and accentuated peak flows. Clearly, relying on conventional detention ponds alone will not achieve preservation of the watershed's hydrology, the flow duration behaviour of the watershed, or by implication, overall stream health.

However, it is also clear that the level of LID proposed in our stormwater management plan is moderately, even if not completely, effective at mimicking the flow-duration behaviour of current development conditions in the watershed. The distribution of flows at the low flow end of the spectrum is fairly close to current conditions at all five reference locations. Despite the limited infiltration capacity of the soils in the Grandview Heights area, implementation of LID as recommended in our stormwater management plan plays an important role in maintaining overall hydrologic response similar to current conditions.

8.2.2.3 Assessment of Measures Required to Fully Protect Stream Health

While the extended period simulation results indicate that the proposed stormwater management plan of Section 7, particularly the recommended LID features, is beneficial in preventing a complete change in the flow duration characteristics of the watershed, it is clear that some degradation will still occur. We further assessed the extent to which additional LID measures would be required to ensure that stream health, as represented by the flow-duration distribution, would be fully preserved.

Increasing the extent of LID implementation (denoted Enhanced LID) beyond that proposed in our stormwater management strategy further improves the flow-duration performance of the Grandview Heights area of the watershed. In our assessment of level of effort required, we used the hydrologic model to simulate progressively more extensive employment of LID measures until the post development flow-duration characteristics at each index location fully mimicked that of pre-development hydrologic conditions. These curves are also plotted on Figures 8-11 to 8-15 for their respective locations.

To fully mimic existing conditions requires that the future EIA be limited to approximately 15% to 20% of the overall watershed area. This implies that in order to allow any reasonable degree of development (with correspondingly increased TIA), yet limit the EIA of the watershed to approximately 15% to 20%, then effective LID measures would need to be applied extensively within Grandview Heights.

This upper limit on EIA can be interpreted in different manners. If, for example, fully effective LID can only be provided for approximately 60% of the future impervious surfaces resulting from development (as represented by our LID modelling in the future condition XP-SWMM model), then the corresponding maximum allowable TIA would be approximately 36% on average over the whole of the Grandview Heights development area.

Conversely, without the application of LID measures, these results indicate that overall TIA would need to be limited to 20% of the total Grandview Heights area in order to preserve watershed health, similar to existing conditions. This restriction would require that future development be very tightly clustered, total development foot prints be restricted, and large proportions of existing forest cover and green space be preserved as they now exist.

The WBM analysis discussed in Section 6 indicates that a TIA of approximately 40%, combined with retention of a greater proportion of existing vegetation, particularly forest cover, would reduce direct surface runoff to similar proportions as existing conditions. Combining the results of the two analyses suggests that an overall upper limit of 40% TIA and 20% EIA is required to maintain the existing hydrology of the Grandview Heights area, and maintain the proportion of total long-term runoff at the estimated 29% occurring under existing conditions. Notably, infiltration based LID system are less effective than use of vegetation to control runoff, a direct consequence of the limited hydraulic conductivities of the predominant soil types in Grandview Heights.

Localized TIA and EIA should also conform to these requirements, to avoid excessive impacts to a single water course. Localized areas of high TIA and EIA, such as a commercial development, should be compensated for by offsetting vegetated/forested areas on the same watercourse.

Retention of existing vegetation, in particular forest cover, should be the priority mechanism for controlling runoff from Grandview Heights. Complete retention of existing forest cover is more effective than implementing infiltration based LID measures in compensation for a loss of forest cover. Maximizing retention of forest cover could allow for a relaxation of requirements to implement other LID measures that are less effective, provided the overall benefit of the trade off is demonstrated. Other measures that rely on vegetation, such as rain gardens, should be emphasized as well. Retaining existing vegetation coordinates well with protection of riparian corridors and sensitive terrestrial habitat and corridors. Clustering of housing developments to avoid encroachment on forested areas should be a priority consideration in land use planning.

The required performance criteria to ensure protection of steam health are:

- Infiltration or evapotranspiration of 50% of the rainfall volume from the 24-hour, 2-year return period design storm.
- Maximum flow release of 0.5 L/s/impervious hectare during the 24-hour, 2-year return period design storm.
- Maximum effective impervious area (EIA) within any given catchment of 20% of the catchment area, as indicated by runoff during the 24-hour, 2-year return period design storm.
- Maximum total impervious area on any identifiable watercourse limited to 40% of the catchment area, and 40% is the Grandview Heights portion of the study area as a whole.
- Total long-term runoff volumes controlled to 29% of the corresponding long-term rainfall volume.
- All surface runoff originating from developed lands routed to peak flow detention systems for events up to and including the 5-year return period, at all durations.

8.2.3 Infiltration System Evaluation

On a runoff volume basis, the WBM model analysis of the Grandview Heights discussed above provides a general indication of the feasibility of the LID measures proposed for the Grandview Heights area of the Erickson Creek watershed. However, it does not explicitly take into account considerations such as the depth to the water table (top of aquifer), and total aquifer depth. In order to ensure the viability of exfiltration systems in the poorly drained soils in the Grandview Heights area, we undertook a detailed analysis of a hypothetical exfiltration facility as proposed to receive runoff from roof areas and impervious paving on a residential lot.

In a similar manner as undertaken for our Campbell Heights analysis and discussed in Section 8.1.2, we used a spreadsheet model of a hypothetical exfiltration facility, into which we routed runoff from a 372 m^2 (4000 ft^2) catchment assuming 60% impervious coverage (representative of the roof and driveway area of a residential lot) generated by 50% of a 24 hour, two-year return period rainfall event (the 50% of MAR target promoted by the GVRD's ISMP template). This storm event is equivalent to approximately 27 mm of rainfall in a 24 hour period. A detailed explanation of our methodology is contained in Section 8.1.2. Figure 8-16 provides a schematic representation of this lot configuration.

The receiving Grandview Heights aquifer was assumed to be 1 m deep, and 0.5 m below the underside of the modelled exfiltration facility. Jacques Whitfords preliminary hydrogeology investigation indicates that the surficial soils are composed of Capilano Sediments (marine and glaciomarine sediments normally less than 3 m thick) and Vashon Drift soils. Hydraulic conductivities in the Vashon Drift soils range from an estimated high of 3.6 mm/hour ($1 X 10^{-6}$ m/s) to a low of 3.6 X 10^{-6} mm/hour (1 x 10^{-12} m/s). The expected hydraulic conductivity is in the range of 0.036 mm/hour (1 x 10^{-8} m/s).

We investigated hydraulic conductivity values of 0.5, 1, 2 and 3 mm/hr. Clearly, these values favour the upper end of the range of hydraulic conductivities estimated by Jacques Whitford for the soils in the Grandview Heights area. Lower values of hydraulic conductivity would likely render an underground infiltration facility ineffective, though benefits would still be realized in the application of the other LID measures proposed (retention of existing vegetation, absorbent landscaping, absorbent soil depth on lawns and similar approaches).

We summarize the required storage volume as a function of underlying hydraulic conductivity in Table 8-4 below. These results confirm, at a conceptual level, the exfiltration facilities can be implemented that will be able to completely exfiltrate the runoff volume resulting from a 50% of MAR rainfall event in a reasonable period of time.

Table 8-4
Estimated Exfiltration Storage Requirements as a Function of Hydraulic Conductivity of Underlying Soils

	Exfiltration Facility Size as percentage of total lot (as area)			
Hydraulic Conductivity (mm/hr)	5% (18.5 m^2)		10% (37 m^2)	
	Required Storage Volume (m^3)	Storage Depth (m)	Required Storage Volume (m^3)	Storage Depth (m)
0.5	5.9	1.06	5.7	0.51
1	5.6	1.00	5.2	0.47
2	4.5	0.81	4.3	0.39
3	4.2	0.76	3.4	0.31

Note: Assumed 372 m^2 (4000 ft^2) lot, with 60% impervious coverage. Exfiltration facility assumed located in lawn area. Indicated volume required to ensure exfiltration of 50% of 24 hour, 2-year return period storm. Storage depth assumes 30% void ratio.

8.2.4 Grandview Heights LID Constraints

However, we note the following constraints and uncertainties that must be considered in the application of LID measures in the Grandview Heights area of the Erickson Creek watershed:

1. Retention of existing vegetation, particularly forest cover, is preferable to relying on infiltration based measures, and should be the first priority in land use planning. Other

measures that increase evapotranspiration to reduce runoff volumes should also be emphasized.

2. Infiltration potential in the Grandview Heights area is limited. Therefore, allowances for overflows from the infiltration systems to the City's storm drainage networks, and safe overland routing of flow from very large events is required in all instances. All storm drainage systems, including infiltration system overflows, should be routed to the appropriate detention pond to ensure attenuation of peak flows is achieved.

3. We estimate that a minimum depth to the winter groundwater table of 1 m from the bottom of a constructed exfiltration facility is required to allow these systems to function to a reasonable degree. Other LID approaches, such as absorbent landscaping, and rain gardens are not as restricted in their applicability.

4. All infiltration dependent LID measures should be designed and sited to avoid the occurrence of nuisance conditions such as a saturated lawn surface, seepage into basements or runoff onto neighbouring properties. Overflows and overland routing to the conventional drainage system should be incorporated in site servicing and grading.

5. An appropriate factor of safety should be employed to allow for degraded performance of infiltration dependent LID measures over time. Also, facilities should be situated to allow them to be maintained and/or rehabilitated without disturbance to significant infrastructure.

8.3 COMPATIBILITY WITH ERICKSON CREEK AND BURROWS DITCH LOWLAND FUNCTIONAL PLAN 2002

Rather than undertake a detailed analysis of the lowland drainage system, our approach is to compare our estimated runoff hydrographs from both Grandview Heights and Campbell Heights with those the functional plan (UMA, 2002) for future conditions in those areas. Our expectation is that if our predicted future runoff hydrographs are consistent with those developed by UMA for the lowland functional drainage plan, then the improvements recommended in that plan are sufficient.

Using the ARDSA storm rainfall hyetographs provided by UMA, we used our future condition XPSWMM model to generate flow hydrographs for both Grandview Heights and Campbell Heights.

Figure 8-17 to 8-23 compares the future condition ARDSA storm runoff hydrographs from the earlier functional plan (UMA, 2002) with those from our proposed stormwater management strategy, at locations corresponding to those in the functional plan. These locations are also marked on Figure 8-4. The future condition hydrographs resulting from our analysis indicate lower peak flows and less total volume than were employed in the lowland Functional Plan.

Accordingly, we assume that the lowland drainage improvements recommended in the “Erickson Creek and Burrows Ditch Functional Plan” (UMA, 2002) are sufficient and will be implemented in parallel with those of this upland ISMP.

8.4 CREEK CHANNEL STABILITY

The following management measures will address erosion in the watershed:

- Implementing detention storage to provide peak flow attenuation in the Grandview Heights area and relying on exfiltration of stormwater in the Campbell Heights area.
- Employing LID measures in Grandview Heights to reduce total runoff volumes, and maintain dry period base flows.
- Stabilizing significant erosion sites using riprap armour and/or bio-engineering techniques as necessary on a case by case basis. See Figures 8-24A & 8-24B for identified erosion sites.
- Monitoring erosion sites on a frequent basis, and remediation works implemented if problems are continuing or worsening.

During the field survey, we identified debris blockages at several locations in the creek systems. These locations are also shown on Figures 8-24A and 8-24B. Debris blockages have the potential to aggravate erosion problems if they divert high flows against sensitive banks or disrupt the stream profile. Debris accumulations should be removed where they have the potential to cause these problems. Debris interception at significant structures is also a worthwhile maintenance strategy.

8.5 EXISTING DEFICIENCIES

We identified upland culverts that surcharge under future conditions, during a 100-year return period event. These are summarized in Table 8-5 and indicated on Figures 8-24A and 8-24B. Certain culverts surcharge because of backwater conditions, not solely due to inadequate size. Table 8-5 includes the proposed diameter for upgrading deficient culverts. Note that we do not identify a culvert upgrade as necessary if the degree of surcharge is less than 10% of the culvert diameter, and we use a minimum culvert size of 600 mm (0.6 m) for any culvert upgrade.

Also, we indicate where improved routing is required to resolve identified local drainage deficiencies, refer again to Figure 8-24A and 8-24B. These measures include securing major flow routing to the lowlands from Grandview Heights and Campbell Heights. In some cases, these improvements may be interim measures until the stormwater management plan is implemented in full.

Pond ID	Pond Detention Volume (m^3)	Water Surface Area at 1.5 m depth (m^2)	Active Storage Depth (m)	Pond Footprint (ha)
G1	6000	4410	1.5	1.12
G2	9000	6500	1.5	1.56
G3	2250	1760	1.5	0.53
G4	1500	1210	1.5	0.40
G5	900	760	1.5	0.29
G6	7500	5460	1.5	1.34
G7	5000	3710	1.5	0.97
G8	18000	14080	1.5	2.83

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Associated Engineering GLOBAL PERSPECTIVE. LOCAL FOCUS.

Jacques Whitford AXYS

Table 8-2
Proposed Detention Facility Volumes for Grandview Heights

Table 8-3
Comparison of Flow
Duration Characteristics

Hydrograph Locatio	Percentile	Exceedance	Pre-Development	Post Development - No LID	Recommended LID
GFD010	95th Percentile	5%	42.9	69.0	43.5
	80th Percentile	20%	24.5	33.5	28.6
	50th Percentile	50%	8.8	15.3	12.9
	25th Percentile	75%	3.2	4.1	3.7
	Percentile for Minimum Reportable Flow (1 L/s)		9.16%	14.22%	9.90%
	Exceedance of Minimum Reportable Flow (L/s)		90.84%	85.78%	90.10%
GFD020	95th Percentile	5%	61.6	96.3	84.1
	80th Percentile	20%	36.3	47.2	45.4
	50th Percentile	50%	11.0	16.9	17.0
	25th Percentile	75%	3.7	4.5	4.6
	Percentile for Minimum Reportable Flow (1 LPS)		8.18%	13.66%	8.68%
	Exceedance of Minimum Reportable Flow (L/s)		91.82%	86.34%	91.32%
GFD030	95th Percentile	5%	273.4	336.1	295.4
	80th Percentile	20%	160.6	149.1	149.1
	50th Percentile	50%	52.1	31.9	47.5
	25th Percentile	75%	18.8	9.2	15.7
	Percentile for Minimum Reportable Flow (1 LPS)		0.20%	7.18%	0.60%
	Exceedance of Minimum Reportable Flow (L/s)		99.80%	92.82%	99.40%
GFD040	95th Percentile	5%	40.8	59.0	50.6
	80th Percentile	20%	23.8	24.1	23.3
	50th Percentile	50%	7.4	2.9	6.1
	25th Percentile	75%	2.5	0.4	1.8
	Percentile for Minimum Reportable Flow (1 LPS)		12.69%	35.86%	16.27%
	Exceedance of Minimum Reportable Flow (L/s)		87.31%	64.14%	83.73%
GFD050	95th Percentile	5%	38.5	47.5	43.0
	80th Percentile	20%	19.7	18.4	19.8
	50th Percentile	50%	6.2	7.1	7.7
	25th Percentile	75%	2.0	1.0	1.8
	Percentile for Minimum Reportable Flow (1 LPS)		14.94%	25.27%	17.77%
	Exceedance of Minimum Reportable Flow (L/s)		85.06%	74.73%	82.23%

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Major Drainage System Culverts - 100 year Return Period Deficiencies							
Culvert ID	**Peak Flow (m3/s)**	**Surcharge (d/D)**	**Current Diameter (mm)**	**Proposed Diameter (mm)**	**Length (m)**	**Unit Cost ($/m)**	**Capital Cost ($)**
C32-S0270	0.08	1.015	300		59		
C184-W0160	0.12	1.079	375		43		
C184-E0130	0.51	1.102	600		50		
C24-S0170	0.1	1.108	300		5		
C184-W0310	0.37	1.126	600	750	5	660	$3,366
C184-W0260	1.34	1.303	900	1050	25	700	$17,290
CJUST-0329.9	0.83	1.311	750	900	6	700	$4,424
C24-S0160	0.1	1.406	300	600	8	610	$4,880
C184-E0210	0.12	1.499	300	600	8	610	$4,575
C184-W0170	0.12	1.5	300	600	17	610	$10,670
C24-S090	0.47	1.542	450	750	7	660	$4,290
CTRIB2-0327	0.04	1.55	200	600	5	610	$3,050
C184-W0290	0.53	1.585	600	750	9	660	$6,131
C32-S082	0.41	1.642	600	750	5	660	$3,525
C184-W0220	0.12	1.646	300	600	8	610	$4,880
C188-E0010	0.04	1.654	250	600	73	610	$44,281
C184-E0140	0.51	1.672	600	750	31	660	$20,632
C32-S0290	0.05	1.734	250	600	32	610	$19,398
C184-E0200	0.11	1.805	300	600	10	610	$6,100
C32-S085	0.41	1.813	600	750	12	660	$8,115
C180-E0260	0.2	1.867	375	600	11	610	$6,576
C180-E0250	0.18	1.874	375	600	8	610	$5,109
CVAN-0328	0.38	1.909	450	750	10	660	$6,890
C28-S020	0.12	1.912	300	600	13	610	$7,930
C184-E0100	0.58	1.914	600	900	44	700	$30,800
C184-E0240	0.12	1.928	300	600	5	610	$3,050
C184-E0360	0.31	1.956	600	750	14	660	$9,002
C24-S0158	0.1	1.987	300	600	21	610	$12,991
C28-S010	0.12	2.02	300	600	7	610	$4,441
C24-S0110	0.56	2.104	450	600	6	610	$3,660
C24-N050	0.36	2.158	500	600	14	610	$8,540
C184-W0210	0.09	2.175	300	600	6	610	$3,660
C24-S040	0.4	2.251	450	750	7	660	$4,620
C24-S030	0.41	2.344	450	750	8	660	$5,280
C24-S020	0.42	2.487	450	750	6	660	$3,960
C184-E0150	0.37	2.502	450	600	6	610	$3,843
C24-S080	0.42	2.584	450	750	6	660	$3,960
C184-W0350	0.31	2.607	450	600	36	610	$22,131
C24-S050	0.42	2.61	450	750	8	660	$5,280
C24-S060	0.42	2.65	450	750	6	660	$3,960
C24-S070	0.38	2.706	450	750	6	660	$3,960
C24-S0100	0.47	3.033	450	600	6	610	$3,660
CVAN-0324	0.06	3.44	200	600	15	610	$9,290
C184-W0280	0.51	3.781	450	900	19	700	$13,209
C180-E0240	0.18	3.908	375	600	4	610	$2,715
C184-E0170	0.15	3.938	300	600	7	610	$4,270
C180-E0270	0.1	4.322	250	600	9	610	$5,323
CVAN-0326	0.07	4.336	200	600	4	610	$2,513
C180-E0280	0.14	5.124	250	600	8	610	$4,880
C184-E0160	0.17	5.141	300	600	20	610	$12,200
C32-S0260	0.08	5.938	300	600	24	610	$14,762
C180-E0200	0.11	6.071	250	600	76	610	$46,117
C180-E0190	0.1	6.107	250	600	16	610	$9,595
C180-E0290	0.13	7.061	250	600	20	610	$12,143
C24-S0180	0.1	8.006	300	600	299	610	$182,635
C184-E0190	0.21	8.448	300	600	8	610	$4,880
C180-E0210	0.13	8.986	250	600	75	610	$45,928
C180-E0170	0.01	13.877	100	600	38	610	$23,464
C180-E0180	0.01	19.82	100	600	63	610	$38,247
Minor Storm Drainage System - 5 year Return Period Deficiencies							
Pipe ID	**Peak Flow (m3/s)**	**Surcharge (d/D)**	**Current Diameter (mm)**	**Proposed Diameter (mm)**	**Length (m)**	**Unit Cost ($/m)**	**Capital Cost ($)**
C180-E0230	0.52	3.096	525	750	67	660	$44,288
C180-W030	0.36	4.614	450	600	122	610	$74,383
C180-W040	0.36	5.601	375	600	126	610	$77,128
C170-E000	0.35	6.093	375	600	170	610	$103,430
C179-E010	0.21	6.659	375	600	86	610	$52,401
C22-N020	0.08	7.468	250	450	37	570	$20,976
C179-W020	0.09	8.54	300	450	8	570	$4,557
C179-E020	0.23	8.805	375	450	124	570	$70,706
C179-E030	0.16	8.942	375	450	62	570	$35,335
C22-N010	0.08	10.756	200	450	59	570	$33,397
C179-W010	0.09	11.011	300	450	75	570	$42,728
C179-E040	0.09	16.016	200	450	27	570	$15,304

LEGEND **TOTAL** **$1,335,714**

Culvert surcharged less than 10%- no upgrade required
Culvert surcharged partially or completely influenced by backwater conditions
Component of piped minor drainage system

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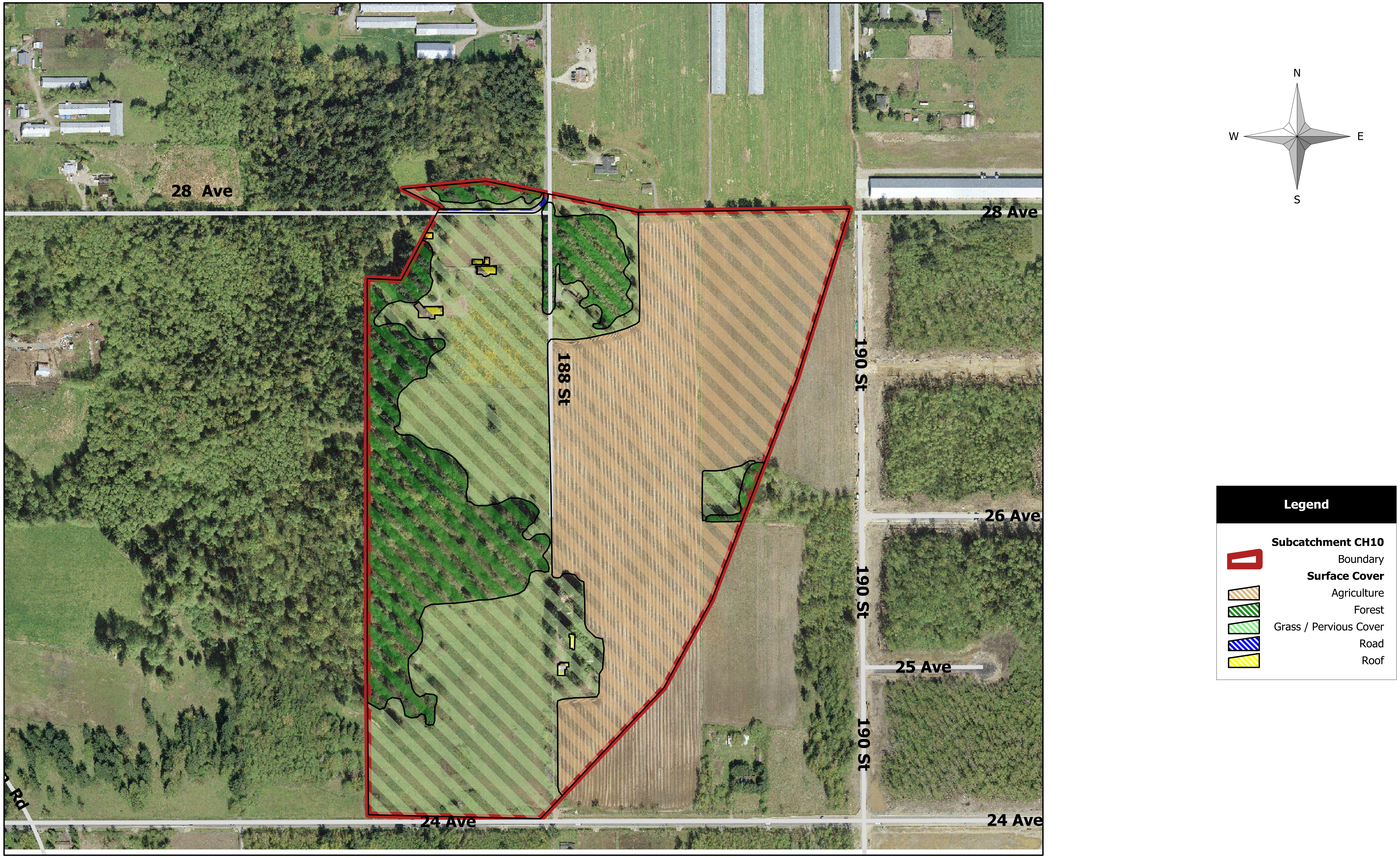
Table 8-5
Proposed Drainage Upgrades
(Future Conditions with BMPs)



SCALE 1:5000

0 200 m

PRELIMINARY
NOT FOR CONSTRUCTION

Associated Engineering

City of Surrey

CH10 Existing Land Use

Erickson Creek ISMP
Campbell Heights LID Assessment

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 8-1		

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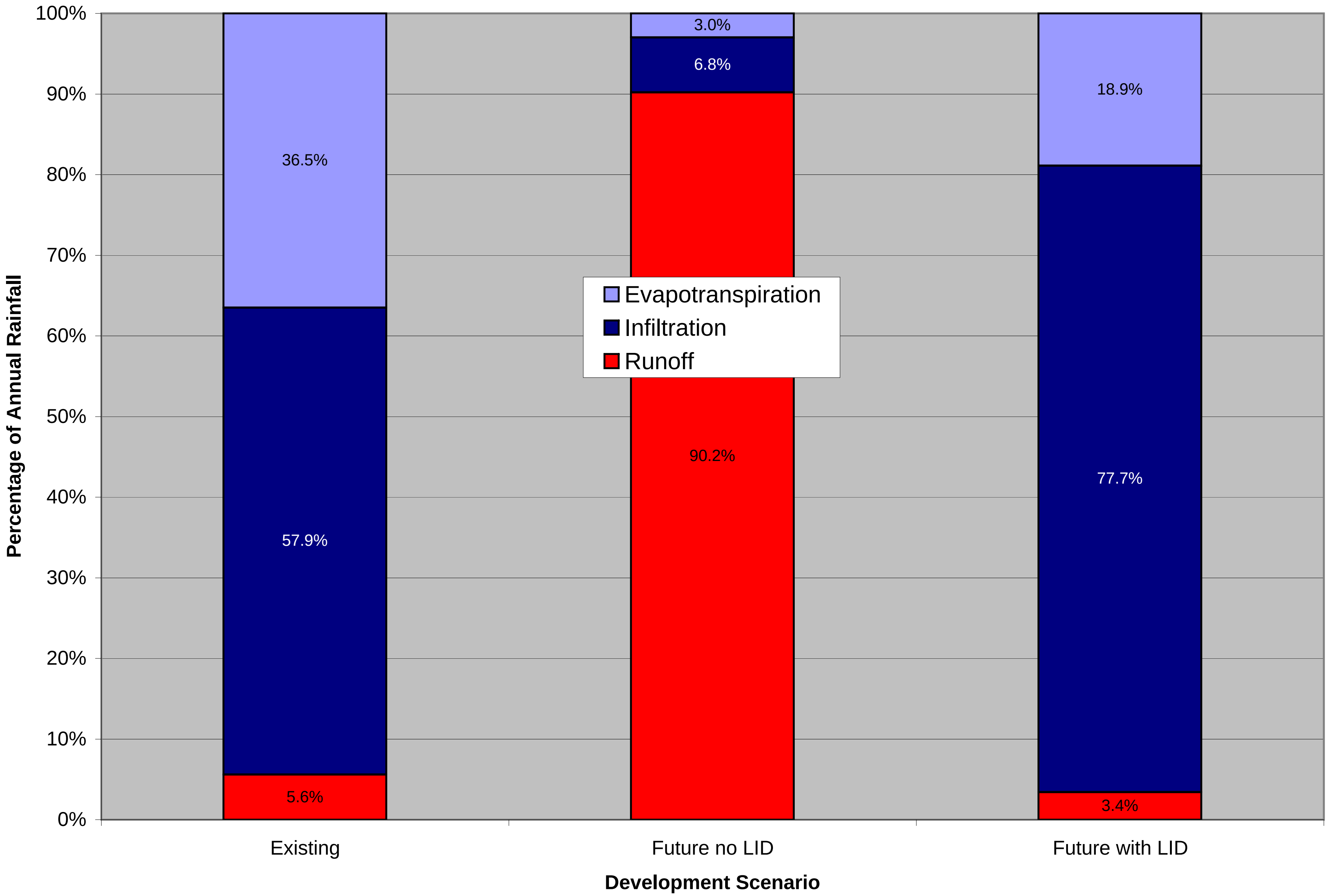
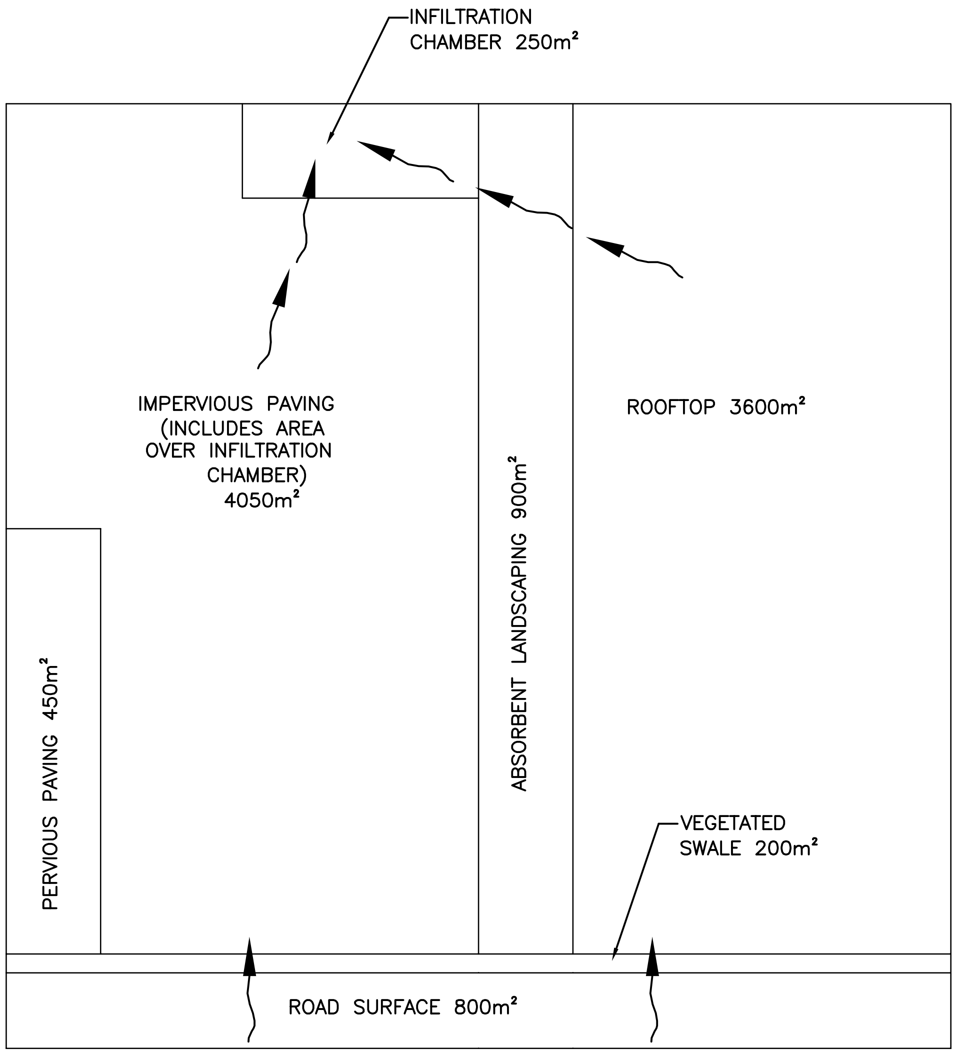


Figure 8-2

Comparison of Water Balance Volumes for Existing and Future Development Conditions



CAMPBELL HEIGHTS
SURFACE COVERAGE AND LID ROUTING
N.T.S.

NOTE:
WATER BALANCE MODEL BASED ON A 10000m² LOT, REPRESENTATIVE OF FUTURE CONDITIONS

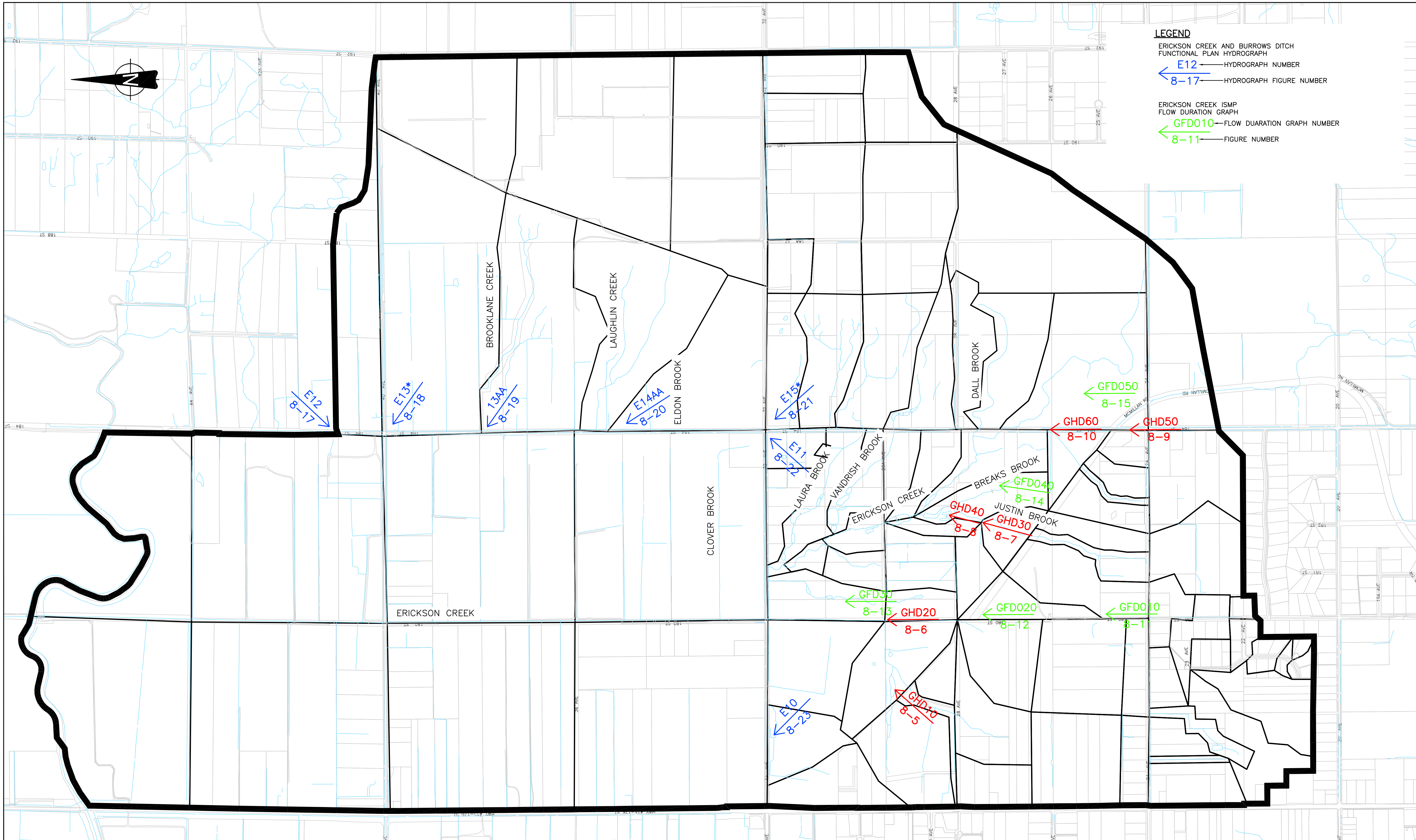
SURREY
CITY OF PARKS

CITY OF SURREY
ERICKSON CREEK ISMP
CAMPBELL HEIGHTS LOT SCHEMATIC

FIGURE 8-3

Associated Engineering

Time: 13:53
Date: 2008/7/2
Plot Scale: 1=1 (Paper Space)
AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\FIGURE 8-3.DWG (GQ)



Associated Engineering

SURREY CITY OF PARKS

ENGINEERING DEPARTMENT

REVISIONS	DESCRIPTION	BY	DATE	APPROVED
5				
4				
3				
2	PHASE 4	G.Q.	JAN. 2008	M.M.
1	PHASE 3	G.Q.	MAR. 2007	N.N.

BENCH MARK – S.M. # ELEV.

SEAL

TITLE
ERICKSON CREEK ISMP MANAGEMENT PLAN
KEY HYDROGRAPH LOCATIONS

SCALE: HOR. 1:10000 VERT. 1:10000
DATE JULY 2008
DRAWN G.Q. CHECKED L.B.
DESIGNED N.N. CHECKED
CONTRACT
P.W. P.U.
AS BUILT
APPROVED
DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS
PROJECT NUMBER
DRAWING NUMBER FIGURE 8-4
SHEET OF
REVISION 1

F-87 PRODUCED BY CAD/CAM

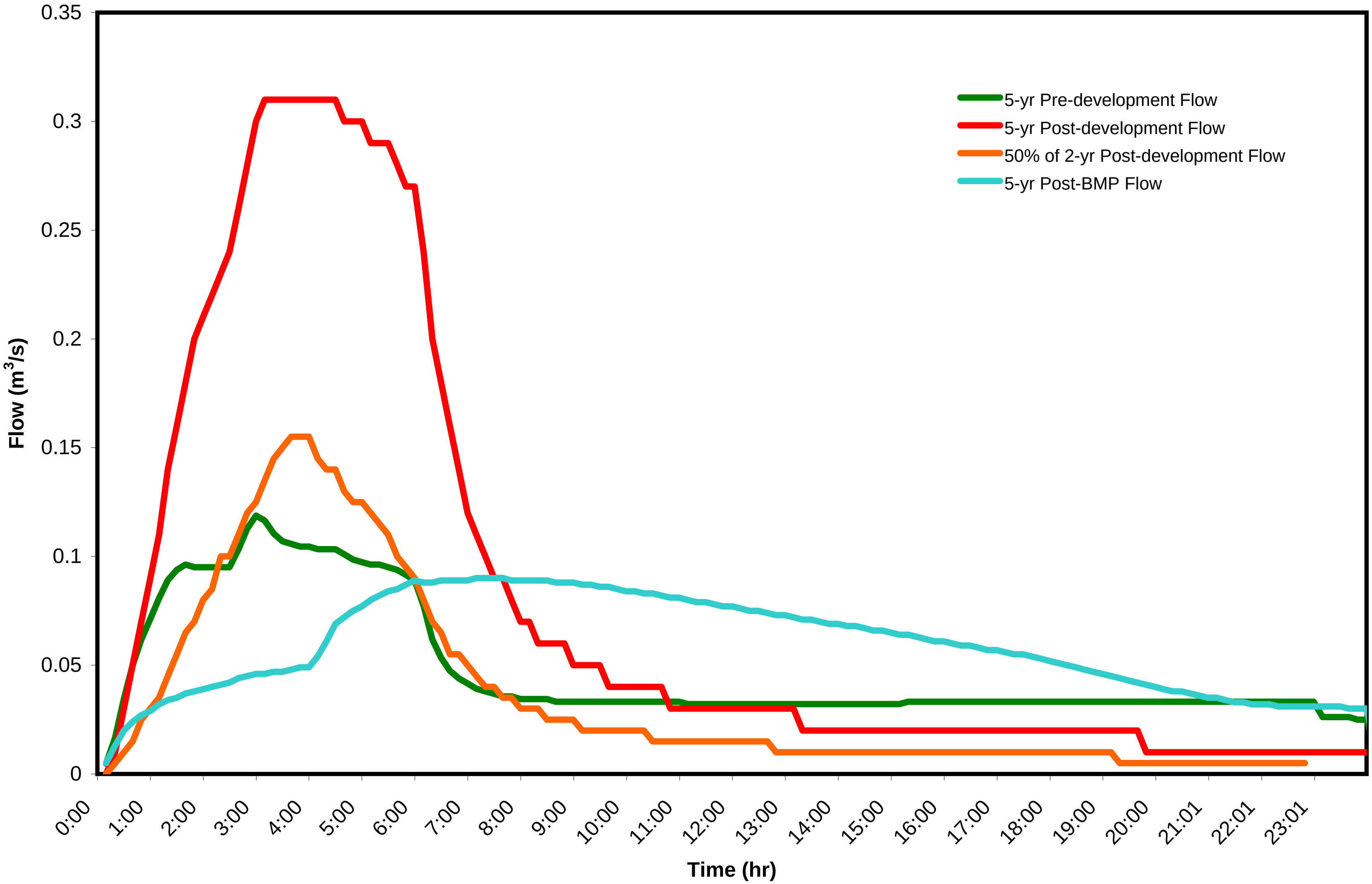


FIGURE 8-5
GHD10 6 Hour Event Hydrographs

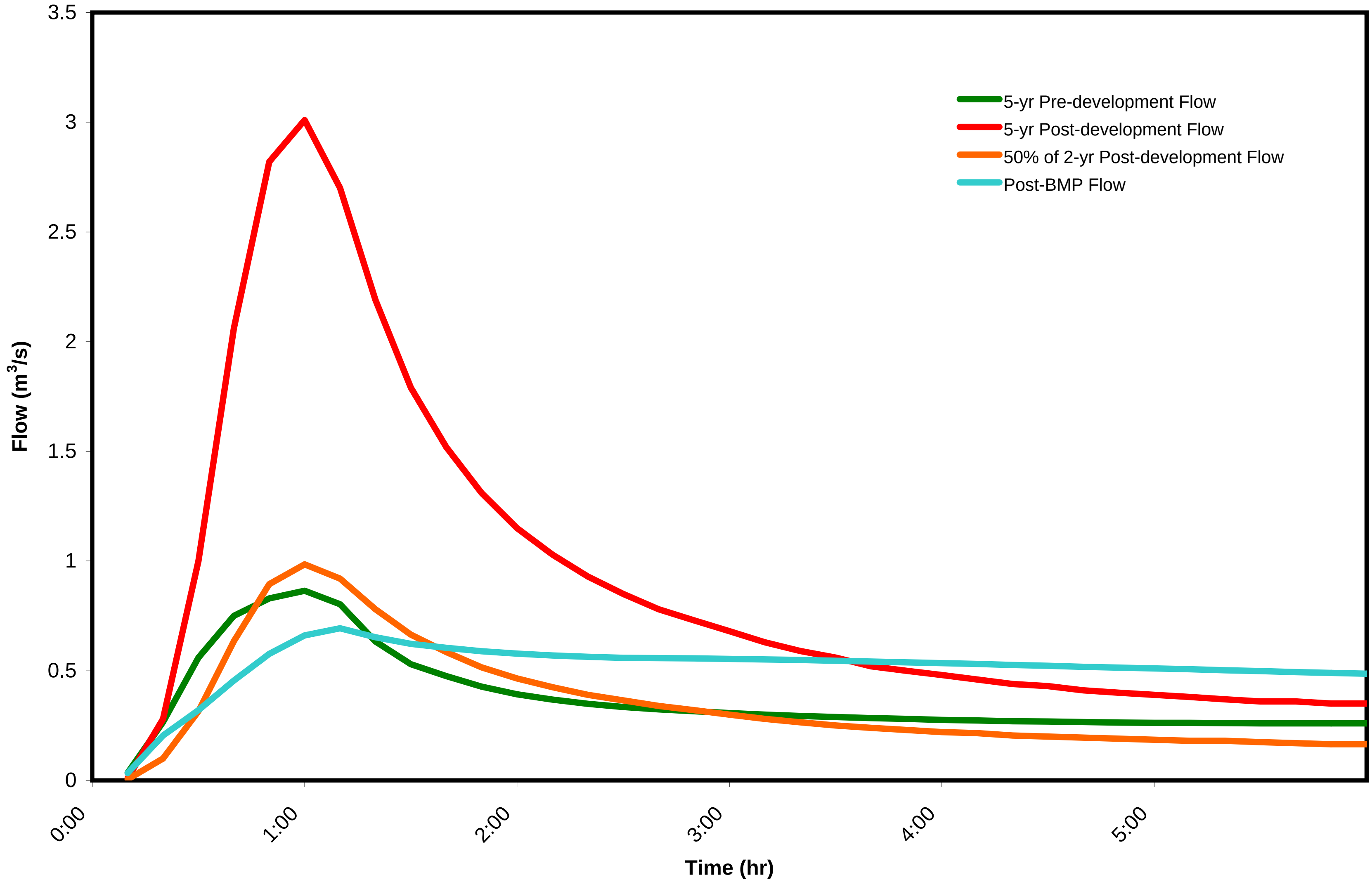


FIGURE 8-6
GHD20 1 Hour Event Hydrographs

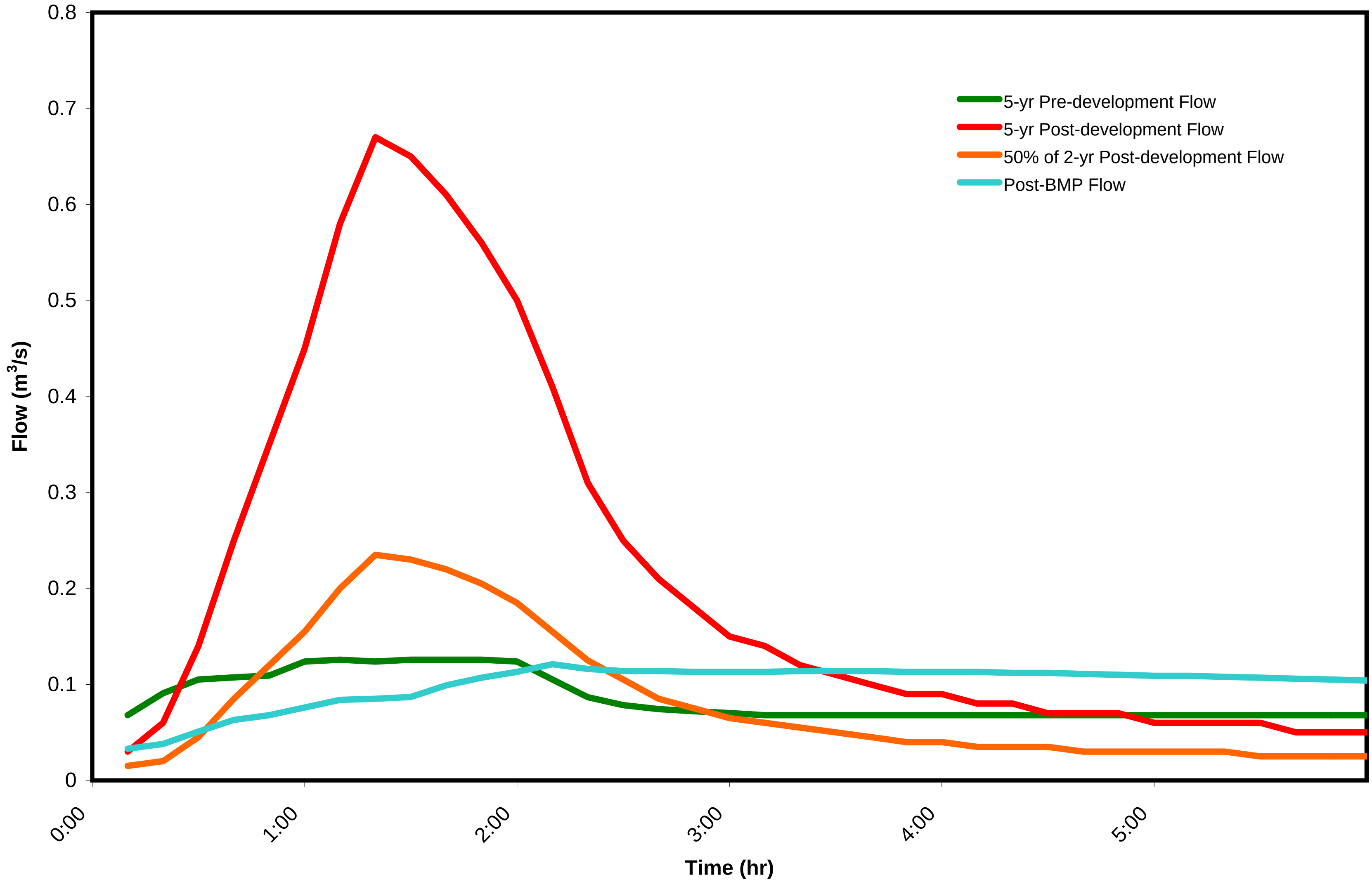


FIGURE 8-7
GHD30 2 Hour Event Hydrographs

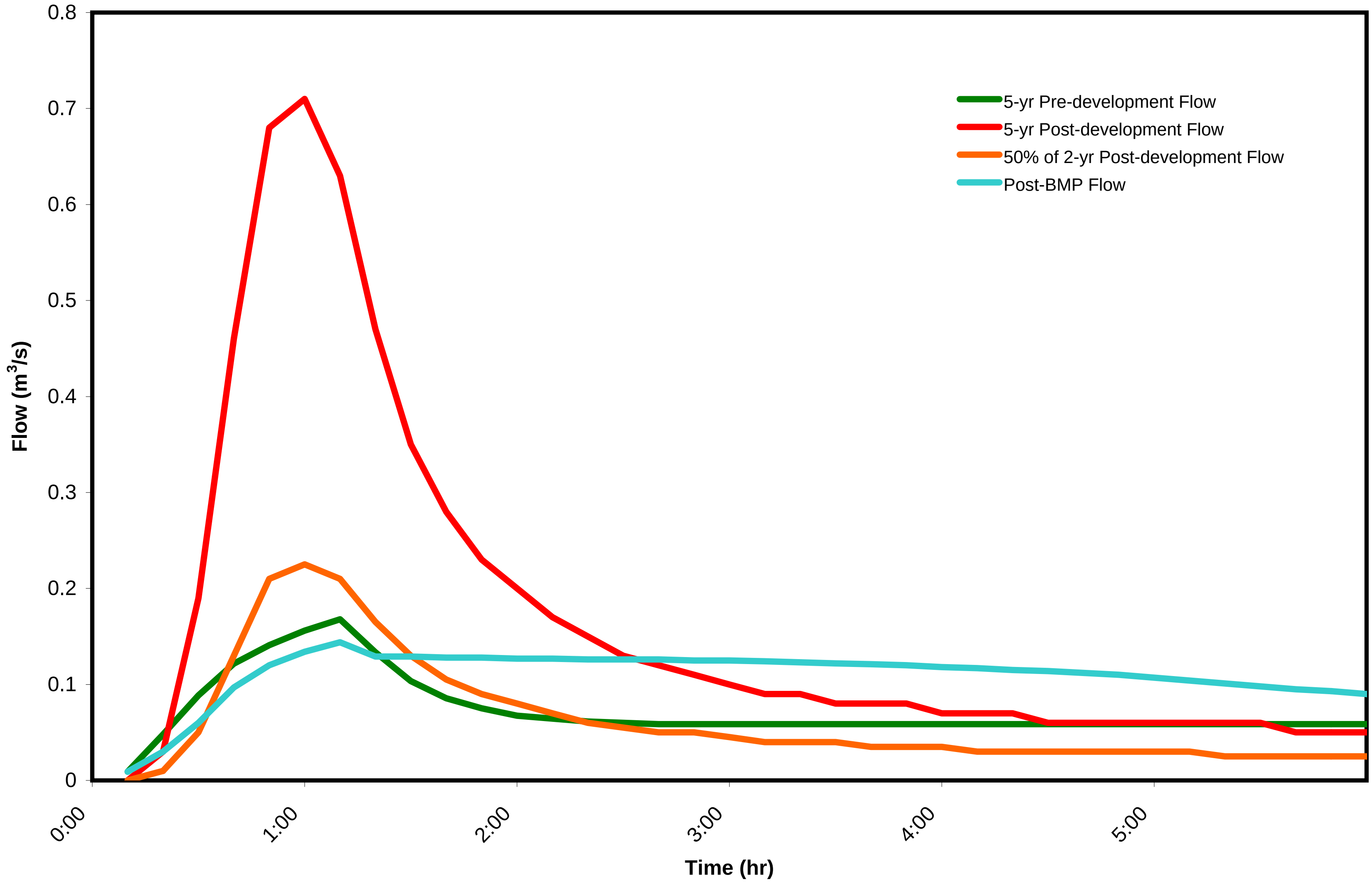


FIGURE 8-8
GHD40 1 Hour Event Hydrographs

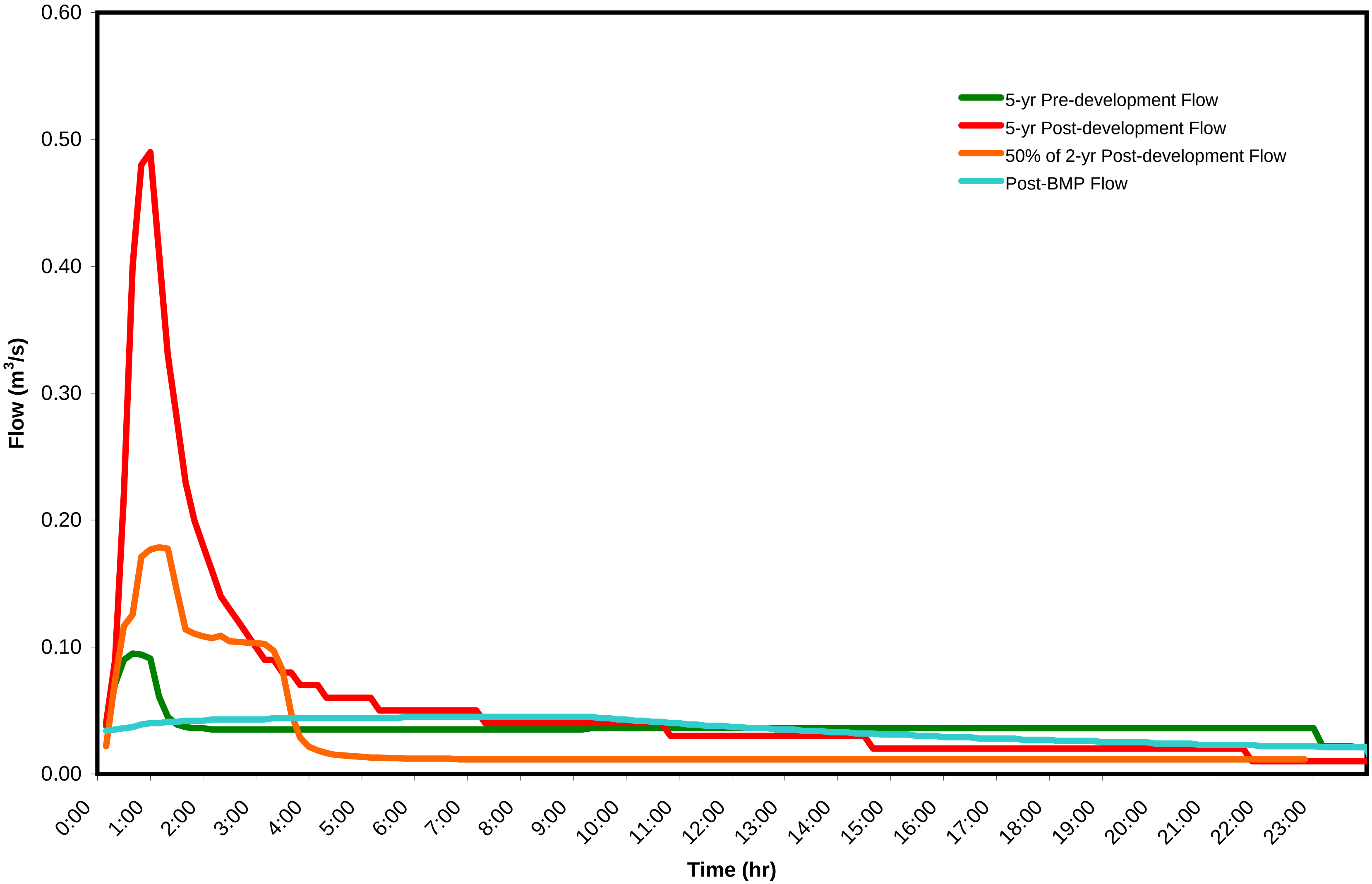


FIGURE 8-9
GHD50 3 Hour Event Hydrographs

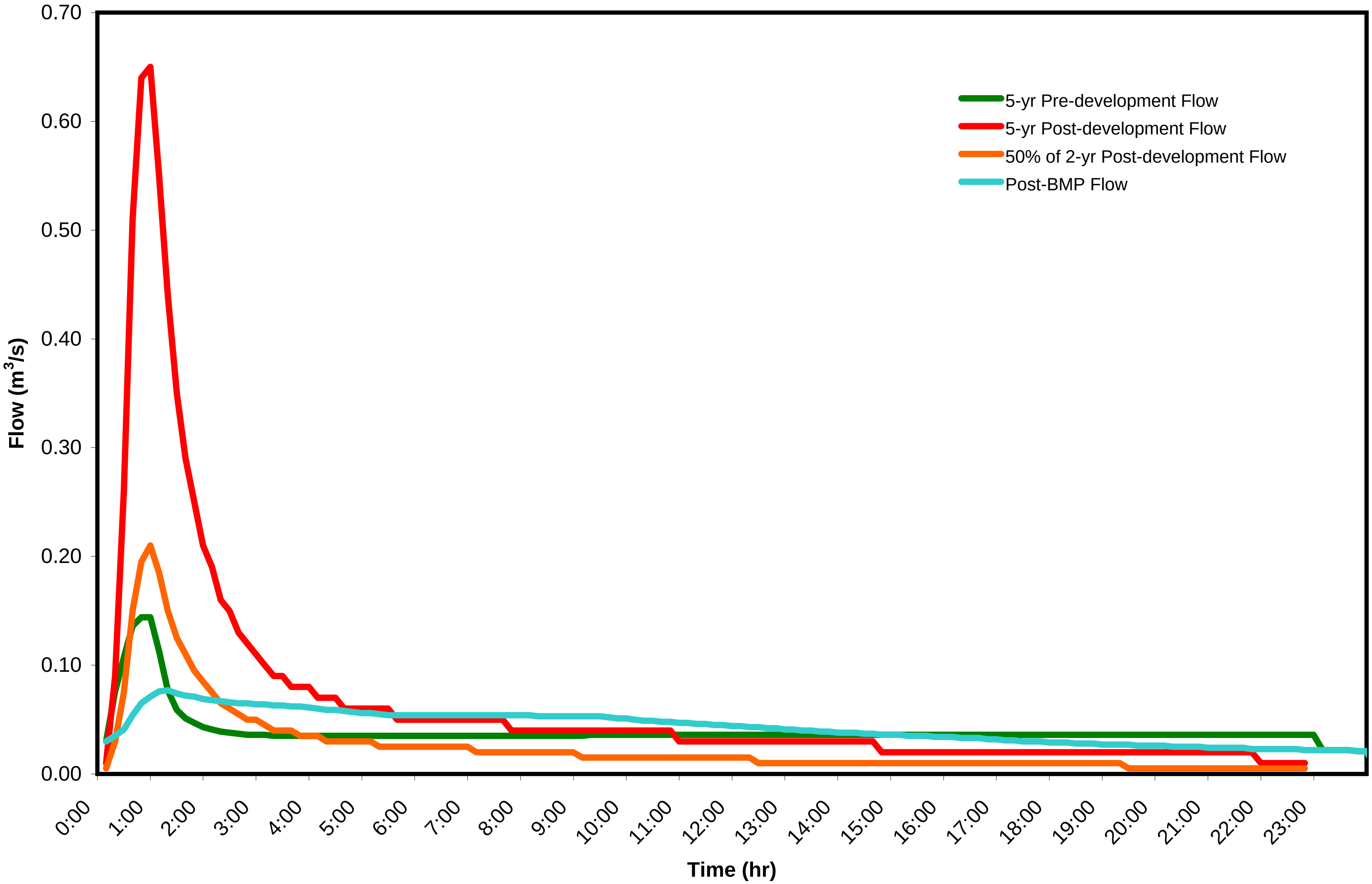


FIGURE 8-10
GHD60 1 Hour Event Hydrographs

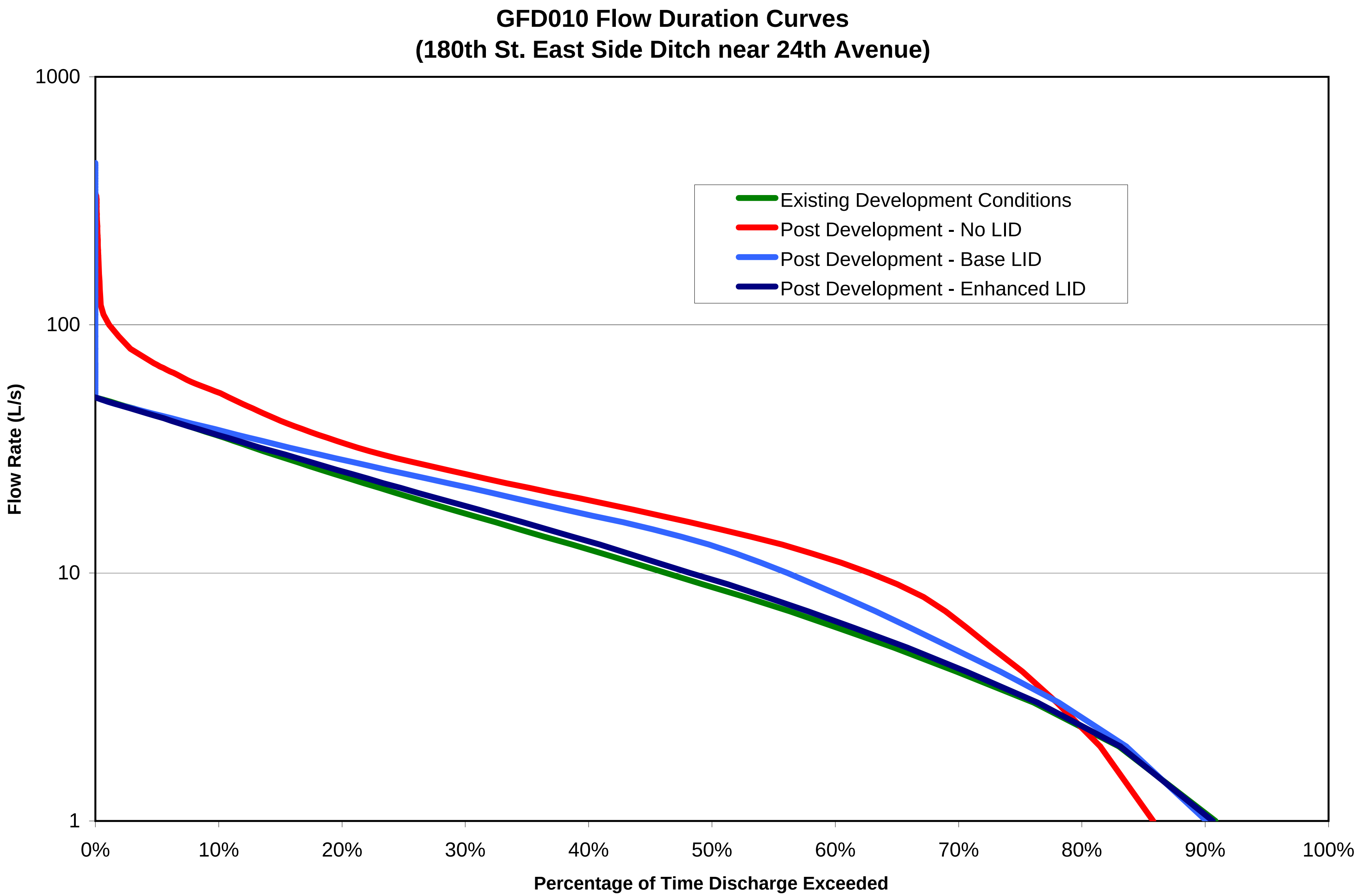

GFD010 Flow Duration Curves
(180th St. East Side Ditch near 24th Avenue)
1000
100
10
1
Flow Rate (L/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Discharge Exceeded
Existing Development Conditions
Post Development - No LID
Post Development - Base LID
Post Development - Enhanced LID

Figure 8-11

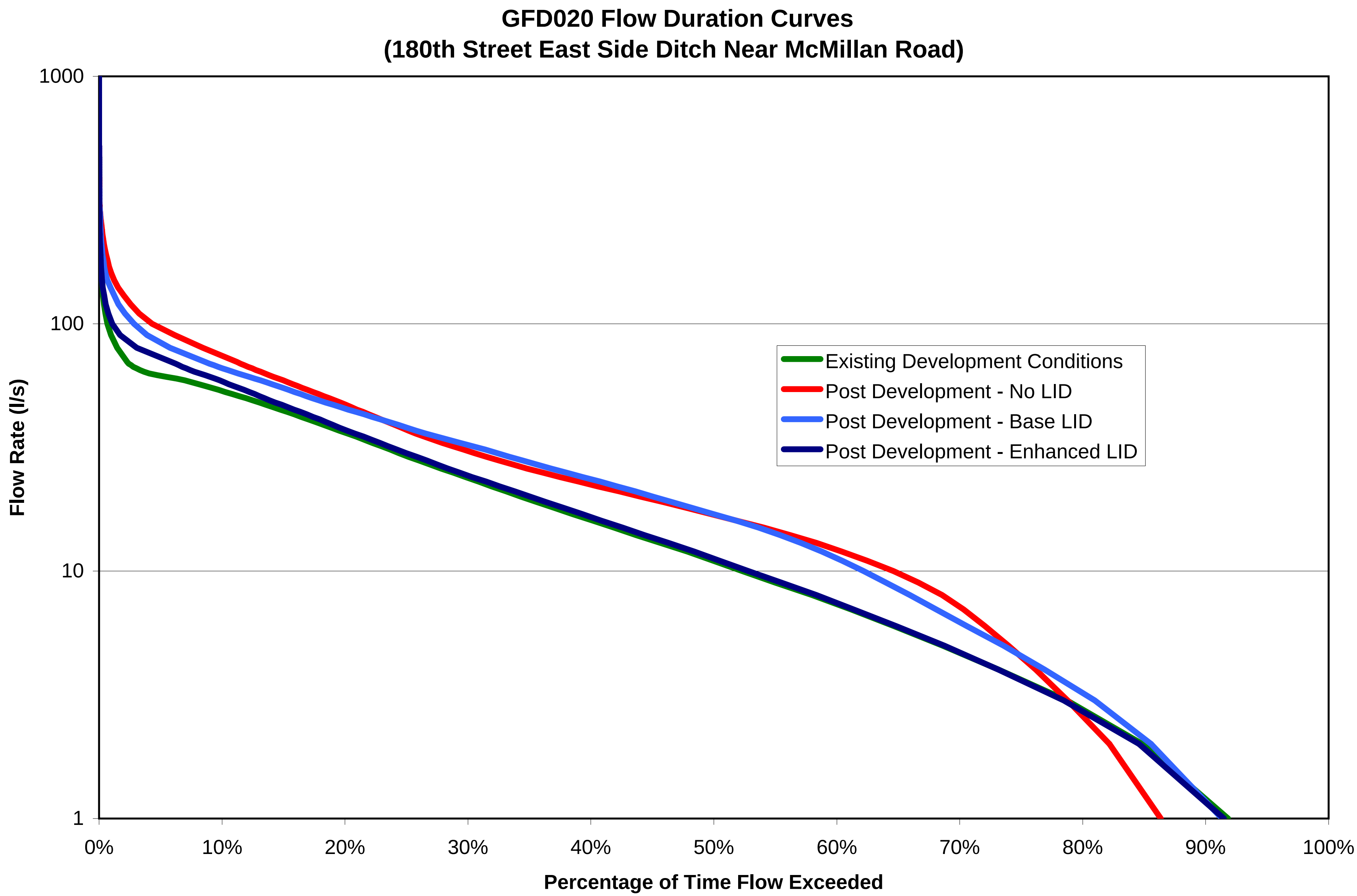
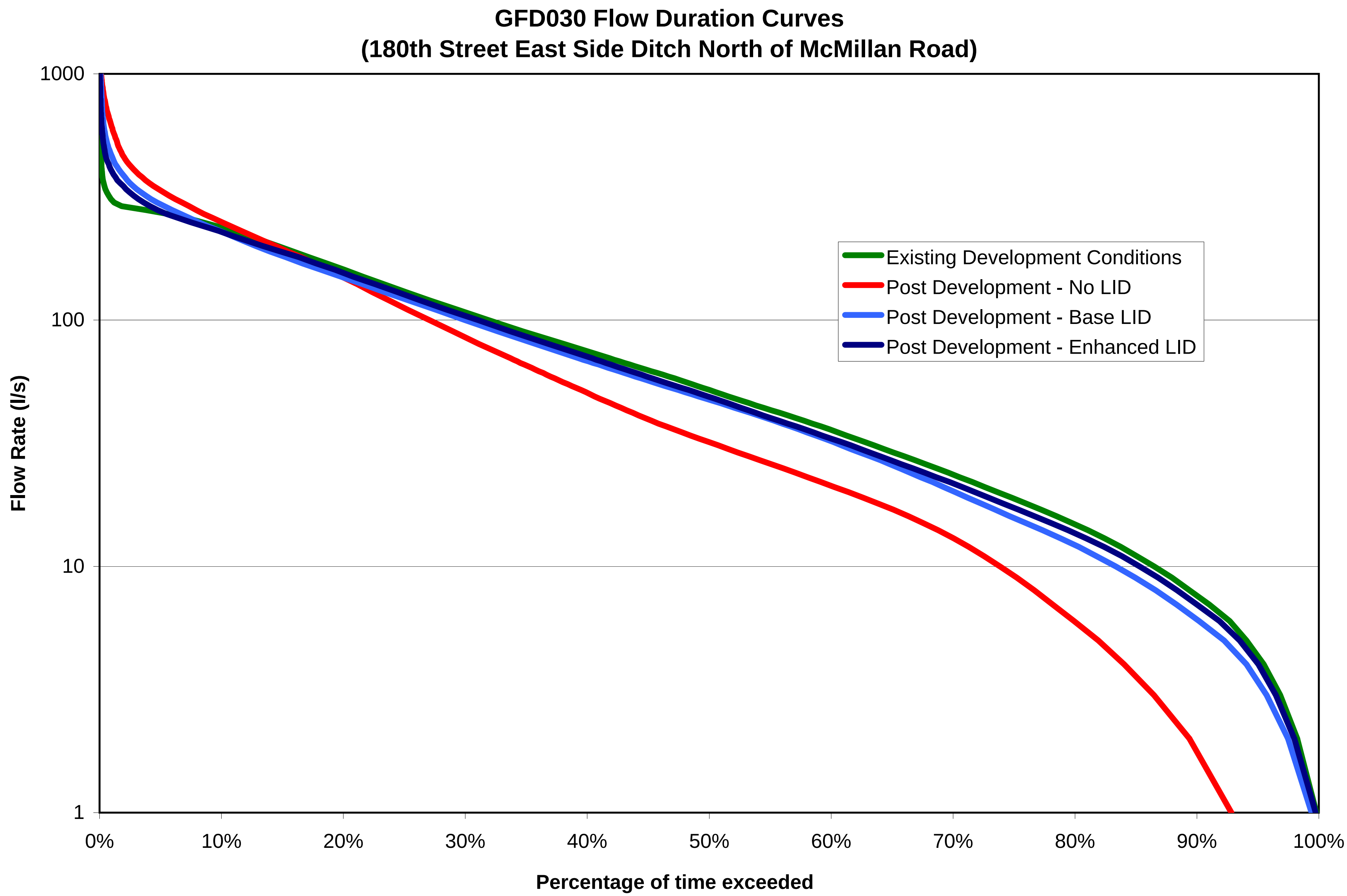
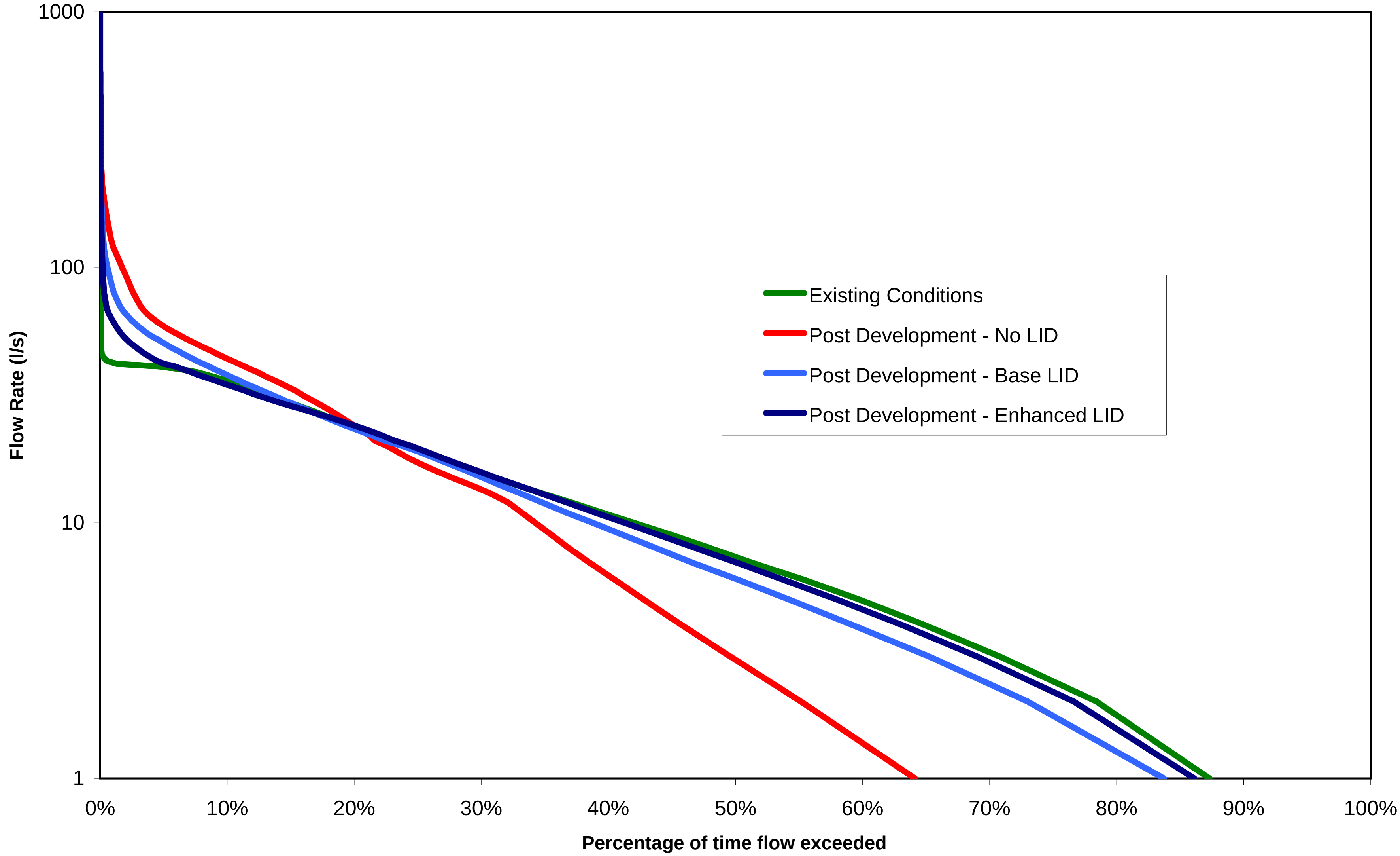
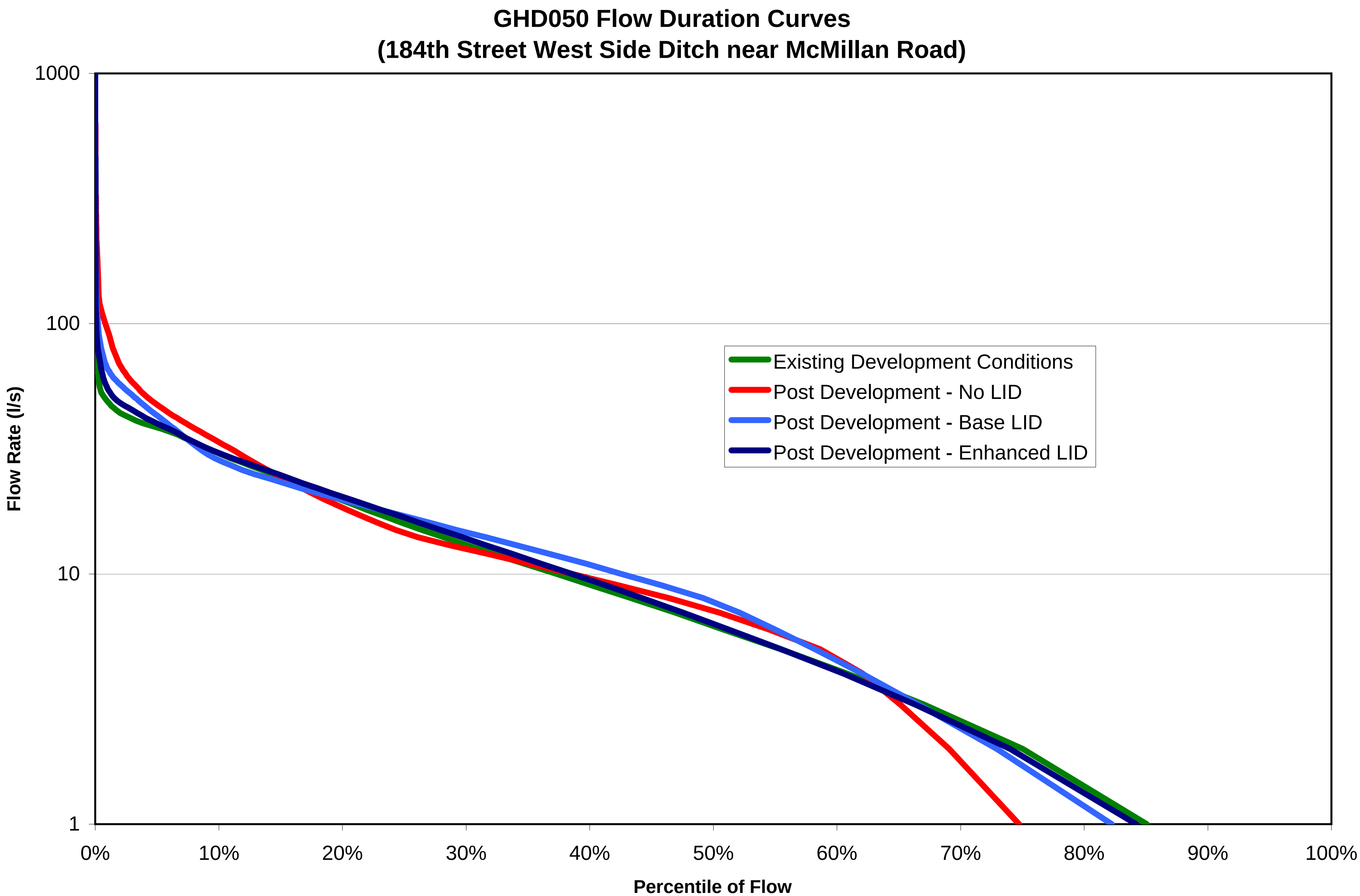

GFD020 Flow Duration Curves
(180th Street East Side Ditch Near McMillan Road)
1000
100
10
1
Flow Rate (l/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flow Exceeded
Existing Development Conditions
Post Development - No LID
Post Development - Base LID
Post Development - Enhanced LID

Figure 8-12

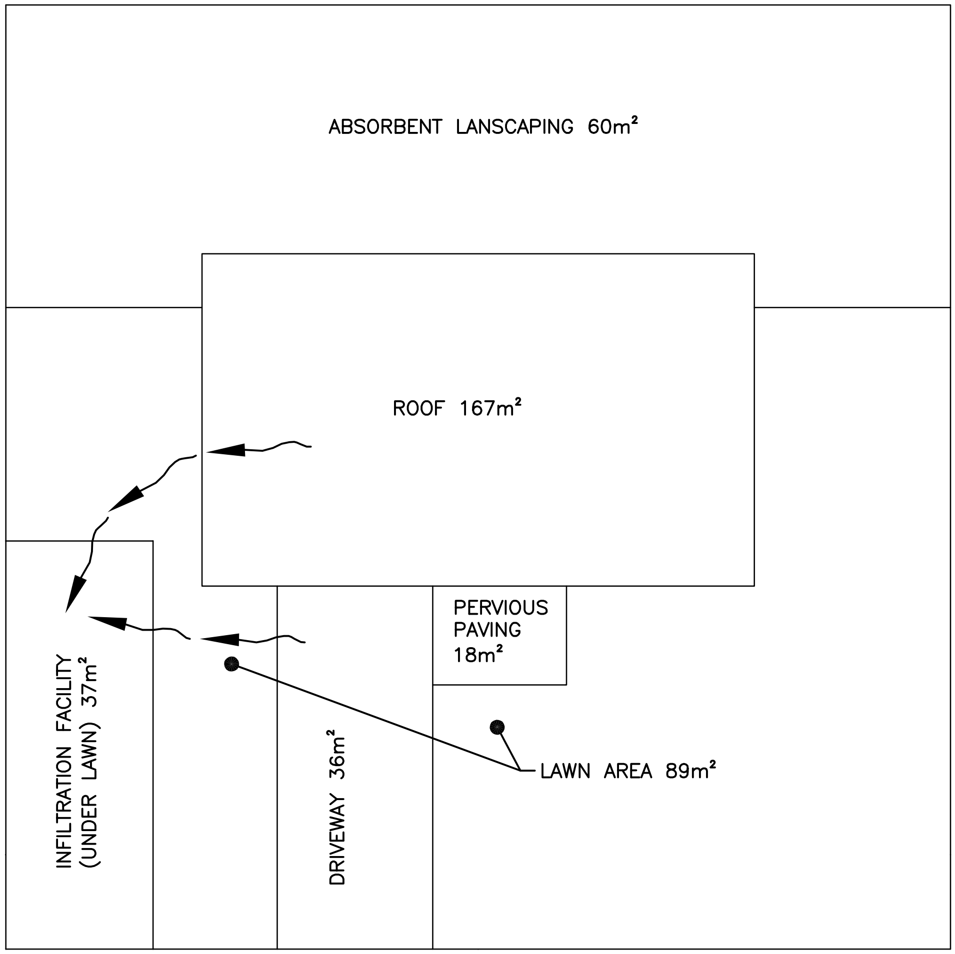

GFD030 Flow Duration Curves
(180th Street East Side Ditch North of McMillan Road)
1000
100
10
1
Flow Rate (l/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time exceeded
Existing Development Conditions
Post Development - No LID
Post Development - Base LID
Post Development - Enhanced LID

GFD040 Flow Duration Curves
(Justin Brook North of McMillan Road)





GHD050 Flow Duration Curves
(184th Street West Side Ditch near McMillan Road)
1000
100
10
1
Flow Rate (l/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentile of Flow
Existing Development Conditions
Post Development - No LID
Post Development - Base LID
Post Development - Enhanced LID



SURREY
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CITY OF SURREY
ERICKSON CREEK ISMP
ASSUMED LOT PROPORTIONS USED IN EXFILTRATION FACILITY EVALUATION

FIGURE 8-16

Associated Engineering

Time: 13:50
Date: 2008/7/2
Plot Scale: 1=1 (Paper Space)
AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\FIGURE 8-16.DWG (GQ)

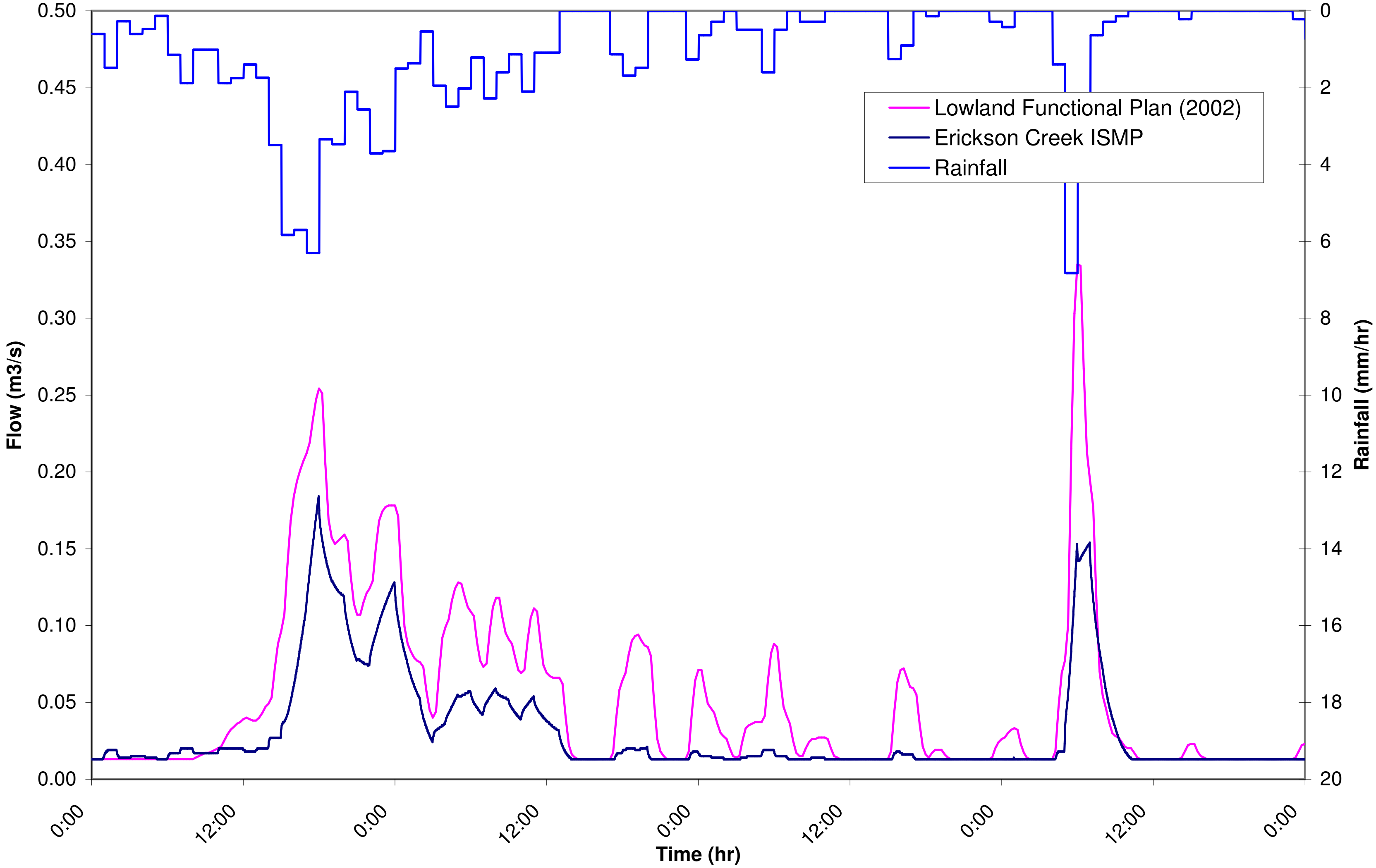


FIGURE 8-17
Hydrographs Comparison between Lowland Functional Plan (2002) and Erickson Creek ISMP
E12

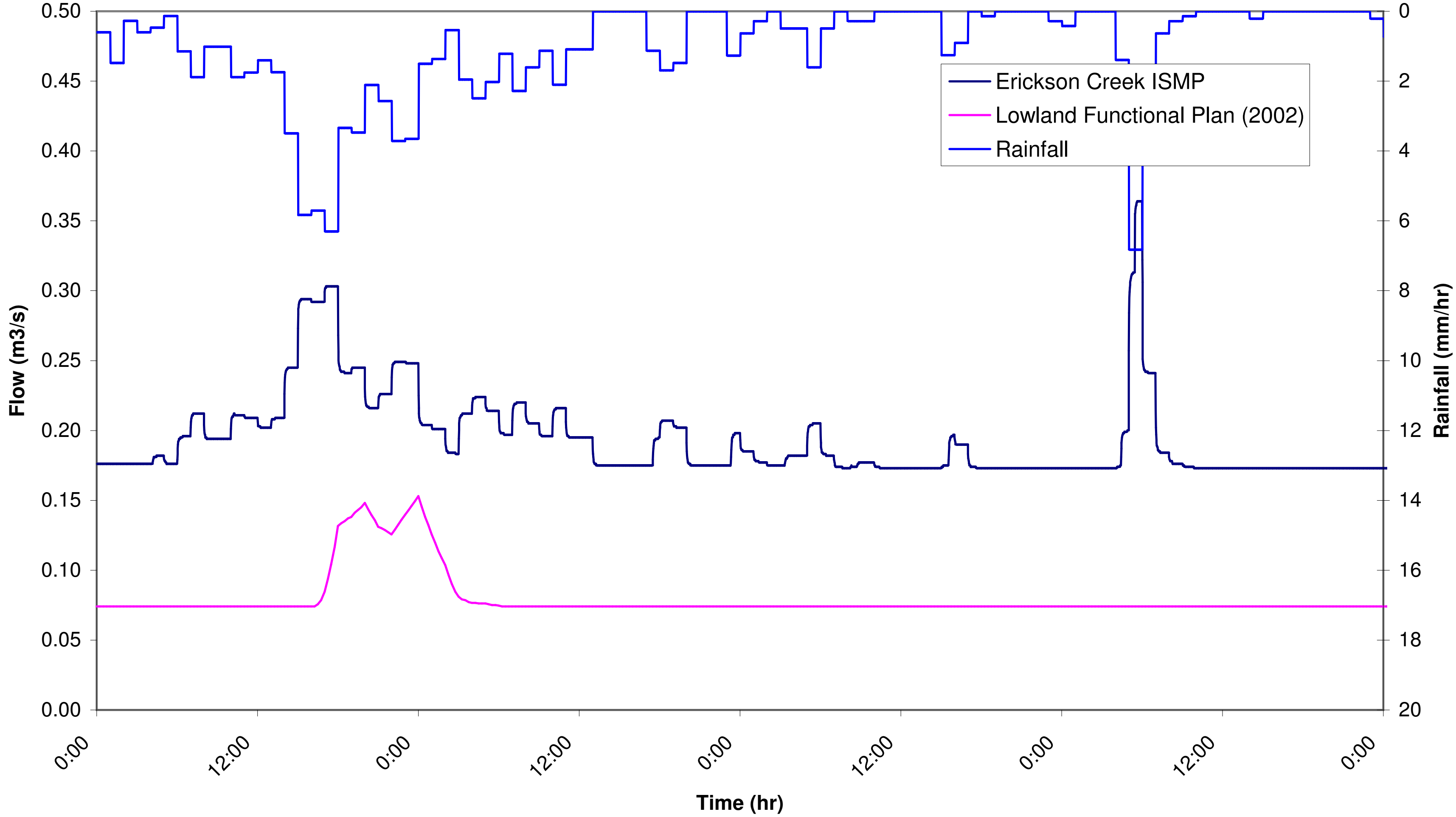


FIGURE 8-18
Hydrographs Comparison between Lowland Functional Plan and ISMP
E13*

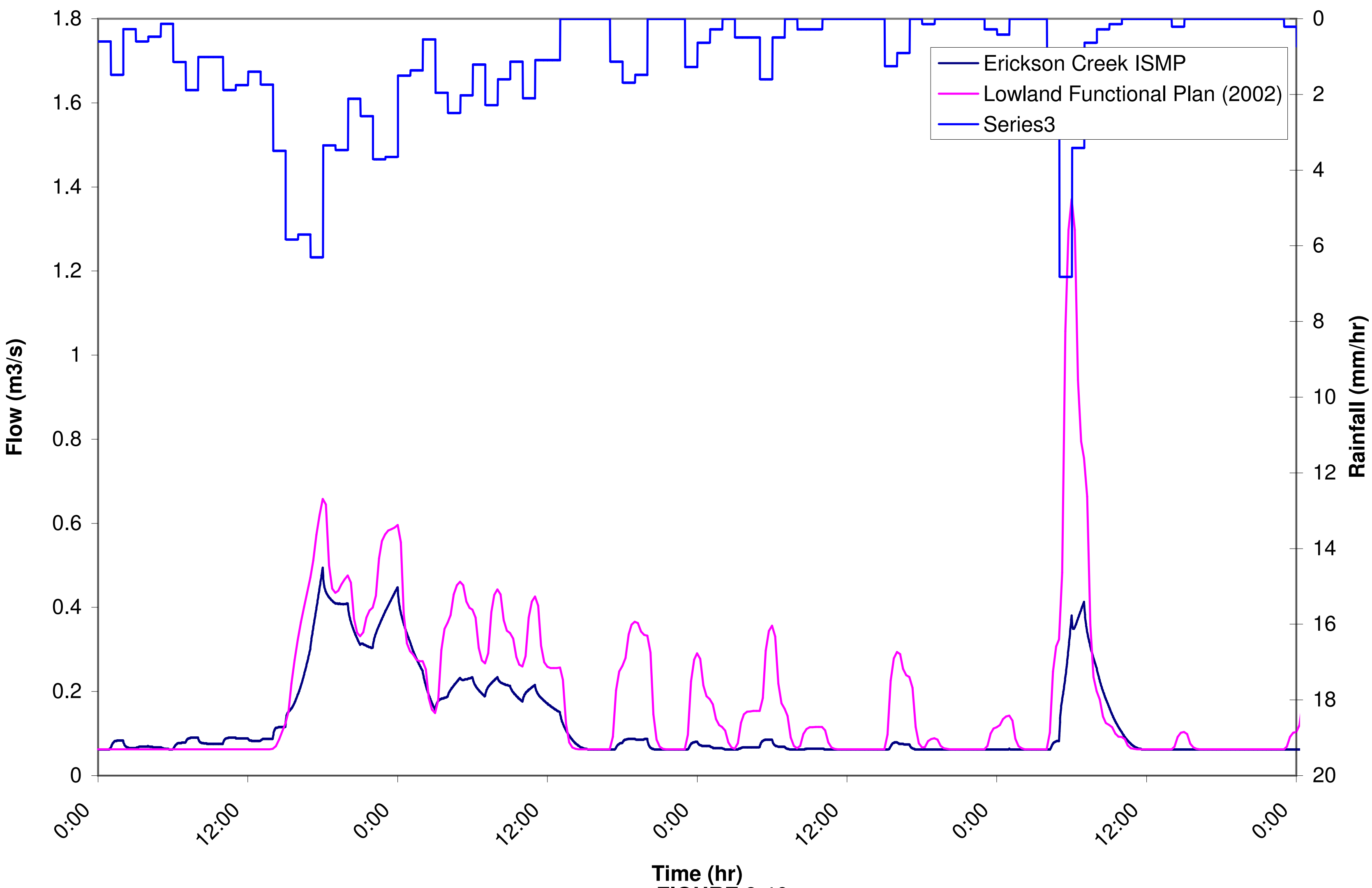


FIGURE 8-19

Hydrographs Comparison between Lowland Functional Plan (2002) and Erickson Creek ISMP

E13AA

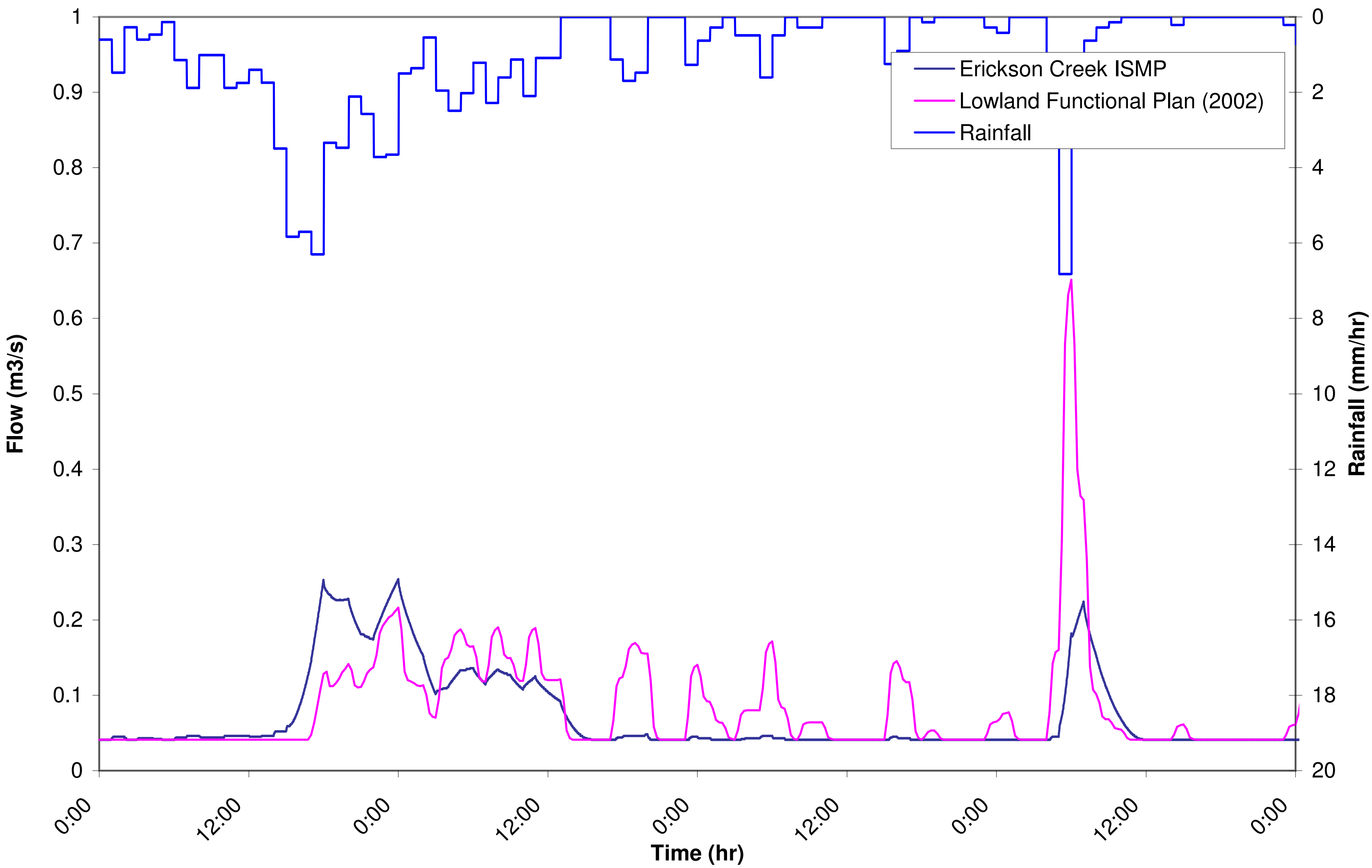


FIGURE 8-20
Hydrographs Comparison between Lowland Functional Plan (2002) and Erickson Creek ISMP
E14AA

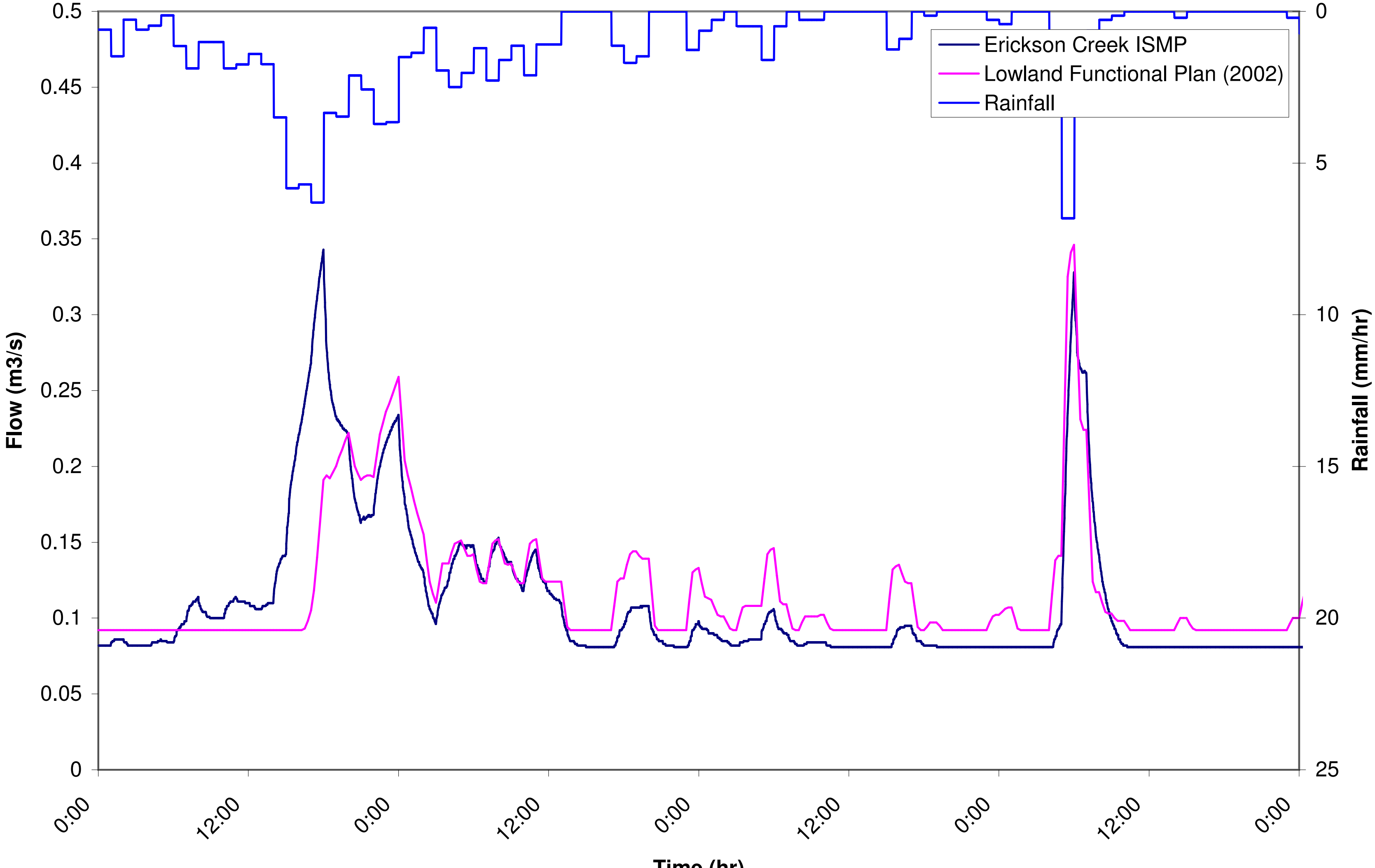


FIGURE 8-21

Hydrographs Comparison between Lowland Functional Plan (2002) and Erickson Creek ISMP

E15*

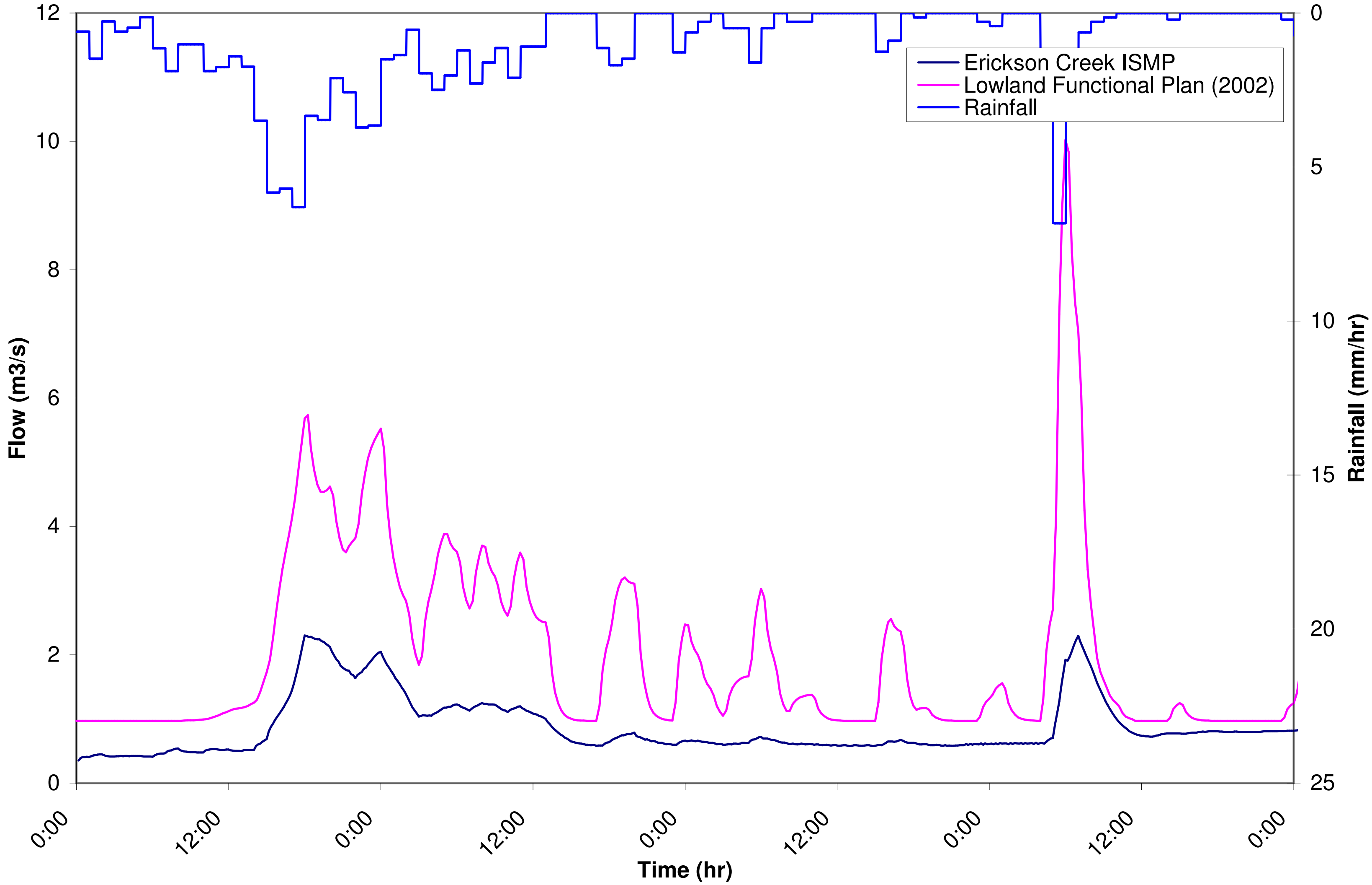


FIGURE 8-22
Hydrographs Comparison between Lowland Functional Plan (2002) and Erickson Creek ISMP
E11*

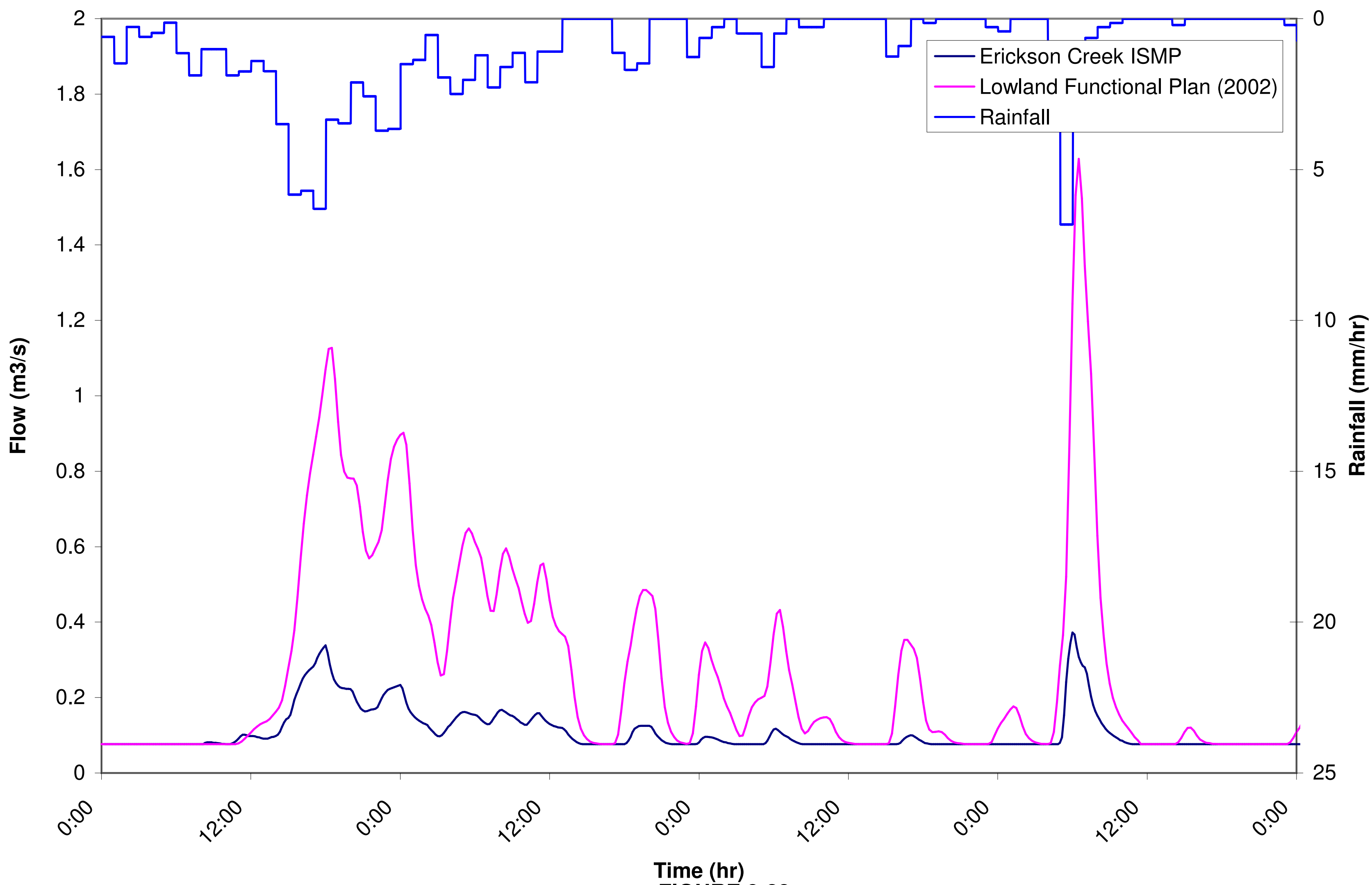
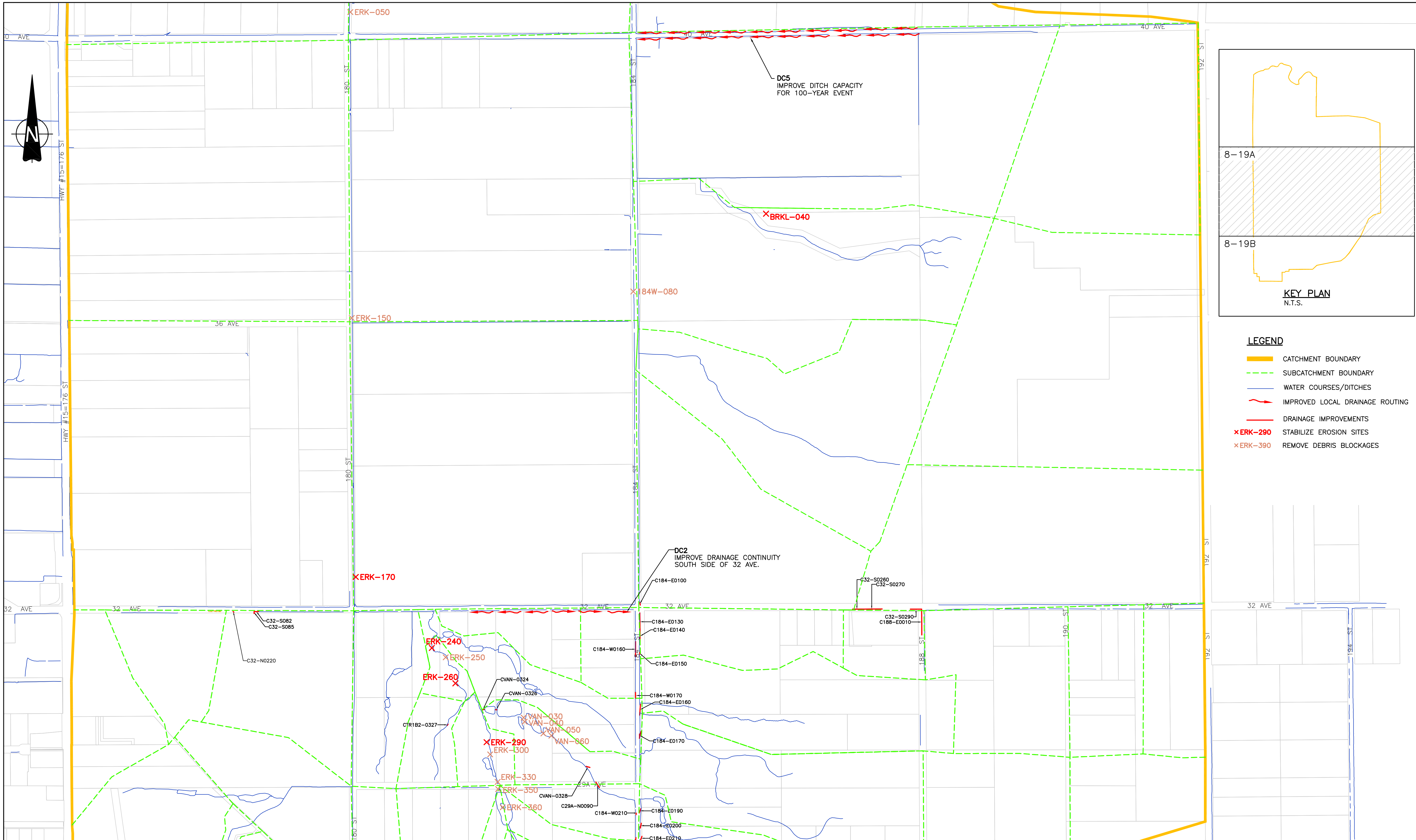


FIGURE 8-23
Hydrographs Comparison between Lowland Functional Plan (2002) and Erickson Creek ISMP
E10



Associated Engineering

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SURREY
CITY OF PARKS

ENGINEERING DEPARTMENT

BENCH MARK – S.M. # ELEV.

SEAL

TITLE

ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN

LOCAL IMPROVEMENTS TO ADDRESS 100 YEAR DEFICIENCIES

SCALE: HOR. 1:10000 VERT. 1:10000

DATE JAN. 2008

PROJECT NUMBER

DRAWN G.Q. CHECKED L.B.

DESIGNED N.N. CHECKED

CONTRACT

DRAWING NUMBER FIGURE 8-24A

P.W. P.U.

AS BUILT

SHEET OF

APPROVED

DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS

REVISION

Time: 10:44 Date: 2008/7/2 Plot Scale: 1=1 (Paper Space) AutoCAD File: P:\20062802\00_STUDY\WORKING_DWGS\100_CIVIL\FIGURE 8-24A.DWG (GQ) Xrefs: 2802R102

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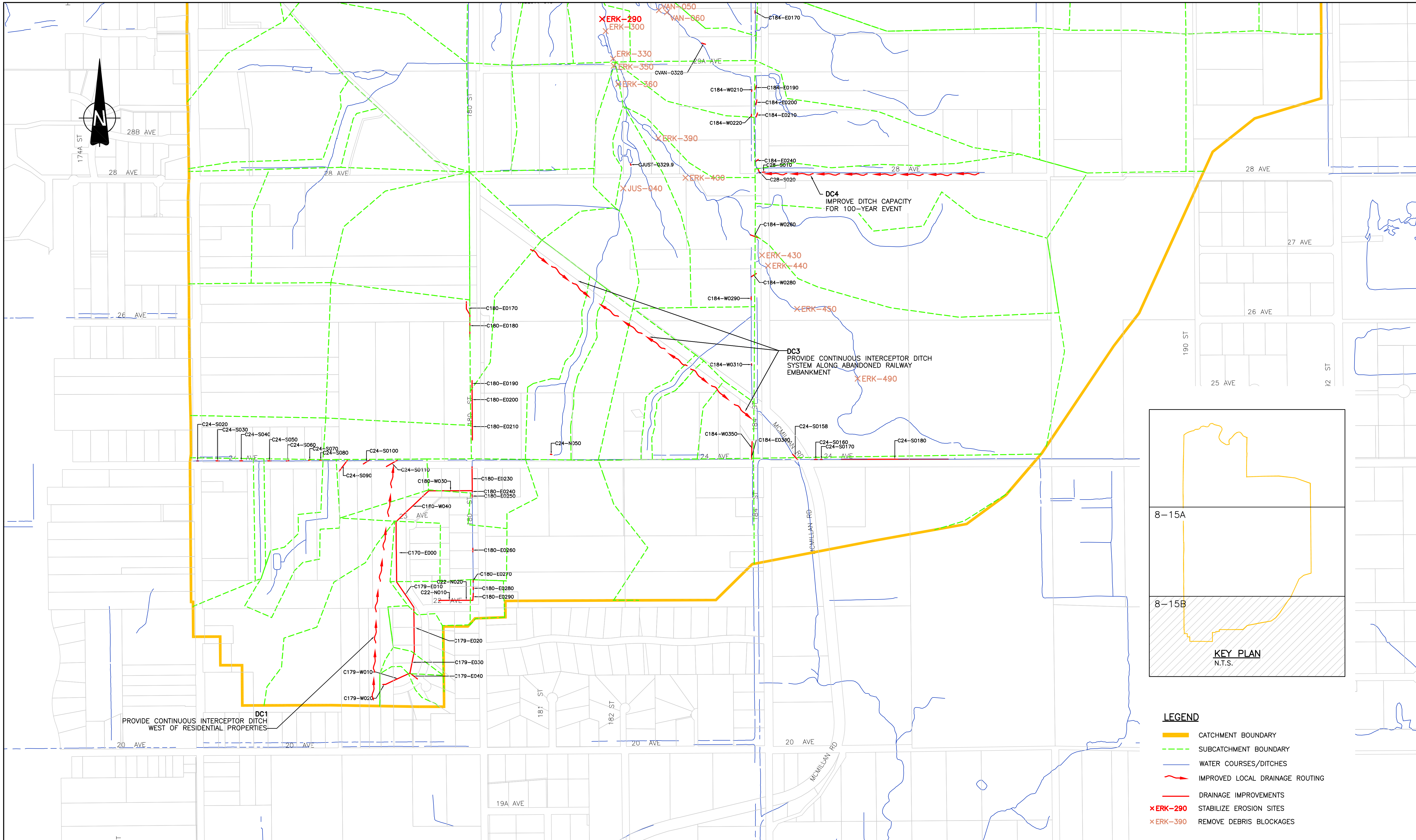

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SURREY
CITY OF PARKS

ENGINEERING DEPARTMENT

BENCH MARK – S.M. # ELEV.

TITLE
ERICKSON CREEK INTEGRATED STORMWATER MANAGEMENT PLAN
LOCAL IMPROVEMENTS TO ADDRESS 100 YEAR DEFICIENCIES

SEAL

SCALE: HOR. 1:10000 VERT. 1:10000	DATE JAN. 2008	PROJECT NUMBER
DRAWN G.Q. CHECKED	L.B.	DRAWING NUMBER
DESIGNED N.N. CHECKED	CONTRACT	FIGURE 8-24B
P.W. P.U.	AS BUILT	SHEET OF
APPROVED	DESTROY ALL PRINTS BEARING PREVIOUS NUMBERS	REVISION

F-87 PRODUCED BY CAD/CAM

9 Recommendations and Implementation

In previous sections, we have discussed the distinct differences between the Grandview Heights and Campbell Heights areas, and the consequence of these differences in terms of stormwater management strategies. Accordingly, our recommendations for the Erickson Creek ISMP reflect these differences, with different approaches recommended for Campbell Heights and Grandview Heights.

9.1 CAMPBELL HEIGHTS STORMWATER MANAGEMENT

Due to the high infiltration capacity of the soils underlying the Campbell Heights area the primary mechanism for stormwater management will be extensive application of infiltration based LID approaches. The recommended target for stormwater infiltration is to design exfiltration facilities to ensure that the entire runoff volume from the five-year return period design storm of 24 hours and shorter durations be detained and infiltrated.

The following LID measures are recommended as candidates for application in the Campbell Heights area of the watershed:

- Exfiltration chambers receiving runoff from the majority of impervious surfaces.
- Absorbent landscaping.
- Pervious pavers on light duty driveways, pathways and sidewalks.
- Grassed or vegetated buffer strips.
- Disconnect impervious areas, sidewalks separated from curbs by buffer strips.
- Infiltration swales and galleries in buffer strips and property perimeters.
- Exfiltration pipes for in-road City drainage systems.

All exfiltration facilities must be analyzed and designed by a qualified professional in consideration of site specific conditions and infiltration capacity.

Green roofs can be considered to supplement infiltration facilities, or to reduce required infiltration volumes. Green roofs must be evaluated and analysis and design undertaken on a site by site basis.

To ensure the long term viability of LID measures and minimize maintenance problems, the following measures must be implemented:

- Oil/water separators for runoff from parking areas, to protect water quality.
- Sediment/grit settling for road and parking area runoff, to protect infiltration capacity and prevent sediment “blinding” by fines.
- Trapping hoods and sediment sumps in catch basins and manholes.
- Restrictive Covenants incorporating operations and maintenance requirements for all stormwater management facilities should be applied to all private lands where they are located.

As noted in Section 3.1.6, current water quality issues related to elevated coliform and nutrient levels, associated with agricultural practices in both the uplands and lowlands, should be addressed through education and awareness programs. This is especially required among the unregulated hobby farm owners, who do not benefit from an ongoing relationship with the Ministry of Agriculture and Lands, in order to improve current and future water quality.

Excess runoff arising from large events, must be routed safely to the lowland drainage system, as indicated on Figure 7-1. Required improvements are indicated on Figures 8-24A and 8-24B.

9.2 GRANDVIEW HEIGHTS STORMWATER MANAGEMENT

9.2.1 Peak Flow Management

For the Grandview Heights area we recommend implementation of conventional detention ponds to limit peak flows conveyed by the various watercourses and discharged to the lowland areas. Primary stormwater management will be provided by a series of eight detention ponds to attenuate peak flows according to the City of Surrey's peak flow criteria. These ponds and their service areas are illustrated in Figure 7-1.

We recognize that the development community will generally wish to minimize the number of ponds. However, the current number of ponds and their proposed locations reflect the connectivity of the current drainage system, including current points of discharge to the lowlands. Some ponds may be consolidated during ongoing development planning, but it should be recognized that significant changes in service areas and flow routing may deprive watercourses of flow, or discharge excessive (increased) flow to other watercourses.

All ponds should be located at the bottom end of their respective service areas to ensure that all runoff can be routed through them. In concept, ponds G1 to G5 could be partially located in the former railway right-of-way to act as a buffer between residential developments and agricultural lands, while also reducing their footprint on developable lands. However, a consultation process with the agricultural community is required before proceeding on this basis, and specifically with agricultural land owners immediately adjacent to the buffer zone or greenway. Feedback to date from local farmers indicates they are concerned with having detention ponds located immediately adjacent to active agriculture. They currently rely upon the established vegetation in the right-of-way to buffer against wind and noise and drainage. In addition any use of the right-of-way will need to be coordinated with current plans to use it for the development of the North Grandview Greenway.

Some components, primarily culverts, of the upland drainage system will require upgrading to ensure safe conveyance of the 100-year design flow. These deficient components are highlighted on Figure 8-24A and 8-24B. Lowland drainage upgrades were identified in the previous lowland drainage strategy. It should be recognized that full implementation of the stormwater management plan as a result of build out in the Grandview Heights area may eliminate some of these components or negate the need for upgrading.

In summary, our recommendations regarding stormwater management infrastructure are to:

- Provide peak flow attenuation using a system of eight detention ponds.
- Ensure that any pond consolidation maintains overall drainage patterns.
- Upgrade deficient culverts and bridge crossings to ensure that they can safely pass the 100-year return period event with flow diversion in place.
- Stabilize watercourses or ditches at locations of active erosion.

Our capital cost estimate for the stormwater management infrastructure related to the ISMP recommendations in the Grandview Heights areas $16,670,000 (2010 dollars). This estimate includes capital costs associated with the detention ponds, as well as the required culvert and conveyance upgrades. Our capital cost estimate does not include any allowance for environmental mitigation or enhancement projects. A breakdown of the estimated capital costs is included in Table 9-1.

9.2.2 Low Impact Development Measures

LID measures are required to maintain the hydrological regime of the Grandview Heights area. Our WBM analysis indicated that retention of existing forest cover and enhancement of vegetation is generally more effective than relying on infiltration based approaches. At a conceptual level these considerations were investigated by the WBM analysis discussed in Section 6 and by the extended period simulation analysis discussed in Section 8.

We recommend several LID measures that appear appropriate given the soils limitations, and application to urban residential development. These candidate measures favour retention or enhancement of vegetation:

- Absorbent landscaping and lawns with 300 mm organic soil depth.
- Pervious paving on paths and driveways, underlain with 300 mm coarse pervious material.
- Sidewalks separated from roads by vegetated buffer strips.
- Roadways and sidewalks draining to vegetated infiltration swales via curb cuts or other means.
- Building roofs and other on-site impervious surfaces draining to absorbent landscaping such as rain gardens with underdrains.
- Maximize retention and enhancement of natural vegetated areas, particularly existing forest cover.
- Minimize use of buried and piped stormwater conveyance in favour of well maintained vegetated ditches along roadways.
- Implement centralized rain gardens in multifamily housing.

Application and effectiveness of any of these measures to a particular development site should be confirmed by a qualified professional and be subject to review by the City. Overall, maximization of evapotranspiration through retention of forest cover and other vegetation should be a priority.

All LID facilities should be equipped with a fail safe overflow or decant to protect against facility failure or saturation during sustained wet weather. The effectiveness of any infiltration dependent LID facility can be improved by provision of associated storage capacity, such as a pervious subgrade or underground chamber, to allow more time for runoff volumes to infiltrate.

9.2.3 Requirements to Protect Stream Health

In completing the assessment of LID measures for use in the Grandview Heights area, we assessed the level of effort that would be required to fully protect stream health by maintaining the current hydrology of the watershed (Section 8).

Based on our analysis, we recommend the following performance criteria to ensure protection of stream health:

- Infiltration or evapotranspiration of 50% of the rainfall volume from the 24-hour, 2-year return period design storm.
- Maximum flow release of 0.5 L/s/impervious hectare during the 24-hour, 2-year return period design storm.
- Maximum effective impervious area (EIA) within any given catchment of 20% of the catchment area, as indicated by runoff during the 24-hour, 2-year return period design storm.
- Maximum total impervious area on any identifiable watercourse limited to 40% of the catchment area.
- Total long-term runoff volumes controlled to 29% of the long-term rainfall volume
- All surface runoff originating from developed lands routed to peak flow detention systems for events up to and including the 5-year return period, at all durations.

These criteria imply that effective LID measures will need to be applied extensively within the Grandview Heights area. The primary mechanisms will maximization interception and evapotranspiration of water by vegetation, and to a lesser extent, by promotion of infiltration.

During upcoming detailed NCP processes for Grandview Heights, clustering of development to retain existing forest cover should be a priority.

9.2.4 Water Quality BMPs

Water quality BMPs in general are recommended for consideration and application as a function of land use activities (i.e. parking lots, vehicle servicing areas). Oil-water separators and similar devices are applicable to address “hot-spot” water quality issues, such as hydrocarbon runoff and spill capture at automobile service stations or shopping centre parking lots, and should be implemented accordingly. As an exception to the recommendation to only apply water quality BMPs in relation to specific concerns, water quality inlets can be widely applied in catch-basins to trap sediment and debris. The water quality BMPs recommended for use within the Erickson Creek watershed include:

- Water quality inlet (sediment and debris trapping catchbasins).
- Oil-water separator (proprietary or generic).
- Water quality swales for parking areas, road runoff (where grade and space allow).

As noted in Section 3.1.6, there are indications of degraded water quality under existing conditions in the watershed. These include elevated coliform and nutrient levels, likely associated with agricultural practices in both the uplands and lowlands, and elevated iron levels, perhaps related to groundwater influences. Education and awareness programs should be promoted, particularly among the unregulated hobby farm owners, who do not benefit from an ongoing relationship and monitoring by the Ministry of Agriculture and Lands, to improve current and future water quality.

9.3 ENVIRONMENTAL QUALITIES

The preliminary watershed health assessment ranked the upland areas of the Erickson Creek watershed in the mid range of the scale, or moderately impacted, primarily due to loss of riparian habitat. This health assessment ranking was based on the RFI and EIA for the watersheds. In contrast, our B-IBI values ranked the watersheds lower. Although the rankings do not correlate well, each watershed health measurement tool may serve as a baseline for future similar estimates to estimate changes in watershed health as a result of development.

In addition to the stormwater management recommendations discussed above, we recommend a number of environmental measures be implemented to minimize development impact on the creek systems.

9.3.1 Riparian Setbacks

The importance of adequate setbacks for maintenance of watershed health, protection of fish habitat, wildlife corridors, access for maintenance, geotechnical and flood plain concerns, as well as for protection of property cannot be overemphasized. Setbacks should be determined based on geotechnical and geomorphological values, in conjunction with existing and proposed flow regimes, as well as fisheries and wildlife values.

The City of Surrey currently requires a 15 m to 30 m riparian setback for fish-bearing streams (30 m setback for residential areas with more than six units per acre, 15 m setback for less than six units per acre). These are based on setbacks outlined in the Land Development Guidelines for the Protection of Aquatic Habitat as its standard (30 m for fish-bearing streams). It is strongly recommended that these setbacks not be relaxed in the Erickson Creek watershed. Riparian setbacks should be the widest provided in existing municipal and provincial legislation to protect fisheries, wildlife, geotechnical and property values.

The Riparian Areas Regulation (RAR) of the Fish Protection Act came into effect on March 31, 2006; however, the City has not formally adopted it yet, as discussions continue between the Department of Fisheries and Oceans, the Ministry of Environment and the Union of BC Municipalities. When the three agencies have signed the agreement, the City will look at implementing RAR with additional setback requirements to address other concerns in creek areas (such as slope stability, drainage access and maintenance, flood plain, hazard trees, property protection, trails and wildlife if legislation dictates). Under the RAR, a qualified environmental professional conducts a simple or detailed assessment of fish habitat values within a 30 metre assessment area along Class A, AO or B watercourses and determines the appropriate setback. Setbacks may range from 5 m to 30 m. RAR setbacks are widest for permanent, fish-bearing streams (Class A) with at least a 15 m width of existing or potential riparian vegetation, and smallest for non-permanent, non fish-bearing streams (Class B or C) with minimal riparian vegetation. According to the RAR, areas within the setbacks are to be maintained as Streamside Protection and Enhancement Areas (SPEAs). Proposed stormwater detention facilities and recreational facilities should be situated outside the riparian area, and access should be restricted to minimize disturbance and discourage encroachment by auxiliary structures (e.g. sheds, fencing, landscaping, swimming pools, garages). The requirement for wider setbacks to fully protect all environmental and property values discussed above will need to be assessed on a site-by-site basis.

In urbanized watersheds, riparian areas often provide significant amounts of wildlife habitat. This applies to both fish bearing (Class A and AO) and non-fish bearing (Class B) streams. Setbacks of 15 or even 30 m will not be enough to provide migration corridors and habitat for large mammals such as deer or for other species or for species of conservation concern. Setbacks recommended for the protection of critical preferred habitat of the red-listed Pacific water shrew are currently 100 m (Ministry of Environment 2005). For habitat of blue-listed red-legged frog and other amphibians (slow flowing, marsh, wetland and pool areas), recommended setbacks are at least 30 m on each side of a stream or wetland, with adequate connectivity with other habitat areas (Ministry of Environment 2004).

The federal Species at Risk Act and the anticipated implementation of the provincial Wildlife Amendment Act should be considered when species of conservation concern are present. In effect, lands considered “critical habitat” for rare, threatened or endangered species will need to be highlighted and considered. It should be noted that the Species at Risk Act only applies to federal lands at this time. The Wildlife Amendment Act lists species of concern, but at this time the list is limited. It may change in the future, in which case this Act should be tracked and setbacks altered to meet its requirements when applicable.

9.3.2 Environmental Enhancements

The following recommendations are made as ways in which the City may continue to protect and enhance riparian, stream and forest habitat in the watershed, maintain biodiversity and protect or restore habitat reservoirs, patches and corridors:

- Establishing, through the planning process, a park and natural area network that recognizes and preserves valuable riparian and terrestrial habitat, based on areas identified in Section 3, and the recommendations listed in Section 9.3.1 above.
- Establishing fenced corridors, dedicated as parkland, to protect riparian habitat (30 m from the top-of-bank or high water mark), with periodic monitoring for encroachment of backyard landscaping or other activities into these areas.
- Ensuring that land use zoning protects natural areas including valuable terrestrial habitat.
- Maintaining existing natural features such as ponds that provide fish and amphibian habitat.
- Conserving or restoring native riparian habitat by removing exotic species and replanting with native species, to be undertaken by development proponents prior to parkland dedication. Ongoing maintenance efforts could be undertaken as part of community education and participation programs involving local stewardship groups.
- Encouraging landscaping with native plants in high density and low density residential areas, at all times but specifically during the development application process.
- Removing or mitigating barriers to fish migration, as identified in Section 3.1.5 and Table 3-4. However, mitigation of fish barriers should not interfere with the maintenance of private ponds. These projects could be undertaken as compensatory work during the development process.

The provincial Draft Environmental Management Practices for Urban and Rural Land Development (Polster and Cullington 2004) should be consulted prior to development to ensure that relevant BMPs are incorporated. There are BMPs for protection of habitat for several species, including nesting raptors, Pacific water shrew, amphibians and reptiles, which should be applied to development applications within the Erickson watershed. A buffer of undisturbed natural vegetation for a distance of 1.5 tree lengths should be established around raptor nest sites (Demarchi and Bentley 2005). The draft BMP for Pacific water shrew (Craig and Vennesland 2005) should be consulted with respect to riparian protection.

For indigenous amphibians and reptile conservation (including red-legged frogs), the provincial BMPs (Ovaska et al. 1994) recommend the following:

- Locate, if possible, developments and roads away from key habitats for amphibians and reptiles (typically in riparian areas).
- Maintain buffers of undisturbed native vegetation around and adjacent to key amphibian and reptile habitats (i.e., particularly in riparian areas).

- Provide suitable landscape linkages to allow movements of animals between important seasonal habitats.
- Minimize road kill of animals migrating between seasonal habitats by locating roads and infrastructure away from these areas or consider special road-crossing structures where this is unavoidable.
- Control the spread of non-native animals and plants.
- Encourage residents to take an interest in protecting these species.

The riparian setbacks described in Section 3.4.5 for protection of fish habitat will also protect habitat for many of the listed terrestrial species discussed in Section 3.2.2.

In addition, existing forested lands provide important connectivity for terrestrial wildlife. In particular, the forested slopes of the escarpment below Campbell Heights are important terrestrial habitat, and provide cover for the numerous small watercourses that rise on the escarpment and flow into the lowlands. Removal or disturbance of the forest cover in this area would likely alter the hydrology of these watercourses and result in thermal impacts during base flow conditions. Therefore a high priority must be placed on avoiding disturbance to this forest cover.

9.3.3 Environmental Monitoring Program

Through the ISMP process we identified a number of environmental concerns and opportunities. To provide the ability to identify and mitigate future environmental concerns and to act on the proposed environmental recommendations, we recommend the following monitoring activities:

- Initiate a periodic water quality monitoring program to monitor water quality impacts of development within the watershed on a three year basis, using the sampling sites and methods described in Section 3.1.6.
- Continue the established benthic invertebrate monitoring program on a three year cycle for monitoring B IBI values as development occurs.
- Periodic watercourse field reconnaissance to assess stream condition (fish habitat, riparian vegetation, invasive plant species, erosion, culvert passability) and infrastructure condition

The estimated costs for the above items are:

- Water Quality Monitoring Program: $7,000 per cycle
- B-IBI Field Program: $4,000 per cycle
- Watercourse Field Reconnaissance: $3,000 per cycle

The water quality and benthic invertebrate monitoring program will help assess the impacts on the watercourses and will build upon the program conducted in 2006.

The recommended water quality sampling program will monitor baseline water quality prior to new development in the study areas. Typical water quality parameters include fecal coliform, metals

(Cu, Mn, Zn), pH, alkalinity, total suspended solids and nutrients (grab samples), as well as temperature, conductivity, dissolved oxygen and turbidity (in situ). Given that the highest concentrations of pollutants are typically conveyed during first flush events from watersheds, water samples should be collected during a period of dry weather and low flow to assess the background level of contaminants in the watershed (as specified in the GVRD Water Quality Sampling Guide, 2003).

9.3.4 Adaptive Management

Consistent with the objectives of this Erickson Creek ISMP, the City of Surrey should adopt an adaptive management approach to the implementation of this ISMP in order to ensure the overall health of the watershed is maintained, and no net loss of habitat occurs at the watershed scale. If the overall monitoring program described above indicates degradation of the health of the watershed, then appropriate measures should be identified and implemented to restore and maintain overall watershed health.

In order to facilitate adaptive management in the watershed, monitoring data should be compiled and reviewed periodically in a systematic and consistent manner, to determine whether overall watershed health is impaired, and to recommend mitigative actions to City Council and Staff. A duly formed oversight committee composed of City staff, community stakeholders and development representatives, similar to the stakeholders group assembled to provide input to the development of this ISMP, could fulfill this role. An independent environmental specialist could be retained to provide advice to the oversight committee when required.

Depending upon the circumstances that arise, an adaptive management response could include:

- Adjustment of BMP requirements and standards.
- Implementation of specific mitigative works.
- Adjustment to subsequent development planning and implementation.

9.4 BYLAWS AND POLICIES

The City of Surrey has a number of bylaws and policies that relate to watershed health and stormwater management. These existing bylaws and policies create a solid platform for future action within the watersheds. To incorporate our findings into these bylaws and policies we recommend the following additions:

- Review and revise existing City development standards to incorporate the LID recommendations of this ISMP for application to development within the Erickson Creek watershed.

- Develop zoning classifications that reflect the TIA and EIA limits recommended in this ISMP.

- Ensure that TIA and EIA limits incorporated in zoning classifications are enforceable through City bylaws.
- Ensure that LID facilities are maintained and not modified by property owners through restrictive covenants and/or bylaws, with periodic City inspection to ensure facilities are not disturbed.
- Implement ongoing surveillance, measurement and reporting protocols, as well as compliance enforcement activities at both the municipal and provincial level. This is necessary given the previous history of spills and illicit discharges in the watershed.
- Require annual monitoring, maintenance, and reporting for “hot-spot” BMP applications through City bylaws.
- Incorporate annual monitoring and maintenance activities for City owned and operated BMP / LID systems into regular City operations.
- Require tree removal permits for tree felling within the City and maintain maximum existing/native vegetation during development.
- Require minimal removal and compaction of surficial soil during construction and development.
- Identify and maintain any areas with reasonable infiltration capacity for siting of LID / BMP facilities.

Although the Erickson Creek ISMP process commenced prior to the development of the City of Surrey’s Sustainability Charter, with the Draft ISMP document submitted in July of 2008, the recommendations of this ISMP are consistent with the overall vision and objectives of the Sustainability Charter.

9.4.1 Stormwater Operation and Maintenance Requirements

Systematic operation and maintenance procedures are required in order to ensure proper long-term operation of detention systems, LID measures and water quality BMPs. LID and BMP effectiveness in particular is susceptible to the quality and frequency of maintenance.

Incorporate the following measures and practices into the City’s regular operations and maintenance activities within the watershed:

- Regular surveillance of documented problem sites, particularly after large storm events.
- Continuation of all regular existing O&M activities for culverts, ditches and storm drain components.
- Annual inspections and servicing of “hot-spot” water quality BMPs (i.e. parking lots, vehicle servicing areas), with documentation provided to the City.
- Regular inspection, maintenance and repair of City inherited LID measures (i.e. grass swales, infiltration trenches).

- Regular community education programs (flyers, community newspaper info-articles) on LID environmental objectives and maintenance guidelines for property owners.

We have not estimated a cost for these tasks as they represent an incremental increase on the City's existing Operation and Maintenance efforts.

9.5 IMPLEMENTATION STRATEGY

Implementation of this Erickson Creek Integrated Watershed Management Plan requires both physical works and institutional measures. These should be implemented at a pace that is achievable given the City's resources, and keeps pace with the stresses placed on the watershed. The following listing indicates the relative priority for implementation:

.1 Construct the recommended stormwater infrastructure, such as detention ponds in Grandview Heights, and major infiltration facilities in Campbell Heights to keep pace with development activities in the respective areas.

.2 As necessary, revise the City's development standards to require adherence to the respective rainfall capture and runoff limitation targets for Campbell Heights and Grandview Heights.

.3 Address capacity deficiencies related to culverts and channel constrictions in the creek systems. Lowland drainage improvements should be implemented as outlined in the "Erickson Creek and Burrows Ditch Functional Plan" (UMA, 2002)

.4 In a systematic manner, implement the environmental enhancements identified in this plan in order to achieve maximum benefit to the watersheds given the resources required. We assume acquisition of private property for environmental enhancements will be infrequent and relatively rare unless the opportunity arises in conjunction with large scale redevelopment. Accordingly, concentrate environmental enhancement efforts on areas located on public lands or within dedicated rights-of-way and/or where they could be undertaken as a component of compensation work required for development activities.

.5 Develop and implement an adaptive management strategy for the Erickson Creek Watershed, including the recommended monitoring activities, and oversight and response mechanisms.

.6 Develop and implement an ongoing education/public awareness program to minimize the removal or disturbance of LID measures on private property. Existing programs not directly related to this ISMP should continue, including Salmon Habitat Restoration Program (SHARP) to address riparian corridor loss and re-establishment of native vegetation along creek corridors. These programs are particularly important to address issues not related to current development activities.

Table 9-1
Estimated Capital Costs

Detention Ponds

ID	Description	Pond Footprint	Unit Cost $/ha	Capital (Land)	Capital (Construction)	Total Capital	Annual O&M (3% of Capital)
G1	Detention Pond	**1.12 ha**	300,000	$340,000	$1,290,000	$1,630,000	$48,900
G2	Detention Pond	**1.56 ha**	300,000	$470,000	$1,360,000	$1,830,000	$54,900
G3	Detention Pond	**0.53 ha**	300,000	$160,000	$520,000	$680,000	$20,400
G4	Detention Pond	**0.40 ha**	300,000	$120,000	$410,000	$530,000	$15,900
G5	Detention Pond	**0.29 ha**	300,000	$90,000	$320,000	$410,000	$12,300
G6	Detention Pond	**1.34 ha**	300,000	$410,000	$1,180,000	$1,590,000	$47,700
G7	Detention Pond	**0.97 ha**	300,000	$300,000	$880,000	$1,180,000	$35,400
G8	Detention Pond	**2.83 ha**	300,000	$850,000	$2,380,000	$3,230,000	$96,900
					Subtotal Capital Costs	**$11,080,000**	**$332,400**
					25% E&C On Capital	**$2,770,000**	
					Total Capital Costs*	**$13,850,000**	

Drainage Upgrades

ID	Description	Length of Channel	Capital (Construction)	Annual O&M (1% of Capital)
	Drainage Upgrades - Culverts and Pipes (refer to Table 8-5, Figure 8-24A & B)		$1,335,714	$13,357
DC1	Drainage Channel - West of 179 St running north to 28th Avenue	700 m	$217,000	$2,170
DC2	Drainage Channel - South side of 32 nd Avenue west of 184th Street	450 m	$139,500	$1,395
DC3	Drainage Channel - South side of former GNR right-of-way	800 m	$248,000	$2,480
DC4	Drainage Channel - North side of 28th Ave. - Campbell Heights to lowlands	500 m	$155,000	$1,550
DC5	Drainage Channel - North and south sides of 40th Ave. - Campbell Heights to lowlands	500 m	$155,000	$1,550
		Subtotal Capital Costs	**$2,250,214**	**$19,402**
		25% E&C On Capital	**$563,000**	
		Total Capital Costs*	**$2,820,000**	
			$16,670,000	**$351,802**

* - Rounded to next ten thousand

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Associated Engineering GLOBAL PERSPECTIVE. LOCAL FOCUS.

Jacques Whitford AXYS

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A Appendix A – Jacques Whitford Field Reconnaissance Photographs

Photo 1: UC-1 looking downstream. Channel is a grassy ditch with little channel complexity or riparian cover. Channel probably dries up in the summer.

Photo 2: UC-1 becomes ponded further upstream. Horses were seen grazing nearby.

Photo 3: EC-1 – although all riparian cover has been replaced by lawn at this location, EC-1 has good rearing habitat overall, with undercut banks and over stream vegetation providing cover upstream.

Photo 4: Some bank erosion at EC-1.

Photo 5: EC-2 has no spawning gravels and low dissolved oxygen levels. Potentially good amphibian habitat.

Photo 6: EC-2 opens up into a pond with an unknown depth further upstream.

Photo 7: EC-3 presents a possible barrier to fish migration. Water flows around the wooden weir when flows are low and may make passage difficult for fish.

Photo 8: Channel erosion is evident in EC-3.

Photo 9: Fish ladder at EC-4, directly south of 29A Avenue.

Photo 10: Metal grates cover most culverts under a small access road at EC-4. Open culverts are only accessible during high flows.

Photo 11: Pond outlet in EC-4 may present a barrier during low flow (0.94 m drop measured during April assessment).

Photo 12: Pond habitat of EC-4

Photo 13: EC-4 includes a marshy channel; spawning gravels are absent.

Photo 14: EC-4 flows through forested riparian area with abundant cover. Some spawning gravels are present in the upper section.

Photo 15: Excellent rearing habitat throughout EC-6. Gravels in lower portion of reach provide excellent spawning habitat.

Photo 16: EC-7 is a tributary to EC-6. Channel was not flowing during April assessment.

Photo 17: EC-8 is a tributary to EC-6. Channel was not flowing during April assessment.

Photo 18: EC-9 is a tributary to EC-6. Channel had minimal flow in April and no flow during July assessment.

Photo 19: Breaks Brook BB-1 had no flow during April assessment. The channel is defined in a small gully and may have historically conveyed larger volumes of water.

Photo 20: Laura Brook LB-1 confluence with Erickson Creek.

Photo 21: LB-3 above 184 Street is undefined and swampy, and does not provide good rearing habitat.

Photo 22: LB-4 above 184 Street has been channelized along fence line and does not provide good habitat. Habitat may improve upstream where the riparian area is largely undeveloped.

Photo 23: LB-5 provides good salmonid rearing habitat, with abundant forested cover and limited spawning gravels at the roadside assessment area.

Photo 24: LB-6 originates in a forested area and flows through an agricultural field with a riparian buffer for most of its length. Poor spawning and rearing habitat at confluence with 184 Street ditch, but habitat may improve upstream.

Photo 25: Vandrishe Brook VB-1 has a barrier at the inlet of the lower pond.

Photo 26: VB-1 has a possible barrier at the inlet of the second pond.

Photo 27: Outlets of third pond in VB-1 are barriers to salmonid migration.

Photo 28: Third pond of VB-1.

Photo 29: Creek flows through a forested marshy area in VB-2. Cows have access to creek, causing bank erosion and potential water quality degradation.

Photo 30: Riffle-pool morphology in VB-3 provides excellent rearing habitat. Localized gravels provide some potential for spawning.

Photo 31: VB-4 ponds provide excellent rearing habitat. “Coho” reportedly present in ponds.

Photo 32: Falls at VB-4 may be a fish barrier.

Photo 33: Overall rearing habitat of VB-5 is poor as part of channel flows underground. Spawning substrate is absent.

Photo 34: Justin Brook JB-1 provides good rearing habitat, with localized gravels for spawning. Cover is abundant.

Photo 35: Small falls at JB-1 should not be a barrier to fish migration.

Photo 36: Dall Brook, DB-1 provides low to moderate rearing habitat. Lack of gravels limit spawning habitat.

Photo 37 and 38: Laughlin Creek LC-1 is a defined grassy channel with poor riparian cover. Bed material is predominantly fines

Photo 39: LC-2 was dry in July.

Photo 40 and 41: Brooklane Creek BC-1. Sparse riparian vegetation near 184 St. but increases upstream. Fish observed rear the residence, where cows have access to the creek.

Photo 42: Habitat complexity in the 32nd Avenue ditch is low. Cover and gravels are limited.

Photo 43: Moderate rearing habitat exists in 184th St ditch, however cover is limited. Spawning may occur in gravels in 3100 block of 184 Street however the ditch is heavily silted.

Photo 44: 184th Street ditch shows signs of erosion.

Photo 45: Moderate rearing habitat but poor spawning habitat in 180th Street ditch due to unsuitable substrates. Sparse riparian cover.

Photo 46: 180th Street ditch shows signs of erosion.

Photo 47: 180th Street ditch shows signs of erosion.

B Appendix B - Jacques Whitford Hydrogeology Assessments

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VIA ELECTRONIC MAIL

Project No. 1010673

June 14, 2006

Mr. Mike MacLatchy
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Suite 300-4940 Canada Way
Burnaby, British Columbia V5G 4M5

Dear Mr. MacLatchy:

**RE: Erickson Creek Integrated Watershed Management Plan
DRAFT - Preliminary Hydrogeological Assessment
Surrey, British Columbia**

1.0 INTRODUCTION

Jacques Whitford Limited (Jacques Whitford) was retained to conduct a non-intrusive, desktop assessment of the hydrogeology of Erickson Creek to support the development of an Integrated Watershed Management Plan (IWMP) for this watershed. The objective of the work was to characterize the soil and groundwater conditions in the watershed and to identify areas with potential for mid- to large-scale shallow infiltration of stormwater during future development. The location of Erickson Creek and its approximate catchment area is shown on Drawing 1 in Appendix A. The results of the preliminary hydrogeological assessment are detailed in the subsequent Sections of this report.

2.0 SCOPE OF WORK AND METHODOLOGY

Jacques Whitford reviewed available geologic, meteorological, hydrologic and hydrogeological information for the watershed and/or similar nearby catchments to develop a conceptual model of the watershed hydrogeology. It should be noted that a site visit by a qualified hydrogeologist was not conducted to validate the results of the preliminary assessment. References used to prepare the assessment are listed in Section 8.0.

3.0 REVIEW OF AVAILABLE INFORMATION

3.1 Geology

In 2005, ECL Envirowest Consultants Ltd. (Envirowest) prepared "G*eneral Environmental Review for the Grandview Heights Plan Area, Surrey, BC"* for the City of Surrey. This report provided an overview of governing regulations and available environmental survey information for the area. As shown on Drawing 2, the Grandview Heights Plan area overlaps the southwest, upland portion of the Erickson Creek watershed.

Envirowest reported that the predominant geologic feature of the Grandview Heights area is Vashon Drift, which is overlain by a thin layer of Capilano Sediments, the predominant unit mapped in the area. The Vashon Drift is comprised of a glacially deposited mix of materials including clay, silt, sand, gravel and boulders up to 100 m thick. The Capilano Sediments are located at the ground surface and extend to about 20 m below grade.

The east side of the watershed consists of a plateau located 40 to 45 m above sea level. The plateau, referred to as the Campbell Heights Area, is fairly level and rises 20 m above the Nicomekl lowland plain (Gartner Lee in New East, December 2005 – July 2003 Technical Report). The western ridge of the plateau, north of 32 Avenue slopes down towards the lowland plain at grades between 10-20%. South of 32 Avenue, the Campbell Heights area adjoins a flatter plateau sloping at 5-10% towards 184 Street.

Geologically, the plateau was formed by a large deltaic deposit of sand and gravel. Gartner Lee noted that this formation contains an unconfined aquifer, recharged in part by infiltration of surface water and precipitation incident on the plateau. Municipal water wells, operated by the Township of Langley, are completed in this aquifer (Gartner Lee in New East, December 2005 – July 2003 Technical Report). Gartner Lee also noted that the aquifer provides base flow for the many streams emanating from the western flank of the plateau, including the Nicomekl lowland watercourses.

Envirowest reported that soils in the greater Erickson Creek area were characterized by Luttmerding (1980, 1981), and that the major soil group of the area is a Bose soil. Bose soils are based on the Capilano Sediments which are moderately-well to well drained, with low water holding capacity (rapidly permeable) in the upper gravelly part and slowly pervious in the lower part (Luttmerding, 1980). This soil structure results in telluric flow (water moving laterally) above the interface between the upper and lower zones.

Estimated porosity of the Bose soils, based on Luttmerding's 1966 *Soil Survey*, is between 0.1 and 0.15; soils of this type tend to have profiles of approximately 100 cm. Agricultural capability of the Bose soils is limited by the low water holding capacity and the general requirement to irrigate, fertilize and remove stones from the soil (Envirowest, 2005).

The mid reaches of the creek are located in the raised beach paleo-sediments. This thin (1 to 5 m thick) layer of medium to coarse grained sand sediments is underlain by impermeable or low permeable clays. North of this unit is the flat Nicomekl River flood plain which consists of peat underlain by fine grained and low permeability, and oftentimes saturated, clay deposits.

Surficial geology of the Erickson Creek watershed is shown on Drawing 2, and summarized below (Geological Survey of Canada, Map 1484A, 1977).

- Salish Sediments, SAb – lowland peat up to 14 m thick
- Salish Sediments, SAd – lowland organic sandy loam to clay loam 15 to 45 cm thick overlying medium to coarse sand and gravel up to 8 m thick and deltaic and distributary channel fill (includes tidal flat deposits) sandy to silt loam, 10 to 40 m thick interbedded fine to medium sand and minor silt beds
- Sumas Drift, Se – raised proglacial deltaic gravel and sand up to 40 m thick
- Capilano Sediments, Cb – raised beach medium to coarse sand 1 to 5 m thick containing fossil marine shell casts
- Capilano Sediments, Cd – marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30 m thick, containing marine shells
- the Vashon Drift, Va – lodgment till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt;

The Envirowest and Gartner Lee reports are consistent with the geology mapped in the area, as detailed above, and with water well logs for the area, as discussed in Section 3.2.

3.2 Aquifers and Water Wells

The British Columbia Water Resources Atlas (BCWRA) contains information on aquifer locations, extents, level of development, productivity and vulnerability to surface sources of contamination. Aquifers in British Columbia are classified according to level of development, from heavy (I) to light (III), vulnerability, from high (A) to low (C), and ranking value component, from 5 (lower priority) to 21 (higher priority) (MWLAP, 2002).

The approximate locations and extents of aquifers underlying the Erickson Creek watershed are shown on Drawing 3, and include: the Langley/Brookswood Aquifer (Aquifer 41 IA (17)); unnamed Aquifer 55 IIIC (8); and the Nicomekl-Serpentine Aquifer (Aquifer 58 IIC (11)).

The Langley/Brookswood Aquifer is classified as heavily developed, moderately productive with a high vulnerability to surface sources of contamination. Aquifer 55 IIIC (8) is classified as lightly developed with a low vulnerability to surface sources of contamination. The Nicomekl-Serpentine aquifer is classified as moderately developed with low vulnerability to surface sources of contamination.

Only the Langley/Brookswood aquifer is ranked towards the higher end of the priority scale, on a province-wide basis.

Approximately 120 wells are registered within the watershed, although not all registered well logs contained data (BCWRA). The locations of registered wells in the watershed and surrounding area are shown on Drawing 3[1].

Wells of interest to this assessment are mainly located in the upland proglacial deltaic deposits (sand and gravel unit) because of the potential for storm water infiltration in this material. In general, these well logs indicated that the raised sand and gravel is underlain by much finer-grained, silt and clay material. The finer grained materials appear to form a lower confining layer to the Langley/Brookswood Aquifer. The deepest well log is reported to be 300 feet (91.4 m). Bedrock was not reported in any of the logs reviewed.

Standing water levels in wells completed in the sand and gravel unit were reported to be approximately 20 – 30 feet (6 – 9 m) below ground surface. Envirowest (2005) reported that water levels in this upland area range from 25 – 50 m below ground. This inconsistency is most likely related to the fact that most wells on record were drilled in or before the 1970s and water levels are decreasing by about 0.25 m (10-inches) per year in many areas of the Lower Fraser Valley (pers. com. Mike Wei, BC Groundwater Protection June 2006 presentation to the Vancouver Geotechnical Society). This apparent drawdown was therefore attributed to increasing domestic and municipal reliance on the groundwater resource in this area.

3.3 Hydrology and Climate

The Erickson Creek watershed drains northward into the Nicomekl River, which in turn drains westward to Mud Bay north of Crescent Beach (Envirowest, 2005). Envirowest reports that the Erickson Creek watershed, and surrounding area, is drained predominantly by manmade ditches along roadsides and property boundaries. Most of the natural channels that still occur are ephemeral (seasonally dry) in upper reaches. Groundwater seepage in topographically lower areas or discharge zones maintains creek and nominal flows.

Annual precipitation summary for meteorological stations located near Erickson Creek (monthly averages presented in Table 3.1) are:

- Surrey Municipal Hall Climatological Station, 1370 mm (96.3% rain, 3.7% snow);
- Surrey Kwantlen Park Climatological Station 1586 mm (96.3% rain, 3.7% snow); and
- Surrey Newton Climatological Station 1409 mm (96.4% rain, 3.6% snow).

[1] The BCWRA contains well logs for wells registered with the Province of British Columbia, Ministry of Environment. Information provided in this database is of variable quality and reliability. Additionally, not all wells that may exist in the area are registered with the Province.

Evapotranspiration for the Erickson Creek watershed was estimated using the Thornthwaite method (1948). Precipitation data from the Surrey Newton station was used as input to the calculation. The results of this calculation are summarized in Table 3.2. Climate data received from Environment Canada is provided in Appendix B.

As shown in Table 3.2, average monthly precipitation exceeds average monthly evapotranspiration during the wet season (October through May). Evapotranspiration is approximately equal to, or greater than precipitation on average from June through September. On an annual basis, on the order of 875 mm of precipitation is available for runoff, infiltration or soil storage.

Table 3.1 Summary of Average Monthly and Average Annual Precipitation Data

Station	EL (masl)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Surrey Municipal Hall	76	176.3	140	125	99	81	64.1	47	46	60	129	209	195	1370
Surrey Kwantlen Park	78	202.2	159	146	116	92	73.6	53	51	72	153	240	229	1586
Surrey Newton*	73.2	185.7	136	129	101	82	68	50	49	64	131	212	202	1409

Notes:
*meets WMO standards
Precipitation data in mm
Stations Elevations in metres above sea level
Average monthly precipitation values for the period from 1971-2000

Table 3.2 Climate and Soil Water Balance Summary

Climate Variables	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Monthly Precipitation	mm	186	136	129	101	81.6	68	50	48.7	64.2	131	212	202	**1409.3**
Daily Average	°C	3.1	4.8	7.0	9.6	12.6	15.2	17.6	17.7	15.1	10.3	5.7	3.3	
Calculated Evapotranspiration	mm	12.6	20.0	29.8	41.5	55.3	67.4	78.6	79.1	66.9	44.7	24.0	13.5	533.6
Remaining for Infiltration, Runoff or Storage	mm	173.1	116.1	98.9	59.0	26.3	0.6	-28.6	-30.4	-2.7	86.7	188.3	188.6	875.7

Notes:
1. Surrey Newton WMO certified weather station Climate Data, see Table 3.1 for more details

4.0 HYDROGEOLOGICAL ASSESSMENT

Geology at Erickson Creek, in the upper reaches, is reported to consist of a raised proglacial sand and gravel deposit. A thin (1 to 5 m) raised beach deposit consisting of fine to medium-grained sands is mapped over large portions of the mid-reaches of the watershed. Lower reaches are comprised of peat, silt and clay loam deposits and form part of the Nicomekl River flood plain.

The range of hydraulic conductivities expected for the various soils underlying the Erickson Creek watershed are summarized in Table 4.1.

Table 4.1 Range of Hydraulic Conductivities by Material Type

Material	High (m/s)	Low (m/s)	Expected Range (m/s)
Lowland peat and clay, silt and clay loams and till-like deposits (e.g. Salish Sediments and Capilano Sediments unit Cd)	1×10^{-6}	1×10^{-12}	1×10^{-8}
Proglacial Deltaic Sand and Gravel (e.g. Sumas Drift)	1×10^{-1}	1×10^{-5}	1×10^{-3}
Raised beach medium to coarse sand (e.g. Capilano Sediments unit Cb)	1×10^{-2}	1×10^{-6}	1×10^{-4}
Lodgment Till (e.g. Vashon Drift unit Va)	1×10^{-6}	1×10^{-12}	1×10^{-8}

After Freeze *et al.* Table 2.2, pg 29, Groundwater, Prentice Hall, 1979

Groundwater levels are reportedly 25 m to 50 m below ground surface in the Campbell Heights Area of the watershed, and are expected to be within 1 – 2 m of ground surface in the lower reaches of the watershed.

Topographic gradient (slope) varies between the upper, mid and lower reaches of the creek as follows:

- the upper reaches of the creek (deltaic sand and gravel deposits), have a reported gradient of 5% to 10%, (Garter Lee [Campbell finalized 2003 page 4 and 5]);
- the mid reaches (medium to fine sand unit) have a gradient of approximately 5% to 12%; and
- the flat marshy lower reaches (clay unit) is estimated to be 0.5% to 1%.

Average topographic gradients were determined to be about 7.5% for the upland sand and gravel materials, 5% for the medium to fine sand materials and 1% for the lowest reaches (clay) unit.

Average annual precipitation is expected to vary between approximately 1370 mm and 1590 mm depending on spatial location within the watershed. Potential annual evapotranspiration was calculated to be approximately 533.6 mm (35% of precipitation), leaving 875.7 mm (65%) to runoff or infiltrate depending on soil permeability, structure and topographic gradients in various areas of the watershed. On an average basis, evapotranspiration is expected to equal or exceed precipitation from June through September.

It is expected that the majority of the net infiltration would percolate most easily into the raised proglacial deltaic sand and gravel deposits, and migrate relatively quickly to Erickson Creek and tributaries, occasionally becoming exposed as seeps and springs. Groundwater flow directions in this unit would be governed by local topography, modified by local variations in material thickness, texture and continuity. Large water supply wells may also affect groundwater flow direction (e.g. municipal wells in Langley/Brookswood Aquifer).

Groundwater flow directions in the shallow soils of the lowland areas will be governed by local variation in topography, proximity to drainage and irrigation ditches and local variation in soil texture and porosity. Flooding reportedly occurs in these lowland areas when high tides and heavy rainfall events coincide (UMA, 2002).

The upper and the majority of the mid reaches of the catchment are expected to act as recharge areas, with discharge to the creeks occurring from the coarser grained sand and gravel. Inferred extents of recharge and discharge areas are shown on Drawing 4 in Appendix A.

5.0 STORMWATER INFILTRATION OPPORTUNITIES

Based on the results of the hydrogeological assessment, opportunities for infiltration of stormwater on a mid- to large-scale are expected to be limited to the mid- and upland areas in the southeast and eastern portions of the Erickson Creek watershed. This conclusion is based on the expected moderate to high hydraulic conductivity and significant depth to groundwater from current grades in materials underlying these areas.

The geologic materials underlying the lowland and plain regions of the catchment are expected to have significantly lower hydraulic conductivities and shallow water tables (1-2 m below grade) thus limiting storage capacity through most of the year. Heavy precipitation through the fall, winter and early spring season are expected to maintain moisture contents in the shallow soils, specifically of the topographically low areas, near saturation for the majority of the year. This leaves little buffer for the accommodation of stormwater recharge in these areas.

6.0 RECOMMENDATIONS

To ground truth the results of this assessment, to evaluate depth to groundwater and to quantify the potential infiltration capacity of coarse-grained soils in the mid- and upland areas of the Erickson Creek watershed, Jacques Whitford recommends that test pits be excavated for the purpose of soil classification and infiltration testing. Estimated costs for this work were provided as an Option to the original proposal for this work.

7.0 CLOSURE

We trust this information meets your present requirements. Should you have any questions or require additional information, please contact the undersigned.

Yours very truly,

JACQUES WHITFORD LIMITED

Reviewed by:

DRAFT

Jennifer Todd
Technician 1, ESA&R

DRAFT

Trevor Crozier, P.Eng., M.Eng.
Senior Hydrogeologist, ESA&R

JT/TC/jc

Appendices: Appendix A – Drawings
Appendix B – Climate Data

[File Ref: P:_CMiC Projects\1010001_to_1011000\1010673 ES - Erickson Surrey ISMP Associated Eng\hydrogeology\Erickson Creek DRAFT June 14.doc]

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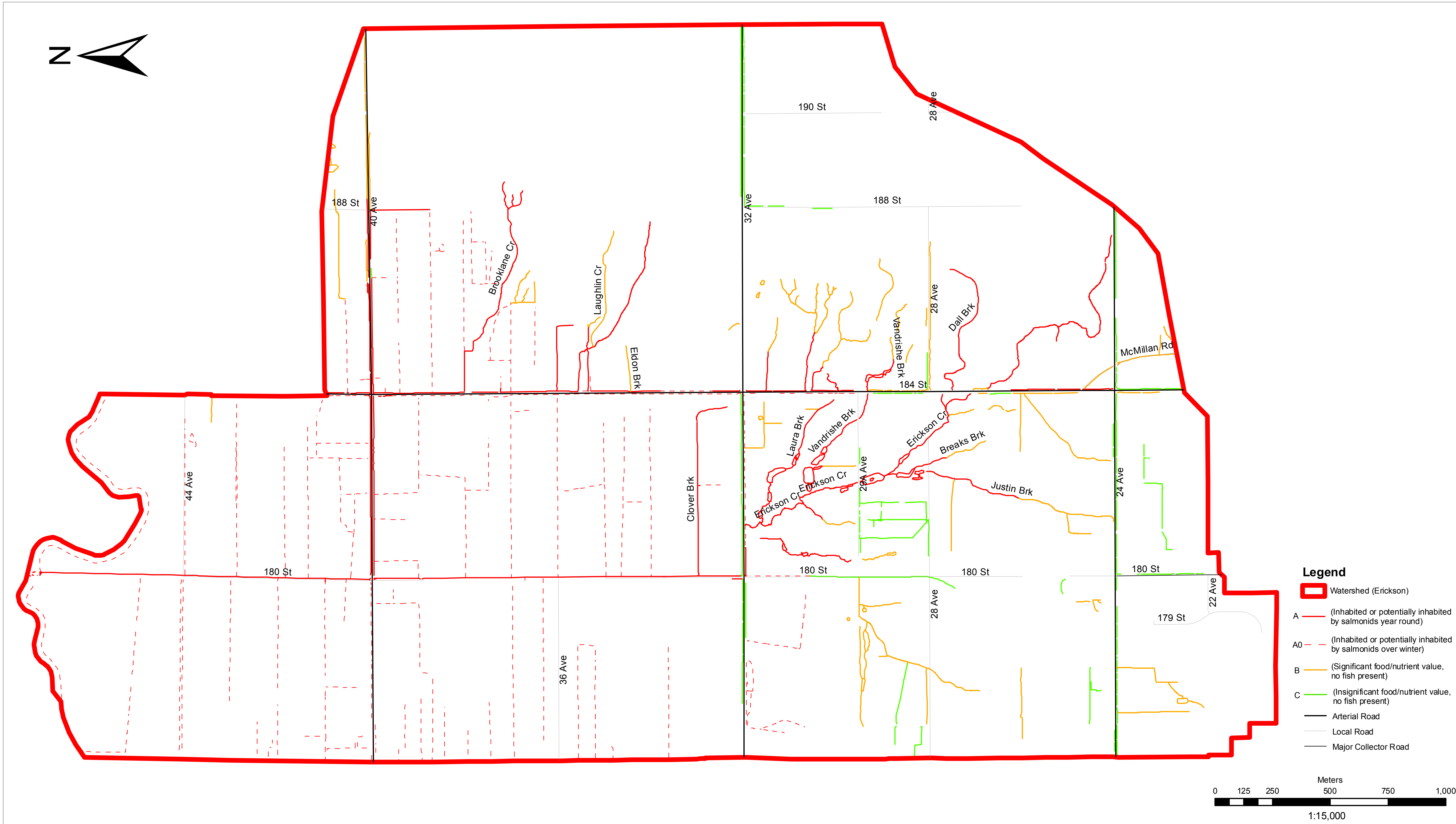
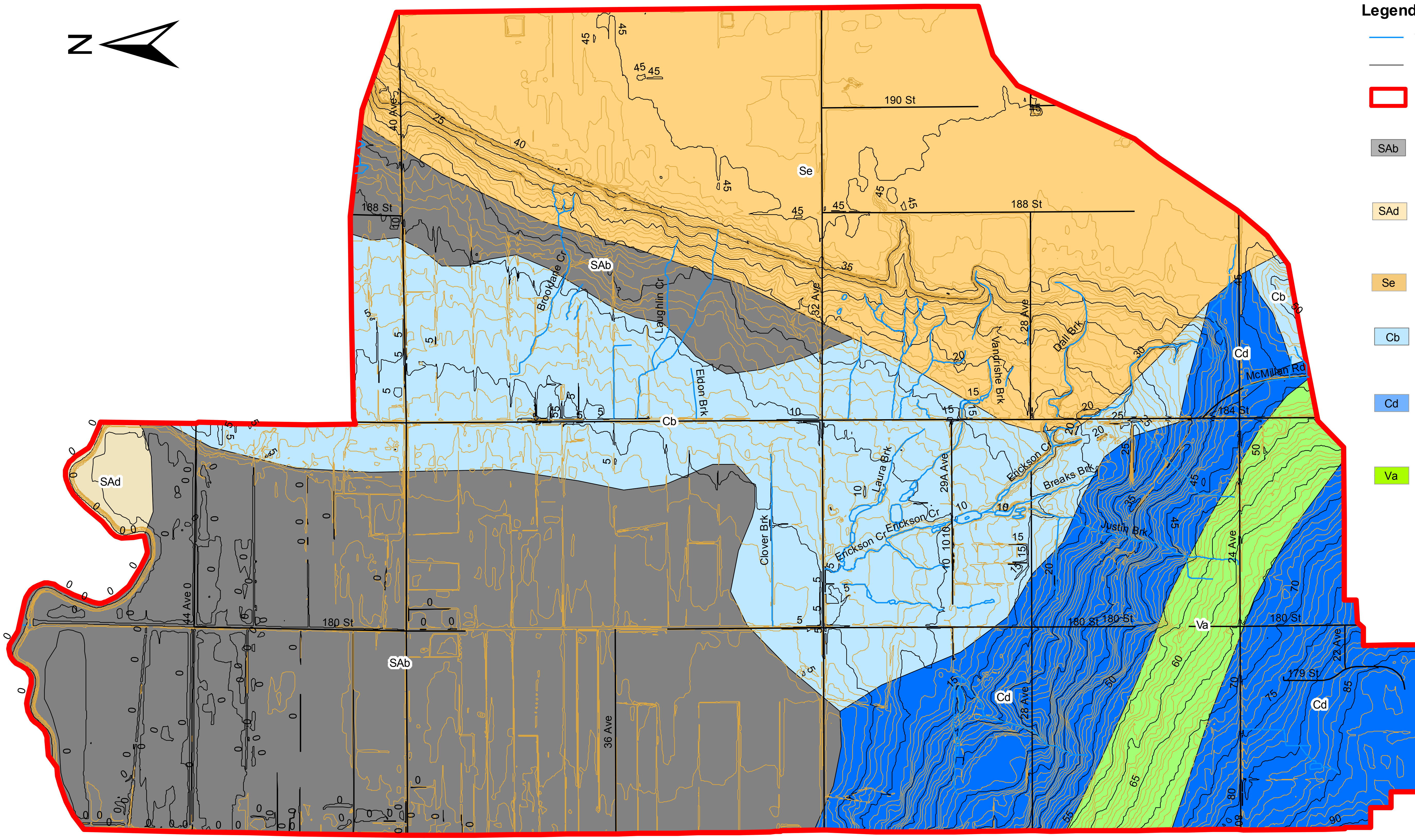
Luttmerding. <u>Soil Survey</u> (1966). 24 May 2006 http://sis.agr.gc.ca/cansis/publications/bc/bc7_pre/bc7_pre_report.pdf

Thornthwaite, C.W., 1948, An approach toward a rational classification of climate, Geog. Rev., 38, pp. 55-94.



Jacques Whitford	PROJECT: **ERICKSON CREEK ISMP** LOCATION: **ERICKSON CREEK, SURREY, BRITISH COLUMBIA** PROJECT No: **1010673**	CLIENT: ASSOCIATED ENGINEERING (BC) LTD.	TITLE: **LOCATION MAP** **ERICKSON CREEK WATERSHED**	DATE: **07-Aug-06** AUTHOR: **MC** APPROVED: **KM**	PROJECTION: **UTM** DATUM: **NAD 83 - ZONE 10**	FIGURE No. **1**



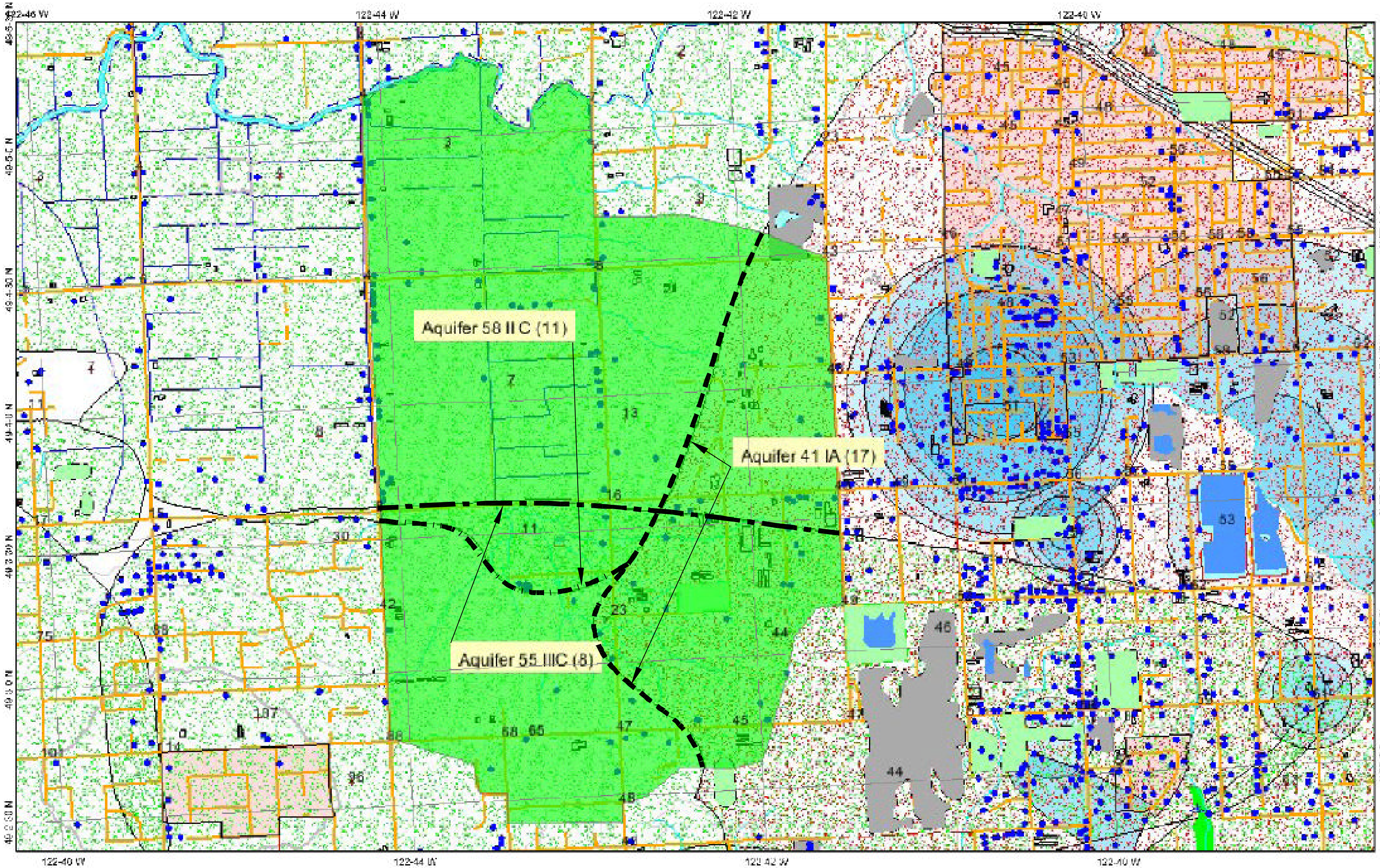
Legend

- Watercourses (Creeks)
- 5m Contours
- Watershed Boundary
- SAb — Salish Sediments - Lowland peat up to 14 m thick, in part overlying overbank sandy to silt loam up to 2 m thick
- SAd — Salish Sediments - Lowland organic sandy loam to clay loam 15 to 45 cm thick overlying medium to coarse sand and gravel up to 8 m thick and deltaic and distributary channel fill.
- Se — Sumas Drift - raised proglacial deltaic gravel and sand up to 40 m thick
- Cb — Capilano Sediments - Raised beach medium to coarse sand 1 m to 5 m thick containing fossil marine shell casts
- Cd — Capilano Sediments - Marine and glaciomarine stony (including till like deposits) to stoneless silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30 m thick
- Va — Vashon Drift - Lodgment till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt

Reference:
Surficial Geology (Per Map 1484a, GSC 1977, 1:50,000 scale)

Meters
0 130 260 520 780 1,040
1:15,000

Jacques Whitford	PROJECT: ERICKSON CREEK ISMP LOCATION: ERICKSON CREEK, SURREY, BRITISH COLUMBIA PROJECT No: 1010673	CLIENT: ASSOCIATED ENGINEERING (BC) LTD.	TITLE: **SURFICIAL GEOLOGY** ERICKSON CREEK WATERSHED	DATE: 07-Aug-06 AUTHOR: MC	APPROVED: KM	PROJECTION: UTM DATUM: NAD 83 - ZONE 10	FIGURE No. 2



Legend

- WDIC - Waterbody Poly
- Commercial and Industrial Well Use
- Domestic Well Use
- Municipal Well Use
- Water Utility Well Use
- Well Capture Zones
- Water Wells

Aquifer Vulnerability

- Bedrock, High Vulnerability
- Bedrock, Moderate Vulnerability
- Bedrock, Low Vulnerability
- Unconsolidated, High Vulnerability
- Unconsolidated, Moderate Vulnerability
- Unconsolidated, Low Vulnerability

Contours (TRIM)

- Contour - Index
- Contour - Index.Indefinite
- Contour - Index.Depression
- Contour - Index.Depression Indefinite
- Contour - Intermediate
- Contour - Intermediate.Indefinite
- Contour - Intermediate.Depression
- Contour - Intermediate.Depression Indefinite
- Areaof Exclusion
- Areaof Indefinite Contours

Elevation - Points (TRIM)

- Spot Height
- Mountain Peak

Miscellaneous Features - Points (TRIM)

- Monument (Horizontal Control)
- Monument (Vertical Control)
- Photo Centre
- Cadastral Point - Permanently Marked

Landmark - Lines (TRIM)

- Yard - Auto Wrecker
- Yard - Lumber
- Fish Hatchery
- Electrical Substation Complex
- Mine (Open-pit)
- Mine (Underground)
- Pile - Raw Material
- Pit
- Pit - Abandoned
- Campground/Campsite
- Drive-in Theatre
- Exhibition Ground
- Golf Course
- Park
- Playing Field (Sports)
- Race Track

Jacques Whitford

PROJECT:	ERICKSON CREEK ISMP	CLIENT: URBAN SYSTEMS	TITLE: **HYDROGEOLOGY** ERICKSON CREEK WATERSHED
LOCATION:	ERICKSON CREEK, SURREY, BRITISH COLUMBIA		
PROJECT No:	1010673		

DATE:	PROJECTION:	FIGURE No.
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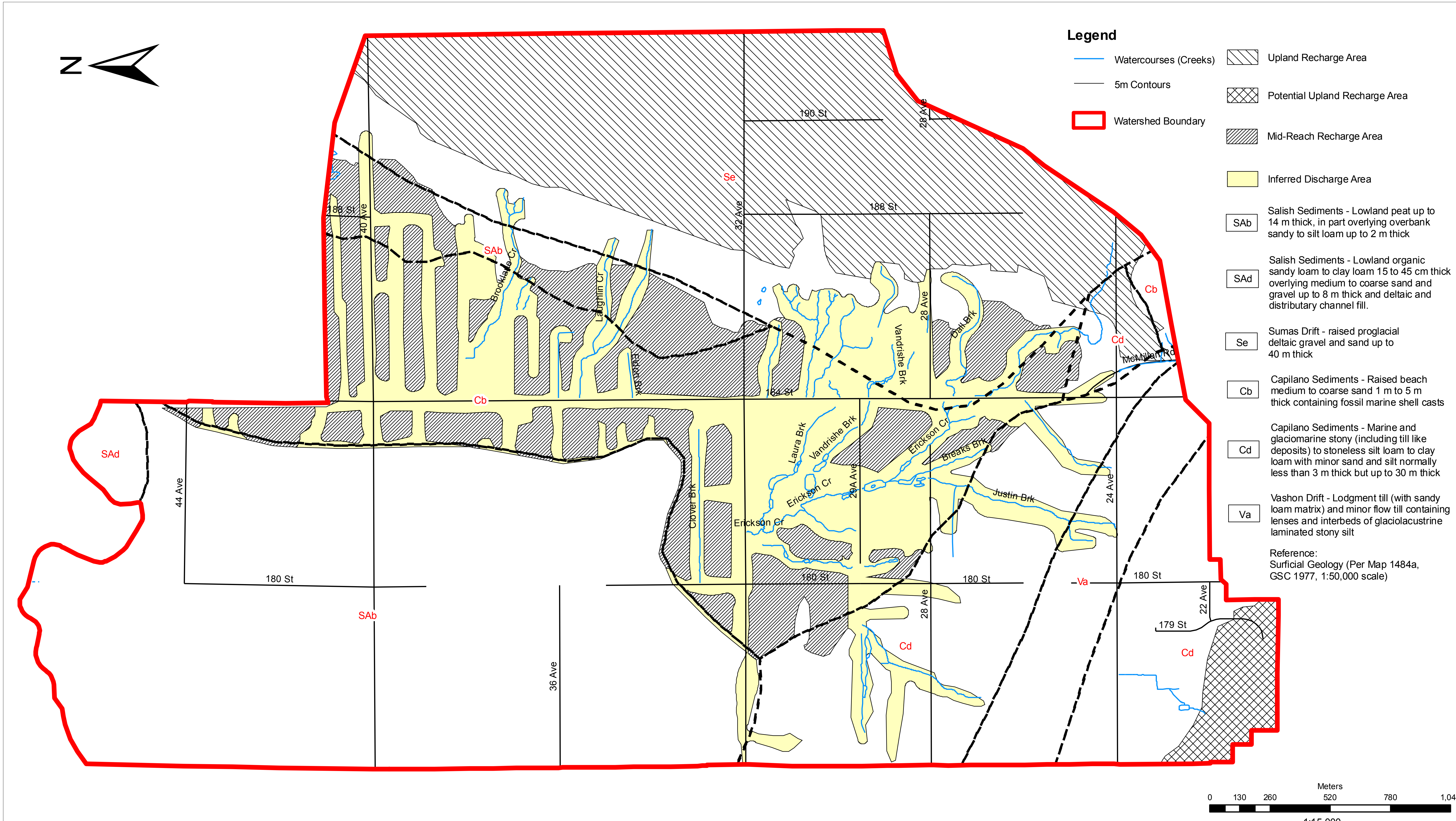
AUTHOR: NP	APPROVED: KM	DATUM: NAD 83 - ZONE 10



PROJECT:	ERICKSON CREEK ISMP
LOCATION:	ERICKSON CREEK, SURREY, BRITISH COLUMBIA
PROJECT No:	1010673

Jacques Whitford

CLIENT: ASSOCIATED ENGINEERING (BC) LTD.

TITLE:

INFERRED RECHARGE & DISCHARGE AREAS

ERICKSON CREEK WATERSHED

DATE:	PROJECTION:	FIGURE No.
07-Aug-06	UTM	4
AUTHOR: MC / APPROVED: KM	DATUM: NAD 83 - ZONE 10	

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VIA ELECTRONIC MAIL

Project No. 1010673

May 8, 2007

Mr. Mike MacLatchy
Associated Engineering (B.C.) Ltd.
Suite 300-4940 Canada Way
Burnaby, British Columbia V5G 4M5

Dear Mr. MacLatchy:

RE: Infiltration Testing for Upland and Midland Areas of Erickson Creek, Preliminary Hydrogeological Assessment, Surrey, British Columbia

1.0 INTRODUCTION

In 2006 Jacques Whitford–AXYS was retained to conduct a non-intrusive, desktop assessment of the hydrogeology of Erickson Creek to support the development of an Integrated Watershed Management Plan (IWMP) for the Erickson Creek watershed. The results of the desktop assessment were presented in our report "Preliminary Hydrogeological Assessment", dated June 14, 2006. In our report it was recommended that a field program be undertaken to ground-truth the results of the desktop assessment.

Subsequently, at your request, Jacques Whitford has recently excavated test pits for the purpose of soil classification and infiltration testing within the upland and midland areas of the Erickson Creek watershed. This letter presents the results of our field work and engineering analysis.

As stated in our desktop assessment report, the geologic materials underlying the lowland and plain regions of the watershed are expected to have significantly lower hydraulic conductivities and shallower water tables than the upland and midland areas, thus limiting storage capacity through most of the year. Heavy precipitation through the fall, winter and early spring season are expected to maintain moisture contents in the shallow soils, specifically of the topographically low areas, near saturation for the majority of the year. This leaves little buffer for the accommodation of stormwater recharge in these areas. For these reasons, infiltration testing was not performed in the lowland and plain regions of the Erickson Creek watershed.

2.0 FIELD PROGRAM

To quantify the potential infiltration capacity of coarse-grained soils in the midland and upland areas of the Erickson Creek watershed, Jacques Whitford completed infiltration testing at the two test sites listed in Table 2.1 on March 28, 2007. Two infiltration tests were completed at each of the two sites, for a total of four tests. Results of the infiltration testing are presented in Section 4.0.

Table 2.1 Infiltration Test Locations

Test Pit No.	Targeted Soil Horizon for Infiltration		Test Site Location	Property Owner
TP07-1	Se	Sumas Drift (sand and gravel)	188th Street & 28th Avenue	City of Surrey (Kerry Park)
TP07-2	Se	Sumas Drift (sand and gravel)	192nd Street & 36th Avenue	Private Property (Commercial Aggregate Supplier)

The test pits were excavated to depths of 1.1 m. The typical soil profile at the two infiltration test sites is as follows.

TP07-1

Depth (m)	**Description**
0.0 – 0.23	Dark brown, SILT and Sand, some organics, loose (Topsoil).
0.23 – 1.1	Light brown, silty SAND, some gravel, trace organics (to 0.76 m), loose to medium dense.

TP07-2

Depth (m)	**Description**
0.0 – 0.46	Unknown (soil stripped off during site development).
0.46 – 1.1	Mottled grey, gravelly SAND, trace silt.

The infiltration tests were carried out within the sand layer at depths varying from 0.36 to 0.97 m. After excavating to the desired test depth, the pit walls were squared up by shovel and scraped to remove any material that may have intruded during excavation. Scraping pit walls is necessary to ensure that the materials being tested are as close to their native state as possible.

Tests were conducted according to standard infiltration test procedures:

- fill the percolation test hole with water to just above 6" (0.15 m) from the bottom of the hole;
- measure the time it takes for the water level in the hole to drop from 6" to 5" (25 mm displacement); and,
- repeat the test until three consecutive infiltration times are within approximately 10% of one another.

3.0 METHODOLOGY AND TEST RESULTS

Infiltration tests were conducted in the test pits to evaluate the hydraulic conductivity of the site. Infiltration times typically increase asymptotically to a steady-state value as the soil around the test pit becomes saturated. We have assumed that the average infiltration rate for the final four tests is the steady-state infiltration rate. The average infiltration rate calculated for each infiltration test location is presented in Table 4.1.

Table 4.1. Steady State Infiltration Rates in Test Pits

Test Pit ID	Steady-State Infiltration Rate (minutes/25 mm)
TP07-1a	2:00
TP07-1b	2:02
TP07-2a	0:46
TP07-2b	1:02

The average infiltration rate, based on the four infiltration tests at the two sites, was 1.46 minutes per 25 mm.

As the infiltration rate becomes steady, it approaches the saturated hydraulic conductivity of the soil[1]. Converting units, the estimated saturated hydraulic conductivities obtained from the infiltration tests are presented in Table 4.2 below:

Table 4.2. Saturated Hydraulic Conductivities Estimated from Infiltration Testing

	Saturated Hydraulic Conductivity, K_s	
Test Pit ID	**(m/s)**	**(m/d)**
TP1a	2.08×10^{-4}	17.97
TP1b	2.05×10^{-4}	17.71
TP2a	5.43×10^{-4}	46.92
TP2b	4.03×10^{-4}	34.82
Average	**3.4×10^{-4}**	**29.4**

4.0 DISCUSSION

Based on the results of the percolation testing, Jacques Whitford estimates that the hydraulic conductivity of the coarse-grained soils in the midland and upland areas of the Erickson Creek watershed (i.e., Soil Horizon Se) is greater than 10^{-4} m/s. This value falls within the range of anticipated hydraulic conductivity, 10^{-5} to 10^{-1} m/s, as stated in our report “Preliminary Hydrogeological Assessment”, dated June 14, 2006, and is in agreement with values obtained from other percolation test investigations conducted by Jacques Whitford in similar soil horizons in Surrey. Furthermore, in their report “Assessment for Options for Infiltration of Stormwater,

[1] Williams, J.R., Ouyang, Y., Chen, J., and Ravi, V., Estimation of Recharge Rate in Vadose Zone: Application of Selected Mathematical Models, US EPA, EPA/600/R-97/128b, 1998.

Campbell Heights, Surrey, BC", dated July 2001, Piteau Associates reference a similar hydraulic conductivity value ($4x10^{-4}$ m/s) for the Campbell Heights area.

As a result, Jacques Whitford considers that the hydrogeologic conditions encountered within the midland and upland areas in the southeast and eastern portions of the Erickson Creek watershed, where the surficial geology consists of Sumas drift deposits, are suitable for infiltration of stormwater on a mid- to large-scale. This conclusion is based on the expected moderate to high hydraulic conductivity and significant depth to groundwater from current grades in materials underlying these areas.

5.0 CLOSURE

We trust this information meets your present requirements. Should you have any questions or require additional information, please contact the undersigned.

Yours very truly,

JACQUES WHITFORD–AXYS

Original signed by

Paul Duffy, B.Sc.Eng., EIT
Geotechnical Engineer

Original signed by

Nigel Denby, M.Eng., P.Eng.
Manager, Geotechnical Group

PD/ND/jc

[File Ref: P:_CMiC Projects\1010001_to_1011000\1010673 ES - Erickson Surrey ISMP Associated Eng\hydrogeology\RPT\Letter Re - Infiltration Test Results, Erickson Creek V2.doc]

C Appendix C – Water Quality Supplement

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Integrated Stormwater Management Planning

WATER QUALITY SUPPLEMENT

ERICKSON CREEK

Prepared for:
Associated Engineering (B.C.) Ltd..
Burnaby, BC

Prepared by:
Jacques Whitford AXYS Ltd.
Burnaby, BC

June 2008

PROJECT NO. 1010673.

PROJECT NO.	**1010673.**
REPORT TO:	**Associated Engineering (B.C.) Ltd.** Suite, 300 – 4949 Canada Way Burnaby, BC V5G 4M5
FOR:	**Integrated Stormwater Management Planning** **Water Quality Supplement**
ON:	**Erickson Creek**

June 23, 2008

Jacques Whitford AXYS Ltd.
4370 Dominion Street, 5th Floor
Burnaby, British Columbia
V5G 4L7

Phone: 604.436.3014
Fax: 604.436.3752

Proprietary Restriction Notice

Table of Contents

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List of Appendices

1 Water Quality

Water quality may be a concern in Erickson Creek, as in many watersheds, related to activities on the land. Physical parameters (temperature, conductivity, pH, dissolved oxygen, turbidity) can provide evidence of degraded water quality due to human influences. The presence of bacteria such as coliforms can indicate contamination with fecal material (coliforms are a group of bacteria that live in soil, water and the intestinal tracts of cold- and warm-blooded animals, with fecal coliforms, including *Escherichia coli*, specific to warm-blooded animals, including humans). Other substances, such as metals, pesticides, nitrate, ammonia and phosphate, can be transported to the stream via stormwater runoff, and reflect vehicle use and commercial, residential and agricultural practices. If unmitigated, future development will increase stormwater runoff and pollutant loads entering Erickson Creek.

1.1 Water Quality Monitoring Program, 2006

Water quality was assessed at two sites in 2006 as part of the Erickson Creek ISMP:

- Site E1 in the lower watershed on Erickson Creek, (the ditch along 180th Street, just downstream of 32nd Avenue); and
- Site E2 in the upper watershed on Vandrishe Brook (just upstream of 29A Avenue).

Samples were collected on June 28 and July 21, following a period of at least five days of dry weather. Two travel blanks (one per trip) and one field duplicate sample were collected. Samples were preserved as required, kept in a cooler at 4°C and submitted to ALS Environmental laboratory (Vancouver, BC) within 24 hours.

At each site, *in situ* water quality (temperature, turbidity, pH, dissolved oxygen [DO], and conductivity) was recorded and grab samples were collected for analysis of metals, nutrients and coliforms. Field meters included a Hanna pH meter, YSI 85 Multimeter (for dissolved oxygen, conductivity, salinity, temperature) and a Lamott turbidity meter. *In situ* and analytical water quality results are summarized below and complete analytical reports are contained in Appendix A.

Results were compared with Ministry of Environment (2006) water quality guidelines for protection of aquatic life for chemical parameters, and with guidelines for recreation/primary contact for microbiological parameters (coliforms), as these are the most protective guidelines.

Quality Assurance/Quality Control

Sample quality (QA/QC) was high, as indicated by:

- two travel blanks (no indication of sample contamination on both dates, trace amounts of phosphates on June 28);
- one field duplicate (close agreement in concentrations for most parameters, 35% difference for coliform counts, 39% difference for total zinc); and
- field vs. laboratory comparisons for conductivity (>98% agreement on the one date available).

Field measurements of pH were notably lower than lab measurements (6.5 to 6.8 for field compared to 7.4 to 8.0 for lab measurements). Such differences are often noted, and can be attributed to differences in field and laboratory conditions and lower accuracy of field meters. As a result, the laboratory values for pH are considered in site comparisons.

In Situ Water Quality

In situ water quality was recorded at two sites (E1 and E2) on four dates between April and July, 2006, with results presented in Table 1. The April measurements were taken during the fish habitat field survey. The June 8 measurements were collected during a trip to collect dry weather samples; however, heavy rain began before the grab samples could be collected, so only *in situ* water quality was measured. The June 28 and July 21 measurements were taken during the dry weather water sampling trips.

Temperature ranged from 10.5 to 19.6°C, and increased between April 10 and July 21. Temperature was up to 2.5°C higher at E2 than at E1. Conductivity ranged from 111 to 238 µS/cm and tended to be lower at E1 than E2. Turbidity ranged from 2.4 to 8.1 NTU. Values for pH ranged from 6.5 to 7.5, with low values likely related to accuracy of the field meter. Dissolved oxygen levels ranged from 48% to 88% (5.5 to 8.6 mg/L).

Table 1: Field Conditions and *In Situ* Water Quality in Erickson Creek, 2006

Parameter	Date	Site	
		E1 (Erickson ditch)	E2 (Vandrishe Brook)
Weather	April 10, 12	Light overcast	
	June 8	Heavy rain	
	June 28	Sunny and dry for previous week	
	July 21	Sunny and dry for previous week	
Temperature (°C)	April 10, 12	10.5	10.5
	June 8	14.0	16.1
	June 28	17.1	19.6
	July 21	17.0	19.4
Specific Conductivity (µS/cm)	April 10, 12	111.0	238.1
	June 8	165.8	193.5
	June 28	179.4	201.0
	July 21	*	*
Turbidity (NTU)	April 10, 12	6.8	6.3
	June 8	2.4	4.1
	June 28	*	*
	July 21	8.1	7.25
pH (field)	April 10, 12	7.5	7.6
	June 8	6.5	6.5
	June 28	6.5	6.5
	July 21	6.7	6.8
DO (%)	April 10, 12	57.3	68.1
	June 8	70.9	47.8
	June 28	74.4	75.4
	July 21	88.0	67.4

* meter not available

Results were compared with BC water quality guidelines for protection of aquatic life (Ministry of Environment 2006). *In situ* parameters were within applicable guidelines.

Also, temperatures recorded during dry weather on July 21 (up to 19.4°C) suggest that summer temperatures are above optimal levels for salmonids (up to 16°C for rearing coho salmon and cutthroat trout). This result highlights the importance of maintaining streamside vegetation.

Total Suspended Solids

Total suspended solids (TSS) is a commonly used measure of sediment loads in a creek, and typically comes from runoff containing sand, silt, clay and organic matter, for example from construction sites, erosion areas and other exposed soils. High levels of TSS can damage the gills of salmonids, other fish and aquatic invertebrates and can degrade instream habitat when the material settles onto gravel and cobble substrates. Storm events have the potential to convey high sediment loads.

The TSS levels at the two sites were low (3.3 to 5.5 mg/L) on the two dates sampled. These values correspond with low turbidity values (2.4 to 8.1 NTU), and reflect background levels during non-storm events. TSS levels were below provincial guidelines (25 mg/L maximum induced TSS).

Table 2: Total Suspended Solids (TSS) in Erickson Creek, 2006

Parameter (mg/L)	Water Quality Guideline	Date	Site	
			E1 (Erickson ditch)	E2 (Vandrishe Brook)
TSS	Maximum induced TSS of 25 mg/L when background is <250 mg/L	June 28	5.5	3.3

Coliforms

Coliforms are a group of bacteria that live in soil, water and the intestinal tracts of cold- and warm-blooded animals, with fecal coliforms, including *Escherichia coli*, specific to mammals, including humans. The presence of *E. coli* and other fecal coliforms indicates contamination with fecal material. Results for Erickson Creek sites are presented in Table 3.

Levels of *E. coli* and fecal coliforms were compared with the BC water quality guidelines for primary contact recreation and the identical guideline for irrigation of ready to eat crops (Ministry of Environment 2006), although it is noted that these guidelines are designed to assess mean values (five measurements in a 30 day period, triplicate samples), rather than the individual measurements collected for the ISMP program, and results should be interpreted with caution. Individual values for *E. coli* and fecal coliforms exceeded guidelines in all samples analyzed (Table 3).

In a predominantly agricultural area, the most obvious source of coliforms is manure from farm animals and from unprotected manure piles near streams. Agricultural activities are spread throughout the watershed, with hobby farms in the uplands and commercial dairy and vegetable farming in the lowlands. Studies conducted by the Ministry of Environment between 2002 and 2004 indicated *E. coli* levels at that time higher than the provincial water quality guideline in several irrigation ditches and tributaries of the Erickson watershed (Payette 2006). Follow-up monitoring suggested compliance concerns with some hobby farms in the watershed and the need for coordinated efforts to engage the hobby farmers to improve awareness, compliance levels and environmental quality (Rushworth and Younie 2006). Results of the 2006 sampling suggest the need for ongoing education and monitoring.

Table 3: Coliform Levels in Erickson Creek, 2006

Parameter (MPN/100 mL)	Water Quality Guideline[1]	Date	Site	
			E1 (Erickson ditch)	E2 (Vandrishe Brook)
Total Coliforms	None	June 28	8660	13000
		July 21	>2420	>2420
Fecal Coliforms	Geometric mean ≤ 200/100 mL	June 28	**660**	**530**
		July 21	**TNTC**	**TNTC**
E. coli	Geometric mean ≤ 77/100 mL	June 28	**1300**	**816**
		July 21	**1730**	**1300**

1. BC water quality guidelines for recreation/primary contact (Min. Env. 2006)
MPN = Most Probable Number per 100 mL
TNTC = too numerous to count
BOLD numbers are higher than water quality guideline (mean value)

Nutrients/Fertilizers

Nitrogen and phosphorus are essential elements for aquatic plants (algae); however, high levels of these compounds (e.g., from agricultural and residential fertilizers, manure, detergents, organic matter) can lead to excessive algal growth in a stream and degradation of stream habitat for aquatic insects and fish.

Results for the various nitrogen fractions at the two sites are shown in Table 4. Nitrogen in streams cycles through its various forms (ammonia, nitrate, nitrite and organic nitrogen) through uptake by and decomposition of algae and bacteria and by chemical processes (Wetzel 2001). All nitrogen compounds were within BC water quality guidelines for protection of aquatic life (Ministry of Environment 2006):

- ammonia levels ranged from 0.0110 to 0.040 mg/L (similar at both sites);
- nitrite levels ranged from 0.0228 to 0.0385 mg/L (similar at both sites); and
- nitrate levels ranged from 3.40 to 4.37 mg/L (increase between Site E2 and Site E1, downstream).
- The increase in nitrate levels between E2 and E1 may be related to inputs from human activities (e.g., runoff from manure on agricultural sites, seepage from septic fields, use of fertilizers) or contributions from groundwater (iron levels also increase between E2 and E1). Although nitrate did not exceed the water quality guideline for protection of aquatic life (200 mg/L, based on toxicity), it was close to the guideline for drinking water (10 mg/L N). Elevated nitrate levels in surface and groundwater have been noted in other areas of the Fraser Valley where there is primarily agricultural land use. For example, nitrate levels in the Abbotsford aquifer (average of 10 to 20 mg/L) are considered a water quality concern and an indicator of groundwater contamination (Ministry of Environment, Lands and Parks and Environment Canada 2000, Environment Canada 2004).

Table 4: Nutrient Levels in Erickson Creek, 2006

Parameter	Water Quality Guideline Maximum[1]	Date	Site	
			E1[2] (Erickson ditch)	E2 (Vandrishe Brook)
Ammonia (mg/L N)	0.76 – 1.54 (based on temp & lab pH)	June 28	0.039	0.040
		July 21	0.0110	0.0190
Nitrate (mg/L N)	200	June 28	4.12	3.40
		July 21	4.37	3.40
Nitrite (mg/L N)	0.24 (based on 6-8 mg/L chloride)	June 28	0.0385	0.0367
		July 21	0.0259	0.0228
Phosphate, ortho (mg/L P)	N/A	June 28	0.0166	0.0543
		July 21	0.0128	0.0407
Phosphate, diss. (mg/L P)	N/A	June 28	0.0228	0.0663
		July 21	0.0202	0.0490
Phosphate, total (mg/L P)	N/A	June 28	0.0484	0.0839
		July 21	0.0268	0.0525

1. BC water quality guidelines for protection of aquatic life (Min. Env. 2006)
2. Mean of duplicates at E1, July 21

Phosphorus occurs in both organic and inorganic forms. Total phosphate ranged from 0.0268 to 0.0839 mg/L. Ortho phosphate (dissolved inorganic phosphate) and total dissolved (organic and inorganic) fractions were lower, ranging from 0.0128 to 0.0663 mg/L. These results suggest the effects of agricultural and residential activities, given that ortho phosphate concentrations for unpolluted streams average approximately 0.01 mg/L and can increase to 0.05 to 0.1 mg/L in areas receiving additional inputs (Wetzel 2001). Concentrations of all fractions analyzed decreased substantially between the upstream and downstream site, suggesting dilution with other sources of water downstream of E2, and were higher on June 28 than July 21.

Metals

Metals such as zinc, molybdenum, copper and cadmium are common components of street runoff and arise from vehicle use (e.g., wear and tear of brakes, tires), house materials (e.g., zinc strips and copper granules used to control moss and algal growth, copper plumbing pipes), lawn treatments (moss control) and other commercial, residential and agricultural practices in the watershed.

Most parameters met the BC water quality guidelines, with the exception of iron (Ministry of Environment 2006, Nagpal *et al.* 2006). Analytical results are provided in Appendix A. Iron levels ranged from 0.306 to 1.30 mg/L and were highest at E1 (Table 5). Levels at E1 were three to four times higher than the provincial guideline of 0.3 mg/L. High total iron levels typically are associated with high TSS levels, as iron is a significant component of silt. Since TSS levels of 3.3 to 5.5 mg/L (Table 2) were not particularly elevated, it is possible that dissolved iron in the groundwater contributed to elevated levels in the stream.

Table 5: Instances in which Metal Concentrations Exceeded BC Water Quality Guidelines[1]

Parameter (mg/L)	Water Quality Guideline Maximum	Date	Site	
			E1	E2
Iron	0.30	June 28	**1.3**	0.306
		July 21	**1.06**	–

[1.] BC Approved and Working Guidelines for protection of aquatic life (Ministry of Environment 2001, Nagpal *et al.* 2001)

1.2 Summary and Recommendations

Baseline surveys at the two Erickson Creek sites indicated elevated levels of coliforms, nutrients and iron during the low flow period of 2006, suggestive of poor water quality. Agricultural runoff is a likely source of the fecal coliforms and phosphate, and may also contribute nitrate and ammonia to the creek. The elevated nitrate and iron levels, particularly at E1 in the lower watershed, may also come from groundwater, which would be particularly noticeable during the low flow period.

Elevated *E. coli* levels in irrigation ditches, Erickson Creek and tributaries have been reported in the past (Payette 2006). There may be ongoing compliance issues at some properties, notably with some hobby farms in upland reaches of the watershed (Rushworth and Younie 2006), which suggests that a coordinated approach to ongoing education and compliance monitoring would be helpful in improving water quality.

1.3 References

Environment Canada. 2004. Nitrate levels in the Abbotsford Aquifer, an indicator of groundwater contamination in the Lower Fraser Valley. Available at: http://www.ecoinfo.org/env_ind/region/nitrate/nitrate_e.cfm#top

Ministry of Environment, Lands and Parks and Environment Canada. 2000. Water quality trends in selected British Columbia waterbodies. Available at: http://www.waterquality.ec.gc.ca/web/Environment~Canada/Water~Quality~Web/assets/images/English/WatTrendFeb29.pdf

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Ministry of Environment. 2001. British Columbia Approved Water Quality Guidelines (Criteria). Available at www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/ approved.html

Nagpal, N K, LW Pommen and LG Swain. 2001. A Compendium of Working Water Quality Guidelines for British Columbia. Available at http://www.env.gov.bc.ca/wat/ wq/BCguidelines/working.html

Respectfully submitted,

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[File Name/Path: P:_CMiC Projects\1010001_to_1011000\1010673 ES - Erickson Surrey ISMP Associated Eng\FINAL REPORT\1010673 Water Quality Report FORMATTED.docx]

Appendix A
Water Quality Reports, ALS Environmental

ALS Environmental

CERTIFICATE OF ANALYSIS

Date:	July 14, 2006
ALS File No.	X7885
Report On:	1010673 29100 Water Analysis
Report To:	**Jacques Whitford** 4370 Dominion Street, 5th Floor PO Box 21 Burnaby, BC V5G 4L7
Attention:	**Ms. Karen Munro**
Received:	June 28, 2006

ALS ENVIRONMENTAL
per:

Andre Langlais, M.Sc. - Senior Account Manager
Can Dang, B.Sc. - Senior Account Manager

File No. X7885

RESULTS OF ANALYSIS - Water

Sample ID			E1	E2	Blank
Sample Date			06-06-28	06-06-28	06-06-28
Sample Time			12:00	12:00	12:00
ALS ID			*1*	*2*	*3*
Physical Tests					
Conductivity	(uS/cm)		178	197	<2.0
Hardness	CaCO3		74.1	85.2	<0.66
pH			8.00	8.04	5.58
Total Suspended Solids			5.3	3.3	<3.0
Dissolved Anions					
Alkalinity-Total		CaCO3	46.2	74.0	<2.0
Bromide	Br		<0.050	<0.050	<0.050
Chloride	Cl		7.12	7.67	<0.50
Fluoride	F		0.039	0.044	<0.020
Sulphate	SO4		13.6	12.2	<0.50
Nutrients					
Ammonia Nitrogen		N	0.039	0.040	<0.020
Nitrate Nitrogen		N	4.12	3.40	<0.0050
Nitrite Nitrogen		N	0.0385	0.0367	<0.0010
Dissolved ortho-Phosphate		P	0.0166	0.0543	0.0015
Total Dissolved Phosphate		P	0.0228	0.0663	0.0025
Total Phosphate		P	0.0484	0.0839	0.0030
Bacteriological Tests					
E. coli			1300	816	<1
Coliform Bacteria - Fecal			660	530	<1
Coliform Bacteria - Total			8660	13000	<1

< = Less than the detection limit indicated.
Results are expressed as milligrams per litre except where noted.
Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

File No. X7885

RESULTS OF ANALYSIS - Water

Sample ID		E1	E2	Blank
Sample Date		06-06-28	06-06-28	06-06-28
Sample Time		12:00	12:00	12:00
ALS ID		*1*	*2*	*3*
Total Metals				
Aluminum	T-Al	0.105	0.0634	<0.0050
Antimony	T-Sb	<0.00050	<0.00050	<0.00050
Arsenic	T-As	0.00128	0.00243	<0.00050
Barium	T-Ba	<0.020	<0.020	<0.020
Beryllium	T-Be	<0.0010	<0.0010	<0.0010
Boron	T-B	<0.10	<0.10	<0.10
Cadmium	T-Cd	<0.000017	<0.000017	<0.000017
Calcium	T-Ca	18.9	21.6	<0.10
Chromium	T-Cr	<0.0010	<0.0010	<0.0010
Cobalt	T-Co	<0.00030	<0.00030	<0.00030
Copper	T-Cu	<0.0010	0.0011	<0.0010
Iron	T-Fe	1.30	0.306	<0.030
Lead	T-Pb	<0.00050	<0.00050	<0.00050
Lithium	T-Li	<0.0050	<0.0050	<0.0050
Magnesium	T-Mg	6.54	7.61	<0.10
Manganese	T-Mn	0.119	0.0346	<0.00030
Mercury	T-Hg	<0.000020	<0.000020	<0.000020
Molybdenum	T-Mo	<0.0010	<0.0010	<0.0010
Nickel	T-Ni	<0.0010	<0.0010	<0.0010
Potassium	T-K	<2.0	<2.0	<2.0
Selenium	T-Se	<0.0010	<0.0010	<0.0010
Silver	T-Ag	<0.000020	<0.000020	<0.000020
Sodium	T-Na	5.5	7.5	<2.0
Thallium	T-Tl	<0.00020	<0.00020	<0.00020
Tin	T-Sn	<0.00050	<0.00050	<0.00050
Titanium	T-Ti	<0.010	<0.010	<0.010
Uranium	T-U	<0.00020	<0.00020	<0.00020
Vanadium	T-V	<0.030	<0.030	<0.030
Zinc	T-Zn	0.0064	<0.0050	<0.0050
Dissolved Metals				
Zinc	D-Zn	<0.0050	<0.0050	<0.0050

< = Less than the detection limit indicated.
Results are expressed as milligrams per litre except where noted.
Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

Appendix 1 - METHODOLOGY

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Conductivity in Water

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

pH in Water

This analysis is carried out using procedures adapted from APHA Method4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

Recommended Holding Time:
Sample: 2 hours
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Solids in Water

This analysis is carried out using procedures adapted from APHA Method 2540"Solids". Solids are determined gravimetrically. Total dissolved solids(TDS) and total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius, TSS is determined by drying the filter at 104 degrees celsius. Total solids are determined by evaporating a sample to dryness at 104 degrees celsius. Fixed and volatile solids are determined byigniting a dried sample residue at 550 degrees celsius.

Recommended Holding Time:
Sample: 7 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Alkalinity in Water by Colourimetry

This analysis is carried out using procedures adapted from EPA Method 310.2"Alkalinity". Total Alkalinity is determined using the methyl orangecolourimetric method.

Recommended Holding Time:

Sample: 14 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Dissolved Anions in Water by Ion Chromatography

This analysis is carried out using procedures adapted from APHA Method 4110 "Determination of Anions by Ion Chromatography" and EPA Method 300.0"Determination of Inorganic Anions by Ion Chromatography". Anions aredetermined by filtering the sample through a 0.45 micron membrane filter andinjecting the filtrate onto a Dionex IonPac AG17 anion exchange column witha hydroxide eluent stream. Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

Recommended Holding Time:
Sample: 28 days (bromide, chloride, fluoride, sulphate)
Sample: 2 days (nitrate, nitrite)
Reference: APHA and EPA

Laboratory Location: ALS Environmental, Vancouver

Ammonia in Water by Selective Ion Electrode

This analysis is carried out, on sulphuric acid preserved samples, usingprocedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammoniais determined using an ammonia selective electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Phosphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". All forms of phosphate are determined by the ascorbic acidcolourimetric method. Dissolved ortho-phosphate (dissolved reactivephosphorous) is determined by direct measurement. Total phosphate (totalphosphorous) is determined after persulphate digestion of a sample. Total dissolved phosphate (total dissolved phosphorous) is determined by filtering a sample through a 0.45 micron membrane filter followed by persulfate digestionof the filtrate.

Recommended Holding Time:
Sample: 2 days
Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

E. coli and Total Coliform Bacteria in Water by Enzyme Substrate

This analysis is carried out using procedures adapted from APHA Method 9223"Enzyme Substrate Coliform Test". E. coli and Total Coliform are determinedsimultaneously. The sample is mixed with a mixture hydrolyzable substratesand then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responsesto a probability table.

Recommended Holding Time:
Sample: 1 day
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Coliform Bacteria in Water by Membrane Filtration

This analysis is carried out using procedures adapted from APHA Method 9222"Membrane Filter Technique for Members of the Coliform Group". Coliformbacteria is determined by colony counting. A known sample volume isfiltered through a 0.45 micron membrane filter. The test involves an initial 24 hour incubation of the filter with the appropriate growth medium, positive results require further testing (up to an additional 48 hours) to confirm andquantify the total and fecal coliform. This method is used for non-turbidwater with a low background bacteria level.

Recommended Holding Time:
Sample: 1 day
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Metals in Water

This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with proceduresadapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using eitherhotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:
Sample: 6 months

Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

Mercury in Water

This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

Recommended Holding Time:
Sample: 28 days
Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

Results contained within this certificate relate only to the samples as submitted.

This Certificate Of Analysis shall only be reproduced in full, except with the written approval of ALS Environmental.

End of Report

ALS Environmental

CERTIFICATE OF ANALYSIS

Date:	August 3, 2006
ALS File No.	X9076
Report On:	1010673 Erickson ISMP Water Analysis
Report To:	**Jacques Whitford** 4370 Dominion Street, 5th Floor PO Box 21 Burnaby, BC V5G 4L7
Attention:	**Ms. Karen Munro**
Received:	July 22, 2006

ALS ENVIRONMENTAL
per:

Andre Langlais, M.Sc. - Senior Account Manager
Can Dang, B.Sc. - Senior Account Manager

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1988 Triumph Street, Vancouver, BC Canada V5L 1K5
Phone: 604-253-4188 Fax: 604-253-6700 Website: www.alsenviro.com

File No. X9076

RESULTS OF ANALYSIS - Water

Sample ID			E1	E2	E3	Blank
Sample Date			06-07-21	06-07-21	06-07-21	06-07-21
Sample Time			08:30	08:50	08:35	
ALS ID			*1*	*2*	*3*	*4*
Physical Tests						
Conductivity	(uS/cm)		184	201	185	<2.0
Hardness	CaCO3		81.6	90.7	81.7	<0.66
pH			7.45	7.62	7.65	6.86
Total Suspended Solids			5.3	4.7	6.0	<3.0
Dissolved Anions						
Alkalinity-Total		CaCO3	47.5	70.6	49.2	<2.0
Bromide	Br		<0.050	<0.050	<0.050	<0.050
Chloride	Cl		7.14	7.69	7.14	<0.50
Fluoride	F		0.042	0.047	0.041	<0.020
Sulphate	SO4		14.1	13.6	14.4	<1.0
Nutrients						
Ammonia Nitrogen		N	0.0110	0.0190	0.0100	<0.0050
Nitrate Nitrogen		N	4.37	3.40	4.38	<0.0050
Nitrite Nitrogen		N	0.0256	0.0228	0.0262	<0.0010
Dissolved ortho-Phosphate		P	0.0130	0.0407	0.0126	<0.0010
Total Dissolved Phosphate		P	0.0202	0.0490	0.0201	<0.0020
Total Phosphate		P	0.0266	0.0525	0.0270	<0.0020
Bacteriological Tests						
E. coli			1730	1300	1120	<1
Coliform Bacteria - Fecal			TNTC	TNTC	TNTC	<1
Coliform Bacteria - Total			>2420	>2420	>2420	<1

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

File No. X9076

RESULTS OF ANALYSIS - Water

Sample ID		E1	E2	E3	Blank
Sample Date		06-07-21	06-07-21	06-07-21	06-07-21
Sample Time		08:30	08:50	08:35	
ALS ID		*1*	*2*	*3*	*4*
Total Metals					
Aluminum	T-Al	0.0842	0.0772	0.0787	<0.0050
Antimony	T-Sb	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	T-As	0.00120	0.00207	0.00120	<0.00050
Barium	T-Ba	<0.020	<0.020	<0.020	<0.020
Beryllium	T-Be	<0.0010	<0.0010	<0.0010	<0.0010
Boron	T-B	<0.10	<0.10	<0.10	<0.10
Cadmium	T-Cd	<0.000017	<0.000017	<0.000017	<0.000017
Calcium	T-Ca	20.4	22.6	20.5	<0.10
Chromium	T-Cr	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt	T-Co	<0.00030	<0.00030	<0.00030	<0.00030
Copper	T-Cu	<0.0010	<0.0010	<0.0010	<0.0010
Iron	T-Fe	1.06	0.285	0.988	<0.030
Lead	T-Pb	<0.00050	<0.00050	<0.00050	<0.00050
Lithium	T-Li	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium	T-Mg	7.44	8.33	7.42	<0.10
Manganese	T-Mn	0.119	0.0534	0.119	<0.00030
Mercury	T-Hg	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum	T-Mo	<0.0010	<0.0010	<0.0010	<0.0010
Nickel	T-Ni	<0.0010	<0.0010	<0.0010	<0.0010
Potassium	T-K	<2.0	<2.0	<2.0	<2.0
Selenium	T-Se	<0.0010	<0.0010	<0.0010	<0.0010
Silver	T-Ag	<0.000020	<0.000020	<0.000020	<0.000020
Sodium	T-Na	6.5	8.1	6.4	<2.0
Thallium	T-Tl	<0.00020	<0.00020	<0.00020	<0.00020
Tin	T-Sn	<0.00050	<0.00050	<0.00050	<0.00050
Titanium	T-Ti	<0.010	<0.010	<0.010	<0.010
Uranium	T-U	<0.00020	<0.00020	<0.00020	<0.00020
Vanadium	T-V	<0.030	<0.030	<0.030	<0.030
Zinc	T-Zn	0.0061	<0.0050	0.0100	<0.0050

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

Appendix 1 - METHODOLOGY

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Conductivity in Water

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

pH in Water

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

Recommended Holding Time:
Sample: 2 hours
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Solids in Water

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total dissolved solids (TDS) and total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius, TSS is determined by drying the filter at 104 degrees celsius. Total solids are determined by evaporating a sample to dryness at 104 degrees celsius. Fixed and volatile solids are determined by igniting a dried sample residue at 550 degrees celsius.

Recommended Holding Time:
Sample: 7 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Alkalinity in Water by Colourimetry

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

Recommended Holding Time:

Sample: 14 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Dissolved Anions in Water by Ion Chromatography

This analysis is carried out using procedures adapted from APHA Method 4110 "Determination of Anions by Ion Chromatography" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions are determined by filtering the sample through a 0.45 micron membrane filter and injecting the filtrate onto a Dionex IonPac AG17 anion exchange column with a hydroxide eluent stream. Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

Recommended Holding Time:
Sample: 28 days (bromide, chloride, fluoride, sulphate)
Sample: 2 days (nitrate, nitrite)
Reference: APHA and EPA

Laboratory Location: ALS Environmental, Vancouver

Sulphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-SO4 "Sulphate". Sulphate is determined using the turbidimetric method.

Recommended Holding Time:
Sample: 28 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Ammonia in Water by Colourimetry

This analysis is carried out, on unpreserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using the phenate colourimetric method.

Recommended Holding Time:
Sample: 72 hours
Reference: BC WLAP

Laboratory Location: ALS Environmental, Vancouver

Phosphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". All forms of phosphate are determined by the ascorbic acid colourimetric method. Dissolved ortho-phosphate (dissolved reactive phosphorous) is determined by direct measurement. Total phosphate (total phosphorous) is determined after persulphate digestion of a sample. Total dissolved phosphate (total dissolved phosphorous) is determined by filtering a sample through a 0.45 micron membrane filter followed by persulfate digestion of the filtrate.

Recommended Holding Time:
Sample: 2 days
Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

E. coli and Total Coliform Bacteria in Water by Enzyme Substrate

This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.

Recommended Holding Time:
Sample: 1 day
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Coliform Bacteria in Water by Membrane Filtration

This analysis is carried out using procedures adapted from APHA Method 9222 "Membrane Filter Technique for Members of the Coliform Group". Coliform bacteria is determined by colony counting. A known sample volume is filtered through a 0.45 micron membrane filter. The test involves an initial 24 hour incubation of the filter with the appropriate growth medium, positive results require further testing (up to an additional 48 hours) to confirm and quantify the total and fecal coliform. This method is used for non-turbid water with a low background bacteria level.

Recommended Holding Time:
Sample: 1 day
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:
Sample: 6 months
Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

Recommended Holding Time:
Sample: 28 days
Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

Results contained within this certificate relate only to the samples as submitted.

End of Report

D Appendix D – Field Data Sheets

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB3-030

SURREY
CITY OF PARKS

Watercourse:	Tributary 3	**Location:**	
Date:	4/13/2006	**Northing:**	5434010
Time:	11:22:55 AM	**Easting:**	520284
Weather:	Rain		

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	3.3:1		
	Right Bank Height:	0.6 m		
	Right Bank Slope (H:V):	3.3:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	m		

Photos P1000101.jpg

Comment: Side channel is well defined and banks are heavily vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB3-020

Watercourse:	Tributary 3	**Location:**	
Date:	4/13/2006	**Northing:**	5434065
Time:	11:24:52 AM	**Easting:**	520301
Weather:	Rain		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	3.0 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	0.6 m		
	Low Flow Channel Depth:	m		

Photos P1000100.jpg

Comment: Side channel is well defined and banks are composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: LAU-010

SURREY
CITY OF PARKS

Watercourse:	Laura Brook	**Location:**	
Date:	4/13/2006	**Northing:**	5434070
Time:	11:32:13 AM	**Easting:**	520456
Weather:	Rain		

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	5.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000102.jpg

Comment: Outlet of two 450 mm diameter culverts that drain a private pond. One of the culverts is for high flow conditions.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-180

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5434183
Time:	10:19:27 AM		**Easting:**	520138
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	1500mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.5 m		

Photos P1000104.jpg

Comment: Twin 1500 mm diameter culverts with concrete headwall and concrete sandbag wingwalls built underneath 32nd Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-170

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5434268
Time:	10:31:09 AM		**Easting:**	520144
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Erosion**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.5 m	**Bank:**	Right
	Right Bank Slope (H:V):	0.6:1	**Length:**	10 m
	Low Flow Channel Width:	3.0 m	**Height:**	2.5 m
	Low Flow Channel Depth:	m		

Photos P1000107.jpg

Comment: East bank undercut with roots exposed. Erosion section is approximately 10 m long.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-160

Watercourse:	Erickson Creek	**Location:**			
Date:	4/14/2006			**Northing:**	5434373
Time:	10:40:04 AM			**Easting:**	520133
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.5 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	2.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos *P1000109.jpg*

Comment: Confluence with Clover Brook channel banks are heavily vegetated. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-150

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5434995
Time:	10:55:33 AM		**Easting:**	520132
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	3.0 m	**Obstruction Type:**	Ped Bridge
	Right Bank Slope (H:V):	0.8:1		
	Low Flow Channel Width:	3.0 m		
	Low Flow Channel Depth:	0.6 m		

Photos P1000111.jpg

Comment: Pedestrian bridge forms a weir whose elevation is controlled by a gate. An inlet for an irrigation pump is located upstream from the weir.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-140

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435046
Time:	11:00:57 AM		**Easting:**	520136
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	3.0 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.6 m		

Photos P1000112.jpg

Comment: Confluence with ditch draining field to the west. Channel banks are steep sided and heavily vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-130

Watercourse:	Erickson Creek	**Location:**			
Date:	4/14/2006		**Northing:**	5435128	
Time:	11:03:19 AM		**Easting:**	520134	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	3.0 m		
	Right Bank Slope (H:V):	0.8:1		
	Low Flow Channel Width:	3.0 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1000113.jpg

Comment: Confluence with ditch draining field to the west. Channel banks are steep sided and heavily vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-120

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**	
Date:	4/14/2006	**Northing:**	5435180
Time:	11:05:58 AM	**Easting:**	520134
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	3.0 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	3.0 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1000114.jpg

Comment: Confluence with ditches draining field from both east and west. Channel banks composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-110

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435382
Time:	11:12:33 AM		**Easting:**	520130
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	3.2 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	2.4 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1000117.jpg

Comment: Confluence with ditches draining field from both east and west. Channel banks composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-100

Watercourse:	Erickson Creek	**Location:**			
Date:	4/14/2006		**Northing:**	5435480	
Time:	11:18:36 AM		**Easting:**	520131	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.5 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1000119.jpg

Comment: Confluence with ditch draining field to the west via a culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-090

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435520
Time:	11:20:48 AM		**Easting:**	520136
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.5 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1000120.jpg

Comment: Confluence with ditch draining field to the east. Channel banks composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-070

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435588
Time:	11:24:52 AM		**Easting:**	520129
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	3.2 m		
	Low Flow Channel Depth:	0.4 m		

Photos

Comment: Confluence with ditch draining field to the east with some erosion of the channel banks. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-081

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435572
Time:	11:32:39 AM		**Easting:**	520127
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.5 m	**Type:**	CSP
	Right Bank Slope (H:V):	1:1	**Diameter:**	2000mm
	Low Flow Channel Width:	1.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1000123.jpg

Comment: Twin 1800 mm diameter culverts with concrete sandbag headwall and wingalls. Culverts built underneath a driveway to private gated property. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-080

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**			
Date:	4/14/2006			**Northing:**	5435577
Time:	11:34:01 AM			**Easting:**	520126
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1800mm
	Low Flow Channel Width:	100.0 m	**Stability Issue:**	Damaged
	Low Flow Channel Depth:	0.5 m		

PROGRESSIO PER DIVERSITATEM

SURREY
CITY OF PARKS

Photos P1000123.jpg

Comment: Twin 1800 mm diameter culverts with concrete sandbag headwall and wingalls. The crown of the culvert on the east side is sagging. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-061

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**			
Date:	4/14/2006			**Northing:**	5435780
Time:	11:39:07 AM			**Easting:**	520125
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	1:1	**Diameter:**	1600mm
	Low Flow Channel Width:	2.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.5 m		

SURREY
CITY OF PARKS

Photos P1000124.jpg

Comment: Twin 2000 mm diameter culverts with concrete sandbag headwall and wingwalls. Access is restricted by private fence. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-060

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435792
Time:	11:43:09 AM		**Easting:**	520125
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	2.4 m	**Type:**	CSP
	Right Bank Slope (H:V):	1:1	**Diameter:**	2000mm
	Low Flow Channel Width:	3.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1000125.jpg

Comment: Twin 2000 mm diameter culverts with concrete headwall and wingwalls built under 40th Avenue. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-050

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435854
Time:	11:50:18 AM		**Easting:**	520128
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.8 m	**Obstruction Type:**	Ped Bridge
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	3.5 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1000127.jpg

Comment: Pedestrian bridge that also anchors an irrigation pump inlet. Bridge has 2 piers and is approximately 0.5 m above the surveyed water surface elevation.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-040

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**		
Date:	4/14/2006		**Northing:**	5435877
Time:	11:52:37 AM		**Easting:**	520133
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m		
	Right Bank Slope (H:V):	Vertical		
	Low Flow Channel Width:	0.0 m		
	Low Flow Channel Depth:	0.0 m		

Photos P1000128.jpg

Comment: Confluence with ditch draining field to the east with some erosion of the channel banks.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40N-010

Watercourse:	40th Ave North Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435794
Time:	11:59:29 AM		**Easting:**	520129
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	750mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.5 m		

Photos P1000129.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwall and wingwalls.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40N-011

Watercourse:	40th Ave North Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435793
Time:	12:00:56 PM	**Easting:**	520133
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.5 m	**Type:**	CSP
	Right Bank Slope (H:V):	1:1	**Diameter:**	750mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	Plugged
	Low Flow Channel Depth:	0.3 m		

Photos P1000130.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwall and wingwalls. Inlet is plugged with debris and garbage.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-010

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435778
Time:	12:05:05 PM	**Easting:**	520130
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	0.0 m	**Site Feature:**	**Culvert Outlet**
Left Bank Slope (H:V):	Vertical		
Right Bank Height:	0.0 m	**Type:**	CSP
Right Bank Slope (H:V):	Vertical	**Diameter:**	900mm
Low Flow Channel Width:	0.0 m	**Stability Issue:**	
Low Flow Channel Depth:	0.0 m		

Photos P1000131.jpg

Comment: 900 mm diameter culvert with concrete sandbag headwall.
Outlet is also a confluence with Erickson ditch.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-011

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435779
Time:	12:05:58 PM			**Easting:**	520134
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.5 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000132.jpg

Comment: 900 mm diameter culvert with concrete sandbag headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-020

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435780
Time:	12:07:28 PM	**Easting:**	520148
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	Vertical	**Diameter:**	750mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000133.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwalls built underneath a private driveway. Some sandbags in the headwall are damaged or have been replaced.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-021

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435778
Time:	12:09:15 PM			**Easting:**	520154
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	Vertical	**Diameter:**	750mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000134.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwalls built underneath a private driveway. Some sandbags in the headwall are damaged or have been replaced.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-030

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435778
Time:	12:12:03 PM	**Easting:**	520216
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.5 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	1000mm
	Low Flow Channel Width:	2.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000135.jpg

Comment: 1000 mm diameter culvert built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-031

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435777
Time:	12:12:49 PM	**Easting:**	520224
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1000mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000136.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwalls built underneath a private driveway. Some sandbags in the headwall are damaged or have been replaced.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-040

Watercourse:	40th Ave South Ditch	**Location:**			
Date:	4/14/2006		**Northing:**	5435779	
Time:	12:14:06 PM		**Easting:**	520260	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.2 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	1:1	**Diameter:**	1000mm
	Low Flow Channel Width:	2.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000137.jpg

Comment: 1000 mm diameter culvert with a concrete sandbag headwall built underneath a private driveway. Sandbag headwall is bulging outwards and some sandbags have been replaced at the upper portion of the headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-041

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435779
Time:	12:17:01 PM	**Easting:**	520267
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.2 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	1:1	**Diameter:**	1000mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000138.jpg

Comment: 1000 mm diameter culvert with a concrete sandbag headwall built underneath a private driveway. Sandbag headwall is bulging outwards and some sandbags have been replaced at the upper portion of the headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-050

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435778
Time:	12:19:29 PM	**Easting:**	520375
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	750mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000139.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-051

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435778
Time:	12:23:55 PM	**Easting:**	520384
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	750mm
	Low Flow Channel Width:	1.7 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000140.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwall built underneath a private driveway. Some debris collected at concrete inlet.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-060

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435780
Time:	12:25:53 PM	**Easting:**	520437
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	1:1	**Diameter:**	1000mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000141.jpg

Comment: 1000 mm diameter culvert with concrete sandbag headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-061

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435779
Time:	12:27:18 PM		**Easting:**	520444
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	2.0 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	1:1	**Diameter:**	1000mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000142.jpg

Comment: 1000 mm diameter culvert with concrete sandbag headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40N-020

Watercourse:	40th Ave North Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435795
Time:	12:42:03 PM			**Easting:**	520916
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1200mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.8 m		

Photos P1000148.jpg

Comment: 1200 mm diameter culvert with timber headwall built underneath 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40N-021

SURREY
CITY OF PARKS

Watercourse:	40th Ave North Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435797
Time:	12:47:07 PM	**Easting:**	520927
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1200mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.8 m		

Photos P1000149.jpg

Comment: 1200 mm diameter culvert with timber headwall built underneath 184th Street. Confluence with partial flow from east side ditch on 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-010

Watercourse:	184th St East Ditch	**Location:**			
Date:	4/14/2006		**Northing:**	5435794	
Time:	12:49:10 PM		**Easting:**	520929	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1200mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.8 m		

Photos P1000150.jpg

Comment: 1200 mm diameter culvert with timber headwall built underneath 40th Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-011

SURREY
CITY OF PARKS

Watercourse:	184th St East Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435783
Time:	12:52:39 PM	**Easting:**	520928
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.0 m	**Type:**	
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1200mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.5 m		

Photos P1000151.jpg

Comment: 1200 mm diameter culvert with timber headwall built underneath 40th Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-071

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435781
Time:	12:54:16 PM	**Easting:**	520927
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1200mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000152.jpg

Comment: 1200 mm diameter culvert with timber headwall built underneath 184th Street. Confluence with partial flow from east side ditch on 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 40S-070

SURREY
CITY OF PARKS

Watercourse:	40th Ave South Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435780
Time:	12:55:17 PM			**Easting:**	520916
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	Vertical	**Diameter:**	1200mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.6 m		

Photos P1000153.jpg

Comment: 1200 mm diameter culvert with timber headwall built underneath 184th Street. Confluence with west side ditch on 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-010

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435779
Time:	12:56:32 PM			**Easting:**	520915
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	Vertical	**Diameter:**	900mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000153.jpg

Comment: 900 mm diameter culvert with timber headwall and built underneath a vehicle access to a private field.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-011

Watercourse:	184th St West Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435760
Time:	12:57:31 PM		**Easting:**	520916
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000154.jpg

Comment: 900 mm diameter culvert with concrete sandbag headwall and built underneath a vehicle access to a private field.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-020

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435746
Time:	12:59:56 PM	**Easting:**	520916
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000155.jpg

Comment: 900 mm diameter culvert with concrete sandbag headwall and built underneath a vehicle access to a private field.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-021

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435739
Time:	1:02:44 PM	**Easting:**	520917
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	2.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000155.jpg

Comment: 900 mm diameter culvert with concrete sandbag headwall and built underneath a vehicle access to a private field.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-020

SURREY
CITY OF PARKS

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435746
Time:	1:03:53 PM		**Easting:**	520929
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	1200mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000157.jpg

Comment: 1200 mm diameter culvert with timber headwall and built underneath a private driveway. Outlet is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-021

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435739
Time:	1:05:12 PM		**Easting:**	520930
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	1200mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000158.jpg

Comment: 1200 mm diameter culvert with timber headwall and built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-030

SURREY
CITY OF PARKS

Watercourse:	184th St East Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435524
Time:	1:14:54 PM			**Easting:**	520929
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.6 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	1.5 m		
	Low Flow Channel Depth:	0.4 m		

Photos P1000160.jpg

Comment: Confluence with ditch draining field to the east.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-040

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435375
Time:	1:19:00 PM		**Easting:**	520932
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	900mm
	Low Flow Channel Width:	2.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.6 m		

Photos P1000161.jpg

Comment: 900 mm diameter culvert with no headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-041

Watercourse:	184th St East Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435356
Time:	1:21:24 PM			**Easting:**	520933
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	900mm
	Low Flow Channel Width:	2.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos

Comment: 900 mm diameter culvert with concrete headwall built underneath a private driveway. Headwall is bulging outwards. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-030

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435354
Time:	1:22:51 PM			**Easting:**	520920
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	0.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000162.jpg

Comment: 450 mm diameter culvert with concrete headwall built underneath a private driveway. The headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-031

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006		**Northing:**	5435345	
Time:	1:24:53 PM		**Easting:**	520920	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000163.jpg

Comment: 450 mm diameter culvert with concrete headwall built underneath a private driveway. The headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-040

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435309
Time:	1:26:30 PM			**Easting:**	520920
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000164.jpg

Comment: 450 mm diameter culvert with concrete sandbag headwall built underneath a private driveway. The headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-041

Watercourse:	184th St West Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435303
Time:	1:30:25 PM		**Easting:**	520920
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000165.jpg

Comment: 450 mm diameter culvert with concrete sandbag headwall built underneath a private driveway. The headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-050

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435273
Time:	1:31:28 PM	**Easting:**	520920
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.6 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000166.jpg

Comment: 600 mm diameter culvert with cinder block headwall build underneath a private driveway. The headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-051

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435259
Time:	1:33:08 PM		**Easting:**	520921
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000167.jpg

Comment: 600 mm diameter culvert with cinder block headwall build underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-050

Watercourse:	184th St East Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435243
Time:	1:35:24 PM			**Easting:**	520935
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	0.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	900mm
	Low Flow Channel Width:	3.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000168.jpg

Comment: 900 mm diameter culvert with cinder block headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-051

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435233
Time:	1:37:44 PM		**Easting:**	520935
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	900mm
	Low Flow Channel Width:	2.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1000169.jpg

Comment: 900 mm diameter culvert with cinder block headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-060

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435201
Time:	1:41:25 PM	**Easting:**	520921
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.6 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	450mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000171.jpg

Comment: 450 mm diameter culvert with cinder block headwall build underneath a private driveway. The headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-061

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435191
Time:	1:42:11 PM	**Easting:**	520921
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.6 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000172.jpg

Comment: 450 mm diameter culvert with cinder block headwall build underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-070

Watercourse:	184th St West Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5435141
Time:	1:44:41 PM		**Easting:**	520922
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	Plugged
	Low Flow Channel Depth:	0.2 m		

Photos P1000173.jpg

Comment: 450 mm diameter culvert with no headwall. The outlet is plugged with gravel that has sluffed off from the private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-071

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006		**Northing:**	5435127	
Time:	1:46:12 PM		**Easting:**	520923	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000174.jpg

Comment: 450 mm diameter culvert with no headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-060

Watercourse:	184th St East Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435102
Time:	1:47:50 PM			**Easting:**	520936
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	900mm
	Low Flow Channel Width:	3.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.6 m		

Photos P1000175.jpg

Comment: 900 mm diameter culvert with concrete headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-061

Watercourse:	184th St East Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5435092
Time:	1:49:24 PM	**Easting:**	520936
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	1.8 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	0.6:1		
Right Bank Height:	1.0 m	**Type:**	Concrete
Right Bank Slope (H:V):	1:1	**Diameter:**	900mm
Low Flow Channel Width:	3.0 m	**Stability Issue:**	
Low Flow Channel Depth:	0.4 m		

Photos P1000176.jpg

Comment: 900 mm diameter culvert with concrete headwall built underneath a private driveway. Inlet is obstructed with vegetative debris.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-080

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5435069
Time:	1:51:37 PM			**Easting:**	520923
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.7 m	**Obstruction Type:**	Vehicle Bridge
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1000177.jpg

Comment: Wooden vehicle bridge providing access to a private property. The bridge is 2 m wide and 3 m long and is approximately 600 mm above the channel invert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-070

Watercourse:	184th St East Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5434987
Time:	1:55:03 PM	**Easting:**	520936
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	1.4 m		
	Right Bank Slope (H:V):	0.8:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1000178.jpg

Comment: Confluence with ditch draining field to the east. Channel banks are well vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-090

SURREY CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434964
Time:	1:57:00 PM			**Easting:**	520924
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	450mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000179.jpg

Comment: 450 mm diameter culvert with concrete headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-091

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5434955
Time:	1:58:10 PM	**Easting:**	520924
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000180.jpg

Comment: 450 mm diameter culvert with concrete headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-080

SURREY
CITY OF PARKS

Watercourse:	184th St East Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434899
Time:	2:00:23 PM			**Easting:**	520935
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.0 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	3.0 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1000181.jpg

Comment: Confluence with ditch draining field to the east. Channel banks are well vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-090

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5434848
Time:	2:01:55 PM		**Easting:**	520938
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	900mm
	Low Flow Channel Width:	3.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	1.0 m		

Photos P1000182.jpg

Comment: 900 mm diameter culvert with cinder block headwall built underneath a private driveway. Outlet is submerged and headwall is bulging outwards and backfilled with gravel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-091

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5434842
Time:	2:03:19 PM		**Easting:**	520937
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	900mm
	Low Flow Channel Width:	2.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	1.0 m		

Photos P1000183.jpg

Comment: 900 mm diameter culvert with cinder block headwall built underneath a private driveway. Outlet is submerged and headwall is bulging outwards.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-100

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434742
Time:	2:08:08 PM			**Easting:**	520925
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000185.jpg

Comment: 300 mm diameter culvert with concrete headwall built underneath a private driveway. Outlet is obstructed by light vegetation

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-101

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434731
Time:	2:09:59 PM			**Easting:**	520925
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000186.jpg

Comment: 300 mm diameter culvert with concrete headwall built underneath a private driveway. Inlet is obstructed by light vegetation

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-110

Watercourse:	184th St West Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5434681
Time:	2:11:28 PM		**Easting:**	520928
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.6 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000187.jpg

Comment: 300 mm diameter culvert with concrete cylinder headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-111

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434670
Time:	2:13:15 PM			**Easting:**	520925
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000188.jpg

Comment: 300 mm diameter culvert with concrete cylinder headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-120

SURREY CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5434640
Time:	2:14:19 PM	**Easting:**	520925
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	1.0 m	**Site Feature:**	**Culvert Outlet**
Left Bank Slope (H:V):	0.7:1		
Right Bank Height:	1.6 m	**Type:**	Concrete
Right Bank Slope (H:V):	0.6:1	**Diameter:**	300mm
Low Flow Channel Width:	0.6 m	**Stability Issue:**	
Low Flow Channel Depth:	0.1 m		

Photos P1000189.jpg

Comment: 300 mm diameter culvert with cinder block headwall built underneath a private driveway. Upper part of headwall has been replaced with concrete sandbags.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-121

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434633
Time:	2:15:31 PM			**Easting:**	520925
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.6 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000190.jpg

Comment: 300 mm diameter culvert with cinder block headwall built underneath a private driveway. Inlet is obstructed by debris.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-100

SURREY
CITY OF PARKS

Watercourse:	184th St East Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5434630
Time:	2:17:15 PM	**Easting:**	520937
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	750mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000191.jpg

Comment: 750 mm diameter culvert with concrete sandbag headwall and confluence with ditch from the east.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-101

Watercourse:	184th St East Ditch	**Location:**	
Date:	4/14/2006	**Northing:**	5434623
Time:	2:19:15 PM	**Easting:**	520937
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	750mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000192.jpg

Comment: 750 mm diameter culvert with cinder block headwall and confluence with ditch from the east. Concrete is damaged behind headwall and flow from east is bypassing inlet.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-110

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5434607
Time:	2:21:57 PM		**Easting:**	520936
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.2 m	**Type:**	
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000193.jpg

Comment: 600 mm diameter culvert with concrete sandbag headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184E-111

Watercourse:	184th St East Ditch	**Location:**		
Date:	4/14/2006		**Northing:**	5434556
Time:	2:23:55 PM		**Easting:**	520936
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	2.6 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	600mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000194.jpg

Comment: 600 mm diameter culvert with cinder block headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-130

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434401
Time:	2:29:56 PM			**Easting:**	520925
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000196.jpg

Comment: 300 mm diameter culvert with no headwall. Outlet is obstructed by light vegetation.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184W-131

Watercourse:	184th St West Ditch	**Location:**			
Date:	4/14/2006			**Northing:**	5434392
Time:	2:30:39 PM			**Easting:**	520926
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.5 m	**Type:**	
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	300mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1000198.jpg

Comment: 300 mm diameter culvert with no headwall. Inlet is obstructed by small debris.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28S-021

SURREY
CITY OF PARKS

Watercourse:	28th Ave South Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5433374
Time:	10:12:08 AM	**Easting:**	520968
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.4 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	300mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000203.jpg

Comment: 300 mm diameter culvet with cinder block headwall. Culvert connects to same manhole as 28E-020.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28S-020

Watercourse:	28th Ave South Ditch	**Location:**			
Date:	4/17/2006		**Northing:**	5433372	
Time:	10:15:00 AM		**Easting:**	520962	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.4 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	300mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000202.jpg

Comment: 300 mm diameter culvert with cinder block headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28S-011

Watercourse:	28th Ave South Ditch	**Location:**			
Date:	4/17/2006		**Northing:**	5433373	
Time:	10:16:16 AM		**Easting:**	520948	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.4 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000201.jpg

Comment: 300 mm diameter culvert with no headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28S-010

Watercourse:	28th Ave South Ditch	**Location:**			
Date:	4/17/2006		**Northing:**	5433374	
Time:	10:17:44 AM		**Easting:**	520942	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	Vertical	**Diameter:**	300mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000204.jpg

Comment: 300 mm diameter culvert outlet is at a manhole located at the south east corner of the intesection between 28th Avenue and 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28E-031

SURREY
CITY OF PARKS

Watercourse:	28th Ave East Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5433349
Time:	10:20:02 AM	**Easting:**	520943
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1000205.jpg

Comment: 300 mm diameter culvet with no headwall built underneath a driveway access to a school parking lot.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28E-030

SURREY
CITY OF PARKS

Watercourse:	28th Ave East Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5433385
Time:	10:22:56 AM	**Easting:**	520944
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000206.jpg

Comment: 300 mm diameter culvet with cinder block headwall built underneath a driveway access to a school parking lot.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28E-021

Watercourse:	28th Ave East Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5433411
Time:	10:25:28 AM	**Easting:**	520941
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	1.6 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	0.8:1		
Right Bank Height:	1.2 m	**Type:**	Concrete
Right Bank Slope (H:V):	0.8:1	**Diameter:**	300mm
Low Flow Channel Width:	1.0 m	**Stability Issue:**	
Low Flow Channel Depth:	0.1 m		

Photos P1000207.jpg

Comment: 300 mm diameter culvert with cinder block headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 28E-020

Watercourse:	28th Ave East Ditch	**Location:**		
Date:	4/17/2006		**Northing:**	5433422
Time:	10:26:31 AM		**Easting:**	520941
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.6 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000209.jpg

Comment: 300 mm diameter culvert with no headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: LAU-021

SURREY
CITY OF PARKS

Watercourse:	Laura Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5433762
Time:	10:41:39 AM		**Easting:**	520928
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	600mm
	Low Flow Channel Width:	0.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000210.jpg

Comment: Inlet of 600 mm diameter culvert and is also at a confluence of west side ditch along 184th Street

CREEK RECONNAISSANCE DATA SHEET

Point ID: LAU-020

Watercourse:	Laura Brook	**Location:**			
Date:	4/17/2006			**Northing:**	5433805
Time:	11:04:53 AM			**Easting:**	520889
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000213.jpg

Comment: Property owner has water rights to Laura Brook. Laura Brook is routed through a concrete spillway that is connected to a water treatment shed. Outlet is located below a wood deck built on concrete piers.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-020

SURREY
CITY OF PARKS

Watercourse:	Clover Brook	**Location:**	
Date:	4/17/2006	**Northing:**	5434227
Time:	11:41:02 AM	**Easting:**	520925
Weather:	Cloudy Showers		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.4 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000219.jpg

Comment: 450 mm diameter culvert with a concrete headwall and wingwalls and a trash rack. Culvert is built underneath 184th Street. Outlet is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-021

SURREY
CITY OF PARKS

Watercourse:	Clover Brook	**Location:**	
Date:	4/17/2006	**Northing:**	5434222
Time:	11:43:32 AM	**Easting:**	520942
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	1.5 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	1:1		
Right Bank Height:	1.2 m	**Type:**	Concrete
Right Bank Slope (H:V):	1:1	**Diameter:**	450mm
Low Flow Channel Width:	1.2 m	**Stability Issue:**	
Low Flow Channel Depth:	0.2 m		

Photos P1000220.jpg

Comment: 450 mm diameter culvert with a concrete headwall and wingwalls and a trash rack. Culvert is built underneath 184th Street. Inlet is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-030

Watercourse:	Clover Brook	**Location:**			
Date:	4/17/2006		**Northing:**	5434207	
Time:	11:44:47 AM		**Easting:**	520943	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000221.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls and a trash rack. Culvert is built underneath 32nd Avenue. Outlet is armored with rip rap. Confluence with west side 184th Street ditch at a manhole at the north east corner of the 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-031

SURREY
CITY OF PARKS

Watercourse:	Clover Brook	**Location:**	
Date:	4/17/2006	**Northing:**	5434161
Time:	11:48:27 AM	**Easting:**	520950
Weather:	Cloudy Showers		

Channel Dimensions:

Left Bank Height:	1.5 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	1.5:1		
Right Bank Height:	1.0 m	**Type:**	Concrete
Right Bank Slope (H:V):	1:1	**Diameter:**	600mm
Low Flow Channel Width:	1.5 m	**Stability Issue:**	
Low Flow Channel Depth:	0.2 m		

Photos P1000223.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls and a trash rack. Culvert is built underneath 32nd Avenue. Inlet is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-040

Watercourse:	Clover Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5434083
Time:	11:51:13 AM		**Easting:**	520949
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.8 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1000224.jpg

Comment: Confluence with ditch coming from the east.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-050

Watercourse:	Clover Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5434062
Time:	11:54:18 AM		**Easting:**	520943
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	62.:1		
	Right Bank Height:	100.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	83.:1	**Diameter:**	450mm
	Low Flow Channel Width:	100.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	1.4 m		

Photos P1000225.jpg

Comment: 450 mm diameter culvert with no headwall built underneath a private driveway. Outlet is armored with gravels.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-051

Watercourse:	Clover Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5434050
Time:	11:55:27 AM		**Easting:**	520944
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000226.jpg

Comment: 450 mm diameter culvert with no headwall built underneath a private driveway. Inlet is armored with gravels.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-060

Watercourse:	Clover Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5433912
Time:	11:58:56 AM		**Easting:**	520941
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.6 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000227.jpg

Comment: 300 mm diameter culvert with no headwall built underneath a private driveway. Confluence with a small ditch from the east.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-061

Watercourse:	Clover Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5433887
Time:	12:02:58 PM		**Easting:**	520937
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.2:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	Damaged
	Low Flow Channel Depth:	0.1 m		

Photos P1000228.jpg

Comment: 300 mm diameter culvert with no headwall built underneath a private driveway. Concrete inlet is connected to a PVC outlet.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-070

SURREY
CITY OF PARKS

Watercourse:	Clover Brook	**Location:**			
Date:	4/17/2006		**Northing:**	5433826	
Time:	12:04:20 PM		**Easting:**	520940	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	0.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000229.jpg

Comment: 300 mm diameter culvert with a cinder block headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-071

Watercourse:	Clover Brook	**Location:**		
Date:	4/17/2006		**Northing:**	5433820
Time:	12:05:27 PM		**Easting:**	520940
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	0.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	300mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000230.jpg

Comment: 300 mm diameter culvert with a cinder block headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: LAU-040

Watercourse:	Laura Brook	**Location:**			
Date:	4/17/2006		**Northing:**	5433766	
Time:	12:08:10 PM		**Easting:**	520940	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	1.2 m		
	Right Bank Slope (H:V):	5:1		
	Low Flow Channel Width:	0.3 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1000231.jpg

Comment: Laura Brook joins east side ditch on 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: LAU-031

SURREY
CITY OF PARKS

Watercourse:	Laura Brook	**Location:**			
Date:	4/17/2006			**Northing:**	5433762
Time:	12:11:08 PM			**Easting:**	520939
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000232.jpg

Comment: Inlet of 600 mm diameter culvert built underneath 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-060

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch South o	**Location:**		
Date:	4/17/2006		**Northing:**	5432762
Time:	1:57:40 PM		**Easting:**	520930
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.4 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000233.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls. Inlet location was not found in the field.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-051

Watercourse:	184th St West Ditch South o	**Location:**	
Date:	4/17/2006	**Northing:**	5432832
Time:	2:00:14 PM	**Easting:**	520930
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	1.0 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	0.5:1		
Right Bank Height:	1.0 m	**Type:**	Concrete
Right Bank Slope (H:V):	0.5:1	**Diameter:**	600mm
Low Flow Channel Width:	1.4 m	**Stability Issue:**	
Low Flow Channel Depth:	0.2 m		

Photos P1000234.jpg

Comment: 600 mm diameter culvert with cinder block headwall and wingwalls.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-050

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch South o	**Location:**	
Date:	4/17/2006	**Northing:**	5432836
Time:	2:01:41 PM	**Easting:**	520931
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.4 m	**Stability Issue:**	
	Low Flow Channel Depth:	1.2 m		

Photos P1000235.jpg

Comment: 600 mm diameter culvert with cinder block headwall and wingwalls. Outlet is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-040

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch South o	**Location:**	
Date:	4/17/2006	**Northing:**	5432968
Time:	2:06:32 PM	**Easting:**	520929
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.8 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1000238.jpg

Comment: Confluence with ditch draining field to the west. Channel banks composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-031

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch South o	**Location:**	
Date:	4/17/2006	**Northing:**	5432986
Time:	2:08:21 PM	**Easting:**	520928
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000239.jpg

Comment: 600 mm diameter culvert with no headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-030

Watercourse:	184th St West Ditch South o	**Location:**			
Date:	4/17/2006			**Northing:**	5432995
Time:	2:09:31 PM			**Easting:**	520929
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.2 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.6 m	**Stability Issue:**	)amaged
	Low Flow Channel Depth:	0.5 m		

Photos P1000240.jpg

Comment: 600 mm diameter culvert with no headwall built underneath a private driveway. Outlet is damaged but flow is not obstructed.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-021

Watercourse:	184th St West Ditch South o	**Location:**			
Date:	4/17/2006			**Northing:**	5433015
Time:	2:11:12 PM			**Easting:**	520931
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000241.jpg

Comment: 600 mm diameter culvert with cinder block headwall and wingwalls built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-020

SURREY
CITY OF PARKS

Watercourse:	184th St West Ditch South o	**Location:**	
Date:	4/17/2006	**Northing:**	5433023
Time:	2:12:37 PM	**Easting:**	520929
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000242.jpg

Comment: 600 mm diameter culvert with cinder block headwall and wingwalls built underneath a private driveway. Outlet is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-011

Watercourse:	184th St West Ditch South o	**Location:**			
Date:	4/17/2006		**Northing:**	5433080	
Time:	2:15:22 PM		**Easting:**	520929	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000243.jpg

Comment: 450 mm diameter culvert with cinder block headwall built underneath 184th Street. A notched weir has been built north of the inlet and is armored with rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SW-010

Watercourse:	184th St West Ditch South o	**Location:**			
Date:	4/17/2006			**Northing:**	5433089
Time:	2:18:29 PM			**Easting:**	520943
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000244.jpg

Comment: 450 mm diameter culvert with concrete sandbag headwall built underneath 184th Street. Confluence with south east 184th Street ditch and Erickson Creek.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SE-020

Watercourse:	184th St East Ditch South of	**Location:**			
Date:	4/17/2006			**Northing:**	5432831
Time:	2:25:59 PM			**Easting:**	520944
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.6 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000246.jpg

Comment: 450 mm diameter culvert with cinder block headwall underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SE-021

Watercourse:	184th St East Ditch South of	**Location:**	
Date:	4/17/2006	**Northing:**	5432817
Time:	2:28:17 PM	**Easting:**	520946
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	1.6 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	0.6:1		
Right Bank Height:	1.6 m	**Type:**	Concrete
Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
Low Flow Channel Width:	1.0 m	**Stability Issue:**	
Low Flow Channel Depth:	0.2 m		

Photos P1000247.jpg

Comment: 450 mm diameter culvert with cinder block headwall underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SE-030

Watercourse:	184th St East Ditch South of	**Location:**	
Date:	4/17/2006	**Northing:**	5432764
Time:	2:30:16 PM	**Easting:**	520947
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000249.jpg

Comment: 600 mm diameter culvert with cinder block headwall underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 184SE-031

Watercourse:	184th St East Ditch South of	**Location:**			
Date:	4/17/2006			**Northing:**	5432712
Time:	2:32:26 PM			**Easting:**	520948
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.6 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000250.jpg

Comment: 600 mm diameter culvert with cinder block headwall underneath a private driveway. Confluence with a small ditch to the east.

CREEK RECONNAISSANCE DATA SHEET

Point ID: CLV-015

SURREY
CITY OF PARKS

Watercourse:	Clover Brook	**Location:**	
Date:	4/17/2006	**Northing:**	5434297
Time:	2:46:17 PM	**Easting:**	520867
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	0.8 m		
	Right Bank Slope (H:V):	1.2:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	m		

Photos P1000251.jpg

Comment: Cross-section downstream of 184th Street crossing. Channel banks are well vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 180-020

SURREY
CITY OF PARKS

Watercourse:	180th St Ditch	**Location:**		
Date:	4/17/2006		**Northing:**	5433681
Time:	3:22:56 PM		**Easting:**	520130
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	1.4 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1000256.jpg

Comment: Confluence with farm ditch draining field to the west.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 180-030

Watercourse:	180th St Ditch	**Location:**		
Date:	4/17/2006		**Northing:**	5433678
Time:	3:26:38 PM		**Easting:**	519959
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	0.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	0.6 m		
	Right Bank Slope (H:V):	1.5:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1000257.jpg

Comment: Confluence with small creek draining from the north.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB1-030

Watercourse:	Tributary 1	**Location:**	
Date:	4/17/2006	**Northing:**	5433907
Time:	3:36:13 PM	**Easting:**	520061
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	0.6 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	0.8 m		
	Low Flow Channel Depth:	m		

Photos P1000259.jpg

Comment: Well defined side channel in farm field. Channel banks are well vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB1-020

Watercourse:	Tributary 1	**Location:**	
Date:	4/17/2006	**Northing:**	5433933
Time:	3:40:42 PM	**Easting:**	519827
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	0.6 m		
	Right Bank Slope (H:V):	1.5:1		
	Low Flow Channel Width:	0.6 m		
	Low Flow Channel Depth:	m		

Photos P1000260.jpg

Comment: Well defined side channel in farm field. Channel banks are well vegetated.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB1-011

SURREY CITY OF PARKS

Watercourse:	Tributary 1	**Location:**		
Date:	4/17/2006		**Northing:**	5434168
Time:	3:46:51 PM		**Easting:**	519856
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	0.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.2:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000262.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls and trash rack. Built underneath 32nd Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-020

Watercourse:	32nd Ave North Ditch	**Location:**		
Date:	4/17/2006		**Northing:**	5434168
Time:	3:54:00 PM		**Easting:**	519485
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	0.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	2.5:1		
	Right Bank Height:	0.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	2.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000264.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls with trashrack built underneath 32nd Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-021

SURREY
CITY OF PARKS

Watercourse:	32nd Ave North Ditch	**Location:**			
Date:	4/17/2006			**Northing:**	5434168
Time:	3:54:00 PM			**Easting:**	519485
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	2.5:1		
	Right Bank Height:	0.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	2.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000265.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls with trashrack built underneath 32nd Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-030

Watercourse:	32nd Ave North Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5434185
Time:	4:01:55 PM	**Easting:**	519796
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	1.0 m	**Site Feature:**	**Culvert Outlet**
Left Bank Slope (H:V):	1.2:1		
Right Bank Height:	2.2 m	**Type:**	Concrete
Right Bank Slope (H:V):	0.8:1	**Diameter:**	600mm
Low Flow Channel Width:	1.8 m	**Stability Issue:**	
Low Flow Channel Depth:	0.3 m		

Photos P1000266.jpg

Comment: 600 mm diameter culvert built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-031

SURREY
CITY OF PARKS

Watercourse:	32nd Ave North Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5434185
Time:	4:01:55 PM	**Easting:**	519796
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	2.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1000267.jpg

Comment: 600 mm diameter culvert built underneath a private driveway.
Inlet slightly obstructed by vegetation.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB1-010

SURREY
CITY OF PARKS

Watercourse:	Tributary 1	**Location:**	
Date:	4/17/2006	**Northing:**	5434184
Time:	4:04:48 PM	**Easting:**	519857
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.8 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000268.jpg

Comment: 600 mm diameter culvert with concrete headwall and wingwalls and trash rack. Built underneath 32nd Avenue and is a confluence with the north side 32nd Avenue ditch.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-040

SURREY
CITY OF PARKS

Watercourse:	32nd Ave North Ditch	**Location:**			
Date:	4/17/2006			**Northing:**	5434184
Time:	4:06:40 PM			**Easting:**	519906
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000269.jpg

Comment: 600 mm diameter culvert with timber headwall built underneath a private driveway

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-041

Watercourse:	32nd Ave North Ditch	**Location:**		
Date:	4/17/2006		**Northing:**	5434184
Time:	4:06:40 PM		**Easting:**	519906
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000270.jpg

Comment: 600 mm diameter culvert with timber headwall built underneath a private driveway

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-050

Watercourse:	32nd Ave North Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5434184
Time:	4:09:30 PM	**Easting:**	519963
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000271.jpg

Comment: 600 mm diameter culvert built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-051

Watercourse:	32nd Ave North Ditch	**Location:**			
Date:	4/17/2006		**Northing:**	5434184	
Time:	4:09:30 PM		**Easting:**	519963	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1000272.jpg

Comment: 600 mm diameter culvert built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-060

Watercourse:	32nd Ave North Ditch	**Location:**			
Date:	4/17/2006			**Northing:**	5434184
Time:	4:12:04 PM			**Easting:**	520020
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1000273.jpg

Comment: 450 mm diameter culvert with concrete sandbag headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 32N-061

Watercourse:	32nd Ave North Ditch	**Location:**	
Date:	4/17/2006	**Northing:**	5434184
Time:	4:12:04 PM	**Easting:**	520020
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	0.6 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	1:1		
Right Bank Height:	1.2 m	**Type:**	Concrete
Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
Low Flow Channel Width:	0.6 m	**Stability Issue:**	
Low Flow Channel Depth:	0.1 m		

Photos P1000274.jpg

Comment: 450 mm diameter culvert with concrete sandbag headwall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: 176-010

SURREY
CITY OF PARKS

Watercourse:	Nicomekl River @ 176th St	**Location:**			
Date:	4/17/2006			**Northing:**	5437039
Time:	4:23:09 PM			**Easting:**	519369
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Pump Station Outl**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m		
	Right Bank Slope (H:V):	Vertical		
	Low Flow Channel Width:	0.0 m		
	Low Flow Channel Depth:	0.0 m		

Photos P1000276.jpg

Comment: Private pump station that services an agricultural field.
Outflow is directed to the Nicomekl River.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-010

Watercourse:	Erickson Creek		**Location:**		
Date:	4/17/2006			**Northing:**	5437183
Time:	4:23:09 PM			**Easting:**	520146
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	3.4 m	**Site Feature:**	**Pump Station Inlet**
	Left Bank Slope (H:V):	0.7:1		
	Right Bank Height:	1.6 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	4.0 m		
	Low Flow Channel Depth:	m		

Photos P1000280.jpg

Comment: Pump station at Nicomekl River.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-181

Watercourse:	Erickson Creek	**Location:**			
Date:	4/10/2006			**Northing:**	5434172
Time:	10:35:14 AM			**Easting:**	520137
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.2 m	**Type:**	CSP
	Right Bank Slope (H:V):	1:1	**Diameter:**	1400mm
	Low Flow Channel Width:	1.3 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1009998.jpg

Comment: Twin 1500 mm diameter culverts with concrete headwall and concrete sandbag wingwalls built underneath 32nd Avenue.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-190

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**		
Date:	4/10/2006		**Northing:**	5434171
Time:	10:50:45 AM		**Easting:**	520146
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.5 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	1200mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010001.jpg

Comment: 1200 mm culvert with concrete headwall built underneath a private driveway to a dog kennel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-191

Watercourse:	Erickson Creek	**Location:**			
Date:	4/10/2006		**Northing:**	5434171	
Time:	10:55:33 AM		**Easting:**	520152	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	1.5 m	**Type:**	CSP
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	1200mm
	Low Flow Channel Width:	2.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1010004.jpg

Comment: 1200 mm diameter culvert with concrete headwall built underneath a private driveway to a dog kennel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-200

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**	
Date:	4/10/2006	**Northing:**	5434172
Time:	11:13:21 AM	**Easting:**	520260
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	2.0 m	**Site Feature:**	**Culvert Outlet**
Left Bank Slope (H:V):	1.6:1		
Right Bank Height:	2.0 m	**Type:**	Concrete
Right Bank Slope (H:V):	1:1	**Diameter:**	1300mm
Low Flow Channel Width:	1.6 m	**Stability Issue:**	
Low Flow Channel Depth:	0.2 m		

Photos P1010006.jpg

Comment: 1300 mm diameter culvert with cinder block headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-201

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**			
Date:	4/10/2006			**Northing:**	5434172
Time:	11:14:10 AM			**Easting:**	520270
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.6:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.2:1	**Diameter:**	1300mm
	Low Flow Channel Width:	2.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1010007.jpg

Comment: 1300 mm diamter culvert with cinder block headwall built underneath a private driveway.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-210

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**		
Date:	4/10/2006		**Northing:**	5434175
Time:	11:21:49 AM		**Easting:**	520359
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	0.8 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	2.2 m		
	Right Bank Slope (H:V):	0.7:1		
	Low Flow Channel Width:	2.0 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1010009.jpg

Comment: Confluence with south side 32nd Avenue ditch. Channel banks composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-220

Watercourse:	Erickson Creek	**Location:**		
Date:	4/10/2006		**Northing:**	5434129
Time:	11:33:07 AM		**Easting:**	520350
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	1000mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1010011.jpg

Comment: One 1000 mm diameter driveway culvert on private property with a 600 mm high flow concrete culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-221

Watercourse:	Erickson Creek	**Location:**	
Date:	4/10/2006	**Northing:**	5434125
Time:	11:42:50 AM	**Easting:**	520351
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	5:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	10:1	**Diameter:**	1000mm
	Low Flow Channel Width:	0.8 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010012.jpg

Comment: One 1000 mm diameter driveway culvert on private property with a 600 mm high flow concrete culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-230

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**		
Date:	4/10/2006		**Northing:**	5434113
Time:	11:47:25 AM		**Easting:**	520364
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	200.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	166:1		
	Right Bank Height:	200.0 m		
	Right Bank Slope (H:V):	166:1		
	Low Flow Channel Width:	1.2 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1010013.jpg

Comment: Confluence with Laura Brook with channel banks composed of grass.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-240

Watercourse:	Erickson Creek	**Location:**	
Date:	4/10/2006	**Northing:**	5434068
Time:	11:56:18 AM	**Easting:**	520357
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Erosion**
	Left Bank Slope (H:V):	1.6:1		
	Right Bank Height:	1.0 m	**Bank:**	Left
	Right Bank Slope (H:V):	10:1	**Length:**	5 m
	Low Flow Channel Width:	5.0 m	**Height:**	2 m
	Low Flow Channel Depth:	0.3 m		

Photos P1010015.jpg

Comment: Erosion area undercuts slope adjacent to work shed. Erosion area is approximately 5 m long and 2 m high.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-260

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**	
Date:	4/10/2006	**Northing:**	5433969
Time:	12:19:14 PM	**Easting:**	520424
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	1.2 m	**Site Feature:**	**Erosion**
Left Bank Slope (H:V):	1:1		
Right Bank Height:	1.2 m	**Bank:**	Left
Right Bank Slope (H:V):	1:1	**Length:**	40 m
Low Flow Channel Width:	2.5 m	**Height:**	1.3 m
Low Flow Channel Depth:	0.4 m		

Photos P1010017.jpg

Comment: Erosion areas on both sides of the channel. Erosion area is approximately 10 m long and 2 m high.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-270

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**			
Date:	4/10/2006			**Northing:**	5433933
Time:	12:24:44 PM			**Easting:**	520454
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1.6:1		
	Right Bank Height:	1.5 m		
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	1.8 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1010018.jpg

Comment: Confluence with Tributary 2.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB2-020

SURREY
CITY OF PARKS

Watercourse:	Tributary 2	**Location:**			
Date:	4/10/2006			**Northing:**	5433839
Time:	12:55:52 PM			**Easting:**	520384
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.3 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	10:1		
	Right Bank Height:	0.3 m		
	Right Bank Slope (H:V):	10:1		
	Low Flow Channel Width:	0.8 m		
	Low Flow Channel Depth:	0.1 m		

Photos P1010019.jpg

Comment: Undefined side channel upstream of 300 mm concrete culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB2-011

Watercourse:	Tributary 2	**Location:**			
Date:	4/10/2006			**Northing:**	5433851
Time:	12:59:50 PM			**Easting:**	520400
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.3 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	10:1		
	Right Bank Height:	0.3 m	**Type:**	Concrete
	Right Bank Slope (H:V):	10:1	**Diameter:**	200mm
	Low Flow Channel Width:	0.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1010020.jpg

Comment: 200 mm diameter culvert with no headwall. Inlet is overgrown.

CREEK RECONNAISSANCE DATA SHEET

Point ID: TRIB2-010

SURREY
CITY OF PARKS

Watercourse:	Tributary 2	**Location:**			
Date:	4/10/2006			**Northing:**	5433854
Time:	1:04:18 PM			**Easting:**	520403
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.3 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	10:1		
	Right Bank Height:	0.3 m	**Type:**	Concrete
	Right Bank Slope (H:V):	10:1	**Diameter:**	200mm
	Low Flow Channel Width:	0.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.1 m		

Photos P1010021.jpg

Comment: 200 mm diameter culvert with no headwall. Outlet is overgrown.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-280

Watercourse:	Erickson Creek	**Location:**	
Date:	4/10/2006	**Northing:**	5433919
Time:	1:22:12 PM	**Easting:**	520485
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	1.5 m	**Site Feature:**	**Culvert Outlet**
Left Bank Slope (H:V):	0.5:1		
Right Bank Height:	1.5 m	**Type:**	CSP
Right Bank Slope (H:V):	0.5:1	**Diameter:**	1200mm
Low Flow Channel Width:	2.5 m	**Stability Issue:**	
Low Flow Channel Depth:	0.3 m		

Photos P1010023.jpg

Comment: 1200 mm diameter culvert built underneath a vehicle access (less than 300 mm of cover) on private property. Outlet is armored with 300 mm diameter rip rap. There is visual evidence of the creek overtopping the culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-281

Watercourse:	Erickson Creek	**Location:**	
Date:	4/10/2006	**Northing:**	5433916
Time:	1:24:37 PM	**Easting:**	520486
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	2.0 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	0.8:1		
Right Bank Height:	2.0 m	**Type:**	CSP
Right Bank Slope (H:V):	1:1	**Diameter:**	1200mm
Low Flow Channel Width:	3.0 m	**Stability Issue:**	
Low Flow Channel Depth:	0.3 m		

Photos P1010024.jpg

Comment: 1200 mm culvert built underneath a vehicle access (less than 300 mm of cover) on private property. Outlet is armored with 300 mm diameter rip rap.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-340

Watercourse:	Erickson Creek	**Location:**	
Date:	4/11/2006	**Northing:**	5433688
Time:	8:29:46 AM	**Easting:**	520543
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	1.2:1	**Diameter:**	1500mm
	Low Flow Channel Width:	3.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1010047.jpg

Comment: 1500 mm diameter culvert built underneath 29A Avenue with a concrete lock block retaining wall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-330

Watercourse:	Erickson Creek	**Location:**			
Date:	4/11/2006		**Northing:**	5433692	
Time:	8:35:15 AM		**Easting:**	520542	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.2 m	**Obstruction Type:**	Other
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1010048.jpg

Comment: V-Notch weir built downstream of 29A Avenue. Rip rap has been installed downstream of the weir.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-290

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433804
Time:	9:15:06 AM		**Easting:**	520511
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.4 m	**Site Feature:**	**Erosion**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.6 m	**Bank:**	Left
	Right Bank Slope (H:V):	0.5:1	**Length:**	12 m
	Low Flow Channel Width:	2.0 m	**Height:**	1.4 m
	Low Flow Channel Depth:	0.3 m		

Photos P1010053.jpg

Comment: Erosion on both sides of the channel, grass has started to grow back. Erosion area approximately 5 m long and 1.5 m high.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-300

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**	
Date:	4/11/2006	**Northing:**	5433770
Time:	9:19:12 AM	**Easting:**	520521
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.6 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	2.0 m	**Obstruction Type:**	Vehicle Bridge
	Right Bank Slope (H:V):	0.8:1		
	Low Flow Channel Width:	2.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010054.jpg

Comment: Vehicle bridge built on private property at the crest of the creek. Owner has installed rip rap downstream of bridge.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-341

Watercourse:	Erickson Creek	**Location:**			
Date:	4/11/2006		**Northing:**	5433675	
Time:	9:26:53 AM		**Easting:**	520549	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.5 m	**Type:**	'ood Stave
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	1500mm
	Low Flow Channel Width:	2.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1010057.jpg

Comment: 1500 mm diameter culvert built underneath 29A Avenue with a concrete lock block retaining wall.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-350

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**			
Date:	4/11/2006			**Northing:**	5433672
Time:	9:31:27 AM			**Easting:**	520543
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	1.2 m	**Obstruction Type:**	Other
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	2.8 m		
	Low Flow Channel Depth:	0.4 m		

Photos P1010058.jpg

Comment: Fish ladder drains an ornamental pond built on private property. A notched weir at the top of the fish ladder may have been replaced.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-360

Watercourse:	Erickson Creek	**Location:**			
Date:	4/11/2006			**Northing:**	5433621
Time:	9:44:12 AM			**Easting:**	520556
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	0.6 m	**Obstruction Type:**	Ped Bridge
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	6.5 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010059.jpg

Comment: Two pedestrian bridges meet join an island in the middle of an ornamental pond to either side of the pond. West bridge is approximately 0.2 m above the surveyed water level. East bridge is approximately 1.5 above the surveyed water level and is built on a

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-011

Watercourse:	Justin Brook	**Location:**			
Date:	4/11/2006		**Northing:**	5433511	
Time:	9:53:45 AM		**Easting:**	520577	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	2.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.8:1	**Diameter:**	750mm
	Low Flow Channel Width:	20.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1010061.jpg

Comment: 750 mm diameter culvert with a log and concrete headwall and trash rack. The culvert drains a large pond.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-010

SURREY
CITY OF PARKS

Watercourse:	Justin Brook	**Location:**			
Date:	4/11/2006		**Northing:**	5433521	
Time:	10:04:47 AM		**Easting:**	520578	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	750mm
	Low Flow Channel Width:	20.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010064.jpg

Comment: 750 mm diameter culvert with a log headwall. Outlet is clogged by vegetation.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-031

Watercourse:	Justin Brook	**Location:**	
Date:	4/11/2006	**Northing:**	5433392
Time:	10:16:55 AM	**Easting:**	520592
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	3.0 m	**Site Feature:**	**Culvert Inlet**
Left Bank Slope (H:V):	1:1		
Right Bank Height:	3.0 m	**Type:**	Concrete
Right Bank Slope (H:V):	1:1	**Diameter:**	750mm
Low Flow Channel Width:	0.6 m	**Stability Issue:**	
Low Flow Channel Depth:	0.1 m		

Photos P1010067.jpg

Comment: 750 mm diameter high flow culvert discharges into a pond. Adjacent to 600 mm diameter low flow concrete culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-030

Watercourse:	Justin Brook	**Location:**			
Date:	4/11/2006		**Northing:**	5433397	
Time:	10:27:20 AM		**Easting:**	520590	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	3.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	750mm
	Low Flow Channel Width:	20.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1010063.jpg

Comment: 750 mm diameter high flow culvert discharges into a pond. Could not locate outlet 600 mm diameter low flow concrete culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-040

SURREY
CITY OF PARKS

Watercourse:	Justin Brook	**Location:**		
Date:	4/11/2006		**Northing:**	5433328
Time:	10:50:11 AM		**Easting:**	520570
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.0 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	3.8 m	**Obstruction Type:**	Other
	Right Bank Slope (H:V):	0.6:1		
	Low Flow Channel Width:	1.2 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1010071.jpg

Comment: Log has fallen across creek channel. Branches have built up and clog the creek channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-051

Watercourse:	Justin Brook	**Location:**			
Date:	4/11/2006		**Northing:**	5433268	
Time:	10:59:25 AM		**Easting:**	520556	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	1.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.2 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010074.jpg

Comment: 900 mm diameter concrete culvert built underneath a vehicle access road.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-050

Watercourse:	Justin Brook	**Location:**		
Date:	4/11/2006		**Northing:**	5433272
Time:	11:01:50 AM		**Easting:**	520559
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	1.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	Damaged
	Low Flow Channel Depth:	0.4 m		

Photos P1010075.jpg

Comment: CSP outlet connected to a 900 mm diameter concrete culvert built underneath a vehicle access road.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-021

Watercourse:	Justin Brook	**Location:**			
Date:	4/11/2006		**Northing:**	5433437	
Time:	11:28:26 AM		**Easting:**	520584	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	2.8 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.9:1	**Diameter:**	300mm
	Low Flow Channel Width:	17.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1010078.jpg

Comment: 300 mm diameter culvert adjacent to a 750 mm diameter high flow culvert draining pond.

CREEK RECONNAISSANCE DATA SHEET

Point ID: JUS-020

SURREY
CITY OF PARKS

Watercourse:	Justin Brook	**Location:**	
Date:	4/11/2006	**Northing:**	5433447
Time:	11:29:29 AM	**Easting:**	520591
Weather:	Sunny		

Channel Dimensions:

Left Bank Height:	3.0 m	**Site Feature:**	**Culvert Outlet**
Left Bank Slope (H:V):	0.8:1		
Right Bank Height:	3.5 m	**Type:**	Concrete
Right Bank Slope (H:V):	1:1	**Diameter:**	300mm
Low Flow Channel Width:	7.0 m	**Stability Issue:**	
Low Flow Channel Depth:	0.5 m		

Photos P1010077.jpg

Comment: 300 mm diameter culvert adjacent to a 750 mm diameter high flow culvert draining into pond.

CREEK RECONNAISSANCE DATA SHEET

Point ID: BRK-020

SURREY
CITY OF PARKS

Watercourse:	Breaks Brook	**Location:**		
Date:	4/11/2006		**Northing:**	5433415
Time:	11:35:05 AM		**Easting:**	520612
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	3.5 m	**Site Feature:**	**Side Channel**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	3.2 m		
	Right Bank Slope (H:V):	0.5:1		
	Low Flow Channel Width:	3.0 m		
	Low Flow Channel Depth:	0.1 m		

Photos P1010079.jpg

Comment: Cross-section of Breaks Creek upstream of confluence some erosion evident on east bank.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-370

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433499
Time:	11:43:51 AM		**Easting:**	520607
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	2.4 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1.2:1		
	Right Bank Height:	1.2 m		
	Right Bank Slope (H:V):	Vertical		
	Low Flow Channel Width:	21.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010080.jpg

Comment: Confluence with Breaks Creek. Channel is not well defined and possibly meanders.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-380

Watercourse:	Erickson Creek	**Location:**	
Date:	4/11/2006	**Northing:**	5433505
Time:	11:47:49 AM	**Easting:**	520611
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	Vertical	**Diameter:**	900mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1010081.jpg

Comment: 900 mm culvert built underneath private driveway that drains an ornamental pond.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-381

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433505
Time:	11:51:12 AM		**Easting:**	520623
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	1.4 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.4 m	**Type:**	Concrete
	Right Bank Slope (H:V):	0.5:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.4 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.4 m		

Photos P1010082.jpg

Comment: 900 mm culvert built underneath private driveway that drains an ornamental pond. Flow is controlled by a notched weir and a 300 mm high flow culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-390

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**	
Date:	4/11/2006	**Northing:**	5433469
Time:	11:59:11 AM	**Easting:**	520669
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.5 m	**Obstruction Type:**	Ped Bridge
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	3.2 m		
	Low Flow Channel Depth:	0.3 m		

Photos P1010084.jpg

Comment: Pedestrian bridge that spans across an ornamental pond. The bottom side of the bridge is approximately 600 mm above the surveyed water surface level

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-400

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433358
Time:	12:12:57 PM		**Easting:**	520745
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.0 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	4.5 m	**Obstruction Type:**	Other
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	2.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010086.jpg

Comment: A tree has fallen across the creek channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: DAL-010

Watercourse:	Dall Break	**Location:**		
Date:	4/11/2006		**Northing:**	5433304
Time:	12:34:47 PM		**Easting:**	520926
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	0.6 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	4.0 m	**Type:**	CSP
	Right Bank Slope (H:V):	1:1	**Diameter:**	600mm
	Low Flow Channel Width:	0.6 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010088.jpg

Comment: 600 mm diameter culvert with no headwall built underneath 184th Street.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-410

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433309
Time:	12:38:43 PM		**Easting:**	520909
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.5 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	4.5 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	1.5 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010089.jpg

Comment: Confluence with Dall Brook. Channel is not well defined and possibly meanders.

CREEK RECONNAISSANCE DATA SHEET

Point ID: DAL-011

Watercourse:	Dall Break	**Location:**		
Date:	4/11/2006		**Northing:**	5433281
Time:	12:58:16 PM		**Easting:**	520949
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	5.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	4.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010089.jpg

Comment: 600 mm diameter culvert with cinder block headwall built underneath 184th Street. Inlet is partially submerged which may indicate obstruction in the culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-420

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek	**Location:**	
Date:	4/11/2006	**Northing:**	5433198
Time:	1:18:28 PM	**Easting:**	520926
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	5.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	5.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1:1	**Diameter:**	900mm
	Low Flow Channel Width:	2.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1010090.jpg

Comment: 900 mm diameter culvert built underneath 184th Street with cinder block headwall and wingwalls.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-421

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433189
Time:	1:25:43 PM		**Easting:**	520949
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.2 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	4.2 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	900mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	Plugged
	Low Flow Channel Depth:	0.2 m		

Photos P1010091.jpg

Comment: 900 mm diameter culvert built underneath 184th Street with cinder block headwall and wingwalls.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-430

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433140
Time:	1:31:52 PM		**Easting:**	520959
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.0 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	4.5 m	**Obstruction Type:**	
	Right Bank Slope (H:V):	0.7:1		
	Low Flow Channel Width:	2.5 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010092.jpg

Comment: Fallen logs and other wood debris present in creek channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-440

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5433111
Time:	1:39:06 PM		**Easting:**	520977
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.2 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	4.5 m	**Obstruction Type:**	
	Right Bank Slope (H:V):	0.8:1		
	Low Flow Channel Width:	6.0 m		
	Low Flow Channel Depth:	0.1 m		

Photos P1010093.jpg

Comment: Fallen logs and other wood debris present in creek channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-450

Watercourse:	Erickson Creek	**Location:**	
Date:	4/11/2006	**Northing:**	5432990
Time:	1:50:12 PM	**Easting:**	521058
Weather:	Sunny		

Channel Dimensions:	**Left Bank Height:**	6.0 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	5.4 m	**Obstruction Type:**	
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	2.0 m		
	Low Flow Channel Depth:	0.1 m		

Photos P1010094.jpg

Comment: Fallen logs and other wood debris present in creek channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-460

SURREY
CITY OF PARKS

Watercourse:	Erickson Creek		**Location:**		
Date:	4/11/2006			**Northing:**	5433019
Time:	1:53:55 PM			**Easting:**	521120
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m		
	Right Bank Slope (H:V):	Vertical		
	Low Flow Channel Width:	0.0 m		
	Low Flow Channel Depth:	0.0 m		

Photos P1010094.jpg

Comment: Confluence with unidentified channel to the west.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-470

Watercourse:	Erickson Creek	**Location:**		
Date:	4/11/2006		**Northing:**	5432888
Time:	2:07:52 PM		**Easting:**	521248
Weather:	Sunny			

Channel Dimensions:	**Left Bank Height:**	4.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	4.5 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	11.0 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010096.jpg

Comment: Confluence with unidentified channel to the east.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-480

Watercourse:	Erickson Creek	**Location:**			
Date:	4/11/2006		**Northing:**	5432821	
Time:	2:14:00 PM		**Easting:**	521222	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Confluence**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.5 m		
	Right Bank Slope (H:V):	1:1		
	Low Flow Channel Width:	1.0 m		
	Low Flow Channel Depth:	0.1 m		

Photos P1010097.jpg

Comment: Confluence with unidentified channel to the west.

CREEK RECONNAISSANCE DATA SHEET

Point ID: ERK-490

Watercourse:	Erickson Creek	**Location:**			
Date:	4/11/2006		**Northing:**	5432794	
Time:	2:19:49 PM		**Easting:**	521228	
Weather:	Sunny				

Channel Dimensions:	**Left Bank Height:**	2.2 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.8:1		
	Right Bank Height:	1.2 m	**Obstruction Type:**	Other
	Right Bank Slope (H:V):	1.5:1		
	Low Flow Channel Width:	0.6 m		
	Low Flow Channel Depth:	0.2 m		

Photos P1010098.jpg

Comment: A broken and plugged 600 mm diameter culvert has created a weir in the creek channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-010

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433895	
Time:	1:30:12 PM		**Easting:**	520498	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.5 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	200mm
	Low Flow Channel Width:	2.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.3 m		

Photos P1010025.jpg

Comment: 200 mm diameter culvert that drains an ornamental pond on private property. Water velocity seems high and an erosion area has formed around the culvert outlet. The culvert outlet is located at the confluence of Vandrish Brook and Erickson Creek.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-011

Watercourse:	Vandrish Brook		**Location:**		
Date:	4/10/2006			**Northing:**	5433896
Time:	1:33:52 PM			**Easting:**	520505
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	1.0 m	**Type:**	PVC
	Right Bank Slope (H:V):	1:1	**Diameter:**	200mm
	Low Flow Channel Width:	20.0 m	**Stability Issue:**	Plugged
	Low Flow Channel Depth:	0.6 m		

Photos P1010026.jpg

Comment: 200 mm diameter culvert that drains an ornamental pond on private property. The inlet is clogged by small floating debris.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-021

Watercourse:	Vandrish Brook	**Location:**	
Date:	4/10/2006	**Northing:**	5433895
Time:	1:39:26 PM	**Easting:**	520540
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	1.0 m	**Type:**	PVC
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	200mm
	Low Flow Channel Width:	30.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.5 m		

Photos P1010029.jpg

Comment: 200 mm diameter culvert that drains an ornamental pond into another ornamental pond. The inlet is controlled by a concrete weir with a mesh gate.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-020

Watercourse:	Vandrish Brook	**Location:**		
Date:	4/10/2006		**Northing:**	5433895
Time:	1:43:43 PM		**Easting:**	520536
Weather:	Cloudy			

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	1.0 m	**Type:**	PVC
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	200mm
	Low Flow Channel Width:	20.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.5 m		

Photos P1010030.jpg

Comment: 200 mm diameter culvert that drains an ornamental pond into another ornamental pond. There is a 45 degree angle in the culvert.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-211

Watercourse:	Vandrish Brook	**Location:**	
Date:	4/10/2006	**Northing:**	5433915
Time:	1:45:29 PM	**Easting:**	520541
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	0.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	Vertical		
	Right Bank Height:	0.0 m	**Type:**	PVC
	Right Bank Slope (H:V):	Vertical	**Diameter:**	150mm
	Low Flow Channel Width:	0.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.0 m		

Photos P1010031.jpg

Comment: 150 mm diameter culvert and a 300 mm diameter high flow culvert draining an ornamental pond into side channel. Inlet is controlled and surrounded by a wire mesh.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-210

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006			**Northing:**	5433930
Time:	1:50:39 PM			**Easting:**	520533
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	0.8 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.7:1	**Diameter:**	150mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010033.jpg

Comment: 150 mm diameter culvert and a 300 mm diameter high flow culvert draining anornamental pond into side channel.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-030

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Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433873	
Time:	1:57:15 PM		**Easting:**	520615	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.2 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.2 m	**Obstruction Type:**	Ped Bridge
	Right Bank Slope (H:V):	0.5:1		
	Low Flow Channel Width:	1.2 m		
	Low Flow Channel Depth:	0.5 m		

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CITY OF PARKS

Photos

Comment: Pedestrian bridge that spans the upstream end of an ornamental pond. No photo available.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-040

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433861	
Time:	2:00:31 PM		**Easting:**	520618	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	0.4 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	0.4 m	**Obstruction Type:**	Ped Bridge
	Right Bank Slope (H:V):	0.5:1		
	Low Flow Channel Width:	2.0 m		
	Low Flow Channel Depth:	0.1 m		

Photos P1010034.jpg

Comment: Pedestrian bridge built on concrete vertical walls at downstream end of ornamental pond. Bridge is approximately 200 mm above the surveyed water level.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-050

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433828	
Time:	2:07:05 PM		**Easting:**	520671	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.0 m	**Site Feature:**	**Obstruction**
	Left Bank Slope (H:V):	0.5:1		
	Right Bank Height:	1.0 m	**Obstruction Type:**	Vehicle Bridge
	Right Bank Slope (H:V):	0.5:1		
	Low Flow Channel Width:	3.5 m		
	Low Flow Channel Depth:	0.5 m		

Photos P1010035.jpg

Comment: Vehicle Bridge spans narrow point between two ornamental ponds. Flow is channelized between wood abutment walls. Bridge is approximately 400 mm above the surveyed water level.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-060

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Watercourse:	Vandrish Brook	**Location:**	
Date:	4/10/2006	**Northing:**	5433822
Time:	2:11:34 PM	**Easting:**	520693
Weather:	Cloudy		

Channel Dimensions:

Left Bank Height:	0.8 m	**Site Feature:**	**Obstruction**
Left Bank Slope (H:V):	0.5:1		
Right Bank Height:	0.8 m	**Obstruction Type:**	Ped Bridge
Right Bank Slope (H:V):	0.5:1		
Low Flow Channel Width:	2.5 m		
Low Flow Channel Depth:	0.3 m		

Photos P1010036.jpg

Comment: Pedestrian bridge built at the upstream end of an ornamental pond.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-070

Watercourse:	Vandrish Brook		**Location:**		
Date:	4/10/2006			**Northing:**	5433736
Time:	2:35:27 PM			**Easting:**	520791
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.8 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	0.6:1		
	Right Bank Height:	2.2 m	**Type:**	PVC
	Right Bank Slope (H:V):	0.6:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010038.jpg

Comment: 450 mm diameter culvert built underneath possible vehicle access road.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-071

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433733	
Time:	2:38:20 PM		**Easting:**	520801	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	1.5 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1:1		
	Right Bank Height:	2.0 m	**Type:**	PVC
	Right Bank Slope (H:V):	1:1	**Diameter:**	450mm
	Low Flow Channel Width:	1.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010039.jpg

Comment: 450 mm diameter culvert built underneath possible vehicle access road.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-080

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Watercourse:	Vandrish Brook	**Location:**	
Date:	4/10/2006	**Northing:**	5433688
Time:	2:44:31 PM	**Easting:**	520819
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	80.0 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	50:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.2:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010040.jpg

Comment: 600 mm diameter culvert built underneath 29A Avenue with minimal erosion around outlet.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-081

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433679	
Time:	2:46:10 PM		**Easting:**	520826	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	2.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	2.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	1.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010041.jpg

Comment: 600 mm diameter culvert built underneath 29A Avenue with minimal erosion around inlet.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-090

Watercourse:	Vandrish Brook	**Location:**	
Date:	4/10/2006	**Northing:**	5433637
Time:	3:18:36 PM	**Easting:**	520931
Weather:	Cloudy		

Channel Dimensions:	**Left Bank Height:**	2.5 m	**Site Feature:**	**Culvert Outlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	2.5 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	2.0 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010042.jpg

Comment: 600 mm diameter culvert build underneath 184th Street with concrete headwall. Possible sediment issue as the culvert invert is below channel bottom.

CREEK RECONNAISSANCE DATA SHEET

Point ID: VAN-091

Watercourse:	Vandrish Brook	**Location:**			
Date:	4/10/2006		**Northing:**	5433641	
Time:	3:20:01 PM		**Easting:**	520943	
Weather:	Cloudy				

Channel Dimensions:	**Left Bank Height:**	3.0 m	**Site Feature:**	**Culvert Inlet**
	Left Bank Slope (H:V):	1.5:1		
	Right Bank Height:	3.0 m	**Type:**	Concrete
	Right Bank Slope (H:V):	1.5:1	**Diameter:**	600mm
	Low Flow Channel Width:	2.5 m	**Stability Issue:**	
	Low Flow Channel Depth:	0.2 m		

Photos P1010043.jpg

Comment: 600 mm diameter culvert build underneath 184th Street and a confluence with the 184th Street east ditch.

E Appendix E - ARDSA Drainage Criteria

ARDSA, or Agrifood Regional Development Subsidiary Agreement, criteria specify allowable durations of flooding of agricultural land during both winter (non-growing season) and summer (growing season) conditions. These drainage criteria are generally stated as:

During the growing season of March 1st to October 31st, flooding of agricultural land is restricted to a maximum duration of two days as a result of a two-day, ten-year return period storm event.

During the non-growing season of November 1st to February 28th, flooding of agricultural land is limited to a maximum of five days as a result of a five-day, ten-year return period storm event.

Between storm events, when positive soil drainage is required, the baseflow water level in the drainage system should be 1.2 m below the minimum field elevation at all field drainage connection points. The minimum field elevation is the lowest cultivatable point in an agricultural field, not including the ditch cross-section, and is generally defined from the hypsometric curve on a field by field basis.

F Appendix F - Public Consultation

Engineering Department
Erickson Creek
Integrated Stormwater Management Plan (ISMP)
Public Open House - June 27, 2006

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SIGN-IN SHEET

	Name	Address	Tel/Email
1	Ken	190 St. & 32 Ave.	
2	Geoff Hepworth Pennyfarthing Development Corp.	176th between 24th + 32nd	geoffreyh@pennyfarthingdevel
3	Danny Gallagher	3147 184th St	danny@gallagherbros.com
4	R + C WAIZ	18222 29A AVE	waiz@shaw.ca
5	Margaret & Doug Sampson	3375 - 180th Street	mdsampson@telus.net
6	Peter or Erzsebet Farkas	3181 184th. St	604-541-0384
7	Pierre Roktar	18665-56 A Avenue	pfrotar@uniserve.com
8	Leigh Mikitta	18171 29 A AVE.	HERONSRESTNURSERY@Telus.net *Report Fish?
9	ANGELA KING	18260 - 29A AVE	541-4676
10	ERIC/CINDY LIGHTHEART	2163-179th St.	541-4196
11	Dianne Berger	2166 - 179 St	541. 0250
12	Ken Lee	#203, 12877-76 Ave	604-591-1915
13	Nelson Comire	18830 32nd Ave	604 542-9785
14	FRANK [illegible]	3460-141 ST. RESCUE NES.	604 535-9291.
15	L. UDY	17653 24 AVE	604-541-0033
16	A. Mahil	18149-29A Ave	604-645-3595
17	Bernie Scholz	2608 180 St.	604 535-7212
18	Larry Ramsell N.E.S. RESCUE	14391 Crescent Rd	" 5367543.
19	DAVID COOTE	3301 184 ST	574 5755
20	Robert Coot	3301 184St	5410426
21	Lori Cotton	13950 35 A Ave	597 8807.
22	Margaret Hewett	2245-180th Street	541-0264
23	STAN Scheves	2133-188 St	Gxp 541-0187 * slide show.

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Engineering Department
Erickson Creek
Integrated Stormwater Management Plan (ISMP)
Public Open House - June 27, 2006

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SIGN-IN SHEET

	Name	Address	Tel/Email
24	Richard Bryson	2185 - 179 TH St.	RSBRYSON@SHAW.CA
25	Dan & Marie-Anne Lenko	18064 32 ND Ave.	(604) 536-0719
26	Dale Rezansoff	17851 - 20 A	604-531-1168
27	Lynda Featherstone	2184 - 179 St.	604 541 2822
28	Catharina Leidel	18060 - 29 A Ave	604-541-0374 *map of water-courses
29	Sylvia + Dale Shury	2616 - 180 St.	604.531.1183
30	Alan White	18225 - 29A Ave	604-542-6112
31	Vic Wallick	17656 - 40 Ave	574-4227
32	David Janssens	4419 + 4307 - 184 St.	690-6874
33	Kulwinder Samra	2105 - 176 St	542-9684
34	Sukhjit Samra	2105 - 176 St	542-9684
35	Corey Fast	18198 - 32	541-0438 *Sharp Program
36	Danuta Macarski	8045 181 St	541-0065
37	Sandra Bryson	2185 - 179th St	541-2494
38	Paul Paulsen	2523 - 184th	541-0340
39	Katherina Ross	14180 Greencrest Dr.	536-4744
40	Jeff Maclean	2976 - 184 St.	541-0379
41	Jake Bredenhof	3481 - 184 St	576 2191
42	David Riley	15425 Columbia Ave, WR	independenthouse@hotmail.com
43			
44			
45			
46			

file: 4806-705

Public Open House
- June 27/06.

Questions from the public:

1. · there is property for sale on the NE side of 184 St. & 32 Ave. → City should buy it

follow-up: contacted Wayne Power about this suggesting that he talk to Parks about the possibility of buying this property from the Crown

2. · ditch on 32 Ave. @ 181 St. → alders in ditch causing back-up of water during heavy rains

follow-up: ditch cleaned by Ops. Staff on June 28/06.

3. · when will development come? → market driven

4. · concerned about having to provide 30m setback on agric. lands → not an issue until you subdivide

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Engineering Department

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Erickson Creek Integrated Stormwater Management Plan (ISMP)
Public Open House – June 27, 2006

Welcome to the Erickson Creek ISMP Open House. Please take some time to review the presentation materials and ask questions of City staff and consultants. Once you've had an opportunity to do so, please provide us with your name, comments and/or concerns below. This is your opportunity to provide input into this project.

Name(s): Corey Fast

Current Address: 18198 - 32 Avenue

Telephone: 604-541-0438 Email: ____________

Have you experienced any of the following problems on your property?:

Flooding [✓] on properties to the west

Erosion [✓] small amount at back of property on Breaks Brook (?)

Sediment Accumulation [ ]

Comments:

- 32 Avenue ditch backs up in the fall + causes flooding on the property located @ 18106-32 Avenue. Concerned it may extend to his property.
- has never seen any fish in the watercourses (Laurel + Breaks Brook) on his property

(recorded for Mr. Fast by J. Umpleby)

cc. Jeff Welch, Drainage Operations

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

City of Surrey
Engineering Department

14245 – 56 Avenue
Surrey, B.C. V3X 3A2

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ATTN: JANE UMPLEBY.

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Name(s): ED + MARLENE JONKMAN

Current Address: 18282-32 AVE

Telephone: 604 541 0434 Email: emjonkman@telus.net

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☑ DON'T FEEL THIS IS A HUGE PROBLEM. HAS BEEN LIKE THAT SINCE WE BOUGHT THE PROPERTY IN 1988.

Comments:

IN THE LAST YEAR OR SO OUR CREEK HAS HAD AN EXPLOSION OF MILLFOIL. LAST SPRING WE ~~ALSO FOUND DEAD ANIMALS THAT APPEARED~~ TO HAVE NOTHING WRONG WITH THEM. OUR ~~OLD~~ OLD NEIGHBOUR TO THE WEST OF US ALSO EXPERIENCED MORTALITIES IN THEIR ALPACA HERD THAT USED THE CREEK AS THEIR WATER SOURCE. OUR MAIN CONCERN IS THE DUMPING OF RAW SEWAGE/WASTE OF THE FISH PACKING PLANT UP THE HILL FROM US. WE DON'T DRINK OUR WELL WATER, JUST IN CASE.

cc. Clay Carl, Environmental Tech. – for follow up with Ministry

AE + JW. Consultants

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* Karen to follow up ? - would like someone to look at the area.

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Name(s): Margaret A. Hewlett (Marnie)

Current Address: 2345 - 180th Street

Telephone: 541-0264 Email: ______

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

There is a spring that bubbles up beside my driveway from November → February.
I am very concerned about proposed development in my area - of particular concern for me is the wooded area behind me - ? What will happen to the natural flow of H_2O if those trees are removed by contractors. like the way Stokes Pit was developed!

cc AE + JW consultants

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Thank you for your time and interest.

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Name(s): Pierre Rovtar.

Current Address: 18665 – 56 A Avenue

Telephone: 576-5965 Email: pfrovtar@uniserve.com

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

Riparian not wide enough.

Groundwater extraction + gravel mining just east is not considered.

cc. AE + JW Consultants

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Thank you for your time and interest.

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Name(s): L. UDY

Current Address: 17653 24 AVE

Telephone: 541-0033 Email: UDY0033@SHAW.CA

Have you experienced any of the following problems on your property?:

Flooding ☐ No

Erosion ☐ No

Sediment Accumulation ☐ No

Comments:

I MADE A NOTE THAT THE DITCH LOCATED NORTH OF THE 8-1 ACRE LOTS AT NE CORNER OF 24TH & 176TH WAS REPLACED BY A LARGE DRAIN PIPE, IN THE EARLY '80'S, WHICH RUNS NW OUT TO 176TH ST.

cc. AE + JW Consultants

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

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Name(s): Paul Paulsen

Current Address: 2523 – 184th St

Telephone: 541-0340 Email:

Have you experienced any of the following problems on your property?:

Flooding [X] Water draining from above

Erosion [ ]

Sediment Accumulation [ ]

Comments:

We have a water drainage prob. "Now" running down from Sunnyside Rd, backing up next to the rail grade pooling in the winter time now. Then flooding over our property. So what are you doing about it befor the developments?

The best thing is ditch the uppe side of the rail grade down to Justin Ck.

cc Remi Dube, Drainage Planning
Carrie Baron, Drainage
AE + JW Consultants

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

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Engineering Department

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Welcome to the Erickson Creek ISMP Open House. Please take some time to review the presentation materials and ask questions of City staff and consultants. Once you've had an opportunity to do so, please provide us with your name, comments and/or concerns below. This is your opportunity to provide input into this project.

Name(s): MUTCH

Current Address: 18171 29 A AVE.

Telephone: 604-535-4041 Email: heronsrestnursery@telus.net.

Have you experienced any of the following problems on your property?:

Flooding ☑

Erosion ☐

Sediment Accumulation ☐

Comments:

Primarily the back of the property floods when we have heavy winter rains. Our concern is that with all the development going on the storm waters will increase Erickson Creek flooding. We hope that this will get looked into.

Also – proper vegetation. – there are cottonwood trees sprouting everywhere and a weed called Bittersweet which runs rampant thru the creeks. They grow prolifically in the summer clogging the stream for the heavy winter rains.

cc. Remi Dube, Drainage Engineer
Rachael Jones, Environmental Co-ordinator
AE + JW Consultants

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

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Jarl.

Engineering Department

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Erickson Creek Integrated Stormwater Management Plan (ISMP)
Public Open House – June 27, 2006

Welcome to the Erickson Creek ISMP Open House. Please take some time to review the presentation materials and ask questions of City staff and consultants. Once you've had an opportunity to do so, please provide us with your name, comments and/or concerns below. This is your opportunity to provide input into this project.

Name(s): Paul Mahil

Current Address: 18143 - 29A Avenue

cel.
Telephone: 604-868-6922 Email:

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

· would like to see DFO @ the Public Open House. Mahil found them to be a "problem" when trying to locate his septic field. He ended up having to put the field in the front yard even after proposing to put it out back outside the watercourse protection area.

- recorded by Jy
telephone conversation)
June 16/06.

cc. Associated Eng.
Jacques Whitford.

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

City of Surrey
Engineering Department

14245 – 56 Avenue
Surrey, B.C. V3X 3A2

Jane

Engineering Department

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Name(s): Tony Willingdon, Surrey Nursery (private company - not part of the Ministry)

Current Address: 192 Street + 36 Avenue.

Telephone: 604-836-5270 Email:

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

- Surrey Nursery has a 66 acre lease within the property. 20 acres in greenhouses, rest is containerized plants therefore there is not much pervious area
- they have historically been pumping between 50,000 - 200,000 US gpd of groundwater into an irrigation pond, to a swamp + creek, then into the main ditch along 184 St. @ 38 Ave.
- they have 2 irrigation wells E. of 192 St., along 36 Avenue
- the site drains NE to SW with streams originating along the toe of the slope

-recorded by JU
telephone conversation
July 4/06.

cc. Associated Eng.
Jacques Whitford.

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Name(s): Ms. Thielemann (telephone conversation June 16/06)

Current Address: 2623-184 St.

Telephone: 604-541-0344 Email:

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

- very upset + "disgusted" over what has gone on in the area → 192 St. + 24 Ave. has been "demolished".
- dumping of wastes into the creek has gone on + is passibley continuing
- not many people may come out to the Open House because they are fed up.

-recorded by J.U.

cc. Associated Eng.
Jacques Whitford.

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Engineering Department

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Name(s): Don Franks (telephone call June 19/06)

Current Address: 19068-32 Avenue

business
Telephone: 604-536-2929 Email:

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

- zero tolerance for any vibration
- Boundary Health Dept should get involved regarding nitrates
- will attend Open House

-recorded by J.U.

cc Associated Eng.
Jacques Whitford.

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Thank you for your time and interest.

City of Surrey
Engineering Department

14245 – 56 Avenue
Surrey, B.C. V3X 3A2

Jane.

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CITY OF PARKS

Engineering Department

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Name(s): Ben Johnson

Current Address: 18676 - 32 Avenue

Telephone: ______ Email: ______

Have you experienced any of the following problems on your property?:

Flooding ☐

Erosion ☐

Sediment Accumulation ☐

Comments:

(1) -concerns regarding a mink farm in the area:
-use 36,000 L/day of groundwater
-fish processing being done on the property now
-dumped into Erickson Creek last year + charges are pending
(2) suggest that a single row of houses (townhouses) might be appropriate along 32 Avenue to take advantage of the views, walking trails, ground-water discharge area, deer trails. this area should also be protected as a park.

Recorded by: JU.

done ✓ * mail out Open House presentation materials

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

City of Surrey
Engineering Department
14245 – 56 Avenue
Surrey, B.C. V3X 3A2

cc. Associated Eng.
Jacques Whitford.

Engineering Department

SURREY
CITY OF PARKS

Jane

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Name(s): Stan Scheves

Current Address: 3133 - 188 Street (3177-188 Street)

Telephone: ____________ Email: ____________

Have you experienced any of the following problems on your property?:

Flooding ☐ ____________

Erosion ☐ ____________

Sediment Accumulation ☐ ____________

Comments:

- questions the fish presence shown on
? the 28 Avenue creek @ end of 188/184
Street
- questions the line shown on the mapping that the creek extends ~~as~~ that far east onto his property (up hill)
- springs coming out of the side of the hill on his land

-recorded by JU.

done ✓ * requested the Open House materials be mailed to him - had to leave the meeting early

cc Associated Eng.
Jacques Whitford

Please deposit this in the drop box provided, or fax it to Jane Umpleby at 604-591-8693, or mail it before **Wednesday July 5** to the address provided below.

Thank you for your time and interest.

City of Surrey
Engineering Department

14245 – 56 Avenue
Surrey, B.C. V3X 3A2

file: 4806-705

CITY OF SURREY
the future lives here.

Engineering Department

Erickson Creek Integrated Stormwater Management Plan (ISMP)

Public Open House –October 27/08

SIGN-IN SHEET

Name	Address	Tel/Email
Ivan & Karin Nilsen	3084. 188st Surrey	604-541-0294
Casey + Teresa VanGurp	3075-188th SRY	604 541 0290
SHIRLEY + LARRY CRAIG	2782-176 ST	604-535-2572
Esther Johnson	7410 - 149A St	- 596-7262
S Domin	18858 - 32 AVE	
Peter Fankorz	3181 - 184TH. ST.	604-541-0384
BILL STILWELL	18341-59A AVE	604-576-6297
Cynthia Waiz	18222-29A Ave	604 538 8163 waiz@shaw.ca
Charlie Hall	4252 -184	604 202 0698
He jun	2518 176	
" "	2546 176	604-722118
YUNXI XIANG	17653 24th Ave.	604 7268113
ERIC CN CHAN	2188 176th St.	604 263 6875
RICH + CYNTHIA WAIZ	18222 29A AVE.	538-8163 waiz@shaw.ca
L FEATHERSTONE	2184-179 ST	604-5412822
A. LIGHTHEART	2163-179 ST	604-54- 4186
DEL BAAR	4157 -184St	604-576-2345
Ron Meadley	14315 25 Ave	604-535- 3507
Torleif Skroder	3041-192 St	604-541-0411
Avtar Johl	15309 58 Ave	604-599-6512
Maxine Heppell	2981-192 St	604 541-9446
ED JONKMAN	18282- 32nd Ave	604 541-0437
Marg Cuthbert	FRIENDS OF SEMIAHMOO BAY	604-536-2636

CITY OF SURREY

the future lives here.

Engineering Department

Erickson Creek Integrated Stormwater Management Plan (ISMP)

Public Open House –October 27/08

SIGN-IN SHEET

Name	Address	Tel/Email
Jim Ellis	4830 North Lawn Dr. Bby	jim@bofo.ca
Leigh Mikotka	18171 29A Ave	604-535-4041
C. [illegible]	2961 – 188 ST	
Manpreet Johal	3300 – 176st.	604-574-0975 Johal176@Hotmail.com.
BILL STEWART	18760 - 20 AVE	604-542-1985
A+K. Holmes	18279 24th Ave	541-0059 K-AMholmes@shaw.ca

591-8693 JLU

→ engineering dep
→ planning

THIELEMANN, I.
61520 Brookswood P.O.
Langley, B.C. V3A 8C8
604 Ph: 541-0344 FAX/TA

29DEC08

MRS
JANE UMPLEBY
PROJECT CO-ORDINATOR

RECEIVED
JAN 05 2009
ENGINEERING DEPT

DEAR MRS UMPLEBY -

IF YOU CONSTRUCT THE DETENTION POOLS AT THE OLD RAIL ROAD, I SURELY WONDER IF YOU HAVE ANY IDEA ABOUT THE VOLUME OF WATER THERE IS PRESENTLY WITH ALL THIS SNOW. IT SHOULD BE A PURE DISASTER! OR INSTEAD LEAVE THE FOREST LIKE IT IS NOW! ISN'T NATURE DOING A BETTER JOB AT THIS?

Happy New Year —

THIELEMANN, I.
61520 Brookswood P.O
Langley, B.C. V3A 8C8
604 Ph: 541-0344 TEL/FAX

12/01/2008 23:27 6045410344 PORTOBELLO PAGE 01

591-8693

RECEIVED
DEC 0 2 2008
ENGINEERING DEPT

CITY OF SURREY

Engineering Department

Erickson Creek Integrated Stormwater Management Plan (ISMP)

Public Open House – October 27/08

Faxed 1 Dec 08

Welcome to the Erickson Creek ISMP Open House. Please take some time to review the presentation materials and ask questions of City staff and consultants. Once you've had an opportunity to do so, please provide us with your name, comments and/or concerns below.

Name(s): Inge Thielemann
Brookswood
PO Box 61520 RPO Brookswood
Langley BC V3A 8C8
MAILING ADDRESS

Address: 2623 - 184 Street

Telephone: 604 541 - 0344 ~~Email:~~
FAX SAME

Comments:

please see letter

copies to MRS Jane Umpleby
1) engineering dep.
2) planning dep.
cc Remi Dube, Drainage Planning

total pages 4
please acknowledge receipt of my letter of objection. Thank you.

Please deposit this at the door, fax it to the attention of Jane Umpleby at 604-591-8693, or mail it before ~~November~~ DEC 10/08 to the address provided below.

Thank you for your time and input.

[signature]

City of Surrey
2nd Floor Engineering Department/Drainage Section
14245 – 56 Avenue
Surrey, B.C. V3X 3A2

cc

We are totally against your plans to install DETENTION PONDS on the south side along the old rail road which borders our property. We already struggle to keep on farming this land of poor thin top soil. If you distroy this buffer of trees, it will only cause more erosion by wind and even more flooding. Worst of all, if you open up this buffer for a nature trail with a sewer trunk line beside the detention ponds, it will attract mosquitos in summer time to breed in stagnant water. The city will then very likely spray and this alone will kill our organic status. There will be no way we can co-exist any longer. By opening up this residential area you are constructing streets (like 180th and 28th Ave.) We fought for years to close off this area to the public. Already 25 years ago we started to have problems with drugs and alcohol parties, garbage left behind, with hunters coming on to the property and shooting at random, so that I was afraid to go into the pasture There was theft and vandalism of our costly farm equipment. Fires were set in our fields, stolen vehicles burnt. Finally the city hall agreed to close off the old rail road.
With the kind of people existing nowadays in comparision to 25 years ago this would present an uncontrollable situation. If you would open this area up again, we would have to shut down, as we would have to deal with the out-of-control youth (and adults). They would come with their noisy distructive dirtbikes and ATV's and use our fields and the rail road as their playfield. It would be hell on earth for us.
There is also another factor: NOISE! Now we are sheltered from the noise levels of 24th Ave., 176th St., 32nd Ave. (and all the semis coming from the industrial area down 32nd). We would not be able to sleep or work outdoors. There will also be more traffic on the road. We already have trouble getting out of our farm on to the road. There seems to be no more courtesy among the public.
You are talking about a wildlife corridor. In order to have a corridor you need large areas like 300 plus acres <u>quiet dense forest</u> and continuous not a small strip and broken up through roads. It must be <u>undisturbed</u> -

This is where wildlife have their young and travel. They need healthy vegetation. A protected area: no dirtbikes, ATV etc.)
It is very clear to us in South Surrey that a forum for the public's opinion is just a show, going through the motion, a one way radio and one sided. The mayor and the pro-development council always take the sides of the developer. This has been our sad but true experience with the precious environment and wildlife. On the other hand is the disasterous Campbell Heights Industriel area which is being distroyed and where the most fertile farm land has been chosen for INDUSTRY!!!

To continue farming under these circumstances and conditions under the continuous threat of development all around us has caused us undeserved stress which in turn is effecting our health.

Why would there be so much water so that you have to construct detention pools? Because you are cutting the w h o l e wooded area. This forest is a wind barrier. When there are severe storms, we are sheltered. The trees which used to take care of the rain water are butchered, this will cause major flooding and soil erosion. These pools will NOT be able to handle the floods. Because of global warming the experts are predicting far more rain than ever before. The wildlife in those forests will die. The shade umbrellas on hot summer days are gone. The forest on a hot summer day is cooling the air and gives so much oxygen which we do not have enough of any more. The homeowners of those new houses will use our pasture as their extended backyard. And the roads you then will build will open up another can of worms.

For the mayor and council

OPINION

PRESERVATION

Large trees crucial for water intake, drainage

Frank
BUCHOLTZ
And Frankly...

Flooding at near-record levels this week has caused many problems in Surrey, mainly closed and damaged roads and damage to personal property.

In White Rock, the low-lying West Beach area once again experienced flooding and sewage back-ups, although on a smaller scale than occurred a few years ago.

Damage has been much less significant than in North Vancouver, where a mudslide did major damage to two homes. However, that lack of damage in White Rock may be the result of good luck more than anything.

A major flood was inevitable when heavy rains followed right behind Saturday's snowfall. Coupled with frozen ground and high tides, which prevented runoff water in the Serpentine and Nicomekl Rivers from getting out to sea quickly, the water quickly pooled in low-lying areas. Surrey Lake has also greatly expanded in size.

Flooding in low-lying areas used to be an ongoing problem every winter, but it has been greatly diminished through massive drainage projects, financed by the new drainage tax collected by the City of Surrey.

In the Fry's Corner area, at Fraser Highway and 176 Street, fields not been worked in decades are now back in production, as a result of the improved drainage.

In White Rock, drainage has been improved through major improvements to the Duprez Creek waterway, which drains a portion of South Surrey. Had those improvements not been undertaken, flooding along Marine Drive would have been much worse.

No drainage project can handle the amount of water that came down this week and not consider all factors that led to the flooding.

Yet Surrey could be doing quite a bit more to improve drainage and reduce the likelihood of flooding.

It could insist on much more tree retention on properties being developed, through hard-nosed negotiations with developers. This would require a major change in attitude by developers and city hall.

Mature trees are among the best way to prevent major flooding. They suck up a tremendous amount of water, and even an area with smaller numbers of big trees can absorb a lot.

I walked by a Fleetwood property Tuesday that is slated for development. One older home sits on it now—it will soon be split up into 10 lots. The property has a number of mature trees on it, among them cottonwoods, maybe the most significant water-devouring trees on the West Coast.

It is very hard to retain cottonwoods in such a development. They have fairly shallow root systems and are easily blown over in major wind storms—particularly when the ground around them has been disturbed. Yet it could make sense to plant young cottonwoods or similar species when the development is complete, just to ensure there are trees growing to absorb water.

I was pleased to see, just up the street from the proposed development, poplars used as street trees. Poplars are another species that retain a great deal of water.

Far more mature trees could be preserved, and while some are, most fall to the chainsaw. The city, developers and buyers all seem to favour placing the maximum number of housing units on a piece of property—thus ensuring existing trees don't have much of a chance.

Surrey's tree preservation bylaw has come in for a great deal of criticism, much of it richly deserved. The city itself has set the worst example in Campbell Heights, levelling thousands of trees and allowing Latimer Lake to fall to unheard-of water levels.

Yet if residents want things to change, they need to say so.

The last meeting of a series of open houses on the tree preservation bylaw, hosted by city staff members, takes place Tuesday from 4:30 to 8:30 p.m. at Shannon Hall, at the Cloverdale Fairgrounds. If you're concerned about trees, for aesthetic and flood control purposes, let your voice be heard.

Frank Bucholtz is editor of The Langley Times. He writes weekly for The Peace Arch News.

TIDES at White Rock • - 1 hr. for DST

ATT: TO Jane Umpleby

CITY OF SURREY

Engineering Department

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Name(s): Peter & Erzsebet Farkas

Address: 3181 - 184th St Surrey B.C. V3S 9V2

Telephone: 604-541-0384 Email: ecfarkas@hotmail.com

Comments:

I have a complained I would like to bring forward toward the city of surrey.
I have residential home on the corner of on 184 st and 32nd st in Surrey. Since 176 st has been opened up as a three way highway and the area around 192 st has been industrialized. Traffic on 32nd street has tripled in the past 3 years. A street light has even been put up to control the traffic regarding this.

My complain is the noise is unbearable. The heavy dump truck that go down the street to the sand pits between 184 st and 192 st everyday shake the foundation of my home. Also the traffic by cars too has increased three times. I would like the city to put a sound barrier to lower the noise to my home.

cc - directed to Philip B., Transportation Planning

Please deposit this at the door, fax it to the attention of Jane Umpleby at 604-591-8693, or mail it

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Name(s): BILL STEWART

Address: 18760 - 20TH AVENUE

Telephone: (604)542-1985 Email: blcanyon@telus.net

Comments:

ALTHOUGH OUR PROPERTY DOES NOT LIE WITHIN THE BOUNDARIES OF THE ERICKSON CREEK ISMP, WE HAVE SOME CONCERNS BASED ON OUR RECENT EXPERIENCE WITH INCREASED GROUNDWATER FLOWS COMING TO THE SURFACE, POSSIBLY RELATED TO NEARBY DEVELOPMENT IN CAMPBELL HEIGHTS.

SPECIFICALLY, WE ARE CONCERNED ABOUT THE EXTENT TO WHICH LOCAL GROUNDWATER (HYDROGEOLOGY ?) IS UNDERSTOOD. DOES THE USE OF INFILTRATION PROCESSES REALLY MIMIC PRE-DEVELOPMENT INFILTRATION? WE DOUBT IT. WE EXPECT THAT, DESPITE BEST INTENTIONS, GROUNDWATER FLOWS OFF-SITE WILL INCREASE DURING WINTER MONTHS, BECAUSE OF THE NET LOSS OF VEGETATIVE COVER.

WE HAVE OWNED OUR PROPERTY FOR ALMOST 6 YEARS, AND LAST FALL & WINTER WE EXPERIENCED SIGNIFICANT SOIL SATURATION NOT EXPERIENCED PREVIOUSLY, MAKING SOME OF PASTURES UNUSABLE. WE WOULD APPRECIATE A RESPONSE.

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Thank you for your time and input.

City of Surrey
2nd Floor Engineering Department/Drainage Section
14245 – 56 Avenue
Surrey, B.C. V3X 3A2

P.S. WE ARE ALSO SEEING CONTINUED PULSES OF SILT IN TWIN CREEK EVERY TIME 24-HOUR RAINFALL EXCEEDS 10 MM.

cc Remi Dube – Development Related
Carrie Baron – Water Quality
AE + JW Consultants

[signature]

Engineering Department

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Name(s): Mike (telephone conversation)

Address: SW corner of 184 St. + 40 Ave.

Telephone: 778-388-7775 (cell.) Email: ___________

Comments: October 8/08:
- can't attend the meeting but would like someone to call him about the flooding of the lower part of his field where he is trying to grow blueberries
- problem has occurred from Nov.–April/07
- hasn't owned the property for very long
- his land slopes to 40 Ave. with about a 5' difference in elevation
- there is a "creek" overflowing onto his property that contributes to the flooding.
- I suggested to Mike that this might be a natural occurrence during the wet months. He would like someone with history on the drainage system in this area to call him.

(ISMP (FD. DCS)) - shows the need for ditch capacity improvement to handle the 100 year event along 40 Ave. EAST of 184 St. intersection

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Thank you for your time and input.

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cc. Carrie → OPS → Service Request.

file: 4806-705

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Name(s): ALAN WHITE

Address: 18225- 29 A AVE

Telephone: 604 542-6112 Email: ______

Comments:

SHARP FISH HABITAT IMPROVEMENT
- gravel/dredging etc. of pond located on his property
- would like someone to contact him about this.

Please deposit this at the door, fax it to the attention of Jane Umpleby at 604-591-8693, or mail it before November 10/08 to the address provided below.

Thank you for your time and input.

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cc Carrie Baron & Liana Ayach ✓
Environmental Coordinator