DISTRICT OF WEST VANCOUVER
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS

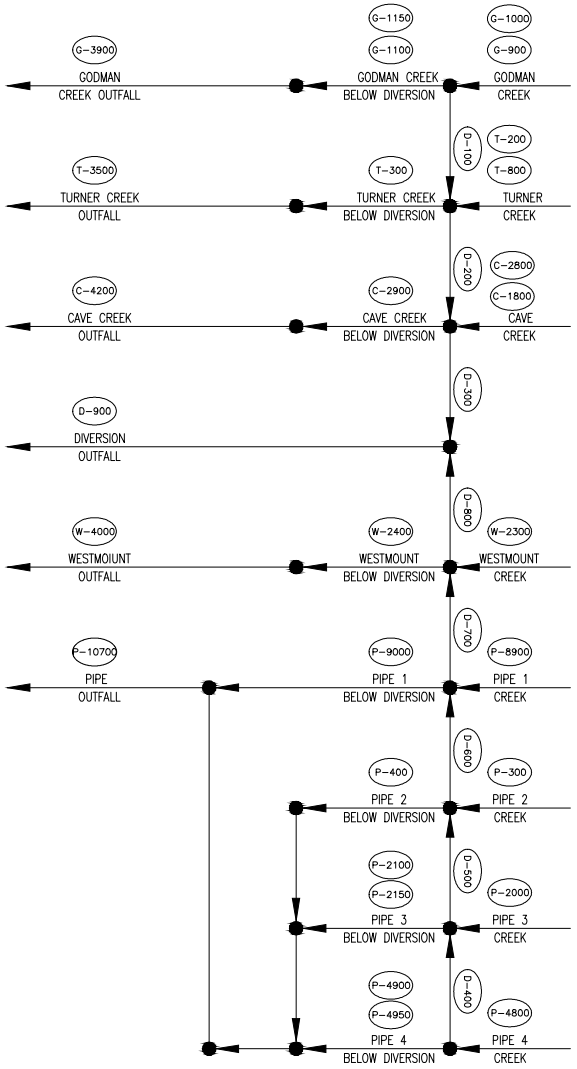
APPENDIX P

DIVERSION SCHEMATIC AND FLOW TABLES

LEGEND

CHANNEL/PIPE

P10700 PCSWMM CONDUIT ID



DISTRICT OF WEST VANCOUVER
DIVERSION SCHEMATIC

FIGURE P-1

OPUS DAYTONKNIGHT
North Vancouver Office
+1 604 9904800
DRAWN BY: GZ
210 - 889 Harbourside Drive
North Vancouver, BC
V7P 3S1, CANADA
DWG. No.D-032A0.00

Table P-1: DIVERSION FLOWS

ID	Watercourse	Description	Scenario 1	Scenario 2	Scenario 3	Scenario 4
			Peak Instantaneous Flow (m^3/s)[1]	Peak Instantaneous Flow (m^3/s)[1]	Peak Instantaneous Flow (m^3/s)[1]	Peak Instantaneous Flow (m^3/s)[1]
G-1000 & G-900	Godman Creek	Creek Flow Above Diversion	14.6	15.4	15.4	15.4
G-1150 & G-1100	Godman Creek	Creek Flow Below Diversion	2.2	2.2	2.2	9.9
D-100	Diversion Pipe	Diverted Flow	11.8	12.5	12.5	3.8
G-3900	Godman Creek	Outfall at Burrard Inlet	8.0	8.7	9.3	15.3
T-200 & T-800	Turner Creek	Creek Flow Above Diversion	3.5	3.5	3.5	3.5
T-300	Turner Creek	Creek Flow Below Diversion	0.5	0.5	0.5	1.8
D-200	Diversion Pipe	Diverted Flow	2.8	2.8	2.8	1.5
T-3500	Turner Creek	Outfall at Burrard Inlet	3.5	3.5	4.0	4.5
C-2800 & C-1800	Cave Creek	Creek Flow Above Diversion	6.9	6.9	6.9	6.9
C-2900	Cave Creek	Creek Flow Below Diversion	1.1	1.1	1.1	4.7
D-300	Diversion Pipe	Diverted Flow	5.5	5.5	5.5	2.2
C-4200	Cave Creek	Outfall at Burrard Inlet	3.2	3.2	3.4	6.7
P-4800	Pipe Creek	Creek Flow Above Diversion	5.6	5.6	5.6	5.5
P-4900 & P-4950	Pipe Creek	Creek Flow Below Diversion	0.9	0.8	0.8	3.9
D-400	Diversion Pipe	Diverted Flow	4.7	4.7	4.7	1.5
P-2000	Pipe Creek	Creek Flow Above Diversion	2.0	2.0	2.0	2.0
P-2100 & P-2150	Pipe Creek	Creek Flow Below Diversion	0.3	0.3	0.3	1.5
D-500	Diversion Pipe	Diverted Flow	1.7	1.7	1.7	0.5
P-300	Pipe Creek	Creek Flow Above Diversion	0.5	0.5	0.5	0.5
P-400	Pipe Creek	Creek Flow Below Diversion	0.05	0.05	0.05	0.4
D-600	Diversion Pipe	Diverted Flow	0.4	0.5	0.5	0.1
P-8900	Pipe Creek	Creek Flow Above Diversion	7.4	7.4	7.4	7.4
P-9000	Pipe Creek	Creek Flow Below Diversion	1.0	1.1	1.1	5.9
D-700	Diversion Pipe	Diverted Flow	6.2	6.2	6.2	1.2
P-10700	Pipe Creek	Outfall to Burrard Inlet	6.0	6.0	6.3	14.8
W-2300	Westmount Creek	Creek Flow Above Diversion	6.8	6.8	6.8	6.8
W-2400	Westmount Creek	Creek Flow Below Diversion	1.1	1.1	1.1	4.2
D-800	Diversion Pipe	Diverted Flow	5.6	5.6	5.6	2.6
W-4000	Westmount Creek	Outfall at Burrard Inlet	4.6	4.7	4.9	7.6

[1] Peak Instantaneous Flows do not always occur at the same time during the simulation, so the various peak flows at each diversion location do not always add up exactly. Continuity has been checked in all instances.

Table P-2: TOTAL FLOWS IN DIVERSION PIPE

ID	Watercourse	Description	Scenario 1	Scenario 2	Scenario 3	Scenario 4
			Peak Instantaneous Flow (m^3/s)[1]	Peak Instantaneous Flow (m^3/s)[1]	Peak Instantaneous Flow (m^3/s)[1]	Peak Instantaneous Flow (m^3/s)[1]
D-100	Diversion Pipe	Flow in Diversion Pipe	11.8	12.5	12.5	3.8
D-200	Diversion Pipe	Flow in Diversion Pipe	14.5	15.1	15.1	5.3
D-300	Diversion Pipe	Flow in Diversion Pipe	19.6	20.4	20.4	7.1
D-400	Diversion Pipe	Flow in Diversion Pipe	4.7	4.7	4.7	1.5
D-500	Diversion Pipe	Flow in Diversion Pipe	6.0	6.0	6.0	1.7
D-600	Diversion Pipe	Flow in Diversion Pipe	6.4	6.4	6.4	1.7
D-700	Diversion Pipe	Flow in Diversion Pipe	12.2	12.1	12.1	2.7
D-800	Diversion Pipe	Flow in Diversion Pipe	17.2	17.2	17.2	5.0
D-900	Diversion Pipe	Outfall at Burrard Inlet	34.8	35.6	35.6	9.9

[1] Peak Instantaneous Flows do not always occur at the same time during the simulation, so the various peak flows in each section of the diversion pipe do not always add up exactly. Continuity has been checked in all instances.

DISTRICT OF WEST VANCOUVER
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS

APPENDIX Q

NHC FLOW MONITORING REPORT AND ICAD FIGURE OF MONITORING CATCHMENTS

30 Gostick Place | North Vancouver, BC V7M 3G3 | 604.980.6011 | www.nhcweb.com

nhc
northwest hydraulic consultants

34875

May 5th, 2010

InterCAD Services Ltd.
1111 West 8th Avenue
Vancouver, B.C. V6H 1C5
Tel (604) 739-7707 Fax (604) 739-7727

Attention: Iain Lowe, P.Eng.

Dear Mr. Lowe:

Subject: **West Vancouver Hydrometric Monitoring Program**
Project Completion

Northwest Hydraulic Consultants Ltd. (NHC) is pleased to provide you with 2 years of discharge and water temperature data for the West Vancouver hydrometric monitoring program at Pipe, Cave, and Godman Creeks. Stream stage and stream water temperature have been recorded at a 10-min interval since March/April 2008 at two locations on each creek: 1) lower in the watershed near tidewater and within developed areas, and 2) above proposed development. Air temperature was recorded at the lower Pipe Creek site.

Please see attached hourly and daily stream stage, discharge, and water temperature data at each site for the period of record in the attached worksheets, where air temperature was measured at the lower Pipe Creek site. Instrumentation problems have resulted in a short data gap at each site (19 days) for the period October 12-30, 2009.

Figure 1 through Figure 12 provide stage-discharge rating curves, daily discharge hydrographs, and water temperature at each site, with air temperature from the lower Pipe Creek site. The error for discharge measurements used in the development of site-specific stage-discharge rating curves is estimated to be ±10. Discharge was measured using several methods including: salt dilution, velocity-area, and volumetric flow rate.

If you have any questions or comments, please do not hesitate to contact us at 604.980.6011.

Sincerely,

northwest hydraulic consultants

Piotr Kuraś, M.A.Sc., RPF, EIT

DISCLAIMER

This document has been prepared by Northwest Hydraulic Consultants Ltd. In accordance with generally accepted engineering and geoscience practices and is intended for the exclusive use and benefit of the client for whom it was prepared and for the particular purpose for which it was prepared. No other warranty, expressed or implied, is made.

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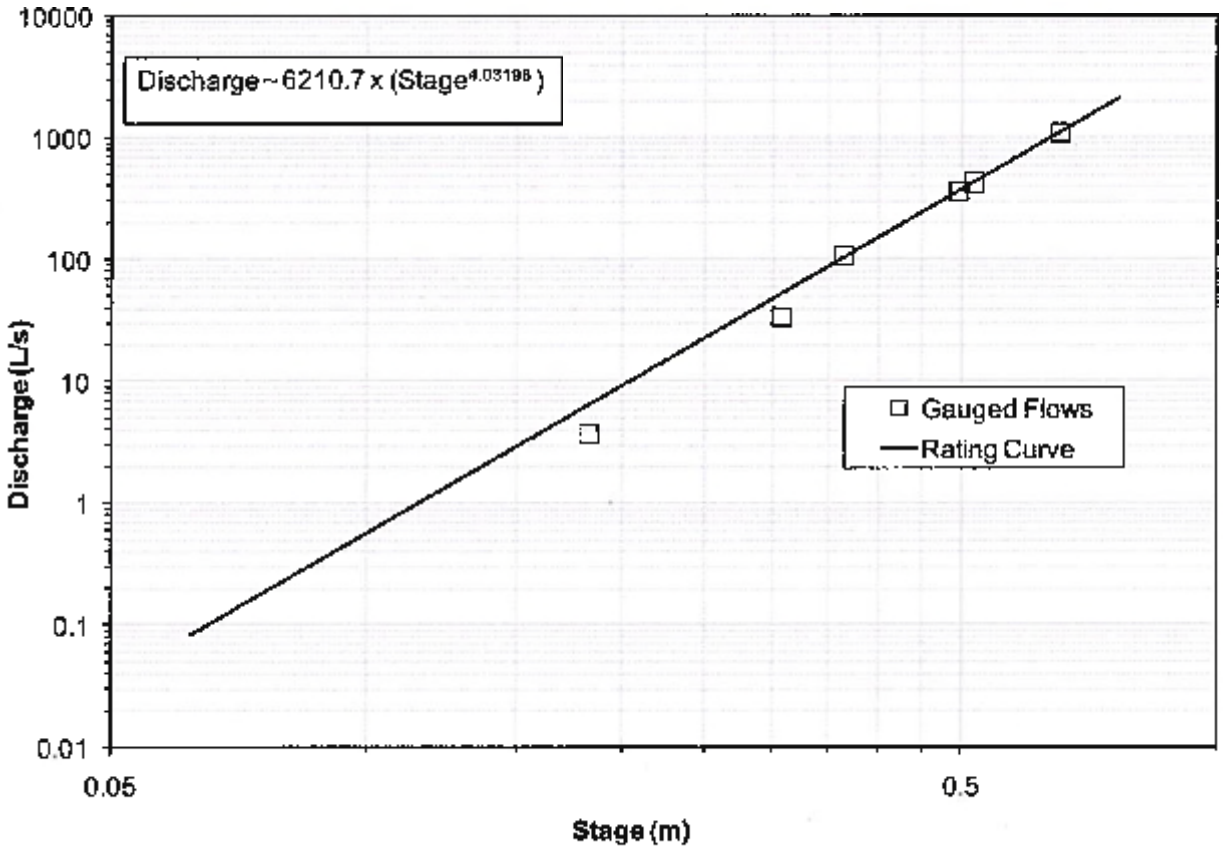


Figure 1. Upper Godman Creek stage-discharge rating curve; discharge measurement error is estimated to be ±10%.

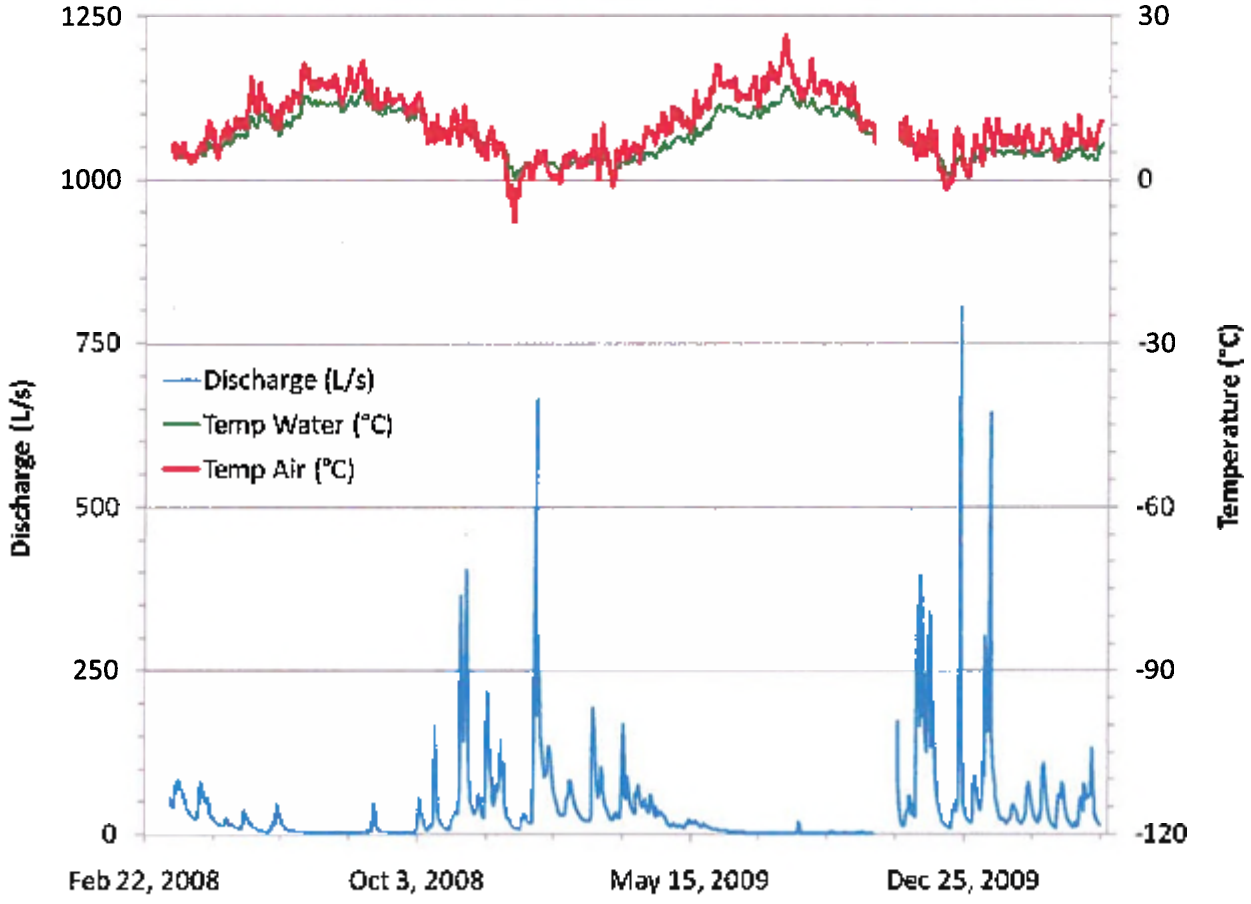


Figure 2. Upper Godman Creek daily discharge hydrograph (L/s) with daily water and air temperature (°C); air temperature was measured at the lower Pipe Creek site.

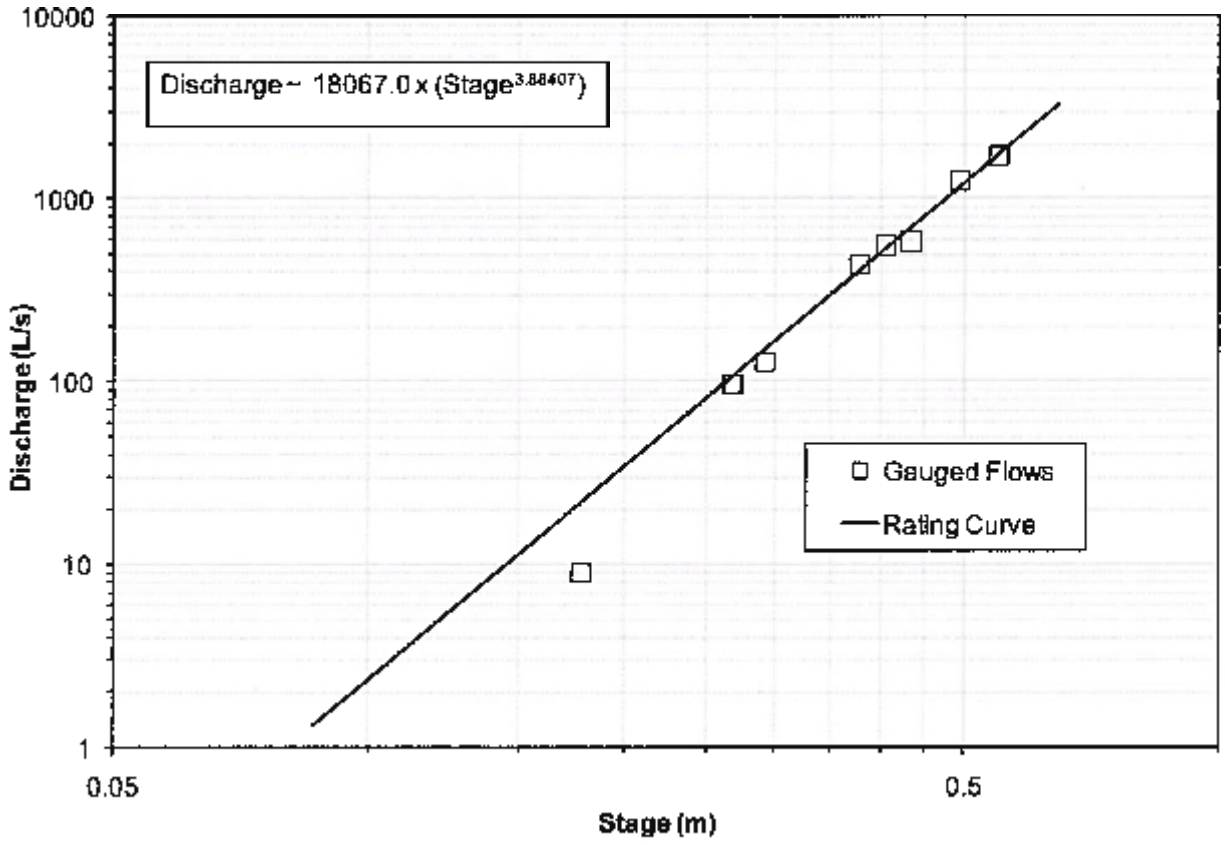


Figure 3. Lower Godman Creek stage-discharge rating curve; discharge measurement error is estimated to be ±10%.

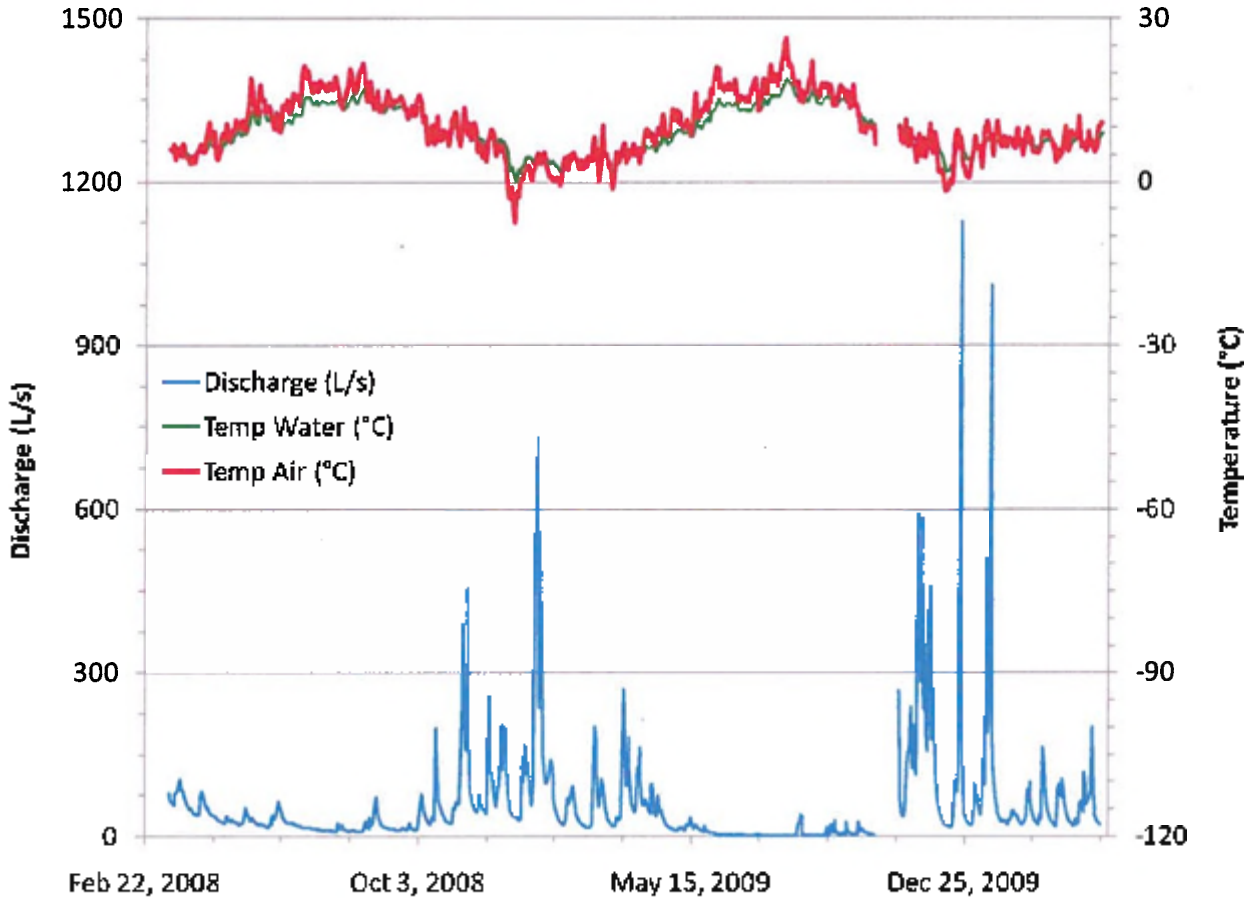


Figure 4. Lower Godman Creek daily discharge hydrograph (L/s) with daily water and air temperature (°C); air temperature was measured at the lower Pipe Creek site.

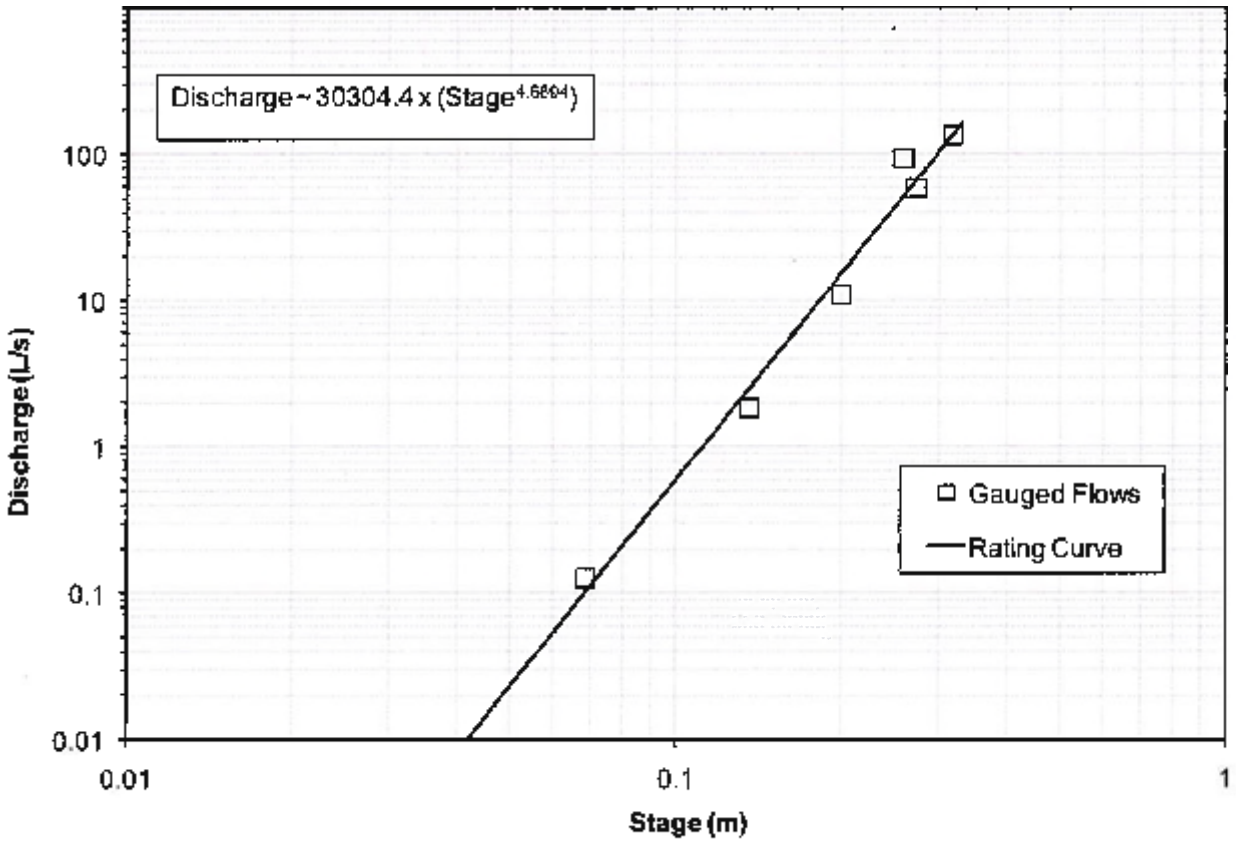


Figure 5. Upper Cave Creek stage-discharge rating curve; discharge measurement error is estimated to be ±10%.

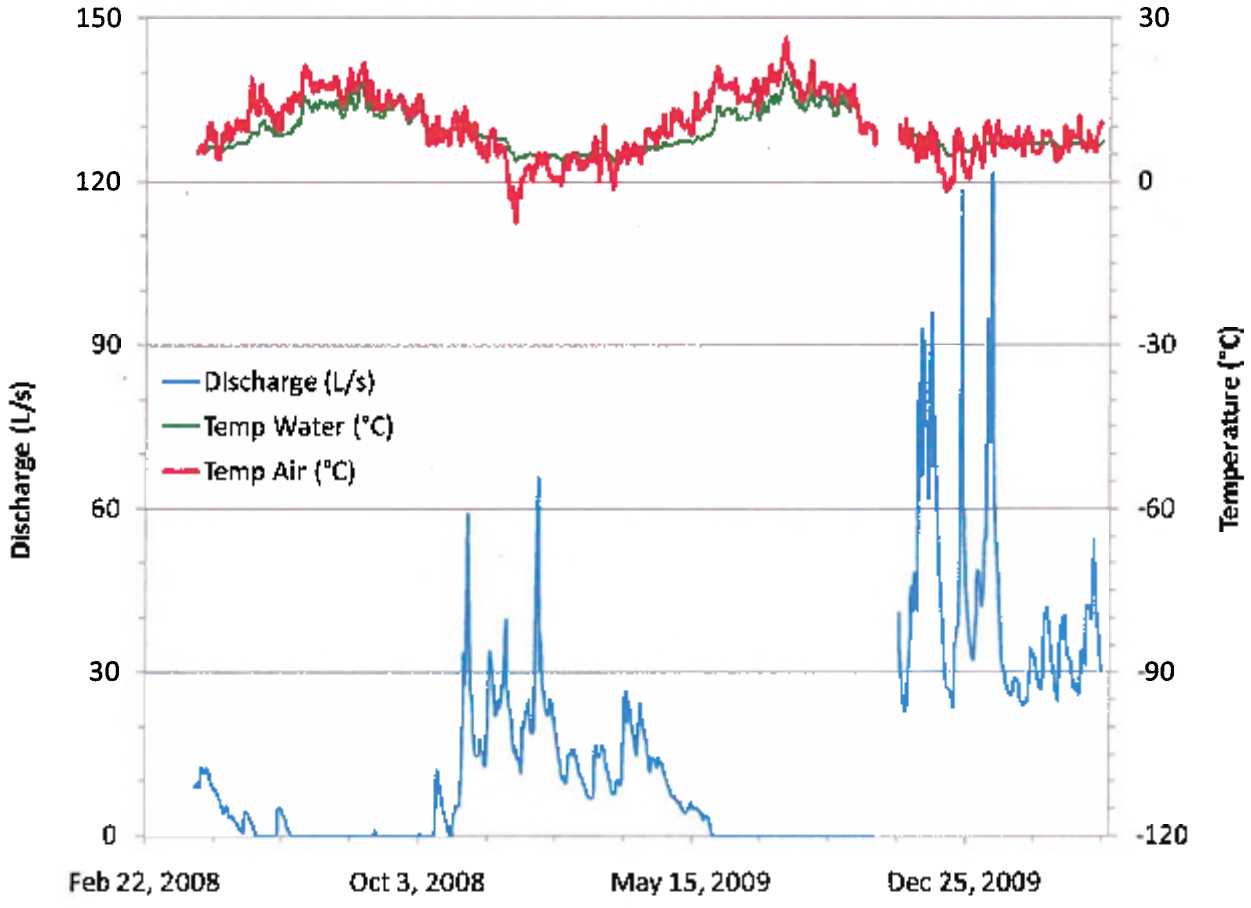


Figure 6. Upper Cave Creek daily discharge hydrograph (L/s) with daily water and air temperature (°C); air temperature was measured at the lower Pipe Creek site.

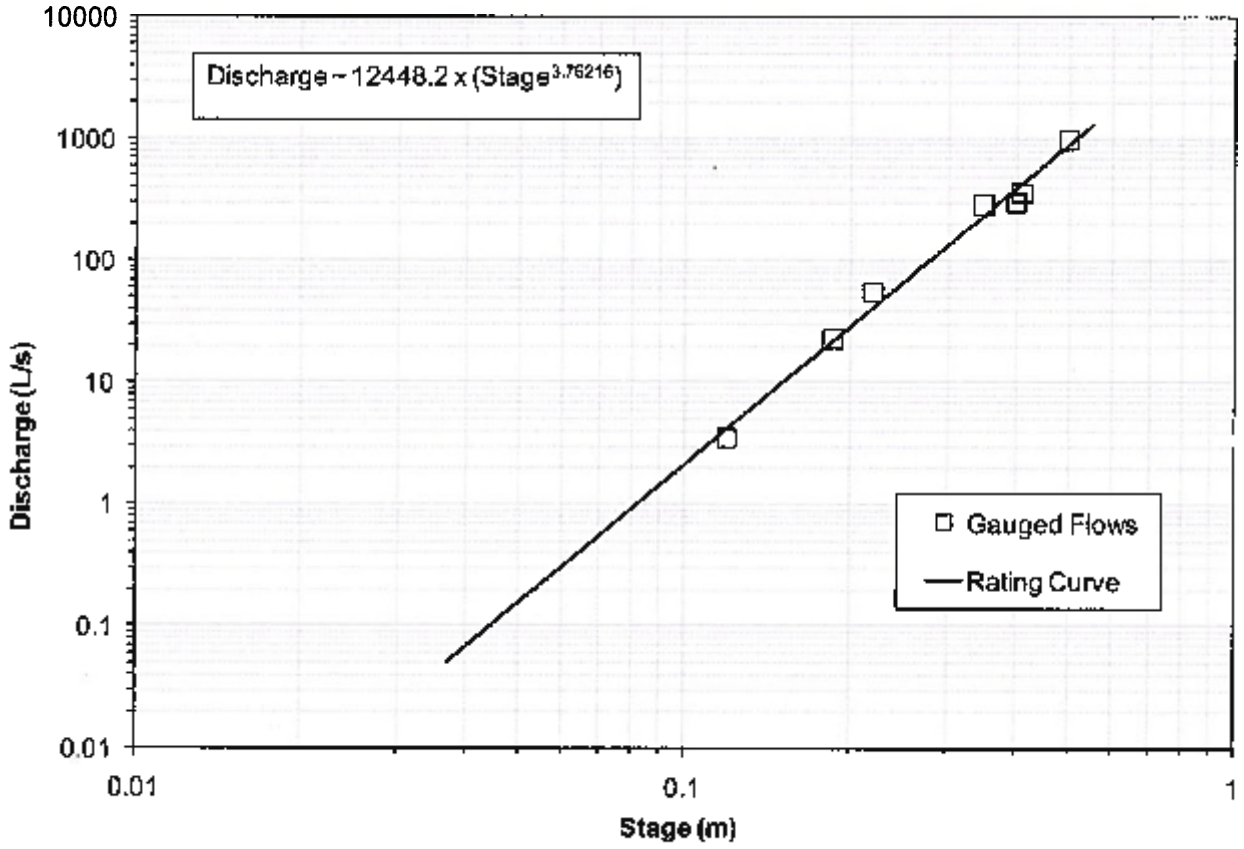


Figure 7. Lower Cave Creek stage-discharge rating curve; discharge measurement error is estimated to be ±10%.

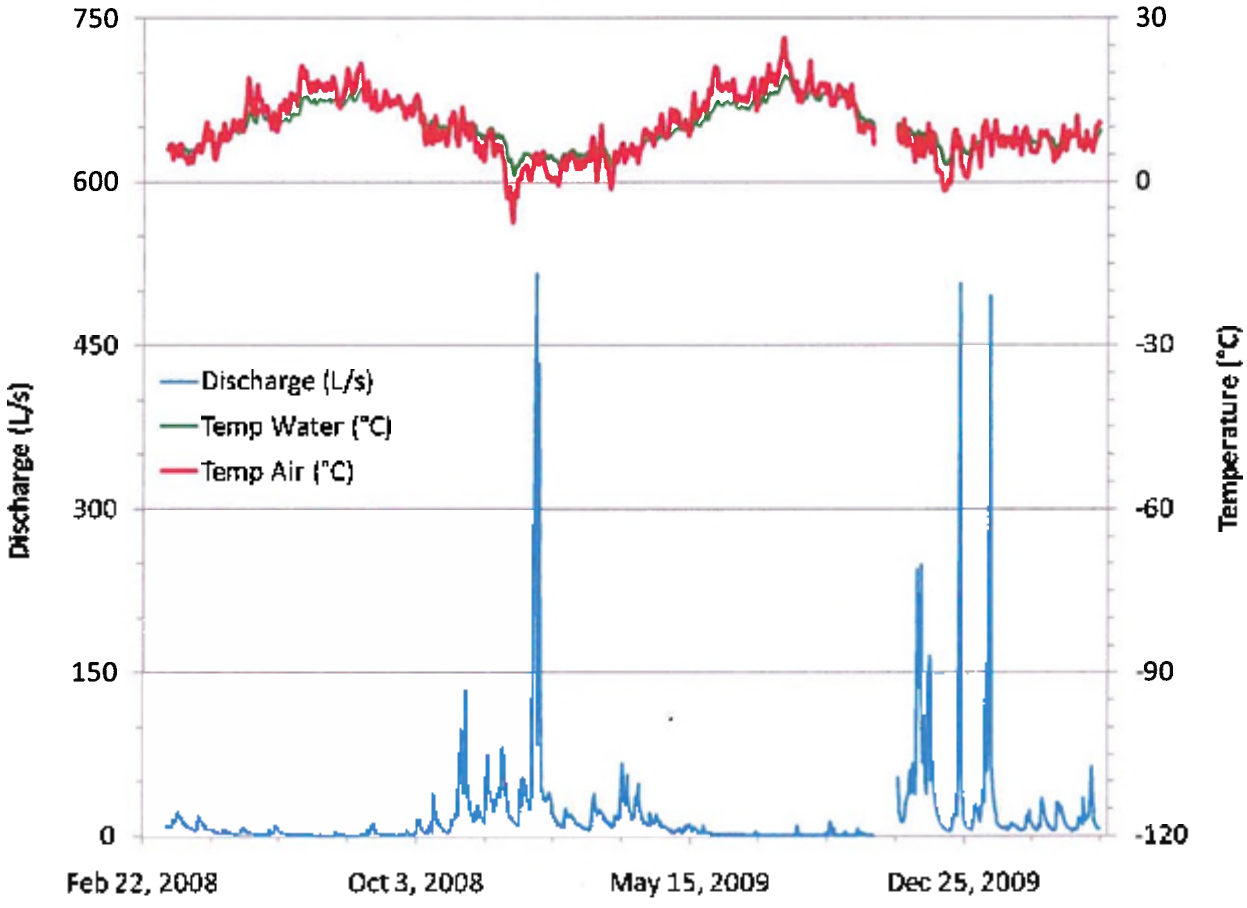


Figure 8. Lower Cave Creek daily discharge hydrograph (L/s) with daily water and air temperature (°C); air temperature was measured at the lower Pipe Creek site.

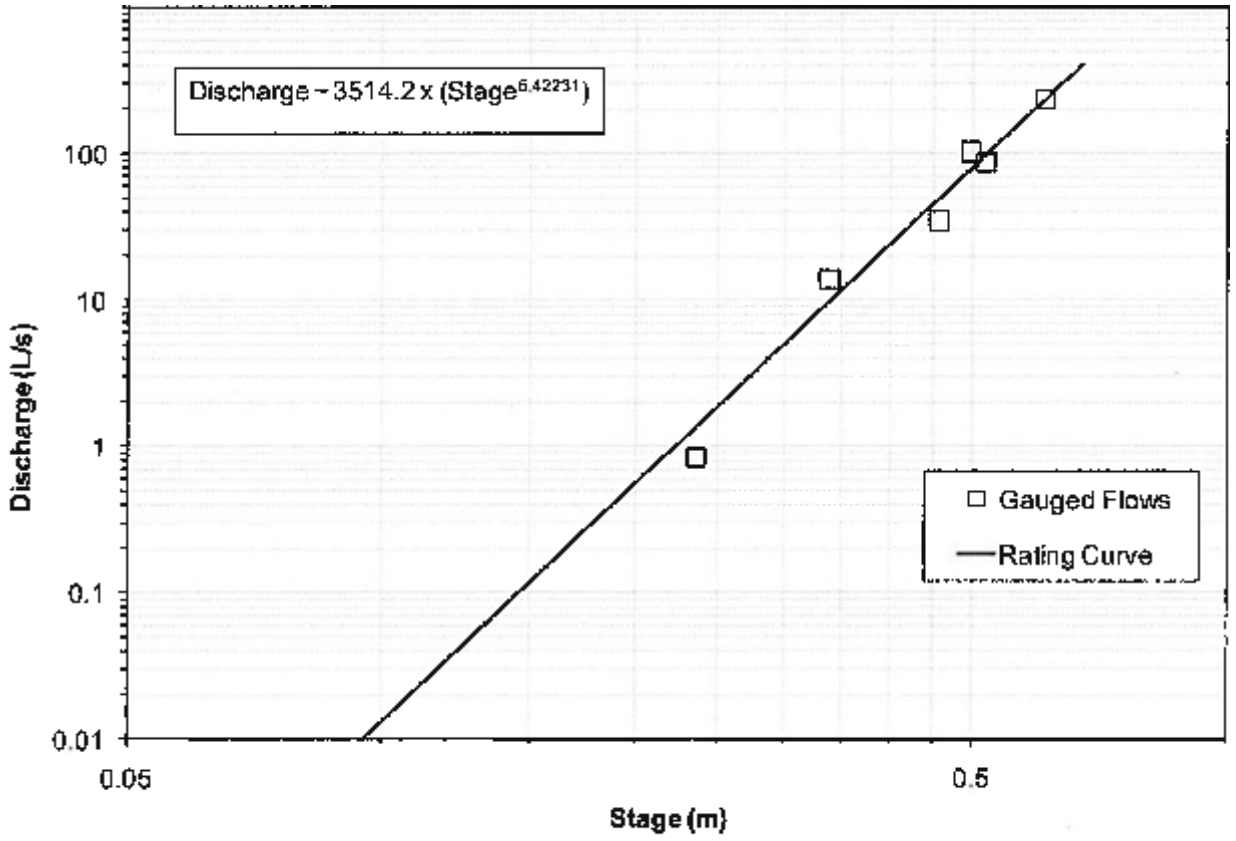


Figure 9. Upper Pipe Creek stage-discharge rating curve; discharge measurement error is estimated to be ±10%.

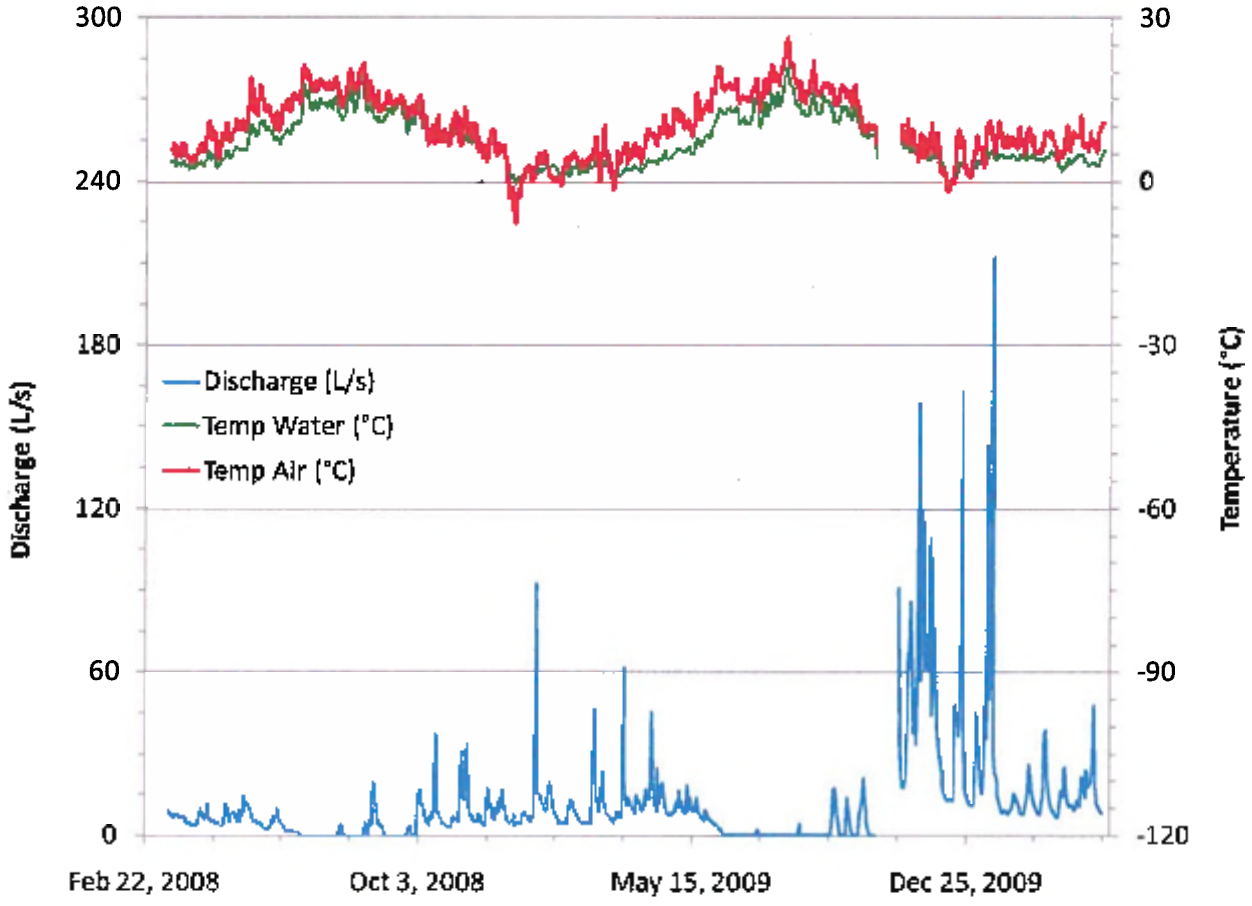


Figure 10. Upper Pipe Creek daily discharge hydrograph (L/s) with daily water and air temperature (°C); air temperature was measured at the lower Pipe Creek site.

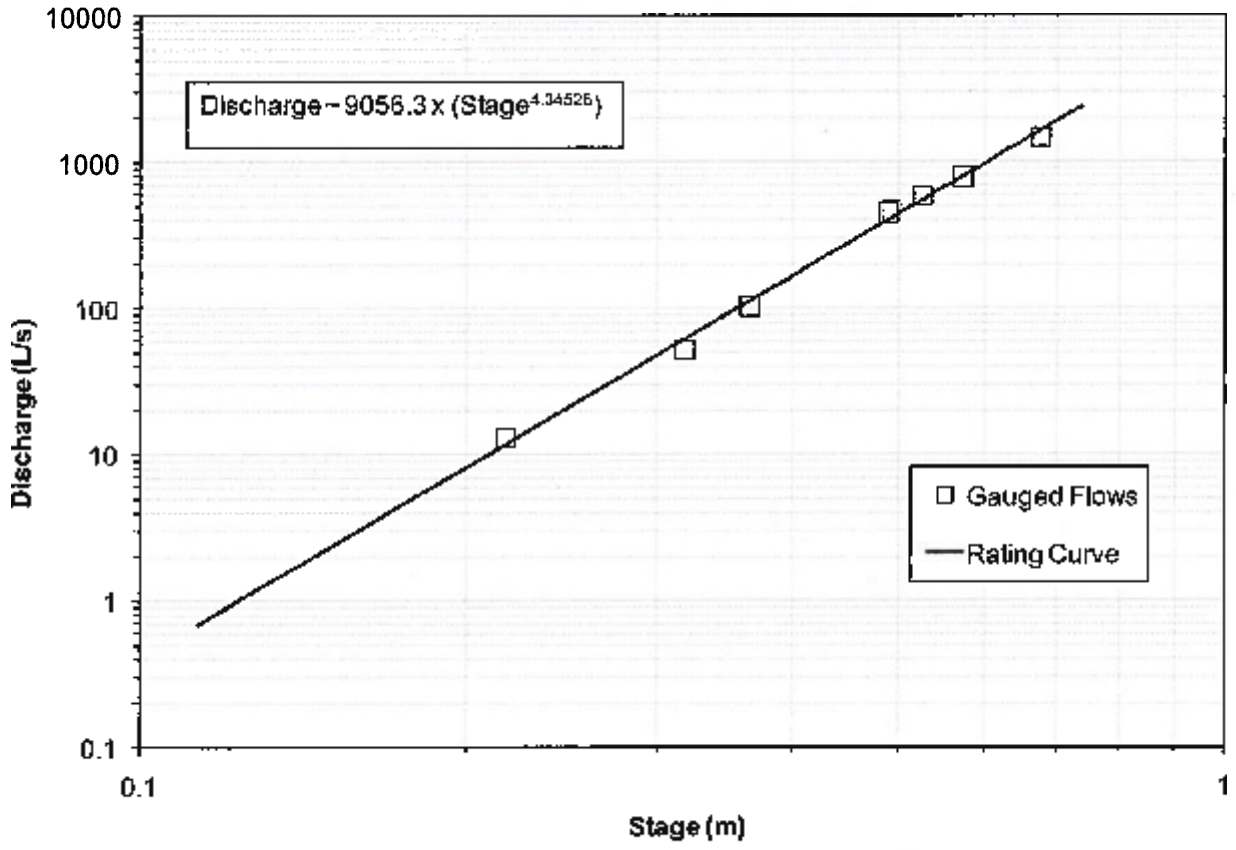


Figure 11. Lower Pipe Creek stage-discharge rating curve; discharge measurement error is estimated to be ±10%.

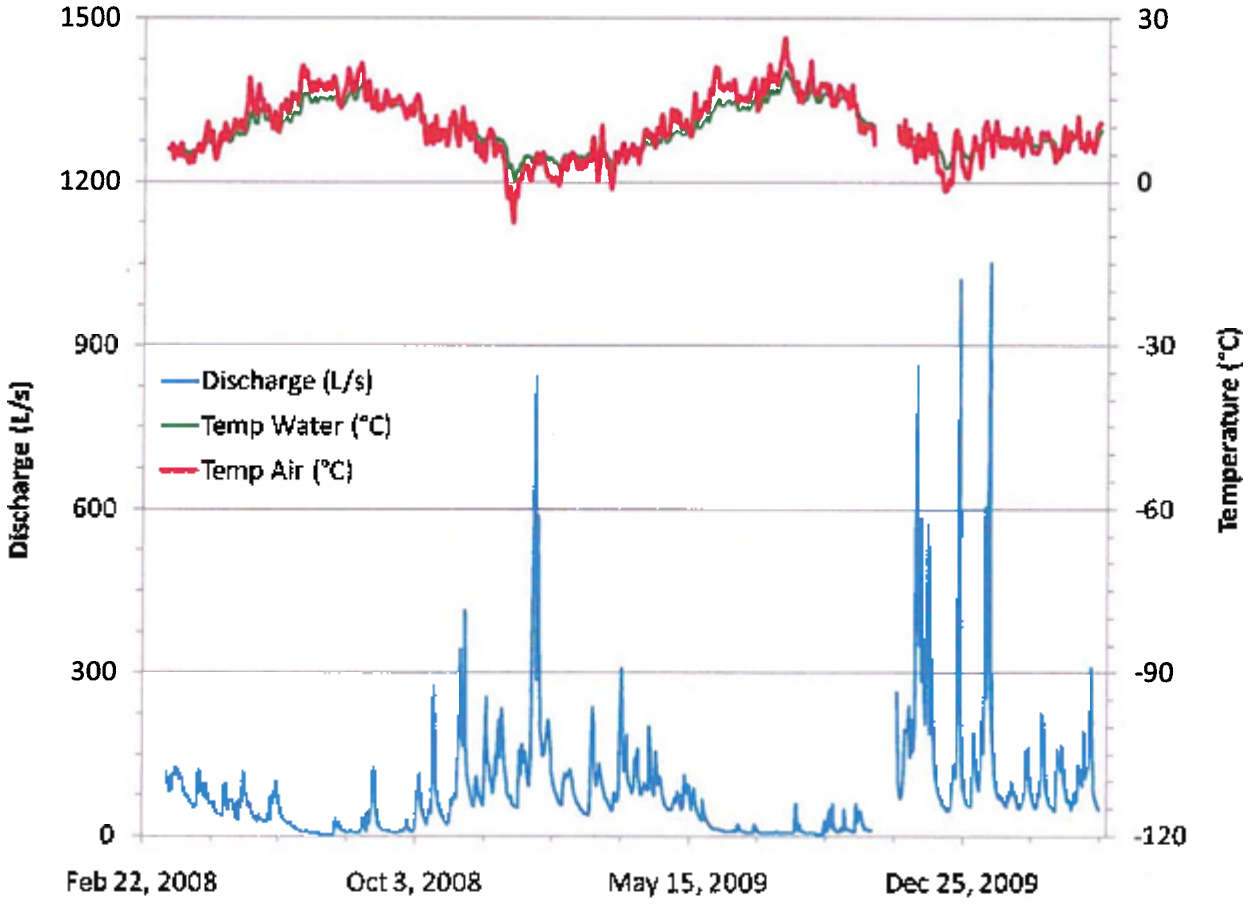
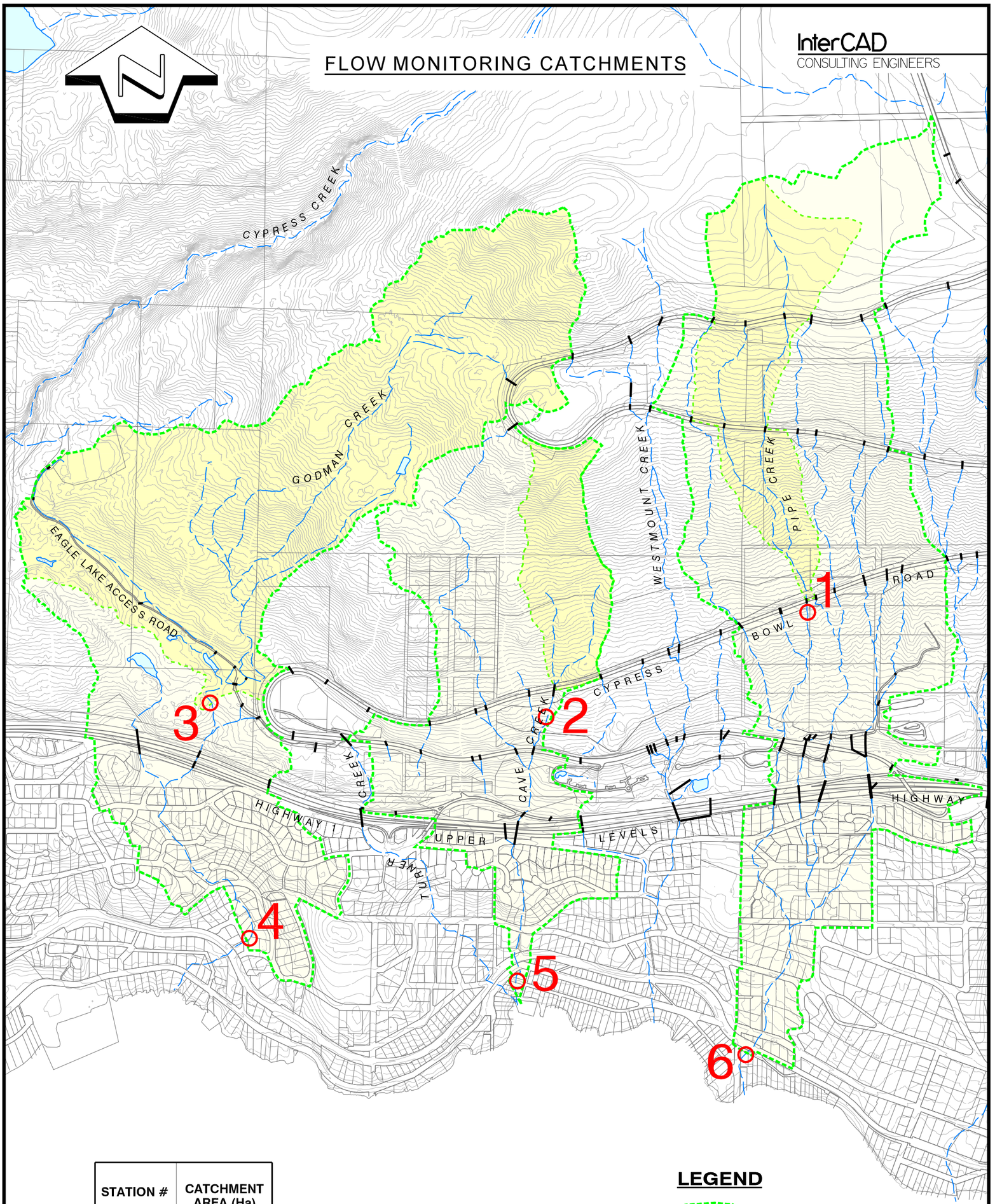


Figure 12. Lower Pipe Creek daily discharge hydrograph (L/s) with daily water and air temperature (°C); air temperature was measured at the lower Pipe Creek site.

FLOW MONITORING CATCHMENTS

InterCAD
CONSULTING ENGINEERS



STATION #	CATCHMENT AREA (Ha)
1	33
2	17
3	119
4	173
5	89
6	170

LEGEND

- CATCHMENT BOUNDARY
- DRAINAGE PATH
- EXISTING CULVERT
- FLOW MONITORING STATION

Title
Flow Monitoring Catchment Areas

Date
November 2011

Scale
1:12500

Drawing Number
Figure 1

British Pacific Properties Ltd.
Rodgers Creek Neighbourhood Development

DISTRICT OF WEST VANCOUVER
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS

APPENDIX R

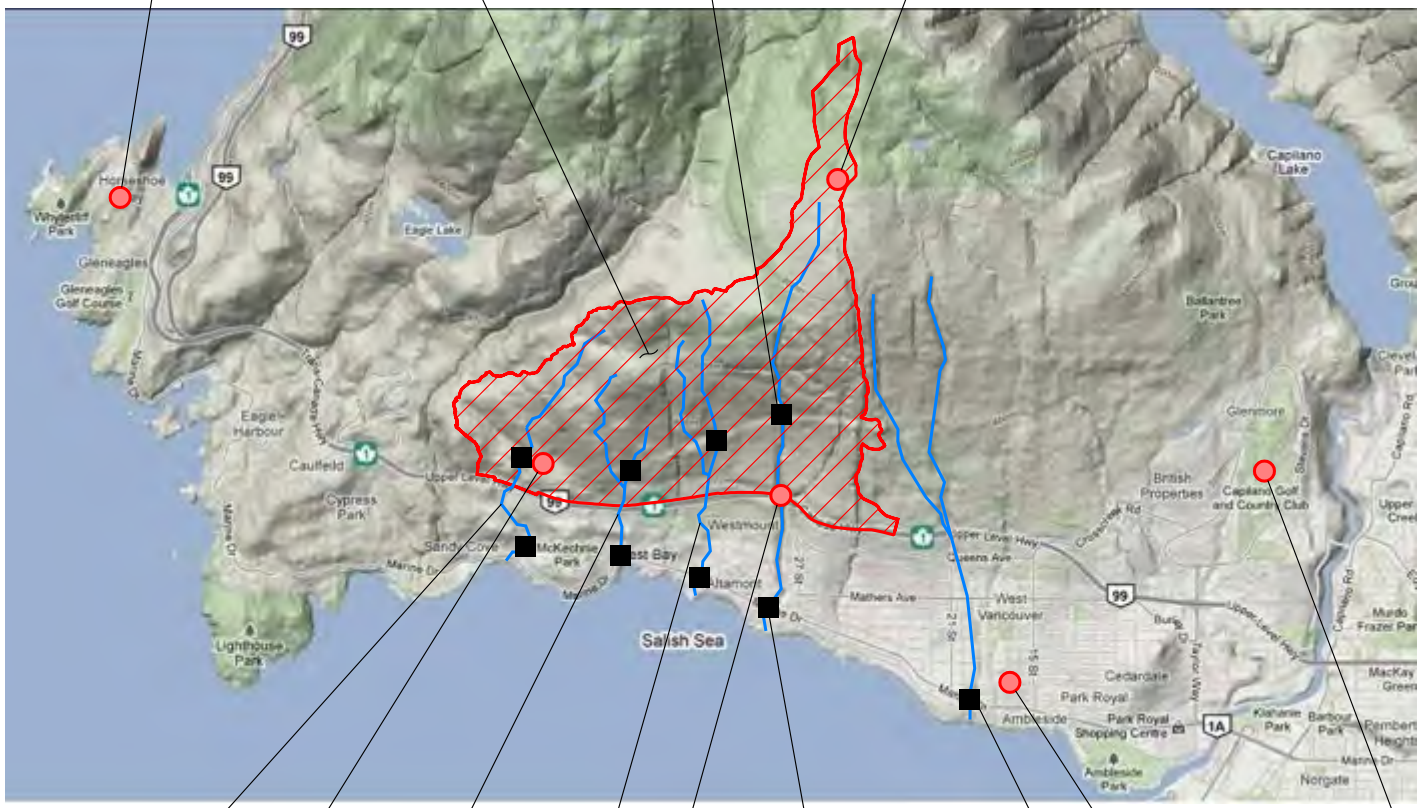
REVIEW OF RAINFALL EVENTS DURING THE FLOW MONITORING PERIOD

British Pacific Properties Ltd.
Rodgers Creek Neighbourhood Development
Cypress Bowl Road Drainage Analysis

Date
March 23, 2011

Scale
1:75000

Drawing Number
Figure C.1



RAINFALL & STREAM FLOW MONITORING SITES

FIGURE R-1: DECEMBER 21, 2009 RAINFALL EVENT

Rainfall Gauge Location	Peak Rainfall Intensity (mm/hr)	Storm Duration (hr)	Time to Peak (hr)	Time of Peak (dd/mm/yyyy hh:mm)	Total Volume of Rainfall (mm)
Madrona	18.0	33.6	14.1	20/12/2009 15:30	92.0
Works Yard	18.0	29.8	25.8	21/12/2009 6:30	89.5
District Hall (VW 14)	12.0	30.7	11.8	20/12/2009 15:40	55.8
Capilano Golf Club (VW 51)	12.0	30.8	8.1	20/12/2009 12:00	70.4
Cypress Ranger Station	18.3	33.2	13.9	20/12/2009 15:40	142.7

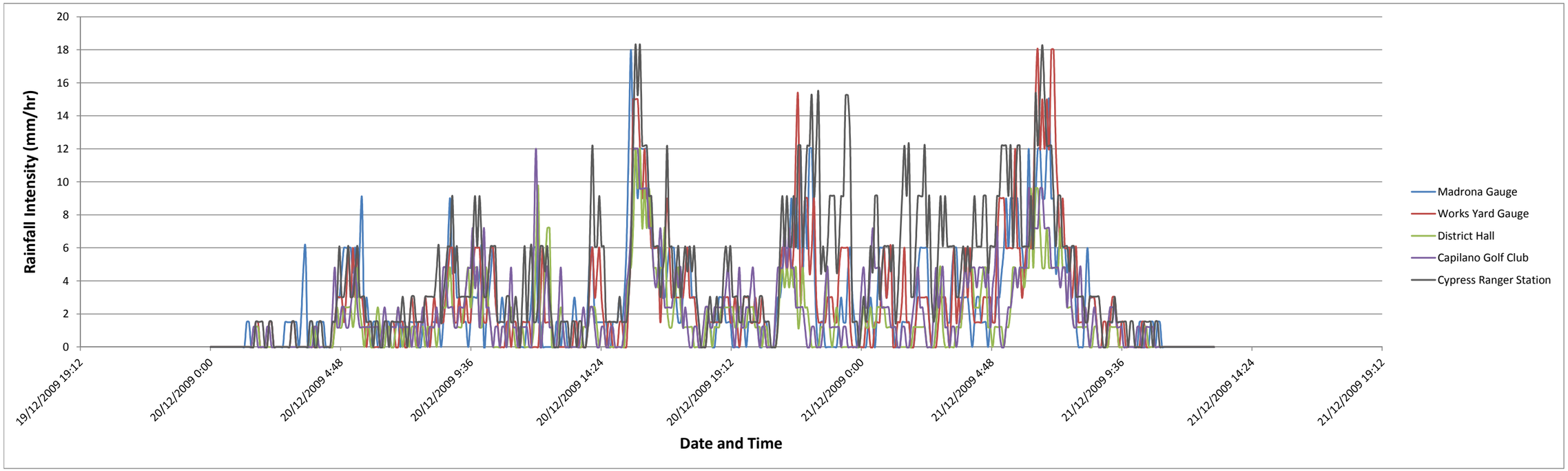


FIGURE R-2: JANUARY 15, 2010 RAINFALL EVENT

Rainfall Gauge Location	Peak Rainfall Intensity (mm/hr)	Storm Duration (hr)	Time to Peak (hr)	Time of Peak (dd/mm/yyyy hh:mm)	Total Volume of Rainfall (mm)
Madrona	12.0	26.7	19.6	15/01/2010 4:00	83.3
Works Yard	12.0	26.6	14.6	14/01/2010 22:50	101.3
District Hall (VW 14)	7.2	27.7	6.8	14/01/2010 13:50	79.8
Capilano Golf Club (VW 51)	7.2	29.2	15.7	14/01/2010 21:40	81.0
Cypress Ranger Station	9.1	27.9	1.8	14/01/2010 8:50	85.1

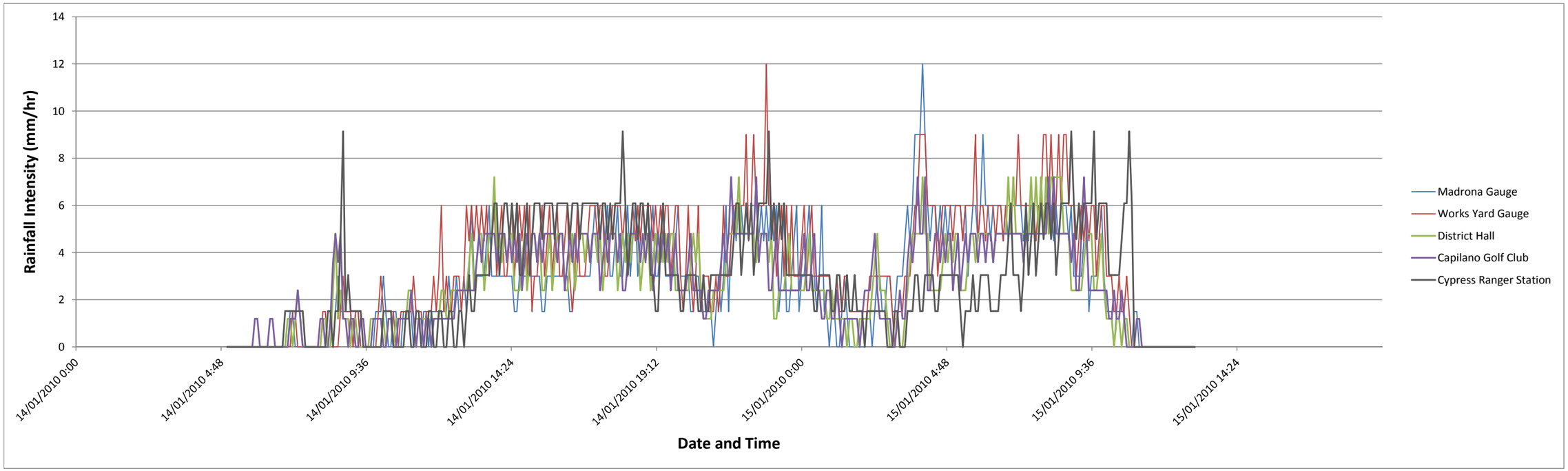


FIGURE R-3: JANUARY 7, 2009 RAINFALL EVENT

Rainfall Gauge Location	Peak Rainfall Intensity (mm/hr)	Storm Duration (hr)	Time to Peak (hr)	Time of Peak (dd/mm/yyyy hh:mm)	Total Volume of Rainfall (mm)
Madrona	6.0	10.2	1.8	07/01/2009 17:55	24.5
Works Yard	6.0	10.9	1.5	07/01/2009 16:55	33.0
District Hall (VW 14)	0.0	0.0	-	-	0.0
Capilano Golf Club (VW 51)	9.6	11.6	1.7	07/01/2009 16:30	36.4
Cypress Ranger Station	12.2	10.3	3.1	07/01/2009 19:10	46.7

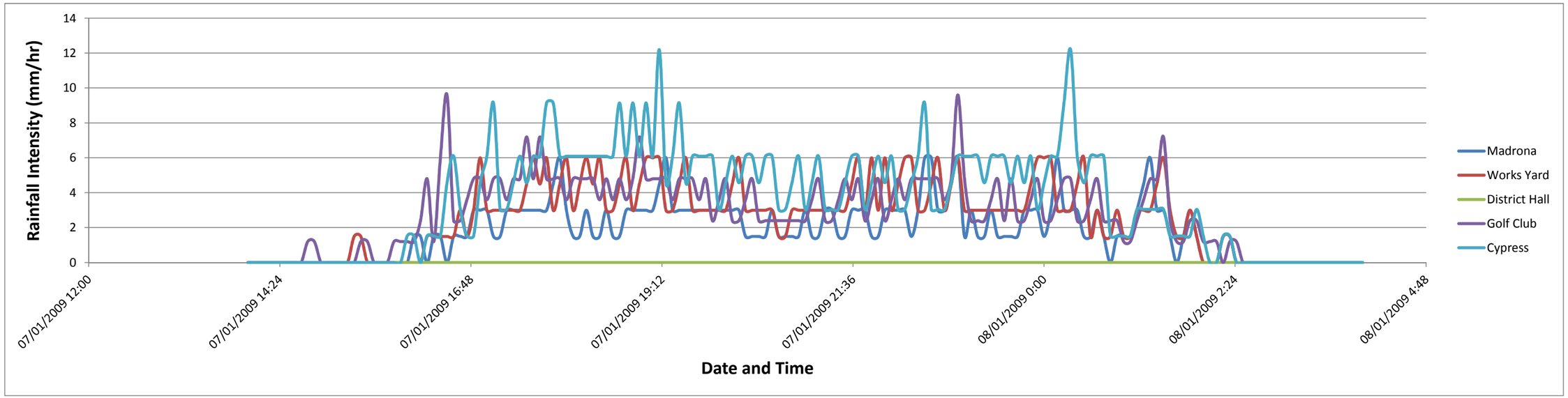


FIGURE R-4: SEPTEMBER 6, 2009 RAINFALL EVENT

Rainfall Gauge Location	Peak Rainfall Intensity (mm/hr)	Storm Duration (hr)	Time to Peak (hr)	Time of Peak (dd/mm/yyyy hh:mm)	Total Volume of Rainfall (mm)
Madrona	12.0	1.1	0.6	06/09/2009 19:15	3.3
Works Yard	48.0	1.2	0.6	06/09/2009 19:25	17.8
District Hall (VW 14)	2.4	2.0	0.0	06/09/2009 17:00	1.0
Capilano Golf Club (VW 51)	4.8	2.1	1.3	06/09/2009 18:15	2.2
Cypress Ranger Station	3.0	2.0	0.0	-	5.1

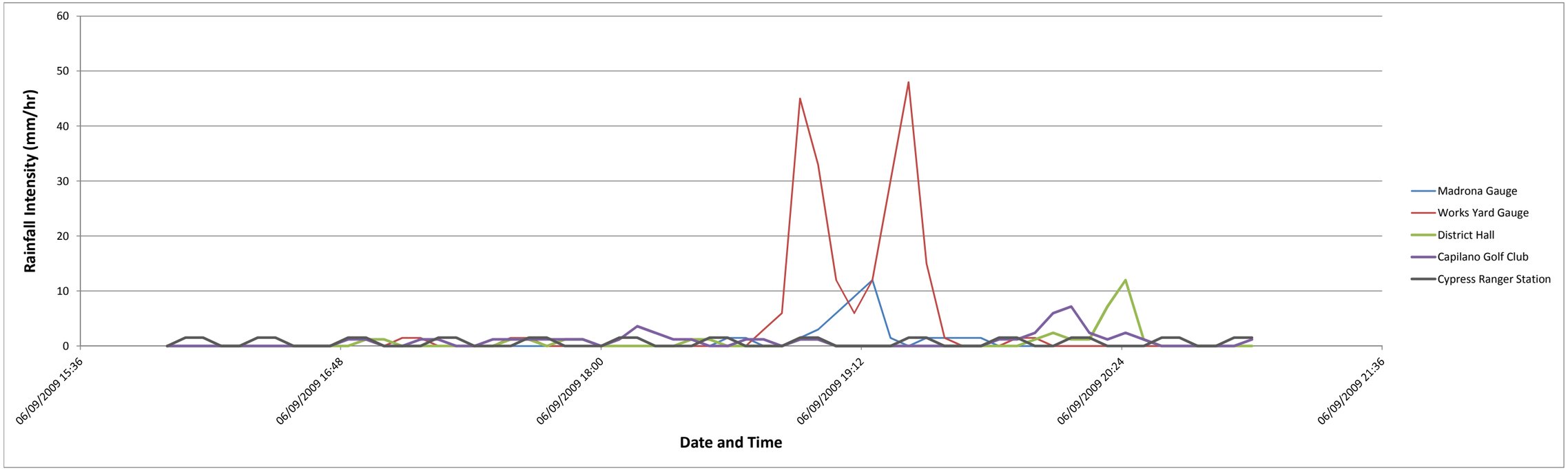
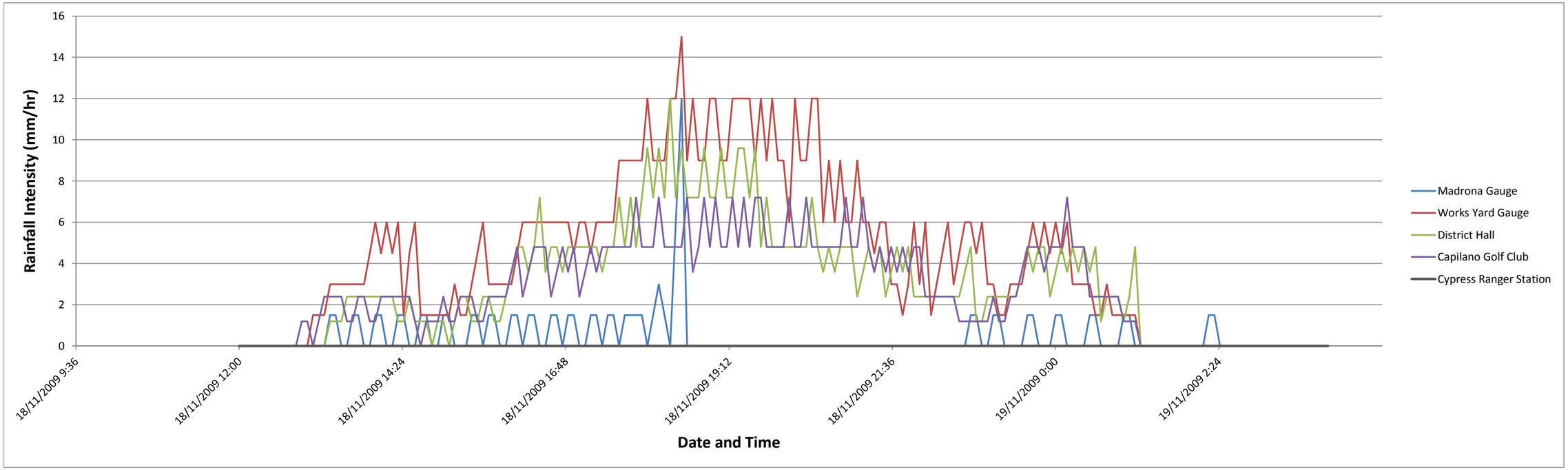


FIGURE R-5: NOVEMBER 18, 2009 RAINFALL EVENT

Rainfall Gauge Location	Peak Rainfall Intensity (mm/hr)	Storm Duration (hr)	Time to Peak (hr)	Time of Peak (dd/mm/yyyy hh:mm)	Total Volume of Rainfall (mm)
Madrona	12.0	12.9	5.1	18/11/2009 18:30	7.3
Works Yard	15.0	12.0	5.3	18/11/2009 18:30	65.8
District Hall (VW 14)	12.0	11.8	4.9	18/11/2009 18:20	46.6
Capilano Golf Club (VW 51)	7.2	12.2	4.8	18/11/2009 17:50	42.8
Cypress Ranger Station	0.0	0.0	0.0	-	0.0



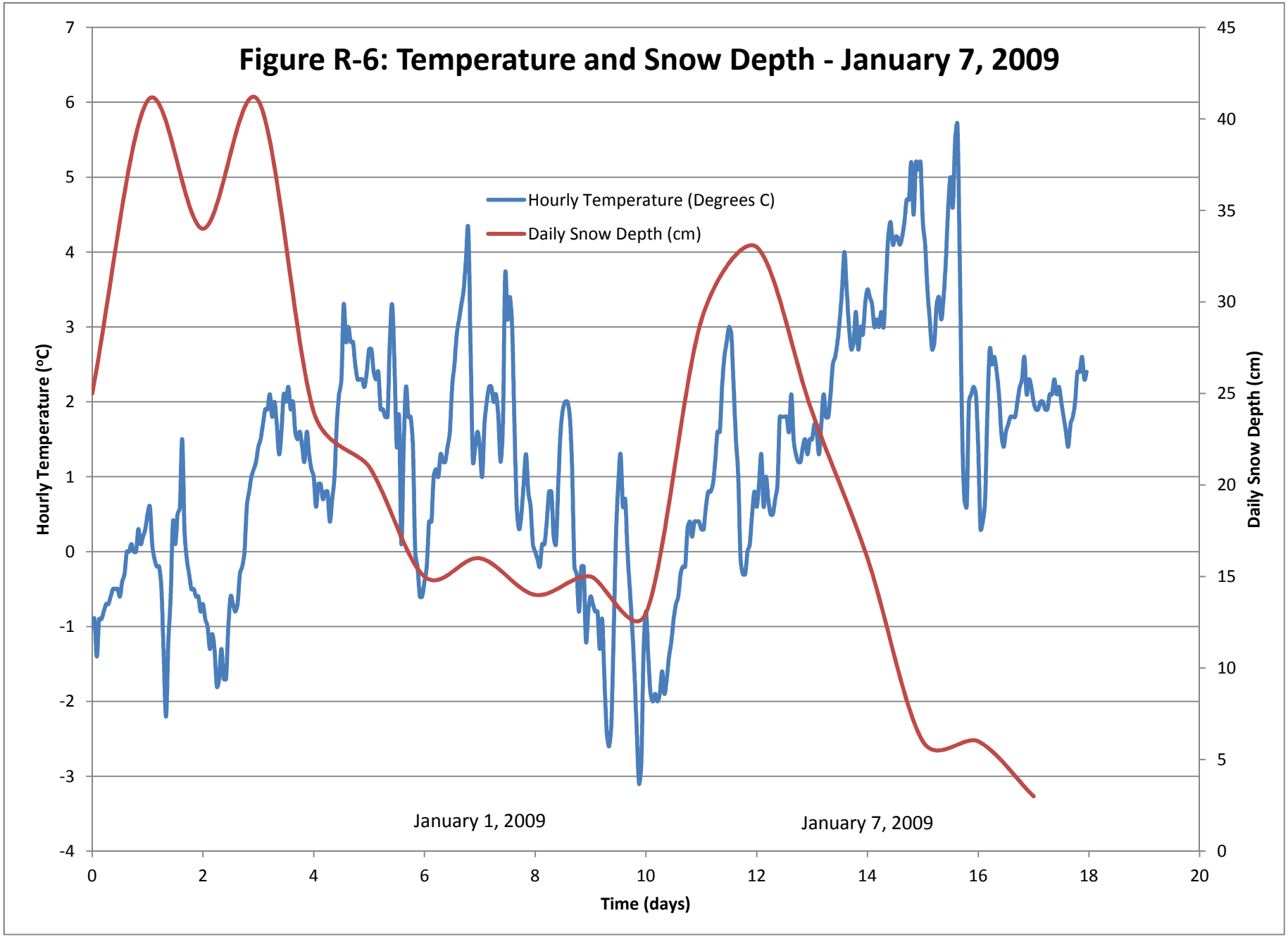


Figure R-6: Temperature and Snow Depth - January 7, 2009
Hourly Temperature (Degrees C)
Daily Snow Depth (cm)
Hourly Temperature (°C)
Daily Snow Depth (cm)
Time (days)
January 1, 2009
January 7, 2009
7
6
5
4
3
2
1
0
-1
-2
-3
-4
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
20

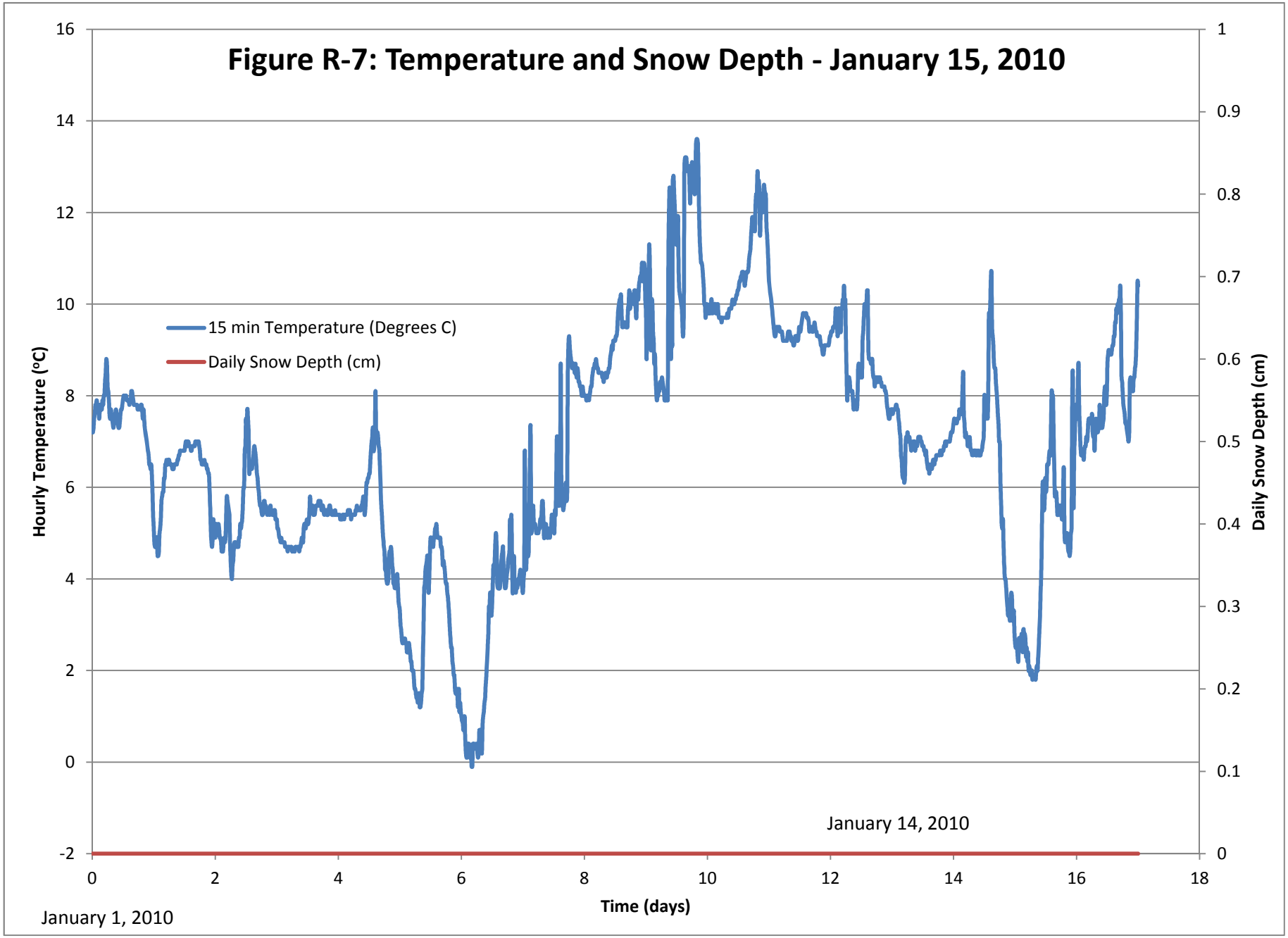
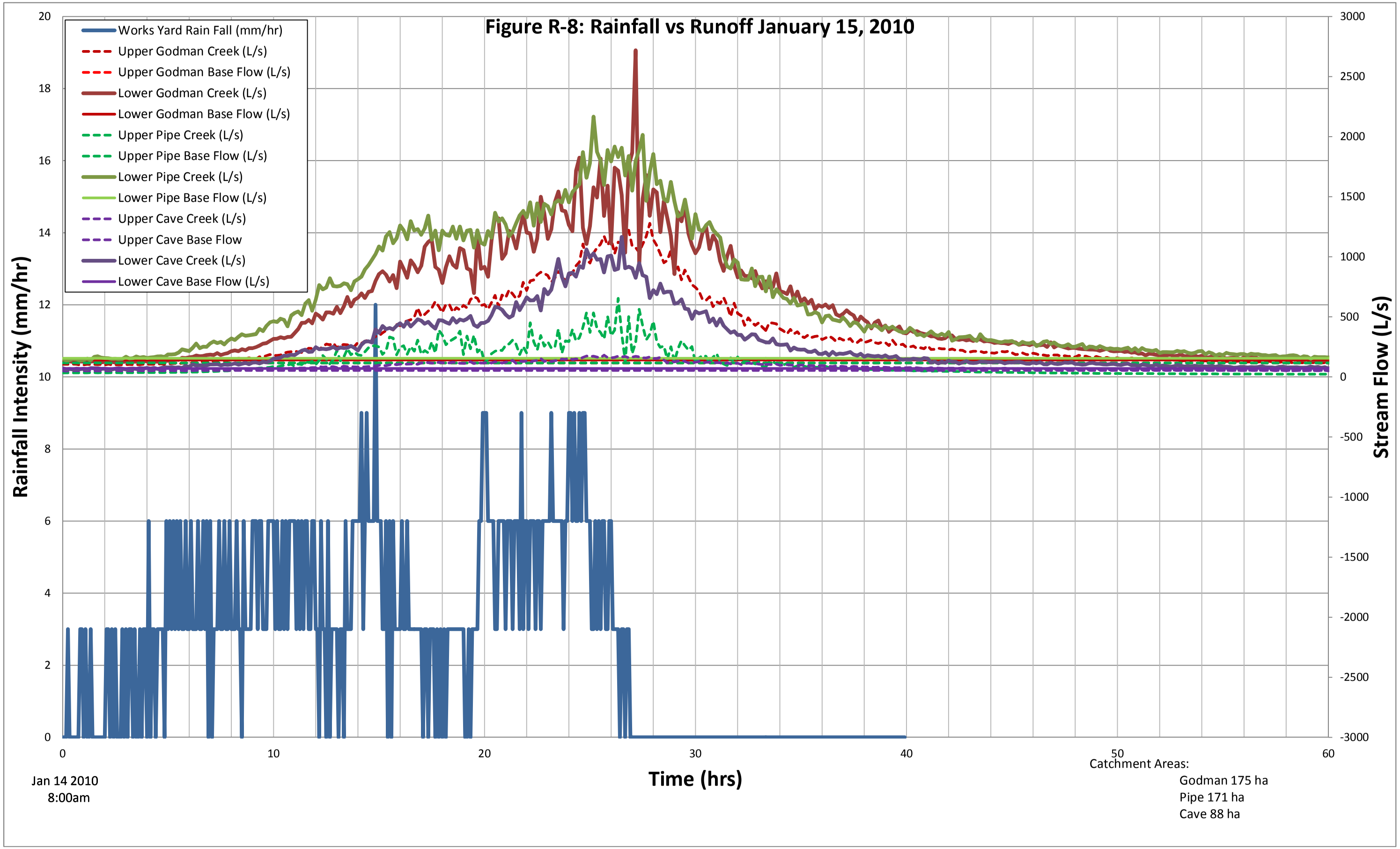


Figure R-7: Temperature and Snow Depth - January 15, 2010
15 min Temperature (Degrees C)
Daily Snow Depth (cm)
Hourly Temperature (ºC)
Daily Snow Depth (cm)
Time (days)
January 1, 2010
January 14, 2010
16
14
12
10
8
6
4
2
0
-2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
16
18

Figure R-8: Rainfall vs Runoff January 15, 2010



Jan 14 2010
8:00am

Catchment Areas:
Godman 175 ha
Pipe 171 ha
Cave 88 ha

DISTRICT OF WEST VANCOUVER
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS

APPENDIX S

SUMMARY OF STAKEHOLDER CONSULTATION

Provided in this appendix is a summary of the stakeholder consultation and meetings to date for the Pipe to Godman Creeks ISMP. The following items are included in this appendix:

1) July 17, 2008 – ISMP Initialization Meeting: See attached meeting minutes and Items 3.1 to 3.6 on public consultation and stakeholders group.

2) August 5, 2008 – Letter distributed to residents living adjacent to the creeks. See attached letter notifying residents of field work taking place along the creek channels as part of the information gathering for the ISMP.

3) December 3, 2008 – Progress Meeting and Presentation of ISMP Criteria. See attached meeting minutes and presentation slides from Opus DaytonKnight, SLR Consulting and Golder Associates.

4) June 3, 2009 – Presentation to Stakeholders:

- Location - Sentinel High School Auditorium, West Vancouver.
- Time - 4:00pm to 6:00pm.
- Presenters - British Pacific Properties Ltd., Opus DaytonKnight, SLR Consultants and Golder Associates. See attached presentation slides.
- Invitees – West Van Streamkeepers, North Shore Coho Society, DFO, MOE, District Staff and General Public. See attached advertisement posted as a quarter page add in the North Shore News on Friday May 29th and Sunday May 31st.
- See attached attendee sign-up sheet for the June 3, 2009 presentation to Stakeholders.

5) September 30, 2010 – Stakeholders Consultation Meeting:

- Location – West Vancouver Community Centre, Cedar Room, 3rd floor
- Time 1:30 pm to 4:00 pm
- Presenters – Opus DaytonKnight Ltd. See attached for summary notes of meeting and presentation slides.

BRITISH PACIFIC PROPERTIES LTD.
INTEGRATED STORMWATER MANAGEMENT PLAN
FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS
IN THE DISTRICT OF WEST VANCOUVER

INITIALIZATION MEETING MINUTES

DATE:	July 17, 2008	
TIME:	0830 to 0930 hours	
LOCATION	West Vancouver Municipal Hall	
ATTENDING:	District of West Vancouver	Raymond Fung Tony Tse Saleem Mahmood
	British Pacific Properties Ltd.	Walter D. Thorneloe Geoff Croll
	Dayton & Knight Ltd.	Al Gibb Sean Rooney
	SLR Consulting	James Neville
	Golder Associates	Matthew Munn Randy Williams
	InterCAD Services Ltd.	Iain Lowe
DISTRIBUTION:	All present; Harlan Kelly	

Item	Description	Action By
1.0	**INTRODUCION OF TEAM MEMBERS**	
1.1	British Pacific Properties Ltd.: Walter Thorneloe is the development manager and Geoff Croll the project manager for the Rogers Creek Area Development.	Info
1.2	InterCAD Services Ltd. is BPP's development consultant: Iain Lowe is the project manager.	
1.3	District of West Vancouver: Ray Fung will be the project manager for the ISMP and Saleem Mahmood will be involved with the technical aspects of the project. Tony Tse is the District land development engineer.	

Item	Description	Action By
1.4	Dayton & Knight Ltd. is the lead consultant for the ISMP: Harlan Kelly is the project manager and Sean Rooney the project engineer. Al Gibb is the senior stormwater and BMP specialist for D&K.	Info
1.5	SLR Consulting is the environmental sub-consultant for the ISMP: Jim Neville is the SLR project manager.	
1.6	Golder Associates is the hydrogeology sub-consultant for the ISMP: Matthew Munn is the lead hydrogeological engineer and Randy Williams the geotechnical engineer.	
2.0	**PROJECT SCOPE AND SCHEDULE**	
2.1	Initialization meeting is two months behind original schedule. Effort will be made to make up this time to achieve original completion date, if possible. Meeting #2 will likely be in September or October. Date and time to be determined.	D&K, SLR, Golder
2.2	The District would like to include benthic sampling and water quality sampling (DO, Temperature, Suspended Solids) in the scope of work. There has been criticism from regulatory agencies on past District ISMP's for excluding this sampling. This data provides a benchmark for future analysis of the watercourse. Educated members of the public would object to omission of this sampling and it would be a risk to exclude from the ISMP. Sampling should be downstream of the development.	
2.3	SLR includes the benthic and water quality sampling as optional work in their proposal. For possible cost savings the District suggests one representative sampling point be chosen for data acquisition. The similarity of the five creeks allows for sampling at only one creek. SLR to review and provide revised fee for this work. Urgency is that the sampling must be carried out within a narrow timeframe in August. Quote to be provided as soon as possible and no later than July 27, 2008.	SLR
2.4	Some baseline data have been collected by BPP and will be made available for the study.	BPP
2.5	The ISMP will be based on Metro Vancouver's ISMP template. The goal of the project is to mimic as closely as possible predevelopment conditions. The ISMP will not address "proper functioning condition" due to its challenging nature and the difficulties associated with following multiple methodologies (not included in ISMP template in any case).	Info
2.6	The District is satisfied with the proposed methodology.	

Item	Description	Action By
3.0	**PUBLIC CONSULTATION AND STAKEHOLDERS GROUP**	
3.1	The District stresses the importance of public consultation and stakeholder input especially since the project is not a municipality led ISMP.	
3.2	BPP to compile list of stakeholders to approach. Suggestions include: North Shore Streamkeepers; The Coho Society; any relevant neighbourhood groups or residential associations.	BPP
3.3	The North Shore Streamkeepers proved very useful in previous projects. They generally assign a lead member to each creek. BPP to determine who lead member is and invite to stakeholder group.	BPP
3.4	Stakeholder group should be invited to Meeting #2 and subsequent meetings. The group can be used as a source of information. Inclusion in meetings will inform the stakeholders of the complexities of storm water management. Involvement of this group will be essential for the public relations side of the project.	District
3.5	Regulatory agencies (DFO, MOE, etc.) should also be invited to the rest of the project meetings. The District is to invite agencies once meeting dates are established.	District
3.6	D&K is to draft a letter to residents informing them of field work in and around the creeks. West Vancouver is to sign and distribute letter to affected residents. Use BPP's letter for Northwest Hydraulics' previous field work that received good response from residents. The letter is to be copied to Mayor and Council.	D&K, District
4.0	**REQUIRED BACKGROUND DATA AND REPORTS**	
4.1	Data gathering underway.	
4.2	District rainfall data at Capilano Golf Club and Municipal Hall is limited to recent years. D&K to contact GVRD for more historical data.	D&K
4.3	The District suggests using rainfall data at the Hollyburn Ranger Station (elevation 150 meters) to determine a relationship of rainfall intensity to elevation. D&K to obtain this data.	D&K
4.4	There is an SFE rainfall station at the Works Yard. InterCAD to provide data to D&K.	InterCAD
4.5	InterCAD to provide data from ongoing groundwater flow monitoring to Golder.	InterCAD
4.6	Northwest Hydraulics installed flow monitoring at 6 locations, 2 stations each at Pipe, Cave and Godman Creeks. Monitoring began in March and no meaningful data will be available until November.	InterCAD

Item	Description	Action By
	InterCAD to provide NWH contact to D&K.	
5.0	**KEY ISSUES**	
5.1	Conveyance of increased run-off from new development without causing flood hazards or creek erosion.	Info
5.2	Flooding of existing developed areas downstream of new development is a high concern; therefore the catchments must be modelled complete to the ocean outfalls.	
5.3	Detention storage difficult due to limited space and steep hillside	
5.4	DFO requirements must be satisfied.	All
5.5	The District guidelines for storm water design are: pipes sized for 10 year storm; flood control designed for 100 year storm; erosion/stream quality control designed for frequent (2 year) storms. This study should flood route the 200 year storm.	D&K
5.6	The District would like ISMP to address rainfall capture and infiltration in spite of the constraints. Rogers & Marr study set goal of 24 mm/hr. The ISMP is to set goals for infiltration to the highest extent feasible. Previous LID work and ground water monitoring by BPP and InterCAD should help in this analysis. This expectation for LID's must be emphasized. This could range in complexity from absorbent topsoil to rain gardens. This will be complicated by differences among lots.	Golder, D&K, InterCAD
	Next Meeting: September/October (Date and Time TBD)	

Minutes recorded by:

Sean Rooney, E.I.T.

SR/
578.001.200

August 5, 2008

Dear Resident:

British Pacific Properties Limited and the District of West Vancouver will be conducting research work in the vicinity of your residence for the next 6 to 8 months. Information is being compiled for the Integrated Stormwater Management Plan currently being developed for the Pipe, Westmount, Cave, Turner and Godman Creek watersheds. A number of specialty consultants have been retained to assist in gathering the information needed to completed the plan; these consultants will be conducting field research along the creek channels during the late summer and early fall of this year. Their activities will mainly involve visual assessments of the creek channels and surrounding areas, road crossings, culverts, etc.

Should you have any questions or concerns, please contact me at 604-925-9000 or Sean Rooney of Dayton & Knight Ltd. at 604-990-4800.

Yours truly,

Geoff Croll, P.Eng.
General Manager Development

GEC:rs

BRITISH PACIFIC PROPERTIES LIMITED
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BRITISH PACIFIC PROPERTIES LTD.
INTEGRATED STORMWATER MANAGEMENT PLAN FOR
PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS
IN THE DISTRICT OF WEST VANCOUVER

MEETING No. 2 MINUTES

DATE:	Wednesday December 3, 2008	
TIME:	1200 to 1400 hours	
LOCATION	West Vancouver Municipal Hall	
ATTENDING:	British Pacific Properties	Geoff Croll Walter D. Thorneloe
	District of West Vancouver	Ray Fung Tony Tse Saleem Mahmood
	InterCAD Services Ltd.	Iain Lowe Richard Skapski
	Dayton & Knight Ltd.	Harlan Kelly Al Gibb Sean Rooney
	Golder Associates Ltd.	Matthew Munn Russ Wong
	SLR Consulting Ltd.	Jim Neville
	Jorden Cook Associates	Rick Cook
	Webster Engineering	Russell Warren
DISTRIBUTION:	All present	

Item	Description	Action By
1.0	**REVIEW OF AGENDA AND PAST MINUTES**	
1.1	Previous minutes for initialization meeting and Meeting No. 2 agenda approved.	Info

Item	Description	Action By
2.0	**D&K ISMP OVERVIEW**	
2.1	See attached D&K presentation slides (photos removed).	Info
3.0	**SLR REVIEW OF DRAFT REPORT**	
3.1	See attached SLR presentation slides (photos removed).	Info
4.0	**GOLDER REVIEW OF DRAFT REPORT**	
4.1	See attached Golder presentation slides (photos removed).	Info
5.0	**D&K DESIGN CRITERIA OVERVIEW**	
5.1	See attached D&K presentation slides (photos removed).	Info
6.0	**DISCUSSION**	
6.1	Parties recognize challenges with setting infiltration goals given the natural conditions of the watershed (steep terrain with shallow bedrock and saturated soils in the wet seasons). Detention storage will also be difficult. Goal will be to mimic existing conditions as close as possible.	D&K, Golder
6.2	ISMP should address the deficiencies with the Rogers Creek diversion system, discussed in Associated's report. Roughly 6 m^3/s may need to be diverted into the Pipe Creek diversion system. The District to provide D&K with the latest Associated report.	District, D&K
6.3	InterCAD has some insight into the proposed infiltration parameters for the model. InterCAD to discuss with D&K.	InterCAD, D&K
7.0	**SCHEDULE**	
7.1	Meeting Number 3 is scheduled for the middle of March. Final Report is scheduled for May. Effort will be made to make up time.	D&K
8.0	**STAKEHOLDERS GROUP**	
8.1	Now is a good time to bring in stakeholders group to the discussions to inform of progress and before upgrading options are presented. BPP and the District are to decide on selection of stakeholder group invitations. Separate meeting to present progress to date possibly scheduled for January.	BPP, District

Next Meeting: March (Date and Time TBD)

Minutes recorded by:

Sean Rooney, E.I.T.

SR/ad
503.002.200

British Properties

Integrated Stormwater Management Plan for Pipe to Godman Creek

Task 2 Progress Meeting

December 3, 2008

Task 2: Inventory and Data Collection

- Dayton & Knight Ltd.
  - Study area overview
- SLR Consulting
  - Environmental inventory
  - Watershed health
- Golder Associates
  - Creek channel assessment
  - Geotechnical hazards
- Dayton & Knight Ltd.
  - Runoff modeling criteria
  - Options for managing large and small storms

ISMP Objectives

- Prepare ISMP for the Pipe, Westmount, Cave, Turner and Godman Creek watersheds
- Follow Guidelines prepared by Metro Vancouver to undertake studies that integrate:
  - Neighborhood planning
  - Land Use planning
  - Environmental health
  - Watershed protection and restoration safeguards
- Protect life and property in the planned development area and in the downstream, currently developed watershed
- Consistent with previous ISMPs

Dayton & Knight Ltd.

Upper Study Area

Dayton & Knight Ltd.

Lower Study Area

Constraints

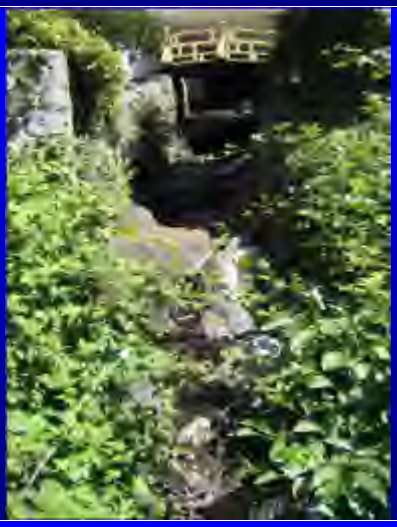
- Protection of fish and fish habitat
- Thin mantle over bedrock
- High drainage density (Pipe Creek)
- Wetland areas (Godman Creek)
- Steep slopes
- Limited conveyance capacity through downstream development
- Creeks flow through private property in downstream development
- Removal of vegetation will reduce holdup, abstractions and slope stability

Constraints

Pipe Creek Outfall at Burrard Inlet

Dayton & Knight Ltd.

Constraints



Westmount Creek at Marine Drive 1

Dayton & Knight Ltd.

Constraints

Godman Creek at Rose Crescent 1

Ecological Overview Report

Integrated Stormwater Management Plan

For Pipe, Westmount, Cave, Turner and Godman Creeks

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Scope of Work

- Desktop synthesis of biophysical inventory information available for the five catchments
- Field survey to confirm synthesis information and to fill only those data gaps that could be filled at the reconnaissance level (included *in situ* water quality at 2 sites on all streams)
- Benthic invertebrate and water quality sampling for lab analyses at one representative site on one stream
- Watershed Health indicators
- Input to ISMP

SLR

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Biophysical Inventory Information

- Primarily two sources:
  - Environmental Overview Update, Proposed Rodgers Creek Neighbourhood Development (SLR 2008a)
    - ✓ Included upper portions of the Pipe, Westmount, and Cave watersheds
  - Environmental Overview Update, Proposed Cypress Creek Neighbourhood Development (SLR 2008b)
    - ✓ Included upper portions of the Godman watershed

SLR

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Biophysical Inventory Information (Cont'd)

Rodgers Neighbourhood Study Area

SLR

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Biophysical Inventory Information (Cont'd)

Cypress Neighbourhood Study Area

SLR

solutions for today's environment

Biophysical Inventory Components

- Streams & Riparian Habitat
  - Stream habitat & fish presence
  - Riparian assessments
- Water Quality Monitoring (*in situ*)
- Terrestrial Ecosystems & Vegetation Characteristics
  - Ecosystem classification, rare species & communities
  - Sensitive Ecosystems
- Wildlife
  - Birds, mammals, amphibians, reptiles
  - Listed vertebrates & insects

SLR

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Data Gaps Filled During August 2008 Fieldwork:

- Turner Creek system (no previous investigations)
  - Channel characteristics & Riparian assessment
  - Habitat suitability for tailed frogs

SLR

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Data Gaps Filled During August 2008 Fieldwork (Cont'd):

- Water quality data was collected *in situ* from all five streams at two locations (to update information)

SLR

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Data Gaps Filled During August 2008 Fieldwork (Cont'd):

- Benthic-invertebrate investigations (none previous)
- Water sampling for lab analyses (none previous)

SLR

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Key Study Findings

- Salmonids are known to inhabit portions of all 5 systems
- Of stream sections evaluated, riparian setbacks were assessed at between 10 m and 15 m from HWM
- No at-risk plant species were found
- The only wetlands are those associated with Godman Creek, and provide red-legged frog habitat
- Tailed frogs have been found in the Pipe Creek and Godman Creek systems
- The only notable water-quality result is that Godman Creek Site G1 was high in faecal coliforms

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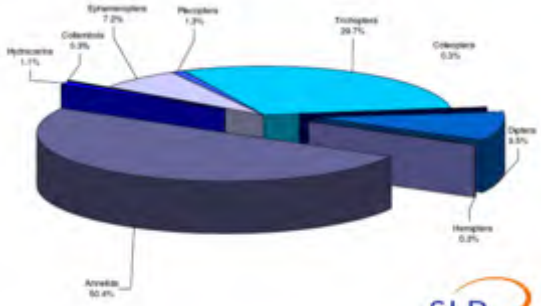
Key Study Findings – B-IBI

- The B-IBI score for Godman Creek Site G1 of 38 was near the low end of the "Good" category, as the samples were high in pollution-tolerant organisms



SLR

SLR

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Key Study Findings – Riparian Forest Integrity

Riparian Forest Integrity For Study Area Streams

Stream	Portion Below Highway 1			Portion Above Highway 1			Total Stream		
	Length[1] (m)	Length With Full Riparian Zone		Length (m)	Length With Full Riparian Zone		Length[2] (m)	Length With Full Riparian Zone	
		m	%		m	%		m	%
Pipe Creek	1,046	0	0	2,091	1,781	85	3,206	1,781	56
Westmount Creek	891	0	0	2,042	1,706	84	2,797	1,708	61
Cave Creek	546	0	0	784	720	92	1,412	720	51
Turner Creek	907	0	0	308	218	71	1,173	218	19
Godman Creek	1,019	0	0	1,913	1,690	88	3,028	1,690	56
Godman Creek West Branch	NA	NA	NA	1,000	200	20	1,000	200	20

Note 1: All stream length measurements are approximate

Note 2: Total stream length includes the portion culverted under Highway 1

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Next Steps – the "So What?"

- Apply ecological information to evaluation of stormwater-management alternatives, including potential positive and negative impacts
- Develop habitat impact mitigation and compensation measures if warranted
- Identify stream sections warranting particular management actions (e.g., base-flow considerations)
- Develop water and sediment quality monitoring criteria

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December 2008

HYDRO-GEOTECHNICAL ASSESSMENT

Input to ISMP

Pipe Creek, Westmount Creek, Cave Creek, Turner Creek and Godman Creek

West Vancouver, B.C.

Russ Wong, P.Geo.
Matthew Munn, P.Eng.

Golder Associates

Work Plan

Metro Vancouver
Template for ISMP 2005

Technical Clause 20

"Natural Hazard Assessment"

Technical Clause 5

"Hydrogeology/Geotechnical Assessment"

Golder Associates

Work Plan Tasks

1. Desk-Top Review
   - Existing geotechnical & hydrogeological information
   - Air photographs (1926 – 2004)
2. Field Reconnaissance Surveys
   As required to:
   - Characterize soil types and distribution
   - Identify areas active/susceptible to erosion
   - Identify and classify natural hazards and associated impacts
3. Reporting (1st Draft Nov 27, 2008)
   - Describe and summarize existing/potential hazards
   - Discusses overall viability/feasibility of stormwater infiltration within development area

   Final Report Submission

Golder Associates

Geotechnical Hazards

- **Summary of Field Work Completed**
- Streams and main tributaries traversed from headwaters to tidewater
- Field characterization of existing or potential stream-related geotechnical hazards
- Mapping of surficial soils
- Assessment of water transport potential, sidewall stability, channel stability, effects of past development

Golder Associates

Geotechnical Hazards

- **Summary of Primary Findings**
- Streams generally do not have associated ravines/gullies (low potential for channelized hazards like debris flows)
- Streams not deeply incised due to prominence of near-surface bedrock
- Surficial soils are thin in middle to upper stream reaches; increasing in thickness to southeast
- Streams have generally low water transport potential (small woody debris, sand-gravel-cobbles)
- Main concerns with respect to stormwater input are bank erosion, channel avulsion, potentially undersized culverts, local debris slides

Golder Associates

Geotechnical Hazards

- **Surficial Geology**
- At mid to upper elevations, granitic bedrock is overlain by a veneer of compact colluvium and/or dense boulder till
- The thickness of till increases downslope and to the southeast (up to 5 m thick)
- Local deposits of “modern” alluvial sediments at slope breaks
- Glaciomarine silt-clay deposits may occur at lower elevations

Geotechnical Hazards

- **Identified Geotechnical Hazards**
- Bank erosion where stream is conveyed in multiple channels on bedrock
- Stream avulsion/flooding due to poor channel confinement
- Erosion of natural banks (thicker and/or more erodible soils) or undermining of constructed walls
- Undersized culverts
- Failing old wood culverts
- Channel destabilization
- Sidewall failures, open slope failures

Geotechnical Hazards

- Godman Creek - near Eagle Lake access road, bank erosion of alluvial sediments

Geotechnical Hazards

- Godman Creek - channel destabilization due to streamside logging

Geotechnical Hazards

- Godman Creek - channel aggradation and bank erosion (Sharon Place)

Geotechnical Hazards

- Turner Creek - bank erosion of glaciomarine silt-clay (Mathers Ave)

Geotechnical Hazards

- Turner Creek - bank erosion of glaciomarine silt-clay (Mathers Ave)

Geotechnical Hazards

- Westmount Creek – unconfined stream flow on bedrock surface

Geotechnical Hazards

- Westmount Creek – potential stream avulsion site (Mathers Ave)

Geotechnical Hazards

- Westmount Creek – Marine Drive residence

Geotechnical Hazards

- Pipe Creek – erosion of thick till on stream sidewall (shotcreted) near Deer Ridge Place

Geotechnical Hazards

- Pipe Creek – perched undersized culvert (Mathers Ave)

Geotechnical Hazards

- Rodgers Creek – debris levee from debris flow above stream channel

Geotechnical Hazards

- Rodgers Creek – sidewall failure from ravine slope

Hydrogeology

Hydrogeology

Primary Findings …..

- Geological Setting
  - Soil distribution, type and thickness similar to that reported by Piteau (2002) and Jacques Whitford (2008)
  - Low-permeability tills common in all watersheds

2. **Infiltration and Storage Potential**

   Limited, due to combination of:
   - Low hydraulic conductivity of till soils/sediments
   - Relatively thin till profile
   - Sloping terrain
   - High seasonal water table

Hydrogeology

Stormwater Infiltration ….

- Optimized Using …..
  Distributed Small-Scale "Network"
  - Centralized stormwater retention/infiltration structures not feasible due to low soil hydraulic conductivity
  - Broadly distributed infiltration network will provide improved opportunity for infiltration

2. Limited Opportunity for Improving Infiltration
   - During November to ~June
   - Water table relatively high and storage capacity low
3. Good Opportunity for Improving Infiltration
   - Seasonally Drier Periods (July to October)
   - Water table relatively low (i.e., deeper)
   - Storage capacity is higher

Golder Associates

Thank You

Thank You

Golder Associates

British Properties

Integrated Stormwater Management Plan for Pipe to Godman Creek

Task 2 Progress Meeting

December 3, 2008

Storm Runoff Modeling

- Use Stormwater Management Model (PC-SWMM 2005)
- Compare pre and post development runoff and stream flows
- Identify hydraulic capacity issues
- Evaluate proposed mitigation measures

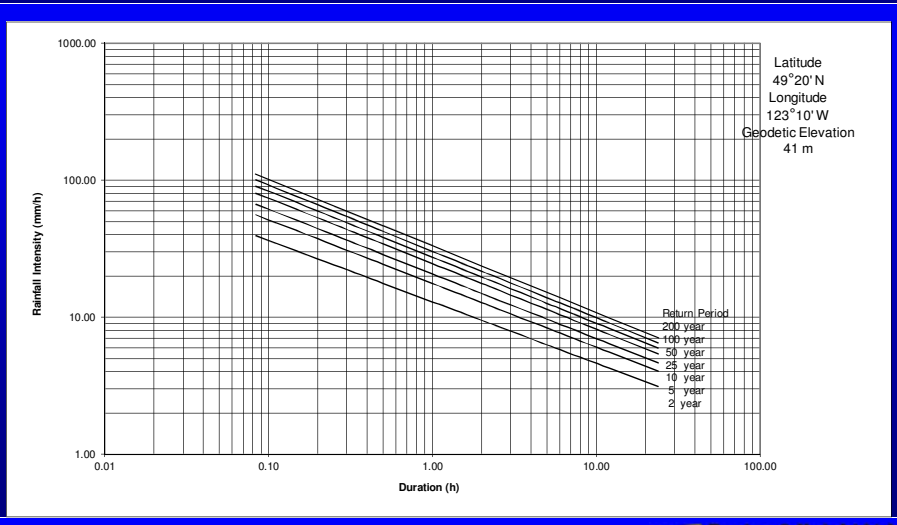
Modeling Constraints

- Model uses single event storm conditions
- Land use based on the most recent development plans and OCP
- Based on topographical maps and municipal record of existing drainage facilities
- Impervious area estimated from aerial photos
- Limited ground proofing of existing facilities
- Model calibration limited to available stream flow and rainfall monitoring data

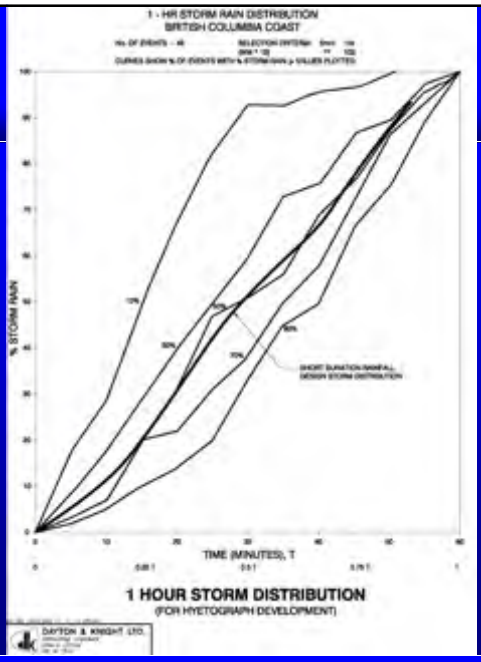
Model Hydrologic Criteria

- Historical rainfall data from the West Van Municipal Hall
- IDF curves based on 44 years of rainfall data
- Single-event synthetic rain storms developed for varying durations and frequencies
  - 2, 10, 100, and 200 tear return periods
  - 1, 2, 6, 12 and 24 hour storm durations
- AES storm distributions for Coastal British Columbia used to develop design storm hyetographs

Rainfall Data



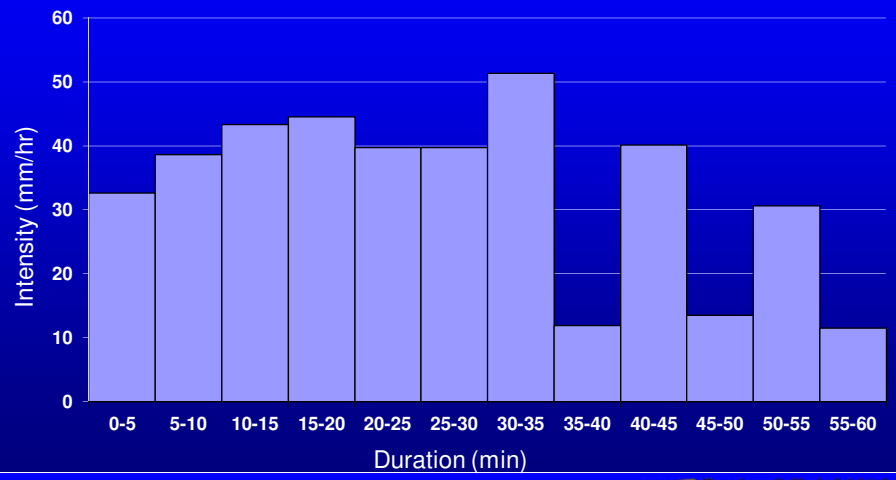
Dayton & Knight Ltd.
CONSULTING ENGINEERS



Storm Distribution

Dayton & Knight Ltd.
CONSULTING ENGINEERS

200 Year 1 Hour Storm Hyetograph (VW14)



Effects of Elevation on Rainfall

- Relationship between elevation and rainfall intensity
- Comparative rainfall data analyzed at 3 rainfall stations:

Rainfall Station	Elevation	Factor of Rainfall Intensity
Municipal Hall	41 meters	1.0
Capilano Golf and Country Club	201 meters	1.4
Cypress Mountain Ranger Station	930 meters	2.0

- Compare precipitation totals and short and long duration rainfall events
- Elevation intensity relationship agrees with previous work by D&K, AESL and KWL

Hydraulic Criteria

- Horton's equation used to model infiltration
- Assume storm occurs on saturated low-permeability soil for fall and winter conditions
- Catchment and creek slopes based on topographical contour data
- Existing culverts and other structures modeled based on District GIS data and field observation
- Typical Manning's "n" values for modeling creek/culvert roughness
- SWMM modules used to simulate hydraulic conditions (rainfall, runoff, storage, conveyance, etc)

Hydraulic Criteria

Percent Impervious Area

Parameter	Pipe	Westmount	Cave	Turner	Godman
Total Drainage Area (hectares)	197	107	77	67	191
Existing Percent Impervious	8%	12%	11%	25%	11%
Post-Development Percent Impervious	11%	15%	14%	28%*	13%*

*Assumes Same Percent Increase as other catchments.

Model Calibration

- Real time flow monitoring currently in progress
- 2 monitoring locations at each of Pipe, Cave and Godman Creeks (upper and lower stream reaches)
- Real time rainfall data being gathered at District Operations yard
- Rainfall data from a significant storm (2 year return period or greater) will be used to calibrate model

Potential Management Solutions

- Large infrequent storms
  - Increase conveyance capacity of creeks
  - Bypass excess flows to Burrard Inlet
  - Detention storage
  - Piped conveyance system will be required
- Small frequent storms
  - Onsite storage / holdup
  - Infiltration
  - Bypass excess flows to piped system
- Address limited conveyance capacity in existing development downstream, protect streams

Potential Drainage Solutions

Dayton & Knight Ltd.

Potential Drainage Solutions

Dayton & Knight Ltd.

Next Steps

- Task 3: Technical Analysis
  - Calibrate model, identify design storms, runoff flows
  - Flood routing, channel velocities, erosion hazards
  - Identify hydraulic deficiencies
  - Habitat protection
- Task 4: Assess Mitigative Alternatives
  - Large and small storms
  - Priorities and cost estimates for improvements
  - Meeting #3
- Task 5: Prepare ISMP

Community Stakeholders Meeting

Please join *British Pacific Properties Limited* for a community stakeholders meeting on the **Integrated Stormwater Management Plan** for Pipe, Westmount, Cave, Turner and Godman Creeks in the District of West Vancouver.

When: Wednesday June 3rd

Where: Sentinel Secondary School, Auditorium, 1250 Chartwell Drive West Vancouver

Time: 4PM – 6PM

With presentations by independent professional consultants Dayton & Knight Ltd., SLR Consulting Ltd., and Golder Associates Ltd., British Pacific Properties and the District of West Vancouver welcome your input.

BRITISH PACIFIC HOMES

Integrated Stormwater Management Plan (ISMP)

- **Maintain watershed health & mitigate potential impacts associated with future development**
- **Required by Metro Vancouver (GVRD) Liquid Waste Management Plan**
- **District has completed ISMP's for McDonald, Lawson, Marr and Rodgers Creeks**

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks
Community Stakeholders Meeting June 2009

Rodgers Creek ADP Area

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks

Community Stakeholders Meeting June 2009

Rodgers Creek ADP Area

- 215 acres (195 acres BPP)
- 3 Owners
- 736 Housing Units, 70% Apartments

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks

Community Stakeholders Meeting June 2009

Key Directions for Rodgers Creek

- Design with Nature
- Cypress Village
- Collecting Density into pockets
- Mountain Path
- Concentrating Density Westward

Rodgers Creek ADP - Overall Site Plan

- 6 distinct development nodes
- 4 neighbourhoods
- 736 housing units, 70% apartments
- linked by Mountain Path (red line)

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks
Community Stakeholders Meeting June 2009

Rodgers Creek Area Plan Watersheds

- Marr Creek
- Rodgers Creek
- Pipe Creek
- Westmount Creek
- Cave Creek

Cypress Village Area Watersheds

- Turner Creek
- Godman Creek

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks
Community Stakeholders Meeting June 2009

ISMP for Pipe, Westmount, Cave, Turner & Godman Creeks

- Funded by BPP & Other Land Owners
- Based on GVRD ISMP Template
- Prepared by independent, professional consultants
- Led by Dayton & Knight Consulting Engineers
- Direction & input from District Staff
- Input from Community Stakeholders

Points to Consider

- These watersheds have been historically disturbed by forest fire and human activity, most notably:
- Logging
- Construction of Upper Levels Highway
- Construction of Cypress Bowl Road
- Development below the highway

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks
Community Stakeholders Meeting June 2009

Points to Consider (continued)

- BPP's development area represents a small portion of total watershed area
- The Rodgers Creek ADP sets aside over 55% of land area as protected green space, most notably creek and riparian corridors
- Main goal of ISMP is managing stormwater to:
  - Maintain environmental functions of watercourses (low & high flows)
  - Ensure public safety (peak flows)

Tonight's Program

- Presentations by Dayton & Knight, Golder Associates and SLR Environmental Consultants
- Questions after each presentation
- Community Stakeholders Input

ISMP – Pipe, Westmount, Cave, Turner & Godman Creeks
Community Stakeholders Meeting June 2009

Inventory and Data Collection

- Dayton & Knight Ltd.
  - Study area overview
- SLR Consulting
  - Environmental inventory
  - Watershed health
- Golder Associates
  - Creek channel assessment
  - Geotechnical hazards
- Dayton & Knight Ltd.
  - Runoff modeling criteria
  - Options for managing large and small storms

ISMP Objectives

- Prepare ISMP for the Pipe, Westmount, Cave, Turner and Godman Creek watersheds
- Follow Guidelines prepared by Metro Vancouver to undertake studies that integrate:
  - Neighborhood planning
  - Land Use planning
  - Environmental health
  - Watershed protection and restoration safeguards
- Protect life and property in the planned development area and in the downstream, currently developed watershed
- Consistent with previous ISMPs

Dayton & Knight Ltd.

Upper Study Area

Dayton & Knight Ltd.

Lower Study Area

Constraints

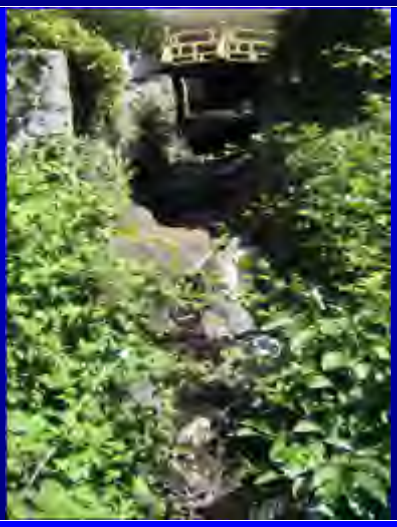
- Protection of fish and fish habitat
- Thin mantle over bedrock
- High drainage density (Pipe Creek)
- Wetland areas (Godman Creek)
- Steep slopes
- Limited conveyance capacity through downstream development
- Creeks flow through private property in downstream development
- Removal of vegetation will reduce holdup, abstractions and slope stability

Constraints

Pipe Creek Outfall at Burrard Inlet

Dayton & Knight Ltd.

Constraints



Westmount Creek at Marine Drive 1

Dayton & Knight Ltd.

Constraints

Godman Creek at Rose Crescent 1

Ecological Overview Report

Integrated Stormwater Management Plan

For Pipe, Westmount, Cave, Turner and Godman Creeks

Jim Neville, SLR Consulting (Canada) Ltd.

June 3, 2009

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Study Area Location

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ISMP Study Area Streams

SLR

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Scope of Work

- Desktop synthesis of biophysical inventory information available for the five catchments
- Field survey to confirm synthesis information and to fill only those data gaps that could be filled at the reconnaissance level (included *in situ* water quality at 2 sites on all streams)
- Benthic invertebrate and water quality sampling for lab analyses at one representative site on one stream
- Watershed Health indicators
- Input to ISMP

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Biophysical Inventory Information

- Primarily two sources:
  - Environmental Overview Update, Proposed Rodgers Creek Neighbourhood Development (SLR 2008a)
    - ✓ Included upper portions of the Pipe, Westmount, and Cave watersheds
    - ✓ Included upper portion of the Turner Watershed for ecosystem classification only
  - Environmental Overview Update, Proposed Cypress Creek Neighbourhood Development (SLR 2008b)
    - ✓ Included upper portions of the Godman watershed

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Biophysical Inventory Information (Cont'd)

Rodgers Neighbourhood Study Area

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Biophysical Inventory Information (Cont'd)

Cypress Neighbourhood Study Area

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Biophysical Inventory Components

- Streams & Riparian Habitat
  - Stream habitat & fish presence
  - Riparian assessments
- Water Quality Monitoring (*in situ*)
- Terrestrial Ecosystems & Vegetation Characteristics
  - Ecosystem classification, rare species & communities
  - Sensitive Ecosystems
- Wildlife
  - Birds, mammals, amphibians, reptiles
  - Listed vertebrates & insects

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Data Gaps Filled During August 2008 Fieldwork:

- Turner Creek system
  - Channel characteristics & Riparian assessment
  - Habitat suitability for tailed frogs
- No previous investigations, apart from ecosystem mapping above Highway 1

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Data Gaps Filled During August 2008 Fieldwork (Cont'd):

- Water quality data were collected *in situ* from all five streams at two locations (to update information)
- Water sampling for lab analyses (none previous)

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Data Gaps Filled During August 2008 Fieldwork (Cont'd):

- Benthic-invertebrate investigations (none previous)

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Key Study Findings

- Salmonids are known to inhabit portions of all 5 systems, with Godman Creek the only one to contain fish above Highway 1
- Of stream sections evaluated, riparian setbacks were assessed at between 10 m and 15 m from HWM
- No at-risk plant species were found
- The only wetlands in the study area are those associated with Godman Creek, and provide red-legged frog habitat
- Tailed frogs have been found in the Pipe Creek and Godman Creek systems
- The only notable water-quality result is that Godman Creek Site G1 was high in faecal coliforms (likely owing to off-leash dogs in Westridge Park, combined with heavy rains)

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Coastal Tailed Frog, Upper Godman Creek

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Key Study Findings – Riparian Forest Integrity

Riparian Forest Integrity For Study Area Streams

Stream	Portion Below Highway 1			Portion Above Highway 1			Total Stream		
	Length[1] (m)	Length With Full Riparian Zone		Length (m)	Length With Full Riparian Zone		Length[2] (m)	Length With Full Riparian Zone	
		m	%		m	%		m	%
Pipe Creek	1,046	0	0	2,091	1,781	85	3,206	1,781	56
Westmount Creek	691	0	0	2,042	1,708	84	2,797	1,708	61
Cave Creek	548	0	0	784	720	92	1,412	720	51
Turner Creek	807	0	0	308	218	71	1,173	218	19
Godman Creek	1,019	0	0	1,913	1,690	88	3,028	1,690	56
Godman Creek West Branch	NA	NA	NA	1,000	200	20	1,000	200	20

Note 1: All stream length measurements are approximate

Note 2: Total stream length includes the portion culverted under Highway 1

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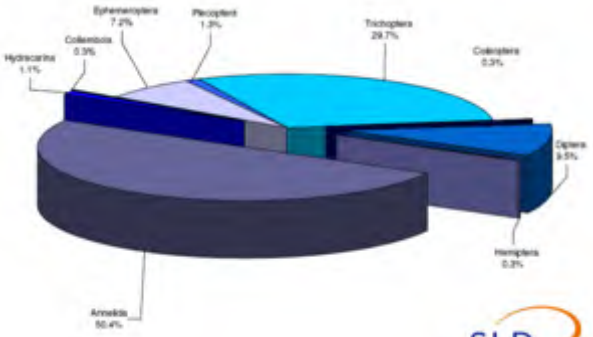
Key Study Findings
- Benthic Index of Biological Integrity (B-IBI)

- The B-IBI score for Godman Creek Site G1 of 38 was near the low end of the "Good" category range, as the samples were high in pollution-tolerant organisms



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Interpretation of B-IBI Score

- Pollution Intolerant Taxa:
  - Ephemeroptera (mayflies)
  - Plecoptera (stoneflies)
  - Trichoptera (caddisflies)
- Require well-oxygenated gravel or cobble substrates
- Considered to be indicators of healthy, fast-flowing streams

Versus

- Pollution-Tolerant Taxa:
  - Nematodes (roundworms)
  - Oligochaeta (aquatic worms)
  - Turbellaria (flatworms)
- May be characteristic of slow-moving waters with soft substrates
- Their tolerance of low oxygen levels *may* indicate polluted conditions

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Watershed Health Tracking System

- Useful way to evaluate effectiveness of low-impact development (LID) measures over time
- Based on 3 quantifiable biophysical characteristics of watersheds:
  1. Effective Impervious Area (EIA
  2. Percent Riparian Forest Integrity (RFI)
  3. Benthic Index of Biological Integrity (B-IBI)
- For Upper Godman Creek,
  - EIA = 5%
  - RFI = 88%
  - B-IBI = 38

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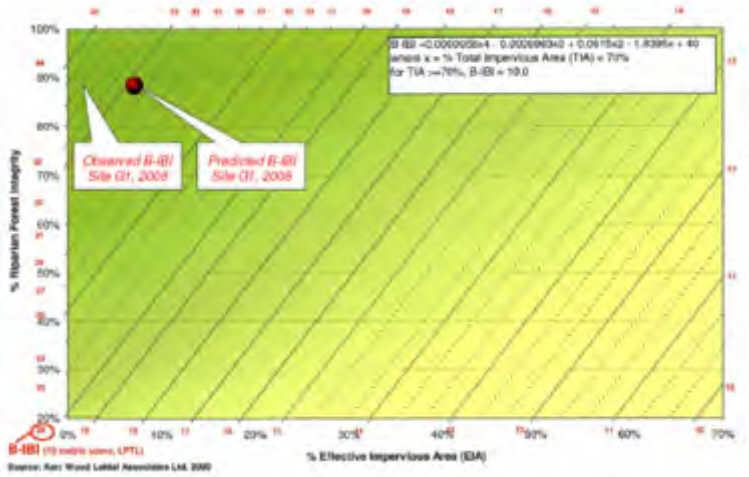
Watershed Health, Upper Godman Creek



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Obligatory Waterfall Photo
Upper Godman Creek

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Next Steps – the "So What?"

- Apply ecological information to evaluation of stormwater-management alternatives, including potential positive & negative impacts
- Develop habitat impact mitigation and compensation measures if warranted
- Identify stream sections warranting particular management actions (e.g., base-flow considerations)
- Develop water & sediment quality monitoring criteria

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Questions?

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June 2009

HYDRO-GEOTECHNICAL ASSESSMENT

Input to ISMP

Pipe Creek, Westmount Creek, Cave Creek, Turner Creek and Godman Creek

West Vancouver, B.C.

Russ Wong, P.Geo.
Matthew Munn, P.Eng.

Golder Associates

Work Plan

Metro Vancouver
Template for ISMP 2005

Technical Clause 20

"Natural Hazard Assessment"

Technical Clause 5

"Hydrogeology/Geotechnical Assessment"

Golder Associates

Work Plan Tasks

1. Desk-Top Review
   - Existing geotechnical & hydrogeological information
   - Air photographs (1926 – 2004)
2. Field Reconnaissance Surveys
   As required to:
   - Characterize soil types and distribution
   - Identify areas active/susceptible to erosion
   - Identify and classify natural hazards and associated impacts
3. **Reporting** (Submission January 2009)
   - Describe and summarize existing/potential hazards
   - Discusses overall viability/feasibility of stormwater infiltration within development area

Golder Associates

Geotechnical Hazards

- **Summary of Field Work Completed**

Russ Wong, P.Geo.

Golder Associates

Geotechnical Hazards

- **Summary of Field Work Completed**
- Streams and main tributaries traversed from headwaters to tidewater
- Field characterization of existing or potential stream-related geotechnical hazards
- Mapping of surficial soils
- Assessment of water transport potential, sidewall stability, channel stability, effects of past development

Geotechnical Hazards

- **Summary of Primary Findings**
- Streams generally do not have associated ravines/gullies (low potential for channelized hazards like debris flows)
- Streams not deeply incised due to prominence of near-surface bedrock
- Surficial soils are thin in middle to upper stream reaches; increasing in thickness to southeast
- Streams have generally low water transport potential (small woody debris, sand-gravel-cobbles)
- Main concerns with respect to stormwater input are bank erosion, channel avulsion, potentially undersized culverts, local debris slides

Geotechnical Hazards

- **Surficial Geology**
- At mid to upper elevations, granitic bedrock is overlain by a veneer of compact colluvium and/or dense boulder till
- The thickness of till increases downslope and to the southeast (up to 5 m thick)
- Local deposits of “modern” alluvial sediments at slope breaks
- Glaciomarine silt-clay deposits may occur at lower elevations

Geotechnical Hazards

- **Identified Geotechnical Hazards**
- Bank erosion where stream is conveyed in multiple channels on bedrock
- Stream avulsion/flooding due to poor channel confinement
- Erosion of natural banks (thicker and/or more erodible soils) or undermining of constructed walls
- Undersized culverts
- Failing old wood culverts
- Channel destabilization
- Sidewall failures, open slope failures

Geotechnical Hazards

- **Godman Creek - near Eagle Lake access road, bank erosion of alluvial sediments**

Golder Associates

Geotechnical Hazards

- Godman Creek - channel destabilization due to streamside logging

Geotechnical Hazards

- Godman Creek - channel aggradation and bank erosion (Sharon Place)

Geotechnical Hazards

- Turner Creek - bank erosion of glaciomarine silt-clay (Mathers Ave)

Golder Associates

Geotechnical Hazards

- Turner Creek - bank erosion of glaciomarine silt-clay (Mathers Ave)

Golder Associates

Geotechnical Hazards

- Westmount Creek – unconfined stream flow on bedrock surface

Geotechnical Hazards

- Westmount Creek – potential stream avulsion site (Mathers Ave)

Geotechnical Hazards

- Westmount Creek – Marine Drive residence

Geotechnical Hazards

- Pipe Creek – erosion of thick till on stream sidewall (shotcreted) near Deer Ridge Place

Geotechnical Hazards

- Pipe Creek – perched undersized culvert (Mathers Ave)

Geotechnical Hazards

- Rodgers Creek – debris levee from debris flow above stream channel

Geotechnical Hazards

- Rodgers Creek – sidewall failure from ravine slope

Hydrogeology

Hydrogeology

Primary Findings …..

- Geological Setting
  - Soil distribution, type and thickness similar to that reported by Piteau (2002) and Jacques Whitford (2008)
  - Low-permeability tills common in all watersheds
- **Infiltration and Storage Potential**
  Limited, due to combination of:
  - Low hydraulic conductivity of till soils/sediments
  - Relatively thin till profile
  - Sloping terrain
  - High seasonal water table

Golder Associates

Hydrogeology

Stormwater Infiltration

- Optimized Using …..
  Distributed Small-Scale "Network"
  - Centralized stormwater retention/infiltration structures not feasible due to low soil hydraulic conductivity
  - Broadly distributed infiltration network will provide improved opportunity for dispersed infiltration
- Limited Opportunity for Improving Infiltration
  - During November to ~June
  - Water table relatively high and storage capacity low
- Good Opportunity for Improving Infiltration
  - Seasonally Drier Periods (July to October)
  - Water table relatively low (i.e., deeper)
  - Storage capacity is higher

Golder Associates

Hydrogeology

Stormwater Infiltration

- Wetland Storage
  - Wetlands associated with Godman Creek system might have a natural capacity to detain rainwater originating from the proposed development area
  - Approach contingent upon ……
    - confirmation of hydraulic capacity
    - consideration of ecological function
    - DFO input regarding wetlands that discharge directly to fish-bearing (e.g., cutthroat) streams

Thank You

Thank You

British Properties

Integrated Stormwater Management Plan for Pipe to Godman Creek

Stakeholders Meeting

June 3, 2009

Storm Runoff Modeling

- Use Stormwater Management Model (PC-SWMM.NET)
- Compare pre and post development runoff and stream flows
- Identify hydraulic capacity issues
- Evaluate proposed mitigation measures

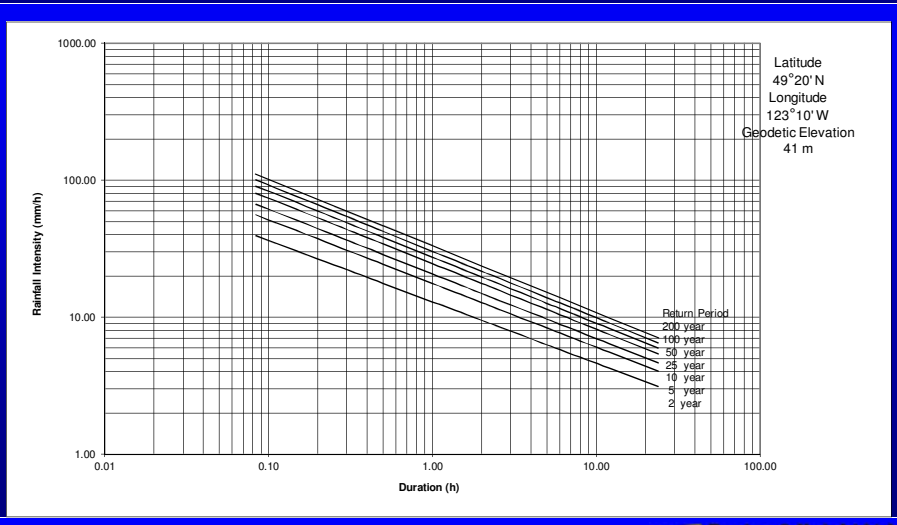
Modeling Constraints

- Land use based on the most recent development plans and OCP
- Based on topographical maps and municipal record of existing drainage facilities
- Impervious area estimated from aerial photos
- Limited field reconnaissance
- Model calibration limited to available stream flow and rainfall monitoring data

Model Hydrologic Criteria

- Historical rainfall data from the West Van Municipal Hall
- IDF curves based on 44 years of rainfall data
- Synthetic rain storms developed for varying durations and frequencies
  - 2, 10, 100, and 200 year return periods
  - 1, 2, 6, 12 and 24 hour storm durations
- AES storm distributions for Coastal British Columbia used to develop design storm hyetographs

Rainfall Data



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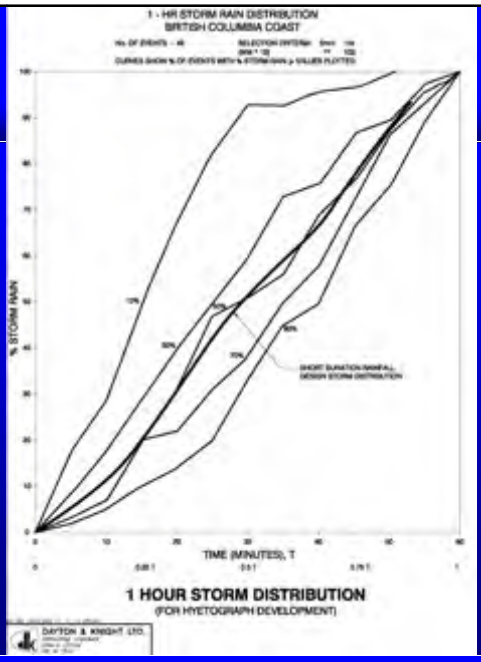
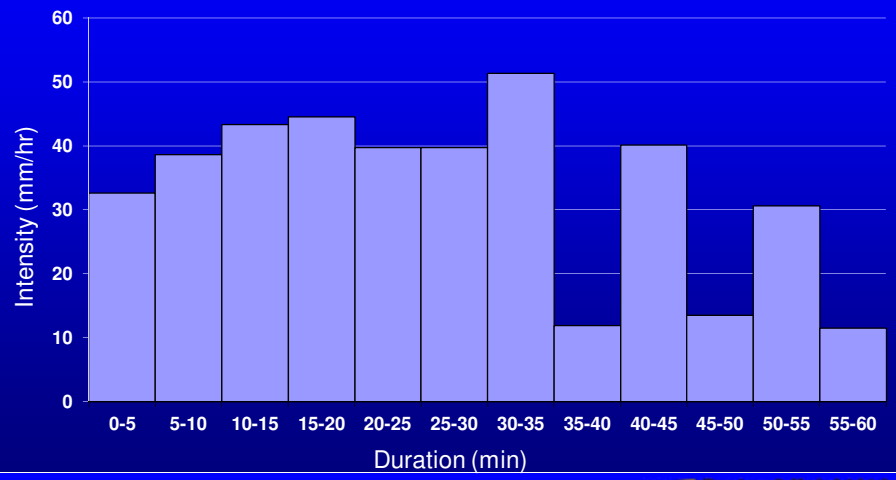
CONSULTING ENGINEERS



Storm Distribution

Dayton & Knight Ltd.
CONSULTING ENGINEERS

200 Year 1 Hour Storm Hyetograph (VW14)



Effects of Elevation on Rainfall

- Relationship between elevation and rainfall intensity
- Comparative rainfall data analyzed at 3 rainfall stations:

Rainfall Station	Elevation	Factor of Rainfall Intensity
Municipal Hall	41 meters	1.0
Capilano Golf and Country Club	201 meters	1.4
Cypress Mountain Ranger Station	930 meters	2.0

- Compare precipitation totals and short and long duration rainfall events
- Elevation intensity relationship agrees with previous work by D&K, AESL and KWL

Hydraulic Criteria

- Horton's equation used to model infiltration
- Assume storm occurs on saturated low-permeability soil for fall and winter conditions
- Catchment and creek slopes based on topographical contour data
- Existing culverts and other structures modeled based on District GIS data and field observation
- Typical Manning's "n" values for modeling creek/culvert roughness
- SWMM modules used to simulate hydraulic conditions (rainfall, runoff, storage, conveyance, etc)

Hydraulic Criteria

Percent Impervious Area

Parameter	Pipe	Westmount	Cave	Turner	Godman
Total Drainage Area (hectares)	197	107	77	67	191
Existing Percent Impervious	8%	12%	11%	25%	11%
Post-Development Percent Impervious	11%	15%	14%	28%*	13%*

*Assumes Same Percent Increase as other catchments.

Model Calibration

- Real time flow monitoring currently in progress
- 2 monitoring locations at each of Pipe, Cave and Godman Creeks (upper and lower stream reaches)
- Real time rainfall data being gathered at District Operations yard
- Rainfall data from a significant storm (2 year return period or greater) will be used to calibrate model

Potential Management Solutions

- Large infrequent storms
  - Increase conveyance capacity of creeks
  - Bypass excess flows to Burrard Inlet
  - Detention storage
  - Piped conveyance system will be required
- Small frequent storms
  - Onsite storage / holdup
  - Infiltration
  - Bypass excess flows to piped system
- Address limited conveyance capacity in existing development downstream, protect streams

Potential Drainage Solutions

Dayton & Knight Ltd.

Next Steps

- Task 3: Technical Analysis
  - Calibrate model, identify design storms, runoff flows
  - Flood routing, channel velocities, erosion hazards
  - Identify hydraulic deficiencies
  - Habitat protection
- Task 4: Assess Mitigative Alternatives
  - Large and small storms
  - Priorities and cost estimates for improvements
  - Meeting #3
- Task 5: Prepare ISMP

Dayton & Knight Ltd.

Intergrated Stormwater Management Plan

Sentinel Secondary Auditorium, 4PM – 6PM Wednesday June 3, '09

Name	Street Address	City	Postal Code	Telephone	Email
JIM MACARTHY	635 King	WV	V7S 1S2	609 92-2058	
SANDI DIX	1122 Millstream	WV	V7S 2C7	609 922 7202	
John Barker	2360 Nelson Av.	W.V.	V7V 2R2	604-922-5780	jrbarker@shaw
Bill MCALLISTER	1340 WHITBY RD	WV	V7S 2N5	604 926 4283	
RAY FUNG	750-17 STREET	WV		604 925-7159	
Fiona Crellon	4799 Union	Bur.	V5C 2Y5	604-886-4205	
Mike Ritter					

Stakeholders Consultation Meeting
Pipe, Cave, Turner, Westmount, Godman ISMP
Monday, September 30, 2013 1:30 - 4:00 p.m.

Summary Notes of Meeting

NAME	ORGANIZATION
Bill McAllister	Streamkeepers
Dave Reed	Streamkeepers
John Barker	Streamkeepers
Celia Utley	Streamkeepers
Elizabeth Hardy	Streamkeepers
Alex Sartori	Sartori Environmental
Bruce McArthur	North Shore Wetland Partners
John Tynan	Webster Engineering
Rick Cook	Jorden Cook Associates
Ian Lowe	InterCAD Services
Geoff Croll	British Pacific Properties
Alastair Meiklem	British Pacific Properties
Harlan Kelly	Opus Dayton Knight
John McMahon	District of West Vancouver
Ray Fung	District of West Vancouver
Andrew Vander Helm	District of West Vancouver
Andy Kwan	District of West Vancouver
Jenn Moller	District of West Vancouver
Tony Tse	District of West Vancouver
Donna Powers	District of West Vancouver
Andrew Banks	District of West Vancouver
Ian Haras	District of West Vancouver

1. Following roundtable introductions a presentation was made by Harlan Kelly of Opus Dayton Knight summarizing the background and some key conclusions and recommendations arising from the study.

2. An open question and answer period was then held where concepts within the report were discussed and inquiries clarified.

3. Next steps were then discussed which include the following:

    a. Finalize the report with modifications and clarifications to the document based on written questions submitted.

    b. Posting of the final document to the District's website.

    c. Circulation of revised pages for insertion to the existing copies of the document to conserve printing efforts.

    d. Proceed with implementation of the recommendations of the report including more detailed design on the various capital works elements.

4. The meeting was adjourned.

OPUS

District of West Vancouver

ISMP – Pipe, Westmont, Cave, Turner & Godman Creeks

Opus DaytonKnight

Introduction

The ISMP is a Concept that Secures Protection of Public Safety, Property and the Environment

1. Establish Principles of Major and Minor Flood Protection for Planned Land Uses
2. Initiate Benchmarking for Environmental Stream Protection
3. Provide Oversight and an Overarching Plan for Stormwater Management for Low Frequency and High Intensity Storms and High Frequency and Low Intensity Storms
4. Estimate Costs and Prioritize Drainage Improvements

Drainage Area Inventory

1. Existing Creek Channel and Culvert Inventory
2. Definition of Drainage Basin Boundaries
3. Watershed Health Assessment
4. Hydro-geotechnical Stream Assessment

Watersheds

Watershed Health Assessment

- Streams and riparian habitat
- Water quality monitoring
- Godman Creek Benthic Invertebrate Community
- Terrestrial Ecosystem and Vegetation Characteristics
- Wildlife in the Study Area
- Watershed Health RFI, EIA, B-IBI

Geotechnical Stream Assessment

Geotechnical Hazards

- **Turner Creek - bank erosion of glaciomarine silt-clay (Mathers Ave)**

Geotechnical Hazards

- **Westmount Creek – Marine Drive residence**

Geotechnical Hazards

- **Pipe Creek – perched undersized culvert (Mathers Ave)**

Options of Drainage Design for Protection of Public and Property

Design considers low frequency high intensity storms

- Improvement to efficiency of existing carriers
- Slowing down the rate of flow through detention and storage
- Diversion
- Combinations

Existing Land Use

Existing Watershed and Land Use

Percent Impervious Area

Parameter	Pipe	Westmount	Cave	Turner	Godman
Total Drainage Area (hectares)	173	106	88	66	182
Natural Forest (hectares)	140 (81%)	90 (85%)	75 (86%)	41 (62%)	144 (79%)
Developed Area (hectares)	33 (19%)	16 (15%)	13 (14%)	25 (38%)	38 (21%)

s.

Future Land Use Assumptions

Options of Drainage Design for Protection of the Environment

Design considers high frequency low intensity storms

- Low impact development and best management practices
- Infiltration and recharge of groundwater
- Lot detention, terraces and overland swales
- Storage structures to detain flow and capture pollutants

LID Rating for the Five Creeks

- Absorbent Soils MODERATE
- Permeable Pavers MODERATE
- Leaders to Rock Pits MODERATE
- Rain Barrels LEAST
- Rain Gardens BEST

Modelling Scenarios

- Diversion for Existing Conditions Only
- Diversion for Post-development Conditions
- Diversion for Post-development Conditions with 25% increase in impervious area to the developed lands below Highway One
- Diversion of Post-development conditions, but only diverting flows greater than 25 year flow. (assumes the creek channel improvments)

Diversion Plan

Modelling Scenarios - Conclusions

- The existing storm system is under capacity for a 200-year storm runoff event
- The predicted creek flows increase after development but not significant enough to warrant an increase in the size of the proposed diversion pipe
- Only diversion flows above the 25-year level reduces the required diversion pipe by 1.2 pipe sizes, but triples the amount of downstream culvert and channel deficiencies

Modelling Scenarios - Conclusions

- The cost savings of allowing the 25 year flow to remain in the creek are negated by the increased risk of the downstream properties

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
No. of Deficient Culverts	3	4	4	16
No. of Deficient Channels	6	6	7	20

Management Options - Recommendations

- Recommend construction of diversion pipe sized for the 200 year flow under post-development conditions
- Monitor areas of potential erosion concerns and prioritize future upgrades
- Prioritize drainage improvements as outlined in the ISMP Implementation Strategy

The ISMP is a Concept that Secure Protection of Public Safety, Property and the Environment

1. Principles of Major and Minor Flood Protection for Planned Land Uses Established
2. Benchmarking for Environmental Stream Protection Initiated for LID Future Comparison
3. Concept Level Management Plan for Stormwater Management for Low Frequency and High Intensity Storms and High Frequency and Low Intensity Storms Established

Questions?